MSPQC
Mississippi Perinatal Quality Collaborative

Cardiac Conditions in **Obstetric Care** Toolkit

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How to Use this Toolkit

This toolkit is organized around the 5 R's outlined in the Alliance for Innovation on Maternal Health (AIM) Cardiac Conditions in Obstetric Care AIM Safety Bundle.
https://saferbirth.org/psbs/cardiac-conditions-in-obstetric-care/

- Readiness – Every Unit
- Recognition & Prevention – Every Patient
- Response – Every Event
- Reporting & Systems Learning – Every Unit
- Respectful, Supportive & Patient-Centered Care – Every Unit, Provider, and Team Member

The committee has curated key resources from AIM and other established toolkits that can be tailored by each facility to support quality improvement initiatives. While this is not an exhaustive collection of materials, it provides the essential components needed to implement effective processes. We strongly encourage providers and hospitals to explore and utilize AIM's full library of resources, as well as additional evidence-based tools and best practices that promote safe cardiac care. Along with the AIM Safety Bundle materials, this toolkit includes resources from multiple organizations designed to assist with successful implementation efforts.

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READINESS

Readiness

There are seven domains of Readiness that apply to all care settings to facilitate safe, appropriate and timely care for obstetrical patients with cardiac conditions. Care settings include but are not limited to:

- Labor and Delivery Departments
- Postpartum Departments
- Emergency Departments
- Urgent Care
- Other practice areas where health care providers may not have specialized training in the care of pregnant and postpartum people

1. Train all obstetric care providers to perform a basic Cardiac Conditions Screen. Screening should include:
   - Patient history of cardiac conditions
   - Patient-reported symptoms
   - Vital signs
   - Physical examination

2. Establish a protocol for rapid identification of potential pregnancy-related cardiac conditions in all practice settings to which pregnant and postpartum people may present.

3. Develop a patient education plan based on the pregnant and postpartum person's risk of cardiac conditions.

4. Establish a multidisciplinary "Pregnancy Heart Team" or consultants appropriate to their facility's designated Maternal Level of Care to design coordinated clinical pathways for people experiencing cardiac conditions in pregnancy and the postpartum period. This team is intended to be the designated group of responders for OB Cardiac emergency care.

5. Establish coordination of appropriate consultation, co-management and/or transfer to appropriate level of maternal or newborn care.

6. Develop trauma-informed protocols and training to address health care team member biases to enhance quality of care.

7. Develop and maintain a set of referral resources and communication pathways between obstetric providers, community-based organizations, and state and public health agencies to enhance quality of care. Resources should include:
   - Specialist care
   - Social driver needs
   - Mental health supports
   - Substance use disorder treatment

Circulation

AHA SCIENTIFIC STATEMENT

Cardiovascular Considerations in Caring for Pregnant Patients

A Scientific Statement From the American Heart Association

ABSTRACT: Cardio-obstetrics has emerged as an important multidisciplinary field that requires a team approach to the management of cardiovascular disease during pregnancy. Cardiac conditions during pregnancy include hypertensive disorders, hypercholesterolemia, myocardial infarction, cardiomyopathies, arrhythmias, valvular disease, thromboembolic disease, aortic disease, and cerebrovascular diseases. Cardiovascular disease is the primary cause of pregnancy-related mortality in the United States. Advancing maternal age and preexisting comorbid conditions have contributed to the increased rates of maternal mortality. Preconception counseling by the multidisciplinary cardio-obstetrics team is essential for women with preexistent cardiac conditions or history of preeclampsia. Early involvement of the cardio-obstetrics team is critical to prevent maternal morbidity and mortality during the length of the pregnancy and 1 year postpartum. A general understanding of cardiovascular disease during pregnancy should be a core knowledge area for all cardiovascular and primary care clinicians. This scientific statement provides an overview of the diagnosis and management of cardiovascular disease during pregnancy.

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Cardiovascular disease (CVD) is the leading cause of pregnancy-related mortality in the United States and has gradually increased over time (from 7.2 to 17.2 deaths per 100 000 live births from 1987–2015).[1] The rise in maternal mortality has been attributed to increasing numbers of women at advanced maternal age undertaking pregnancy, comorbid preexisting conditions such as diabetes mellitus and hypertension, and the growing number of women with congenital heart disease surviving to childbearing age.[1,2] Racial and ethnic disparities in pregnancy-related mortality are significant, peaking among black non-Hispanic women followed by American Indian/Alaskan Native non-Hispanic women, Asian/Pacific Islander non-Hispanic women, white non-Hispanic women, and Hispanic women (42.8, 32.5, 14.2, 13.0, and 11.4 deaths per 100 000 live births, respectively).[1]

Early and specialized multidisciplinary care in the antepartum, peripartum, and postpartum time frames is essential to improve cardiovascular outcomes and to reduce maternal mortality up to the first year postpartum (Figure 1). The cardio-obstetrics team (also referred to as the pregnancy heart team)[3,4] should provide a comprehensive review of maternal cardiovascular risk, obstetric risk, and fetal risk and outcomes. This includes expectant management and prepregnancy counseling on cardiac medication safety throughout pregnancy and lactation phases. The cardio-obstetrics team is often made up of obstetricians, cardiologists, anesthesiologists,

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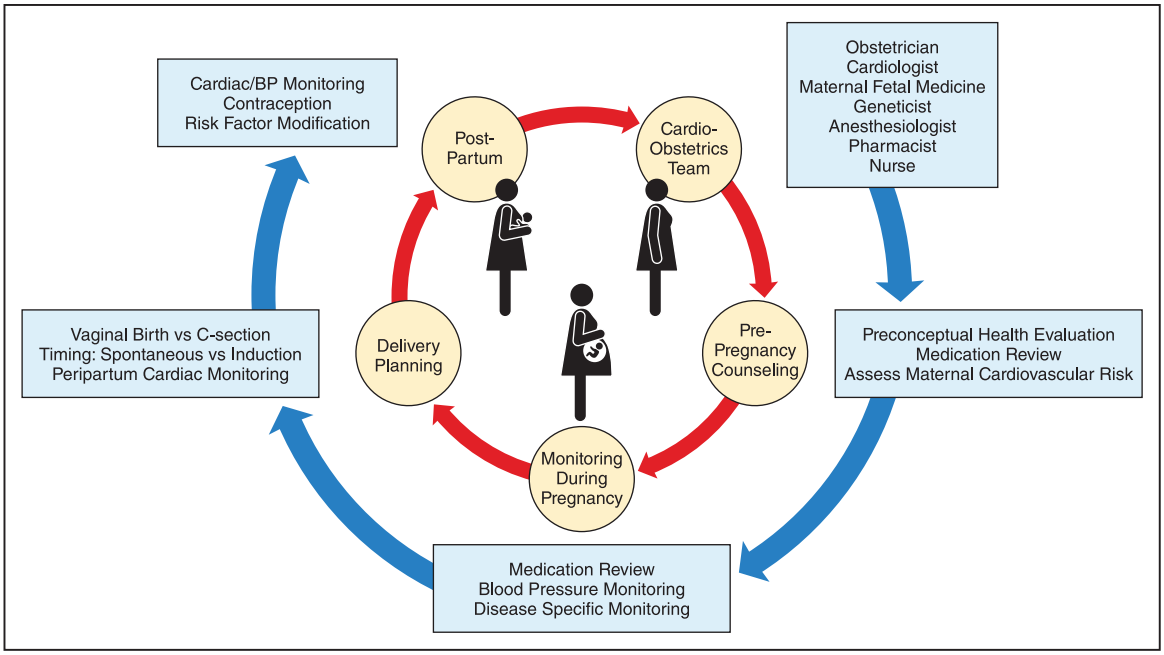

Figure 1. Cardio-obstetrics team in the management of women before pregnancy, during pregnancy, and postpartum.
BP indicates blood pressure.

maternal fetal medicine specialists, geneticists, neurologists, nurses, and pharmacists who jointly develop a comprehensive strategy for management of CVD during pregnancy, delivery, and postpartum.

This scientific statement provides an overview of CVD during pregnancy, exclusive of congenital heart disease and sudden cardiac arrest, which are addressed in recent American Heart Association (AHA) scientific statements on these specific topics.[5,6] In addition, this scientific statement highlights the need for a cardio-obstetrics team for the management of CVD in women during a high-risk pregnancy.

PHYSIOLOGICAL CHANGES DURING PREGNANCY

Predictable and expected hemodynamic and structural changes occur during pregnancy (Data Supplement

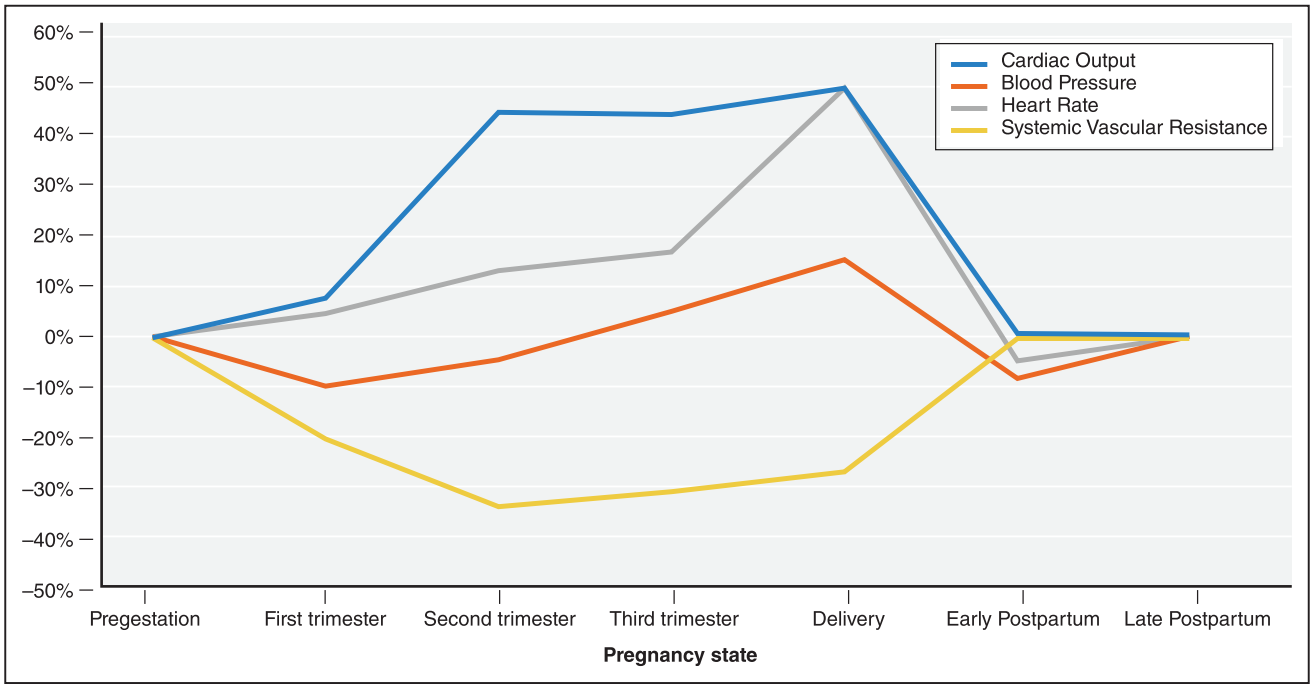

Figure 2. Physiological changes during pregnancy, including variation in cardiac output, blood pressure, and heart rate.[4,7]

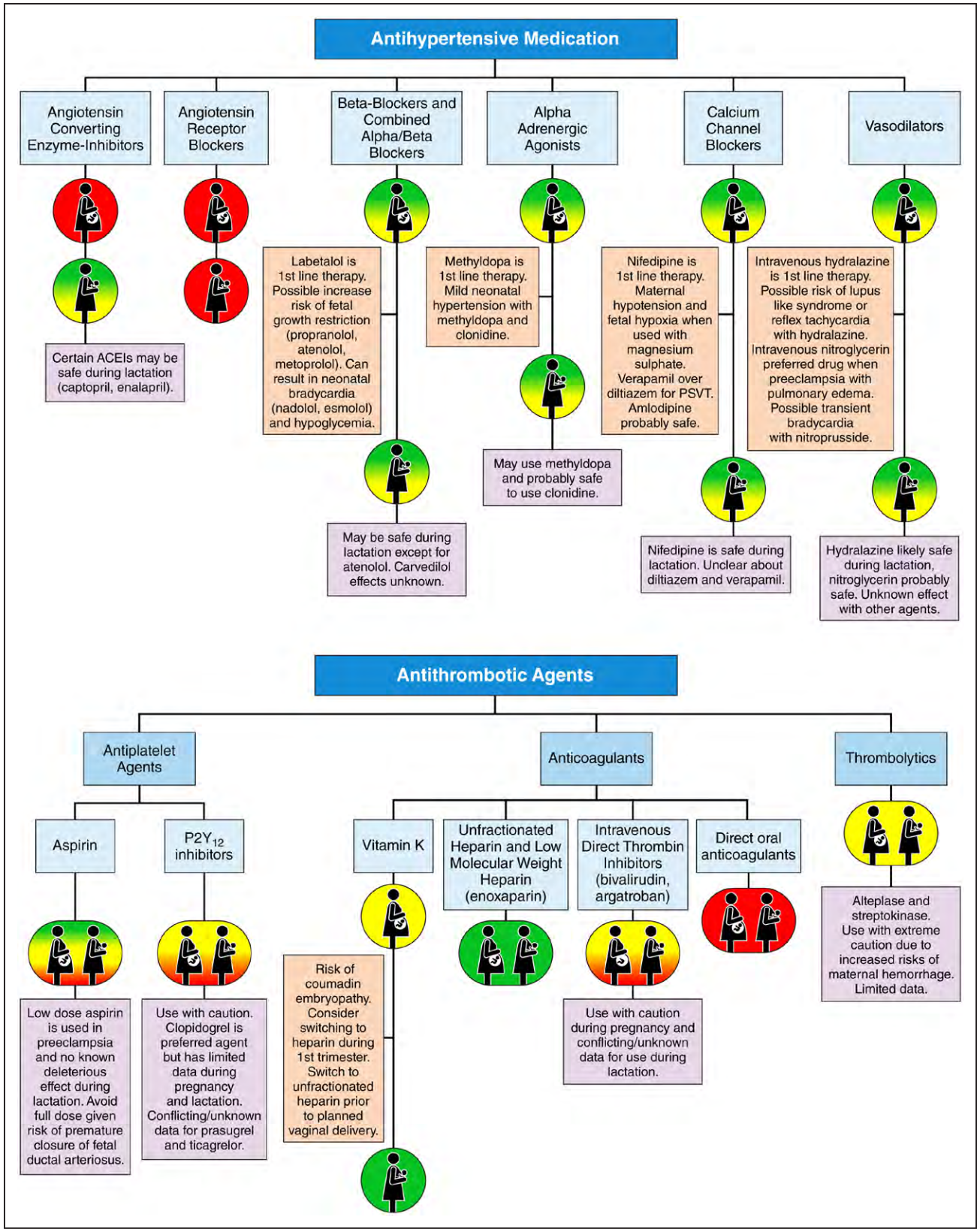

Figure 3. Antihypertensive medications and anticoagulants used during pregnancy.[3,5,9–12]
Boxes with various shades: Red shows contraindicated medications; yellow, use-with-caution medications; and green, relatively safe medications. ACEI indicates angiotensin-converting enzyme inhibitor; and PSVT, paroxysmal supraventricular tachycardia.

Table 1 and Data Supplement Figure 2).[4,7] Along with structural changes of the left ventricle (LV) in pregnancy, activation of the renin-angiotensin-aldosterone system and hormonal fluctuations contribute to the increase in plasma volume, rise in cardiac output, and decline in systemic vascular resistance. Significant fluid shifts at delivery lead to labile peripartum blood pressure, often rising before delivery and then falling within week.[4,7]

PREPREGNANCY COUNSELING

CVD is the leading cause of indirect maternal mortality, and women with CVD should receive counseling on both maternal and fetal risks before conceiving. These women should be cared for by a specialized cardio-obstetrics team (Figure 1) with experience in managing high-risk women with CVD during pregnancy.[8] Preconception counseling is important to ensure that estimates of individual risk are considered when women begin family planning. This counseling permits the high-risk cardio-obstetrics team to include the patient in shared decision-making and to outline anticipated or potential events during pregnancy and management strategies at every stage of the process. In preconception planning, all medications should be reviewed to ensure safety during pregnancy (Figure 3).[3,5,9–12] For example, angiotensin-converting enzyme inhibitors and angiotensin receptor blockers are teratogenic and should be replaced with medications known to have a better safety profile in pregnancy. A comprehensive clinical review of a woman's overall health before conception should include reviewing the need for supplemental folic acid and monitoring nutritional status.[13]

The modified World Health Organization (WHO) classification is often the preferred method to estimate individual maternal cardiovascular risk in women with CVD who are contemplating pregnancy (Data Supplement Table 2).[14] Several risk models that estimate maternal cardiovascular risk have been evaluated, but the WHO classification remains the only prospectively validated method for risk assessment. Nonetheless, most models have included several factors known to increase maternal cardiovascular risk, including prior CVD event, history of arrhythmia, prior heart failure, poor functional class, resting cyanosis, use of anticoagulant therapy, and presence of a mechanical valve. In most models of maternal cardiovascular risk estimation, several conditions are felt to be of high/prohibitive risk to continue with pregnancy, including pulmonary arterial hypertension, severe ventricular dysfunction, severe left-sided heart obstruction, and significant aortic dilatation with underlying connective tissue disease.[3] Women with these conditions are often advised to avoid pregnancy. However, it is not uncommon for women to present pregnant, and at that point, the high-risk cardio-obstetrics team must work together to come up with the best way to mitigate maternal cardiovascular and obstetric risk and fetal risk moving forward.

MEDICAL CONDITIONS DURING PREGNANCY

Hypertensive Disorders in Pregnancy

Hypertensive disorders of pregnancy (HDP) are common in the United States, occurring in 912 per 10 000 delivery hospitalizations.[15] HDP are classified into 4 categories by the American College of Obstetricians and Gynecologists (ACOG): preeclampsia/eclampsia, gestational hypertension, chronic hypertension, and chronic hypertension with superimposed preeclampsia[11,12] (Data Supplement Figure 1). Preeclampsia is defined hypertension (systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg in women after 20 weeks of gestation who were previously normotensive) along with evidence of proteinuria. The salient features of preeclampsia with severe features and associated risk factors are highlighted in Data Supplement Table 3.[16] Preeclampsia is important because women with preeclampsia have a 71% increased risk of CVD mortality, a 2.5-fold increased risk of coronary artery disease, and a 4-fold increased risk of heart failure compared with normal cohorts.[17]

A recent joint presidential advisory from the ACOG and AHA highlighted the need for a multidisciplinary management strategy incorporating lifestyle and behavioral modifications, including diet, exercise, and smoking cessation, as well as electronic medical record–based standardized algorithms targeting cardiovascular risk factors.[18] Several studies have proposed that regular exercise during pregnancy may improve vascular function and prevent preeclampsia.[19,20] Moderate exercise has been studied to evaluate the prevention of preeclampsia. However, large randomized controlled trials evaluating the potential reversal of endothelial dysfunction leading to improved outcomes have still not been done.[21] For women with high-risk conditions (chronic hypertension, previous preterm preeclampsia, preterm birth at <34 weeks of gestation, diabetes mellitus), low-dose aspirin may be considered and should be started in the late first trimester.[3,11,12]

Expeditious triage and treatment within 30 to 60 minutes of confirmed severe hypertension (blood pressure ≥160/110 mm Hg and persistent for 15 minutes) should be initiated to reduce the risk of maternal heart failure, myocardial ischemia, stroke, or renal disease.[11] For severe hypertension, treatment with intravenous labetalol or intravenous hydralazine is typically recommended. However, if intravenous access has not been established, immediate-release oral nifedipine may be administered (Data Supplement Figure 2).[11] Intravenous

nitroglycerin is the preferred drug when preeclampsia is associated with pulmonary edema. For the prevention of eclampsia and treatment of seizures, intravenous magnesium sulfate is recommended. However, there is a potential synergy with calcium channel blockers, which can result in hypotension.[3,11]

Less severe hypertension can be managed with labetalol, nifedipine, and methyldopa, which are commonly used as first-line antihypertensive medications. Hydrochlorothiazide can be used as a second-line agent in patients with developing hypertension.[3,12] In a meta-analysis of 49 trials in pregnant women with mild to moderate hypertension (systolic blood pressure of 140–169 mm Hg and diastolic blood pressure of 90–109 mm Hg), antihypertensive medications reduced the risk of developing severe hypertension, but it was no better than placebo at preventing maternal complications (preeclampsia, death) or neonatal outcomes (preterm birth, babies who were small for gestational age, or neonatal/perinatal death).[22] One large multicenter international trial of women with preexisting or gestational hypertension compared fetal and maternal complications of patients with less tight and those with tight blood pressure control. In this trial, there were no significant differences in adverse perinatal outcomes or overall maternal complications between the blood pressure control groups. However, there was a significantly higher frequency of severe maternal hypertension in the less tight blood pressure control group.[23] Several consensus and guideline statements in this area are published, but there is no clear consensus on the optimal blood pressure threshold to initiate antihypertensive treatment or to target blood pressure in women with nonsevere HDP.[3,11,12,24,25]

Maternal risk stratification is needed to help guide patient care, including timing of delivery, and may help improve cardiovascular outcomes. One such model is the fullPIERS model (Preeclampsia Integrated Estimate of Risk), which was developed to identify predictors of adverse maternal outcomes in women who were admitted with preeclampsia or developed it after admission. Predictors included gestational age, symptoms of chest pain or dyspnea, oxygen saturation levels, platelet count, and serum creatinine and aspartate transaminase concentrations. In this multivariate model, blood pressure did not independently predict adverse maternal outcomes, and it was largely felt to be the only element for which an easy intervention is possible.[26]

For women with HDP requiring antihypertensive therapy, early outpatient blood pressure surveillance during the first 1 to 2 weeks postpartum is encouraged. Antihypertensive therapy should be continued in postpartum patients with persistent hypertension (≥150/100 mm Hg). Blood pressure control continues to be an important consideration in the postpartum period because even those women who are not treated with antihypertensive medications during pregnancy may warrant close surveillance, monitoring, and initiation of medications in the postpartum time frame. An important recognition is that severe hypertension or superimposed preeclampsia also may develop for the first time in the postpartum period; therefore, early ambulatory visits in the first 1 to 2 weeks after delivery or home blood pressure monitoring may be prudent. Medication in the first few weeks postpartum should be adjusted to maintain a systolic blood pressure not higher than 150 mm Hg and a diastolic blood pressure not higher than 100 mm Hg. For those women with persistent hypertension beyond 6 weeks to 3 months postpartum, blood pressure management should be initiated as per the current American College of Cardiology/AHA guidelines and on an individualized basis.[12,24]

Hypercholesterolemia in Pregnancy

Total cholesterol, triglycerides, and low-density lipoproteins levels rise steadily during pregnancy and reach peak levels at the time of delivery. However, neither triglycerides nor total cholesterol exceeds 250 mg/dL in normal pregnancies.[27] After delivery, major lipoprotein levels decline over the next 3 months to near prepregnancy levels (Data Supplement Figure 3). According to the 2018 multisociety guideline on the management of blood cholesterol, estimation of atherosclerotic CVD risk and documentation of baseline low-density lipoproteins with a lipid panel are recommended for adults who are ≥20 years of age and not on lipid-lowering therapy.[28] However given the variation in lipids during pregnancy, it is preferable to screen for dyslipidemia before pregnancy according to the National Lipid Association's recommendations for patient-centered management of dyslipidemia.[29]

The 2 most common conditions in which lipids should be addressed during pregnancy are severe hypertriglyceridemia and familial hypercholesterolemia; however, pharmacological treatment is limited because of fetal risks. Pregnancy-related complications such as preeclampsia and gestational diabetes mellitus are associated with triglyceride levels >250 mg/dL.[27] A heart-healthy lifestyle (diet, exercise, weight management) is recommended for all patients. Those with very high triglyceride levels (>500 mg/dL) are at risk for pancreatitis and may benefit from pharmacological agents (omega-3 fatty acids with or without fenofibrate or gemfibrozil) during the second trimester. The risk for premature atherosclerosis is elevated in patients with familial hypercholesterolemia, and during pregnancy, this risk may be further exacerbated by supernormal atherogenic lipoproteins while the patient is off statin therapy. Statins are contraindicated during pregnancy, and all women who are on any lipid-lowering agents should review with their physician the safety of treatment during pregnancy and whether to discontinue treatment

before pregnancy. Current treatment options for pregnant women with familial hypercholesterolemia include bile acid sequestrants, which lack systemic circulation, and, as last resort, low-density lipoprotein apheresis in severe cases (Data Supplement Figure 4).[28,29]

Ischemic Heart Disease in Pregnancy

Ischemic heart disease during pregnancy constitutes a rare but potentially fatal condition. The risk of acute myocardial infarction (MI) is 3- to 4-fold higher in pregnant women compared with their nonpregnant counterparts. The incidence is between 2.8 and 8.1 cases per 100 000 deliveries, with mortality rates of 4.5% to 7.3%.[30–32] Although atherosclerosis accounts for <50% of patients,[33] pregnancy-related spontaneous coronary artery dissection and MI with nonobstructive coronary arteries are prevalent causes (Data Supplement Figure 5) of acute MI in pregnancy.[34] The third trimester and postpartum are the highest-risk periods.[32,34]

A multidisciplinary team approach should be adopted,[4] and the treatment strategy is guided by the clinical presentation. In patients with atherosclerotic ST-segment– elevation MI, timely coronary reperfusion by percutaneous coronary intervention (PCI) is recommended.[35] Fetal radiation protection with lead shielding and radiation reduction measures should be implemented.[36] If PCI is not readily available, thrombolysis is very rarely used and has been administered with extreme caution because of the risk of maternal hemorrhage.[37,38] An invasive approach is also recommended in patients with non–ST-segment–elevation MI who are unstable or have high atherosclerotic burden. Stable patients at low risk can be managed conservatively.[39]

Angiography is the gold standard for the diagnosis of ischemic heart disease in pregnancy (Data Supplement Figure 6). In the case of atherosclerotic plaque rupture or coronary thrombosis, PCI with stent implantation is recommended.[35,40] Because pregnant women were generally excluded from stent trials, scarce evidence is available for this population. Post-PCI low-dose aspirin is considered safe throughout pregnancy, and clopidogrel may be used with caution for the shortest duration possible. Other antiplatelet agents should be avoided.[9]

Pregnancy-related spontaneous coronary artery dissection is a challenging diagnosis in clinical practice (Data Supplement Table 4).[41] Similar to the general population, conservative management with inpatient monitoring is recommended for most patients,[42] with a high rate of lesion recovery within months of its occurrence.[43,44] Radial forces generated by balloon inflation or stent expansion may broaden the dissection, resulting in procedural failure.[43–45] PCI should be performed only in a patient presenting with left main coronary artery dissection, hemodynamic instability, recurrent chest pain, or ongoing ischemia.[42,43] Although pharmacotherapy in this clinical scenario is not well established, antiplatelet agents combined with β-blockers (ie, labetalol) represent the most accepted regimen.[3,45,46] MI with nonobstructive coronary arteries should be considered a working diagnosis warranting further investigation. The recent AHA scientific statement on MI with nonobstructive coronary arteries offers a comprehensive diagnostic algorithm.[47] Treatment should be tailored to the underlying pathophysiology.

Pregnancy in women with preexisting coronary artery disease is considered to be very high risk. The probability of developing ischemic complications is ≈10%, and only 21% of women have a completely uncomplicated pregnancy.[48] In those patients with prior spontaneous coronary artery dissection, LV dysfunction, and signs of residual ischemia, consultation and shared decision-making with the cardio-obstetrics team are essential when these women are counseled about the increased cardiovascular risks with future pregnancy.[39] Women with a history of these conditions who become pregnant should be monitored very closely.

Cardiomyopathies in Pregnancy

The diagnosis and management of cardiomyopathy during pregnancy are challenging because both dilated cardiomyopathy and peripartum cardiomyopathy (PPCM) may represent a condition within a spectrum of similar pathophysiology. Therefore, it is important to exclude reversible causes of left ventricular dysfunction (eg, myocarditis, hypertension, underlying valve disease, toxin-induced, ischemia).[49] PPCM is defined as new-onset cardiomyopathy with systolic dysfunction (LV ejection fraction <45%) without a reversible cause presenting near the end of pregnancy or in the postpartum period in a woman without known heart disease and is a significant cause of maternal morbidity and mortality.[50] The prognosis for women with PPCM is strongly linked to LV ejection fraction at presentation. The IPAC study (Investigations of Pregnancy Associated Cardiomyopathy) followed up 100 women with PPCM with echocardiography during the first postpartum year and determined that recovery of LV function occurred almost exclusively within the first 6 months postpartum, with little subsequent change. In addition, major cardiovascular events (heart transplantation, LV assist device, or death) occurred almost exclusively in women with an ejection fraction of <30%.[51] Treatment of heart failure during pregnancy is directed at controlling volume status (eg, diuretics), afterload reduction (eg, nitrates, hydralazine), rhythm control (eg, β-blockers, digoxin), and anticoagulation if necessary (Data Supplement Figure 7). Many causes of PPCM have been proposed, and animal models of suppression of prolactin production have been shown to prevent the development of PPCM. Bromocriptine, which

suppresses prolactin production, has been shown to be associated with improvement in LV function[52] and may be considered as adjunctive treatment in women with PPCM according to the 2018 European Society of Cardiology guidelines for the management of CVD during pregnancy.[3] Appropriate contraception choices and risk in future pregnancies of recurrent PPCM must be discussed early in the management of these women.[53]

The management of pregnant women with other forms of cardiomyopathies is often determined by the individual's physiology and the severity of the condition. For example, some women with hypertrophic cardiomyopathy tolerate pregnancy well. However, up to 23% of women experience heart failure or arrhythmia-related complications during pregnancy, most commonly in the third trimester or postpartum.[54] Treatment should be tailored for specific indications (eg, β-blockers for LV outflow tract obstruction or arrhythmias). Diuretics must be used cautiously for volume overload because many of these women need to maintain preload in the setting of LV outflow tract obstruction.[55] Particular attention must be paid in the early postpartum period, when dramatic fluid shifts and changes in afterload may worsen underlying hemodynamics.

Arrhythmias in Pregnancy

Data gathered between 2000 and 2012 in 57 million pregnancies have shown a rise in the number of pregnancy-related hospitalizations for arrhythmias, a finding that has been felt to be related to increasing numbers of women pursuing pregnancy at advanced maternal age, particularly in women 41 to 50 years of age.[56] Pregnant black women have an increased frequency of any arrhythmia compared with women in other ethnic groups.[57] Palpitations caused by sinus tachycardia and atrial and ventricular ectopy are usually self-limited and benign and require no pharmacological treatment.[58] More complex arrhythmias require a cardio-obstetrics team approach, and management strategies may include initiation or titration of antiarrhythmic therapy or consideration of an electrophysiological study and radiofrequency ablation.

Sustained arrhythmias are more frequent in patients with underlying structural heart disease or thyroid or electrolyte disturbances. Stable supraventricular tachycardia treatment should be no different in pregnant patients, and if vagal maneuvers fail, then intravenous adenosine may be used.[59] Wolff-Parkinson-White syndrome can worsen during pregnancy[60]; intravenous procainamide can be used for wide-complex tachyarrhythmia.[61] Catheter ablation for atrial arrhythmias may be needed if medical therapy fails, ideally with minimal radiation exposure.[62,63]

New-onset atrial fibrillation in pregnancy usually indicates underlying heart disease and should be treated on an inpatient basis by a cardiologist.[64] If the patient is unstable, direct cardioversion is recommended over chemical cardioversion because it is highly safe and effective. Digoxin, β-blockers, and calcium channel blockers can be used for rate control; however, amiodarone should be avoided. If necessary, catheter ablation can be used for atrial flutter refractory to medication, avoiding/limiting fluoroscopy if possible and preferably delaying the ablation until the second trimester. For stroke prevention in patients with valvular heart disease or high stroke risk, vitamin K antagonists can be used after the first trimester, whereas low-molecular-weight heparin (LMWH) should be accompanied by periodic evaluation of anti–factor Xa.[64]

Prepregnancy counseling in women with congenital long-QT syndrome is advised to discuss the significantly increased risk of malignant tachyarrhythmias, and these women require β-blockade throughout pregnancy.[65] Recent American and European practice guidelines for the management of patients with ventricular arrhythmias outline nuances of management of this condition (Data Supplement Table 5).[66,67] Because there are no trials, registry data, or systematic analyses, data on the safety of antiarrhythmic drugs are limited. In patients with severely symptomatic bradycardia, a pacemaker is indicated regardless of pregnancy status.

Synchronized cardioversion is used if there is hemodynamically significant supraventricular tachycardia, atrial fibrillation, and ventricular tachyarrhythmia, similar to nonpregnant patients.[68] In the event of hemodynamic compromise, treatment is similar to that in a nonpregnant patient with direct unsynchronized cardioversion.[69] There are limited human reports on pharmacological therapy for the treatment of sustained ventricular tachycardia in hemodynamically stable patients; in general, intravenous procainamide and lidocaine are considered safe.[70] Data Supplement Table 6 summarizes antiarrhythmic treatment options for pregnant patients according to underlying arrhythmia.

Valvular Heart Disease in Pregnancy

Valvular heart disease pathologies in women of childbearing age are most commonly congenital but may include rheumatic, acquired, and native degenerative causes. Many young women have undergone preconception valvular repair or replacement. Regardless of pathogenesis and prior treatment, women with a history of valvular heart disease should undergo preconception evaluation by the cardio-obstetrics team. Safety and potential risks should be discussed before pregnancy, including in those with mechanical prosthetic valves or moderate to severe native regurgitant or left-sided stenotic valvular lesions and those with associated ventricular dysfunction or pulmonary hypertension. Frequency of monitoring, composition of the care team,

delivery planning, and management during pregnancy are determined on the basis of patient risk.[2,5,71–76] The recently published ACOG guidelines recommend the estimation of risk and subsequent management with the modified WHO classification (Data Supplement Table 2).[4,77] Ideally, severe valvular heart disease should be treated before conception. Clinical judgment prevails in each case; however, consideration should be given to performing valvular repair/replacement with a bioprosthesis to minimize the need for therapeutic anticoagulation during pregnancy.[4,78]

Left-sided stenotic valvular lesions are associated with the highest-risk valve lesion in pregnancy. A summary of the clinical features is presented in Data Supplement Table 7. Symptoms may develop in previously asymptomatic patients because increased blood volume, higher heart rate, and diminished cardiac output exaggerate stenotic physiology. Pregnancy-related hemodynamic changes lead to expected physiological augmenting of derived velocity, and imaging specialists must be aware of these normal changes when interpreting studies performed throughout pregnancy. Mitral stenosis, most commonly from rheumatic heart disease, is associated with increased maternal and fetal morbidity and mortality. Untreated mitral stenosis can lead to heart failure with pulmonary edema, atrial arrhythmias, cerebrovascular events, and death.[77,79,80] Although the cardiovascular risk profile of mitral stenosis in pregnancy has changed over time, the risks escalate with increasing severity of stenosis.[81] β-1–Selective β-blockers along with activity restriction are the primary treatment recommendations for patients with mitral stenosis who either are symptomatic or have significant pulmonary hypertension. Percutaneous mitral commissurotomy can be performed in pregnant (preferably after 20 weeks of gestation) patients with mitral stenosis with severe symptomatic heart failure or significant pulmonary artery hypertension despite optimal medical management.[3] While typically associated with better outcomes than mitral stenosis, severe aortic stenosis can also be associated with increased maternal cardiovascular risk during pregnancy, including heart failure, arrhythmias, and rarely death.[82] Adverse fetal outcomes include prematurity and fetal growth restriction, with the highest risk again occurring in those with more severe aortic stenosis. The management of women who are contemplating pregnancy or who are already pregnant is guided largely by the severity of aortic stenosis and whether symptoms are present.[83]

Valvular regurgitant lesions are generally well tolerated in pregnancy. These lesions are less likely to cause complications because diminished afterload is present as a result of low-resistance placental circulation and an expected decrease in systemic vascular resistance. However, the presence of ongoing symptoms despite optimal medical therapy before pregnancy should lead to consideration of valvular repair or replacement before conception.[84,85] Even if stable throughout pregnancy, women with valvular regurgitant lesions may be at risk for developing pulmonary edema postpartum when systemic vascular resistance abruptly increases in the setting of high total body volume.[86]

Pregnancy in women with mechanical prosthetic heart valves is associated with increased risk of fetal and maternal morbidity and mortality.[4,75,76,78] Maternal risks include increased mortality, valve thrombosis–associated valvular dysfunction, heart failure, stroke, and maternal hemorrhage. Risks to the fetus include increased mortality, teratogenicity, and hemorrhage.[75,78,87] The optimal strategy for maintenance of anticoagulation during pregnancy in women with prosthetic heart valves remains controversial. Given the known dose-dependent teratogenicity, the 2014 AHA/American College of Cardiology Guideline for the Management of Patients with Valvular Heart Disease and the 2018 European Society of Cardiology Guideline for the Management of CVD During Pregnancy recommend continuing warfarin if therapeutic anticoagulation can be maintained at a dose ≤5 mg/d.[3,85] If the dose of warfarin required to maintain therapeutic anticoagulation exceeds 5 mg/d or the patient prefers to avoid warfarin, suggested alternatives include dose-adjusted LMWH (guided by weekly peak and consideration of trough anti–factor Xa levels, targeting a range of 0.8–1.2 U/mL) or dose-adjusted continuous unfractionated heparin (UFH). Warfarin can be resumed safely in the second trimester and then transitioned to dose-adjusted continuous UFH in anticipation of delivery. Brief cessation of anticoagulation is required before delivery. With regard to labor and delivery, the use of epidural anesthesia is contraindicated in the anticoagulated patient. The American Society of Regional Anesthesia and the Society for Obstetric Anesthesia and Perinatology recommend holding intravenous UFH for 4 to 6 hours and LMWH for 24 hours before the administration of epidural anesthesia.[88,89] The 2018 European Society of Cardiology guidelines for the management of CVD during pregnancy recommend planned delivery in women with mechanical valves. These women should be hospitalized and placed on intravenous UFH or LMWH with close monitoring at 36 weeks, and at ≈36 hours before planned delivery, they should be on intravenous UFH, which is recommended to be discontinued 4 to 6 hours before delivery. Intravenous UFH can be restarted as early as 4 to 6 hours after delivery, depending on the type of delivery and whether there were bleeding complications.[3] Cesarean section should be performed in women who go into labor while therapeutically anticoagulated with warfarin because of the risk of fetal hemorrhage associated with vaginal delivery.[3,5]

Aortic Disease and Pregnancy

Aortopathy in the pregnant woman carries substantial cardiovascular risk (modified WHO pregnancy risk category of III–IV, Data Supplement Table 2) because of the combination of hemodynamic changes and hormonally driven structural effects on the integrity of vascular/connective tissue.[90,91] Heritable fibrillinopathies, bicuspid valve–associated aortopathy, and Turner syndrome are a few of the many causes of aortopathy, which results in aneurysms and dissection in women of childbearing age. The heritability and syndromic features of genetic aortopathies are heterogeneous, as is the risk of pregnancy-associated maternal cardiovascular morbidity and mortality (Data Supplement Figure 8). Unfortunately, this contributes to the challenging nature of caring for these women in pregnancy.

Several published guidelines address prophylactic aortic root replacement to avoid spontaneous dissection.[84,85,92–95] However, data in pregnancy are less clear and may include consideration of absolute diameter and the ratio of cross section to height (Data Supplement Table 8). In general, a multipronged approach to women with aortopathy is required during the antepartum, peripartum, and postpartum periods with clinical

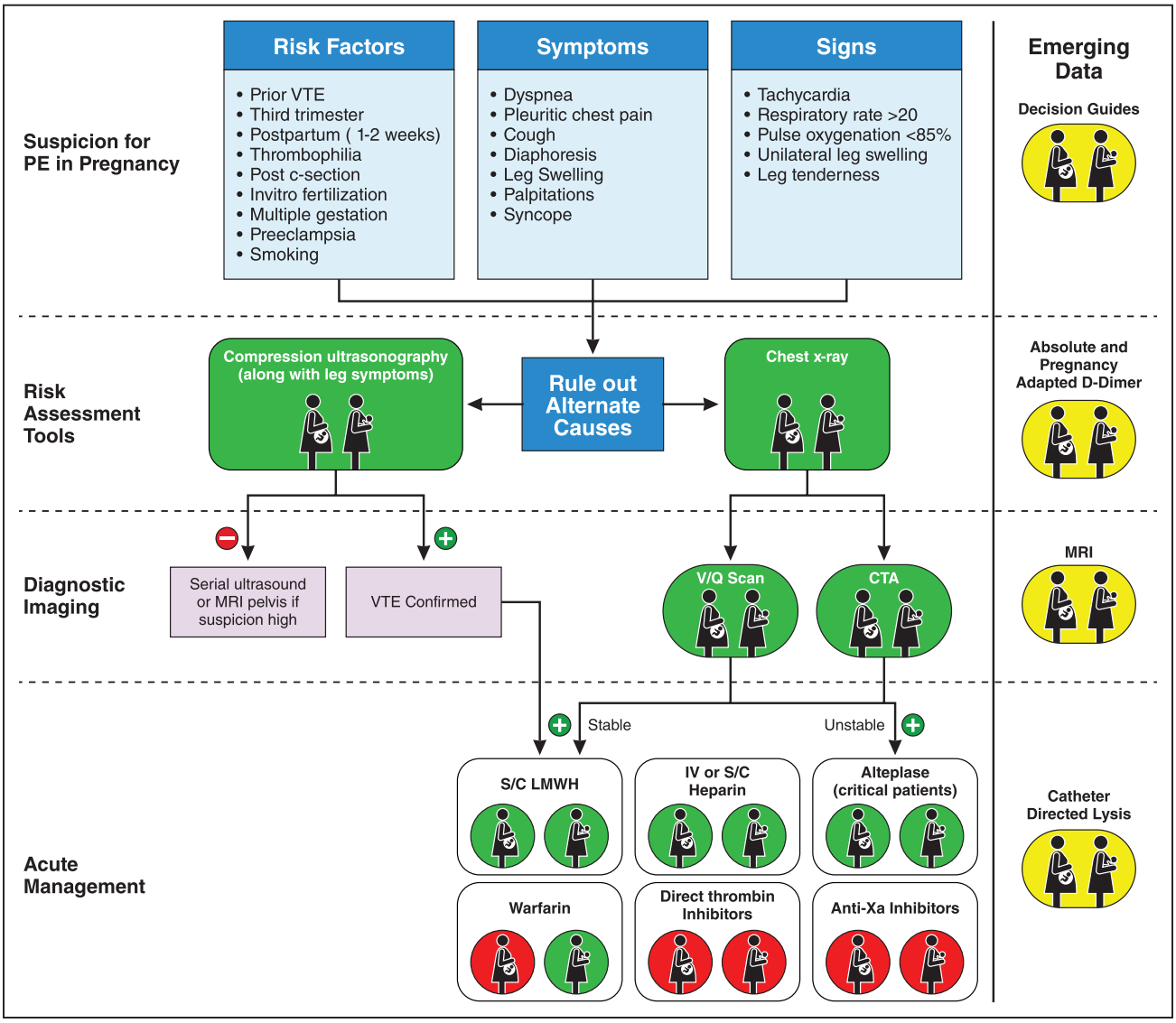

Figure 4. Proposed algorithm for the diagnosis of pulmonary embolism (PE) during pregnancy.[3,99–116]
Guidelines for diagnosing PE during pregnancy are limited and based on low-level evidence derived primarily from data from small observational trials. Acquired or inherited thrombophilia include lupus anticoagulant, shortened activated partial thromboplastin time, factor V Leiden, prothrombin variations, familial proteins C and S, and antithrombin deficiency. Other population-based risk factors include age; presence of autoimmune conditions, sickle cell disease, or obesity; history of cancer; or bed rest for >72 hours. Absolute cutoff for D-dimer is typically <500 μg for most commercial assays, and the adjusted cutoff may be <500 or <1000 μg or dependent on gestation.[101–103,108] Given the high risk of hemorrhage with systemic thrombolytics, particularly in the postpartum period, catheter-based thrombolysis may be considered as an alternative.[112] In stable patients, low-molecular-weight heparin (LMWH) is preferred over unfractionated heparin given the longer half-life, similar efficacy and safety, and lower risk of thrombocytopenia and osteoporosis.[97] CTA indicates computed tomographic angiography; IV, intravenous; MRI, magnetic resonance imaging; S/C, subcutaneous; V/Q, ventilation/perfusion; and VTE, venous thromboembolism.

evaluation of blood pressure and echocardiographic assessment of aortic dimensions. Consideration of pharmacological therapy with β-blockers for strict blood pressure control is recommended. Echocardiographic evaluation of the aorta should be performed during pregnancy (may be reasonable every 12 weeks in low-risk women with mildly dilated aorta and warranted every month in women with severely dilated aorta or at high risk of dissection) and at 6 months after delivery.[3] The cardio-obstetrics team approach would also include consideration of intervention if appropriate, multidisciplinary delivery planning, and postpartum follow-up (Data Supplement Figure 9), including when surgical replacement of the aorta is recommended (Data Supplement Table 8). During pregnancy, Stanford type A dissection is a surgical emergency that would necessitate cardiothoracic surgical intervention to rapidly deliver the fetus and repair the dissection. Conservative medical management, including strict blood pressure control, is recommended for stable type B aortic dissections.[3]

Deep Venous Thrombosis and Pulmonary Embolism in Pregnancy

Venous thromboembolism (VTE), referring to deep venous thrombosis (DVT) and pulmonary embolism (PE), is 4 to 5 times more common during pregnancy. However, the absolute risk of VTE during pregnancy remains low at 0.3% for PE and 1.2% for DVT, with the majority (70%) occurring in the postpartum period.[96,97] Accordingly, low rates of pregnancy-related PE have been reported in emergency department evaluations.[98]

DVT commonly presents with extremity pain or swelling and is diagnosed with compression ultrasonography. However, DVT in pregnancy is often proximal (iliac or iliofemoral) and predominantly left-sided.[96] Therefore, if ultrasonography is negative and clinical suspicion remains high, serial ultrasonography measurements in 3 to 7 days or magnetic resonance imaging of the pelvis should be considered.[3,99]

The diagnosis of PE is challenging because the presentation often overlaps with symptoms common during normal pregnancy (Figure 4). It therefore requires a high index of suspicion, particularly in the presence of risk factors such as a history of VTE or thrombophilia. One-third of patients with PE do not have any symptoms.[100] The initial evaluation for PE should include ECG, chest x-ray, and blood tests to rule out alternative causes such as ischemia, anemia, or infection. A clinician may weigh risk factors and presentation (Figure 4) to estimate pretest probability in order to guide the need for testing or early up-front therapy before obtaining imaging results.[3,99–116] However, there is no consensus on this approach. Recently, pregnancy-adapted decision algorithms have been proposed with promising early data, but they require validation in larger studies.[102–104]

D-dimer testing to rule out PE during pregnancy has remained controversial (Data Supplement Table 9). D-dimer physiologically increases with each trimester, leading to low specificity[101,105,117] and even, in rare cases, false negatives.[118,119] Emerging data support a negative predictive value of ≈100% for high-sensitivity D-dimer assay in low-risk patients, especially during the first and early second trimesters.[103,106,107,120] Further work is needed to determine normal levels for each week of gestation.[105,108]

A definitive diagnosis of PE requires imaging such as lung scintigraphy (ventilation/perfusion scan) or coronary tomographic angiography. The choice of diagnostic test should be based on institutional protocols, availability, and shared decision-making that involves a discussion of maternal and fetal risks with the patient (Data Supplement Table 10).[121] Coronary tomography and ventilation/perfusion scans have similar sensitivity, yet coronary tomographic angiography is often more readily available and more efficient with lower interobserver variability than the ventilation/perfusion scan in an emergency department setting. However, selection of the most appropriate test is often guided by local expertise and the level of radiation exposure.[108,122,123]

Once diagnosed, all VTE should be treated with antithrombotic therapy (Table 1). Intravenous UFH is recommended for acute PE and for DVT with large clot burden, for hemodynamic instability, and when surgery or delivery is anticipated. In stable patients, LMWH is preferred over UFH. Approximately 4% of pregnant patients with VTE experience cardiac arrest. Thrombolysis is recommended for patients with hemodynamic instability or massive PE.[37] Inferior vena cava filters may be considered only in cases in which anticoagulation is contraindicated or has failed.[124]

Cerebrovascular Disease in Pregnancy

Pregnancy introduces specific cerebrovascular risk factors uncommon in an otherwise healthy young-adult female population. Cerebrovascular risk is highest in the third trimester and within 6 weeks postpartum (puerperium) and includes ischemic stroke, cerebral venous thrombosis (CVT), intracerebral hemorrhage, reversible cerebral vasoconstriction syndrome (RCVS), and posterior reversible encephalopathy syndrome (PRES). In the United States, combined ischemic and hemorrhagic stroke risk is estimated to occur in 30 per 100 000 pregnancies.[125]

In a recent meta-analysis, the arterial ischemic stroke rate in pregnancy was 12.2 per 100 000 (separating arterial and venous thrombosis).[125] There are multiple risk factors for ischemic stroke in pregnancy, including hypertension, sickle cell disease, systemic lupus erythematosus, and migraines. Pathogenetic factors for stroke in

Table 1. Anticoagulation for Thromboembolic Events During Pregnancy

Drug	Teratogenic	Crosses Placenta	Compatibility with Breastfeeding	Antepartum Indications	Postpartum indications	Therapeutic Doses
Warfarin	Yes	Yes	Probably compatible	Atrial fibrillation/flutter, after first trimester (bridge with LMWH during first 6–12 wk of gestation)	DVT/PE	Individualized starting dose and adjusted to INR (goal 2.0–3.0 typically but may be higher with certain conditions such as mechanical valves)
Direct thrombin inhibitors (dabigatran)	Insufficient data	Yes	Avoid	Avoid	DVT/PE	150 mg twice a day
Anti–factor Xa inhibitors (rivaroxaban, apixaban, edoxabab, betrixaban)	Insufficient data	Yes	Avoid	Avoid	DVT/PE	Rivaroxaban 15 mg twice a day Apixaban 10 mg twice a day Edoxaban 60 mg once a day Betrixaban 160 mg once a day
UFH	No	No	Probably compatible	DVT/PE	DVT/PE	80 U/kg intravenous bolus followed by 18 $U \cdot kg^{-1} \cdot h^{-1}$ Subcutaneous 10 000 units every 12 h Therapeutic target aPTT is 1.5–2.5 times the control 6 h after injection (aPTT is at least 2 times the laboratory control in mechanical valves)
LMWH	No	No	Probably compatible	Atrial fibrillation/flutter, DVT/PE	Preferred	Enoxaparin 1 mg/kg subcutaneous every 12 h Deltaparin 200 U/kg once a day Tinzaparin 175 U/kg once a day Target is 0.6–1.0 U/mL anti–factor Xa level 4 h after last injection for twice-daily dosing regimen; may be higher for once-daily dosing injections (if mechanical valve present, then target anti–factor Xa level is 0.8–1.2 U/mL 4–6 h after dosing)
Fondaparinux	Insufficient data	Yes	Probably compatible	In cases of heparin allergy DVT/PE	In cases of heparin allergy DVT/PE	5 mg (body weight <55 kg) 7.5 mg (body weight 55–100 kg) 10 mg (body weight >100 kg)
Thrombolysis alteplase	No	No	No information	Massive PE or limb-threatening DVT	Massive PE or limb-threatening DVT	Intravenous 100 mg

aPTT indicates activated partial thromboplastin time; DVT, deep venous thrombosis; INR, international normalized ratio; LMWH, low-molecular-weight heparin; PE, pulmonary embolism; and UFH, unfractionated heparin.

Adapted from American College of Obstetricians and Gynecologists and American Society of Hematology guidelines.[109,113]

pregnancy include hypercoagulability, paradoxical embolism via patent foramen ovale, amniotic fluid embolism, arterial dissection, and cardioembolic phenomena resulting from PPCM.[125,126] Hypercoagulability in pregnancy is mediated by increased von Willebrand factor, factor VIII, plasminogen activators 1 and 2, and fibrinogen, as well as protein C resistance, reduced protein S concentration, and platelet aggregation caused by hyperprolactinemia, compressive and hemodynamic venous stasis, and endothelial trauma during delivery.[126] Elevated blood pressures are not the only cause of acute strokes in pregnancy. In fact, rates of cerebral hemorrhage are low in women with preeclampsia, including those with sustained severe hypertension. Another contributory cause of stroke in women with preeclampsia is endothelial dysfunction, which leads to proteinuria and edema and, as a result, injury to the normal blood-brain barrier system.[126,127]

Intravenous thrombolysis in acute ischemic stroke of the pregnant patient is still considered a relative contraindication in the absence of disabling deficits; however, retrospective studies have found it to be safe. In the setting of a disabling ischemic stroke, thrombolysis should be considered.[128] Patients with an indication for anticoagulation or antiplatelet therapy should follow the aforementioned pharmacological recommendations for ischemic stroke prevention during pregnancy and postpartum.[129–131]

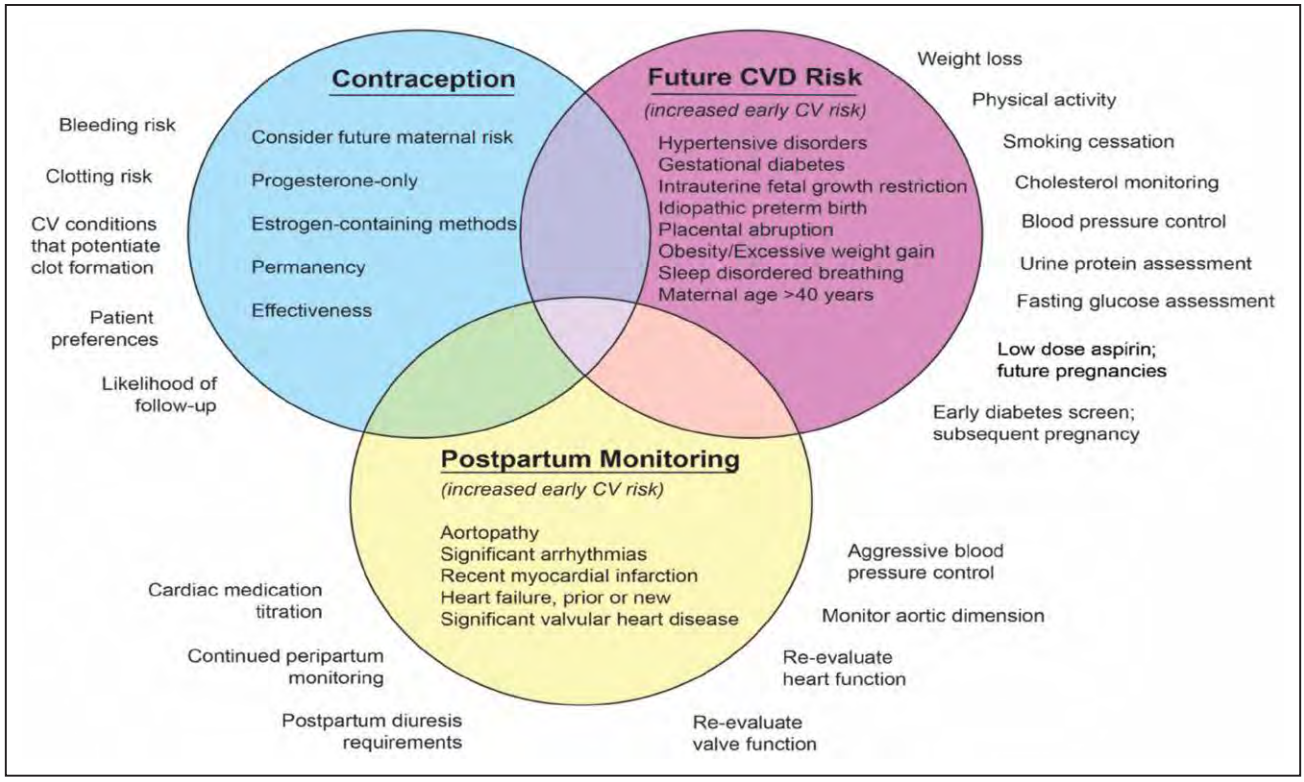

Figure 5. Postdelivery follow-up and late cardiovascular (CV) risk.
CVD indicates cardiovascular disease.

CVT rates pooled in a recent meta-analysis were 9.1 per 100 000 pregnancies, with pregnant and postpartum women making up 20% of adult patients with CVT.[125,132] In a recent retrospective case-control study of 813 cases and 6296 controls, CVT was associated with the puerperium, not with pregnancy.[133] The choice of anticoagulant for CVT should be guided by stage of pregnancy and breastfeeding status.[129]

Intracerebral hemorrhage and nonaneurysmal subarachnoid hemorrhage risk is also increased during pregnancy and puerperium, especially in the setting of preeclampsia and eclampsia. In a meta-analysis, the intracerebral hemorrhage rate was 12.2 per 100 000 pregnancies.[125] Risk factors for puerperium intracerebral hemorrhage include age >35 years, black race, preexisting hypertension, gestational hypertension, preeclampsia and eclampsia, coagulopathy, and tobacco use.[134] Intracerebral aneurysms and vascular malformations pose increased risk during pregnancy.[128,134] Prepregnancy counseling in patients with known vascular malformations should include vascular neurology and neurosurgical evaluation with lesion-specific monitoring.

Both RCVS and PRES are associated with preeclampsia and eclampsia and are considered to be secondary to dysfunctional cerebral autoregulation.[135] RCVS typically presents with a thunderclap headache (reaching peak intensity within ≤1 minute). Compared with nonpregnant populations, PRES tends to present with a higher prevalence of headaches and less encephalopathy in pregnant women. RCVS and PRES can occur at the same time and can manifest with convexity nonaneurysmal subarachnoid hemorrhage. Treatment for RCVS may include calcium channel blockade (nifedipine) and magnesium. PRES is treated with hypertension management.[135]

Neurological emergencies may warrant the use of computed tomography and contrast dye; however, when able/indicated, magnetic resonance imaging and angiography are the preferential modalities to avoid radiation and contrast dye exposure. Given the breadth of cerebrovascular disease that presents during pregnancy and the puerperium, it is important to thoroughly evaluate neurological symptoms in pregnancy and to seek expert consultation (Data Supplement Figure 10).

TIMING AND MODE OF DELIVERY

Contemporary approaches to labor and delivery favor spontaneous labor and vaginal birth for the majority of women with heart disease in pregnancy.[3,5,136] Cesarean delivery is known to carry increased risk of infectious morbidity and thrombotic complications and increased blood loss.[137] In general, cesarean delivery should be reserved for obstetric indications such as breech presentation, failure to progress in labor, elective repeat cesarean delivery, and fetal heart rate abnormalities. Induction of labor may be recommended for care coordination for women planning to deliver at a tertiary care center that may not be close to home. There is evidence that induction of labor may

be protective against cesarean delivery and other obstetric morbidity and therefore should be used to facilitate care planning as needed.[138,139] Induction agents are generally safe in women with CVD. The cardio-obstetrics team will determine delivery plans, including determination of which patients should not deliver vaginally or require assisted second stage of labor.[4] Many hemodynamic changes occur during labor and delivery, particularly in the second stage of labor during Valsalva. For the highest-risk gravidas, it may be appropriate to allow passive descent of the fetal head during the second stage and assist with either forceps or vacuum for delivery when the head reaches the perineum. Cesarean delivery for the indication of cardiac disease should be reserved for the most decompensated women for whom delivery needs to be achieved in the shortest time possible and for women who are fully anticoagulated with vitamin K antagonists in order to protect the fetus from hemorrhagic complications.

The timing of delivery may be a contentious topic because the care team is often weighing maternal, obstetric, and fetal risks, and should include input from the cardio-obstetrics team. The ACOG recommends elective induction of labor for pregnant women with cardiac disease between 39 and 40 weeks of gestation in patients who do not have spontaneous onset of labor or clinical indications for preterm delivery. The timing of delivery for women with active, maternal, or fetal conditions is highly variable according to the underlying medical problem.[4] The ACOG literature does not provide specific information about delivery timing in WHO class IV maternal cardiac conditions; thus, these decisions are frequently made on a case-by-case basis by the high-risk cardio-obstetric team.[140]

POSTPARTUM FOLLOW-UP

The peripartum admission offers an excellent time to discuss the possibility of future pregnancy, contraception, follow-up needs, and the likelihood of late cardiovascular risk. Unique considerations exist prospectively in each of these areas and are often directly related to the specific type of underlying CVD (Figure 5).

Ideally, contraceptive plans have been made in the antepartum period, but if not, contraception should be discussed and offered before discharge. Many long-acting reversible contraceptives such as the intrauterine device or progesterone-only subdermal implants can be used in the immediate postpartum period. Thrombogenic conditions (complex congenital heart disease, cyanotic heart disease, VTE risk), rheumatological conditions, and bleeding risk (women on dual antiplatelet therapy, cyanotic heart disease) need to be carefully considered during the selection of the type of contraception offered. The Centers for Disease Control and Prevention Medical Eligibility Criteria for Contraceptive Use is the trusted resource to consult in the evaluation of contraception safety and appropriateness

Table 2. Approach to Contraceptive Use in Women With CVD

Condition	Subcondition	IUD	Implant	DMPA	POP	CHC
DVT/PE	Remote, not receiving anticoagulation	R	R	R	R	U
	Acute	R	R	R	R	U
	History, receiving ≥3 mo of anticoagulation	R	R	R	R	U
	Family history (first-degree relative)	R	R	R	R	R
High blood pressure in pregnancy	History in prior pregnancy	R	R	R	R	R
Hypertension	Controlled	R	R	R	R	U
	SBP >140–159 mm Hg, DBP >90–99 mm Hg	R	R	R	R	U
	SBP >160 mm Hg, DBP >100 mm Hg	R	R	U	R	U
	Vascular disease	R	R	U	R	U
IHD	Current	Variable depending on whether IHD is present before vs after contraception. Copper IUD safe. For progesterone-IUD, implants, DMPA, and POP, risk likely outweighs benefit. CHC should be avoided.				
Multiple cardiovascular risk factors	Tobacco, diabetes mellitus, hypertension, older age, dyslipidemia	R	R	U	R	U
PPCM	Normal/mild systolic dysfunction	R	R	R	R	U
	Moderate to severe systolic dysfunction	R	R	R	R	U
Valvular heart disease	Uncomplicated	R	R	R	R	R
	Complicated*	R	R	R	R	U

CHC indicates combined hormonal contraception; CVD, cardiovascular disease; DMPA, depot medroxyprogesterone acetate; DBP, diastolic blood pressure; DVT, deep venous thrombosis; IHD, ischemic heart disease; IUD, intrauterine device; PE, pulmonary embolism; POP, progestin-only pill; PPCM, peripartum cardiomyopathy; R, reasonable (benefit outweighs risk); SBP, systolic blood pressure; and U, unreasonable (risk outweighs benefit).

*Defined as a condition that places the woman at an increased risk as a result of pregnancy.

Adapted from Curtis et al.[141]

in the context of general underlying medical conditions, including CVD (Table 2).[141]

In general terms, specific types of maternal CVD affect immediate and postdischarge monitoring requirements. Early after delivery, women with preexisting or new heart failure, significant arrhythmia, severe valve disease, aortopathy, or recent MI will require continued invasive monitoring until postdelivery hemodynamic stability is achieved. In some cases such as patients with aortopathy or the development of new PPCM, risk continues throughout the fourth trimester and beyond. These women require specialized long-term cardiovascular follow-up.

Adverse pregnancy outcomes such as preterm birth and HDP, including gestational hypertension and preeclampsia, gestational diabetes mellitus, and small for gestational age, are a group of interrelated disorders that share common pathways and are thought to be caused by placental dysfunction and oxidative stress.[142] These adverse pregnancy outcomes are associated with increased risk of future CVD (hypertension, ischemic heart disease, stroke)[17,143–146] and are included in the 2018 multisociety guideline on the management of blood cholesterol as cardiovascular risk–enhancing conditions.[28] These patients warrant follow-up in the fourth trimester, at which time aggressive risk factor modification should be undertaken and future risk should be discussed with the patient.[4]

CONCLUSIONS

CVD is the primary causative condition related to the maternal mortality in the United States. Advancing maternal age and preexisting comorbid conditions (including congenital heart disease) have contributed to the increased rates of maternal mortality. Preconception counseling and early involvement of the multidisciplinary cardio-obstetrics team are warranted in order to provide a comprehensive review of maternal and fetal risks associated with pregnancy. In women with a high-risk pregnancy, a cardio-obstetrics team is essential to prevent maternal morbidity and mortality during the length of the pregnancy and postpartum.

ARTICLE INFORMATION

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

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*Modest.

†Significant.

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Pregnancy in congenital heart disease: risk prediction and counselling

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INTRODUCTION

Pregnancy is a major life event for almost every woman. However, for women with heart disease pregnancy is associated with additional risks and deserves special attention. The number of pregnancies in women with congenital heart disease has increased over the past decades and is expected to rise further in the coming years.[1] Physiological changes in the cardiovascular system during pregnancy may bear a risk for those with congenital heart disease who are not able to sufficiently adapt.[2] Subsequently, heart failure, arrhythmias and worsening of the cardiac condition may complicate pregnancy and expose mother and child to an increased risk of morbidity and mortality. Congenital heart disease is often already diagnosed and treated at the time women start thinking about pregnancy, and hence counselling and risk prediction can be offered. In contrast to acquired heart disease, congenital heart disease bears a relatively low risk of complications during pregnancy. This is partly attributable to good counselling and close follow-up in specialised centres. Dedicated guidelines on pregnancy and heart disease have become available in the past decade, enabling the physician to provide standard and individualised care during pregnancy.[3] A multidisciplinary 'pregnancy heart team' is required to support management of counselling, follow-up and delivery. This review addresses risk stratification and counselling in women with congenital heart disease contemplating pregnancy.

Learning objectives

- How to estimate risk of pregnancy in women with congenital heart disease.
- What to discuss during prepregnancy counselling in women with congenital heart disease.
- Global overview of follow-up during pregnancy.

Cardiovascular physiology during pregnancy

Pregnancy is associated with various physiological adaptions of the cardiovascular system.[4–6] Cardiac output needs to increase up to 50% during pregnancy, to enable the fetal circulation, and this increase starts already during the first trimester. There is a 30%–40% decrease in vascular resistance. As part of the cardiac output, plasma volume expands in the first and second trimester, followed by an increase in heart rate of around 10%–20%. Delivery further pushes these changes to a temporary maximum. After delivery, large fluid shifts are responsible for a transient volume overload in the first days post partum.

As a consequence of these haemodynamic changes, echocardiographic studies show a clear increase in left ventricular end-diastolic dimensions, while the systolic measurements remain stable.[7] The subsequent increase in stroke volume leads to a rise of the ventricular outflow tract velocity, and it mimics a hyperkinetic state. The same probably holds for the right ventricle, although less evidence is available. Finally, the expansion of stroke volume and lower afterload influence absolute regurgitation volumes. Regurgitant lesions will therefore hardly be worse during pregnancy.

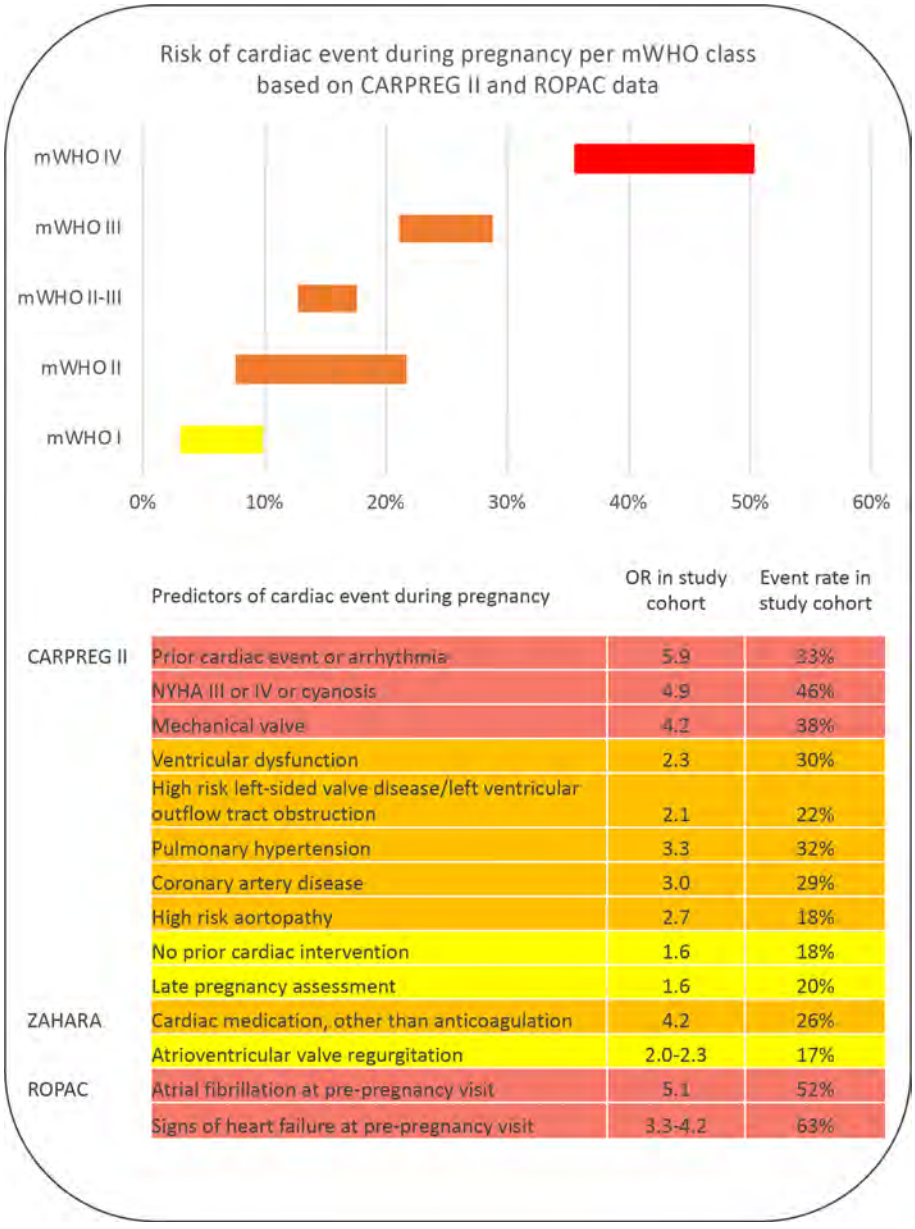
Hormonal changes influence the integrity of the vessel wall. The structure of the aortic wall may have a subtle weaker composition, which is not of significant importance to healthy women, but may enhance the risk of aortic dissection in women with aortic disease. Furthermore, pregnancy is known for its hypercoagulable state, which is very relevant in those with a mechanical prosthetic heart valve or Fontan circulation.

Pharmacokinetic processes will change during pregnancy, due to the increased plasma volume and total body water, and through changes in absorption, glomerular filtration rate, hepatic metabolism and protein binding activity.[8] Moreover, drugs may cross the placental border and reach the fetal circulation. The European Medicines Agency (EMA) and US Food and Drug Administration (FDA) provide available evidence for medication during pregnancy, which is helpful when considering or revising drug therapy during pregnancy and breast feeding.

RISK STRATIFICATION

Several risk scores have been proposed to estimate the risk of maternal complications during and after pregnancy (figure 1). The modified WHO (mWHO) risk classification provides an important step in recognition of risks. The stratification is based on the underlying diagnoses and may also give direction as to who should be referred immediately, and who may be evaluated in non-tertiary centres. In addition, two clinical risk tools are available: the CARdiac disease in PREGnancy (CARPREG) and the Zwangerschap bij Aangeboren HARtAfwijking (ZAHARA) risk scores. In women with congenital heart disease, the WHO classification seems to perform best,[9] but the addition of clinical characteristics will further enable an individualised strategy.

Prepregnancy investigations include thorough history taking, physical examination, an ECG, echocardiogram and exercise test. Clues like diminished exercise tolerance, symptoms of heart failure



	Predictors of cardiac event during pregnancy	OR in study cohort	Event rate in study cohort
CARPREG II	Prior cardiac event or arrhythmia	5.9	33%
	NYHA III or IV or cyanosis	4.9	46%
	Mechanical valve	4.2	38%
	Ventricular dysfunction	2.3	30%
	High risk left-sided valve disease/left ventricular outflow tract obstruction	2.1	22%
	Pulmonary hypertension	3.3	32%
	Coronary artery disease	3.0	29%
	High risk aortopathy	2.7	18%
	No prior cardiac intervention	1.6	18%
	Late pregnancy assessment	1.6	20%
ZAHARA	Cardiac medication, other than anticoagulation	4.2	26%
	Atrioventricular valve regurgitation	2.0-2.3	17%
ROPAC	Atrial fibrillation at pre-pregnancy visit	5.1	52%
	Signs of heart failure at pre-pregnancy visit	3.3-4.2	63%

Figure 1 Risk tools modified WHO (mWHO), CARdiac disease in PREGnancy (CARPREG), Zwangerschap bij Aangeboren HARtAfwijking (ZAHARA), Registry Of Pregnancy And Cardiac disease (ROPAC). OR's and rates are derived from cohorts consisting of approx. 60% patients congenital heart disease (63% in CARPREG II and 58% in ROPAC). Numbers derived from: Silversides et al, JACC, 2018; Drenthen et al, Eur Heart J, 2010; van Hagen et al, Eur J Heart Fail. *NYHA, New York Heart Association functional class. OR, Odds Ratio*

or palpitations may increase pregnancy risk. Also, a family history of sudden death or dissection is important information to enable risk stratification. Complete physical examination is required to reveal (progression of) heart murmurs, gallop sound, elevated central venous pressure, rales, hepatosplenomegaly and peripheral oedema. Normal pregnancy complaints may be difficult to distinguish from symptoms and signs of heart failure during pregnancy. An ECG provides prognostic information if for instance new or known atrial fibrillation is found. Signs of heart failure or atrial fibrillation before pregnancy are associated with a significant accumulation of complication risk.[10]

Prepregnancy echocardiography should be performed in every woman, with detailed assessment of the cardiac lesion, dimensions, ventricular function and filling pressures. These baseline measurements allow for serial follow-up during pregnancy. Exercise capacity, measuring VO2 max, is an established criterion used in the general evaluation of congenital heart disease, and a sufficient oxygen uptake is associated with better outcome of pregnancy as well.[11] In individual cases, current cardiac state may be further investigated using other diagnostic modalities such as Holter, cardiac CT or magnetic resonance (CMR) imaging. CT and CMR are used to determine aortic diameters in those with predisposition to or established aortic pathology. Women with aortic disease presenting during pregnancy, without preconception counselling, should preferably be

Figure 2 Advised counselling.

evaluated using CMR without gadolinium, as the effect of gadolinium on the fetus is unknown.[12] CMR in pregnant women is preferred over CT because of radiation exposure to the fetus.

Modified WHO risk stratification

The mWHO classification provides a first impression about the potential risk of pregnancy (figures 1 and 2). A comprehensive description of the classification has been published in the latest European Society of Cardiology (ESC) guideline of pregnancy.[3] Class I consists of mild congenital heart disease such as a small patent ductus arteriosus or mitral valve prolapse, and repaired simple lesions. These lesions are not associated with a significant risk of morbidity or mortality compared with the general pregnant population. The risk of pregnancy gradually increases with an extremely high risk in mWHO class IV, including women with pulmonary arterial dilatation, severe systemic ventricular dysfunction or severe aortic dilatation. Women in class I can be cared for in a peripheral hospital, while those in class IV are advised against pregnancy. The classes mWHO II, II–III and III include women at a mild-to-moderate increased risk, and evaluation and management

Table 1 Lesion-specific risks

	Maternal cardiovascular risk	Obstetric risk (other than caesarean section)	Fetal/Neonatal risk*	References
ASD, repaired	3.6% arrhythmia, 3.6% persistent NYHA deterioration	11% hypertension/pre-eclampsia, 16% PPH	1.8% offspring mortality†	Yap *BJOG* 2009
ASD, unrepaired	4.5% arrhythmia, 3% persistent NYHA deterioration, 0.8% TIA	11% hypertension/pre-eclampsia, 8.3% PPH	3.0% offspring mortality	Yap *BJOG* 2009
VSD, repaired	2.3% arrhythmia	7% hypertension/pre-eclampsia, 12% PPH	21% SGA	Yap *BJOG* 2010
VSD, unrepaired	1% arrhythmia, 1% endocarditis	15% hypertension/pre-eclampsia, 9.6% PPH	6.7% SGA, 1% offspring mortality	Yap *BJOG* 2010
PDA	‡	‡	‡	
AVSD	23% persistent NYHA deterioration, 19% arrhythmias	17% hypertension/pre-eclampsia, 6.3% gestational diabetes, 21% PPH	10% SGA, 6.3% neonatal mortality	Drenthen *EHJ* 2005
TOF	8%–12% arrhythmia or heart failure, 2% persistent NYHA deterioration	8% hypertension/pre-eclampsia, 10% PPH	17%–21% SGA, 18% prematurity, 6.5% offspring mortality	Meijer *Heart* 2005, Balci *AHJ* 2011, Kampman *Us Obst Gyn* 2017
Ebstein	7.3% arrhythmia or heart failure	8.5% PPH	19%–27% prematurity, 18% offspring mortality	Connoly *JACC* 1994, Katsuragi *AJObstGyn* 2013, Lima *Arch Cardiovasc Dis* 2016
LVOT obstruction	3.8%–12% heart failure, 2%–5.7% arrhythmia, 1% endocarditis	6.4%–11% hypertension/pre-eclampsia, 4.2% PPH	8%–21% prematurity, 13% SGA, 0%–1.1% fetal mortality	Silversides *AJC* 2003, Yap *IJC* 2008, Tzemos *AHJ* 2009, Orwat *JACC* 2016
RVOT obstruction	9% heart failure	15% hypertension-related complication	17% prematurity, 4.8% offspring mortality	Drenthen *Heart* 2006, Greutmann *EHJ* 2010
TGA—after arterial switch	0%–12% arrhythmia or heart failure	‡	9%–21% prematurity	Stoll *JAMA* card 2018, Tobler *Am J Car* 2010, Fricke *Heart Lung Circ* 2019, Horiuchi *J Card* 2019
TGA—after atrial repair	6.6%–22% arrhythmia, 11%–14% persistent NYHA deterioration	18% hypertension/pre-eclampsia, 14% PPH	24%–38% prematurity, 22%–38% SGA, 12% offspring mortality	Drenthen *EHJ* 2005, Cataldo *BJOG* 2016, Trigas *Circ J* 2014
ccTGA	26%–32% heart failure, CVA or worsening of cyanosis	2% hypertension/pre-eclampsia, 14% PPH	9% prematurity, 1.3% offspring mortality	Therrien *Am J Card* 1999, Gelson *EJOG* 2011, Drenthen *JACC* 2007
Fontan	3%–37% arrhythmia, 4% thrombotic event, 3%–11% heart failure	14% PPH	59% prematurity, 20% SGA, 7.6%–17% offspring mortality	Garcia Ropero *Circ CV Qual Outcomes* 2018
Cyanotic disease	32% heart failure, arrhythmia or progression of hypoxaemia	10% PPH	37% prematurity, up to 24% fetal mortality	Ladouceur *Circ* 2017, Presbitero *Circ* 1994, Drenthen *JACC* 2007
PAH in CHD (note: very broad spectrum of results)	0%–28% mortality, 31%–35% RV failure, 7% pulmonary hypertensive crisis, 7%–14% thromboembolism, 9% arrhythmia	0%–6% pre-eclampsia, 0%–38% PPH	17%–86% prematurity, 0%–7% offspring mortality	Thomas *JAHA* 2017, Sliwa *EJHF* 2016, Bedard *EHJ* 2009
Eisenmenger	36% mortality, 21%–45% heart failure, 19% thromboembolism	29% PPH	65%–88%% prematurity, 38%–83% SGA, 10%–27% fetal mortality, 18%–25% perinatal mortality	Drenthen *JACC* 2007, Duan *BMC Pregnancy and Childbith* 2016
Coarctation	None reported	22% hypertension/pre-eclampsia	2% offspring mortality	Vriend *EHJ* 2005

This is a generalisation of lesions with very heterogenous patients, included in both prospective and retrospective studies. Specific characteristics such as ventricular dysfunction, valve stenosis or regurgitation, cyanosis and the presence of a mechanical valve may impact risks to a large extent. For detailed information, we recommend to evaluate the papers referred to in the last column. The full references are available in the online additional material (online supplementary file 2).
*SGA and prematurity only reported if >10%.
†Offspring mortality: late fetal death or neonatal death.
‡Not reported.
ASD, atrial septal defect; AVSD, atrioventricular septal defect; ccTGA, congenitally corrected transposition of the great arteries; CHD, congenital heart disease; CVA, cerebrovascular accident; LVOT, left ventricular outflow tract; NYHA, New York Heart Association; PAH, pulmonary arterial hypertension; PDA, persistent ductus arteriosus; PPH, postpartum haemorrhage; RVOT, right ventricular outflow tract; SGA, small for gestational age; TGA, transposition of the great arteries; TIA, transient ischaemic attack; TOF, tetralogy of Fallot; VSD, ventricular septal defect.

during pregnancy is required accordingly in a tertiary centre. The mWHO classification is based on expert opinion. It has been tested in several cohorts, and has a moderate discriminative capability in women with congenital heart disease. Therefore, the classification provides mainly a first impression, and more detailed information about pregnancy risks should be obtained through additional clinical information, as included in the risk tools mentioned in the paragraph directly hereafter.

Clinical risk scores: CARPREG II and ZAHARA

The CARPREG was the first risk tool for pregnancy and heart disease, developed in 2001.[13] Recently, it was updated and the CARPREG II risk score performed clearly better.[14] The risk predictors are shown in figure 1 and were derived from, and validated in, a large Canadian cohort of women with heart disease in general, of whom 64% had congenital heart disease. The authors also show the additive information of the CARPREG II predictors on top of the mWHO classification.

The ZAHARA risk score was developed in particular for women with congenital heart disease.[15] Predictors are listed in figure 1. Two predictors of this risk prediction rule are not mentioned in the CARPREG II study: the use of cardiac medication, and atrioventricular regurgitation.

The Registry Of Pregnancy And Cardiac disease (ROPAC) showed improved accuracy of

the WHO classification, by adding prepregnancy atrial fibrillation and signs of heart failure to the classification.[10]

Validation of all tools in different congenital heart disease cohorts lead to different results.[9 16–18] This is probably driven by several factors. First, not all cohorts focused on congenital heart disease only and congenital heart disease consists of a very broad spectrum of cardiac lesions. Also, centre-specific care and logistic issues such as local infrastructure may influence outcome. Finally, patient-specific factors such as late presentation or patient adherence may hamper the discriminative accuracy. The above-mentioned scoring systems should not be seen as standalone tools: individualised care is crucial based on both type of lesion and clinical features, and evaluated in a multidisciplinary team as discussed hereafter.

HIGH RISK CHARACTERISTICS AND CONGENITAL DEFECTS

Table 1 presents lesion-specific risks for several frequently encountered congenital heart defects. Lesions with high-risk characteristics are discussed in detail in this paragraph. In this section, several specific recommendations are discussed. In general, the ESC guidelines for the management of cardiovascular diseases during pregnancy is a dedicated guideline that can be helpful to all care providers dealing with women with congenital heart disease in childbearing age.

In general, women with characteristics discussed ahead are in modified WHO class III or IV. Women in class IV should be advised against pregnancy following the latest guidelines. However, some women decide to pursue on embarking pregnancy and do return pregnant to the outpatient clinic. Therefore, we will discuss the main issues, and how to perform follow-up in these high-risk situations. Without exception, these women need referral and frequent follow-up in a tertiary centre.

Pulmonary arterial hypertension

Pulmonary arterial hypertension is indicated as modified WHO class IV. It is associated with a substantial risk of heart failure, ventricular arrhythmias for the mother and also an increased mortality risk, although outcome seems to be better in the current era of advanced therapies. Poor outcome for the fetus is another reason to be very restrained with positive advice on pregnancy. It must be marked that evidence on outcome is limited. Maternal mortality varies from absolute high risk of 28%, to slight improvement in outcome in selected patients with congenital heart disease, but still a maternal mortality rate of 7%.[19 20] Counselling about the high-risk and thus absolute contraindication to pregnancy remains paramount. When women do become pregnant, options on termination should be given. Otherwise, a plan on strict follow-up, advanced therapy and delivery should be made in a multidisciplinary team with expertise in pulmonary hypertension.

In case of Eisenmenger syndrome, there is also an absolute contraindication for pregnancy. Pregnancy-induced decrease in peripheral vascular resistance causes an additional risk of progressive right-to-left shunt, cyanosis and paradoxical emboli. Very poor fetal outcome can be expected in the majority of cases.[20]

Cyanosis

Cyanotic disease at adult age may exist in the presence of persistent or uncorrected shunt defects. Early studies showed high numbers of complicated pregnancies in women with cyanotic heart disease. Recently, a retrospective study included 71 pregnancies in 31 women with cyanotic heart disease, without pulmonary arterial hypertension.[21] Only two women had systemic ventricle dysfunction. Up to 32% of patients developed cardiovascular complications during pregnancy, mainly heart failure and progression of hypoxaemia requiring hospitalisation. Also, late follow-up (with a broad range of 1–15 years) revealed another 13% of chronic heart failure, although natural course may also prompt these late complications. In general, the underlying cardiac lesion will mainly influence maternal risk. The severity of cyanosis confines the chance of a completed pregnancy ending in live birth, with a disappointing low number of live births of only 12% in patients with a saturation below 85%.[22] Women with a saturation level below 85% are therefore discouraged on embarking pregnancy.

Fontan

In women with a Fontan circulation, other reasons than cyanosis also influence the level of risk associated with pregnancy. Mainly systemic ventricular dysfunction, and significant atrioventricular valve regurgitation and protein-losing enteropathy are clinical factors associated with higher complication rates. Major complications are heart failure, supraventricular arrhythmias, thromboembolic events and bleeding. Next to these frequent maternal complications, the chance of a pregnancy loss is around 70%.[23]

Systemic ventricular dysfunction

Any type of congenital heart disease with a diminished ventricular dysfunction is at risk of deterioration during pregnancy. It is an independent risk factor for a complicated pregnancy, as listed by the CARPREG, ZAHARA and ROPAC studies. Signs of heart failure before pregnancy should be treated first as it is a clear additional risk factor. Women with severely diminished left ventricle function, or a moderate systemic right ventricle function should be advised against pregnancy.[3]

Aortic dilatation

Women with aortic disease may face the risk of further dilatation, or worse, dissection during

pregnancy. The extent of diameter growth during pregnancy is difficult to predict and the results diverge between no significant growth up to 3 mm growth during the entire pregnancy with potential decrease of diameter after pregnancy.[24–26] The risk of dissection depends on the underlying syndrome, as it does outside pregnancy. Hence, women with Marfan syndrome and Loeys-Dietz syndrome are at highest risk. In the absence of Marfan syndrome or other high-risk heritable thoracic aortic disease (HTAD), a cut-off of 50 mm, also in the presence of a bicuspid valve is used to advise against pregnancy. In Marfan syndrome and Loeys-Dietz syndrome or other HTAD, women should not embark on pregnancy in the presence of an aortic root diameter >45 mm.[3] In Turner syndrome, diameters specifically need to be corrected for body surface area, and a threshold of 27 mm/m^2 is adopted.[27] Elective surgery in women beyond these thresholds may be considered, however the risk of type B dissection and other complications is still not zero after surgery. Risk factors such as (family) history of dissection also need to be taken into account.

A caesarean section is advised in all women with an aortic root diameter >45 mm. Below 40 mm, a vaginal delivery is considered safe. Between 40 and 45 mm the choice may depend on diameter growth during pregnancy and risk factors for dissection.

Mechanical valve

The presence of a mechanical valve is an independent risk factor of complications. The balance between thrombotic and bleeding risks determine the chance of a successful uncomplicated pregnancy, which was about 57% in a large registry of women with a mechanical valve prosthesis.[28] A valve thrombosis occurred in 4.7%, and 20% of these women died. Anticoagulation strategies are predefined in the ESC guidelines, but a broad spectrum of regimes used globally, emphasises the difficulty of anticoagulation management. In women who are not on low-dose vitamin K antagonists, a switch to some type of heparin in the first trimester is advised, due to the teratogenicity of vitamin K antagonists. To limit the risk of thrombosis with heparin, women should be switched back to a vitamin K antagonist at the start of the second trimester, until the 36th week. A plan for heparin prescription around delivery should be ready. However, still there is no clear consensus on the best anticoagulation regime.[3 29 30]

Table 2 Recurrence risk of congenital heart disease

Atrial septal defect	4.5%–6%
Ventricular septal defect	6%–9.5%
Patent ductus arteriosus	4%
Atrioventricular septal defect	7.5%–15%
Ebstein	3.9%–6%
Tetralogy of Fallot	2.5%–10%*
Transposition of the great arteries	0.5%†
Bicuspid aortic valve	4.6%–9.3%
Aortic coarctation	4%
Marfan syndrome	50%
Pulmonary valve stenosis	7%

Modified and updated from van Hagen/Roos-Hesselink, SA Heart 2014.
*Range varies to 50% if associated with 22q11.2 deletion.
†Total recurrence risk, affected mother or father.

COUNSELLING

Prepregnancy counselling is crucial to identify the high-risk patients, and to reassure many patients who are at low risk, because pregnancy is well tolerated in most women with congenital heart disease. During counselling several topics need to be discussed: the risk for the mother and for the fetus, medication use and possible adaptations needed before pregnancy, the recurrence risk for congenital heart disease in the baby and the long-term outcome for the mother. Also reproductive therapies and contraception need attention.

Maternal and fetal risk

In the largest prospective cohort of 3295 pregnant women with congenital heart disease, mortality occurred in 0.2%, heart failure in 6.2%, an arrhythmia in 2%, a thrombotic event in 1% and aortic dissection in 0.03%.[31] As discussed, the maternal and fetal risks depend on the underlying disease. In general, the risk of heart failure, arrhythmias and deterioration of cardiac defect should be mentioned during counselling. figure 1 can guide in the emphasis to be made in each individual based on their clinical characteristics. In women with aorta pathology, after risk stratification, the risk of aortic dissection needs discussion.

Obstetric events such as pregnancy-induced hypertension (3%), (pre-)eclampsia (2%) and postpartum haemorrhage (3%) do not occur more often in women with congenital heart disease in general.[31] Caesarean section is performed in as much as 40% of women, while it is generally preserved for women with an obstetric indication or in a high-risk situation such as heart failure, early labour while on oral anticoagulation or in advanced pulmonary hypertension or Eisenmenger.

Overall, uteroplacental flow is lower in women with congenital heart disease, compared with normal pregnant women. An impaired uteroplacental flow is associated with adverse fetal and neonatal outcome.[32] As such, fetal growth restriction occurs more often in mothers with a complex congenital heart disease.[33] Women with congenital heart disease face a higher risk of fetal mortality (1%), premature birth (14%) and a low Apgar score (6%).[31] Neonatal death occurs in 0.5% and is comparable to the background population, but this depends on the underlying congenital diagnosis of the mother (table 1).

Assisted reproductive therapies

With the advancing technologies conception also becomes an option for women with congenital

heart disease dealing with subfertility or infertility. However, assisted reproductive therapies may be prothrombotic and may induce hypertensive complications, depending on the method and doses used. Overstimulation can lead to ovarian hyperstimulation syndrome. There is an additional risk of conceiving multiple pregnancy which may be poorly tolerated. Thus, women in high-risk conditions such as WHO class III and IV should be discouraged to use these advanced methods if it requires hormonal stimulation, or at least natural cycle options should be considered to prevent the risk of overstimulation.[3]

Contraception

Women with congenital heart disease are sexually active at about the same age as other women, with a significant amount of unintended pregnancies.[34 35] Women with a high-risk condition, or those who are advised against pregnancy, need careful advice about contractive methods already at young age. A balanced choice needs to be made between effectiveness, safety and personal preference. Little data are available on safety of contraception in women with congenital heart disease.[36] Oral contraception may be associated with a potential increased risk of thromboembolic complications, specifically in women with an increased risk of thrombosis, such as a Fontan palliation, although the evidence is contradictory. Thrombosis risk is highest in ethinyloestradiol-containing contraceptives. Progestin-only contraceptives are a suitable alternative. Levonorgestrel-based intrauterine devices are probably safest.[37] Irreversible options such as tubal occlusion or vasectomy are a serious option to discuss with women in WHO class IV, although there is a general increased operation risk including postoperative infection.

Case reports are available on endocarditis following intrauterine device implantation in specific congenital heart diseases such as Fallot.[38] Since there is no evidence that the risk of endocarditis is increased compared with the background population, endocarditis prophylaxis is not indicated in genitourinary tract procedures.[39]

Recurrence risk

Part of the preconception counselling is the risk of recurrence of congenital heart disease in offspring as it is increased. The extent of recurrence risk depends on underlying defect. In autosomal dominant diseases such as Marfan syndrome, the risk is obviously 50%. In the absence of a clear genetic diagnosis, the risk is estimated at 2.9% for all offspring of women with congenital heart disease.[40] The specified recurrence risks are listed in table 2. In all patients with congenital heart disease, genetic counselling may be considered. Particularly in those with aortic disease, those who have other affected family members or if other non-cardiac congenital abnormalities might be present. In patients with a known genetic defect, preimplantation diagnostic testing has become available.[41]

Medication

Medication used before pregnancy should be evaluated for teratogenicity. ACE inhibitors and angiotensin receptor blockers (ARB) have potential adverse effects on the fetus and are therefore contraindicated. In women who are prescribed ACE inhibitors or ARB, a prepregnancy trial without these agents may show whether they remain stable. In women with high risk of heart failure, already pregnant, the risk of discontinuing may outweigh potential fetal risks, a balance to be made by the physician. Beta-blockers can be continued, with strict fetal monitoring because of potential low birth weight. Atenolol is contraindicated during pregnancy, because of reported birth defects. Life-threatening acute heart failure during pregnancy should be treated as outside pregnancy, with no restrictions, to enable the mother to survive such a hazardous event. The FDA classification has been replaced by the Pregnancy and Lactation Labelling Rule, and can be found in prescription labels, and online on the website of both the FDA[42] and the EMA.[43] Evaluation of this information is key to enable counselling and provide the best available information on medication during pregnancy.

FOLLOW-UP DURING PREGNANCY

Frequency of clinical follow-up depends on risk stratification. Women with a low-risk diagnosis can be seen once or twice in a local hospital. In WHO class II, it is advised to evaluate at least every trimester. If unremarkable than both follow-up and delivery can take place in a local hospital. Women in WHO II-III and higher require follow-up in a dedicated expert centre, and at least bimonthly, increasing per WHO class. Women with cyanosis, pulmonary hypertension or systemic ventricular dysfunction require weekly or biweekly follow-up in the third trimester. Advise on follow-up is summarised in figure 2. A delivery plan should be made in a multidisciplinary team consisting of at least a cardiologist, obstetrician and anaesthesiologist.[3]

The default mode of delivery in almost all women with congenital heart disease is vaginal with spontaneous labour. Exceptions are to be made for obstetric reasons, or in case of a very high-risk cardiac situation as mentioned before. In general, no benefit has been found for caesarean section over vaginal delivery, while gestational age and birth weight in women with a caesarean section is lower.[44] All women with congenital heart disease should deliver in a hospital and in moderate-to-complex disease in an expert centre.

Additional haemodynamic monitoring during delivery might be required in women who are at risk of acute heart failure or arrhythmias. The first step is pulse oximetry, which includes continuous heart rate monitoring. In advanced risk patients, continuous ECG monitoring should be considered. An arterial

Key messages

- Prepregnancy prediction of risks for both mother and child can be done based on lesion-specific tools and clinical characteristics.
- The available risk tools all have their limitations, and interpretation needs to be done with care.
- The modified WHO classification is the first step in guiding management and follow-up during pregnancy.
- Clinical characteristics, as provided by the WHO, CARdiac disease in PREGnancy, Zwangerschap bij Aangeboren HARtAfwijking and Registry Of Pregnancy And Cardiac disease studies, and as listed in figure 1, may further define individual risk.
- Counselling should at least consist of explanation of maternal and fetal risks, recurrence risk, evaluation of medication, options for contraception and risks of assisted reproductive therapy.

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catheter for invasive blood pressure monitoring or non-invasive cardiac output measurement provides close follow-up in women who are in WHO class IV, or clinically instable. In suspected high risk of heart failure, consider prolonged observation up to 48 hours after delivery, since this is the timespan of large fluid shifts inducing clinical deterioration.[45]

SUMMARY

Risk prediction and counselling are the key to limit risks of complications during pregnancy in women with congenital heart disease. The WHO classification and clinical risk tools will guide the physician to the best available risk estimate, but an individualised approach and expert opinion remains paramount in counselling women with congenital heart disease with a pregnancy wish. In women with an estimated low-risk or intermediate-risk pregnancy, planned follow-up and a delivery plan made by a multidisciplinary team provides the best chance of an uncomplicated pregnancy. While the majority do well, there is a small group of women that need an explicit advice not to embark pregnancy, to prevent devastating situations.

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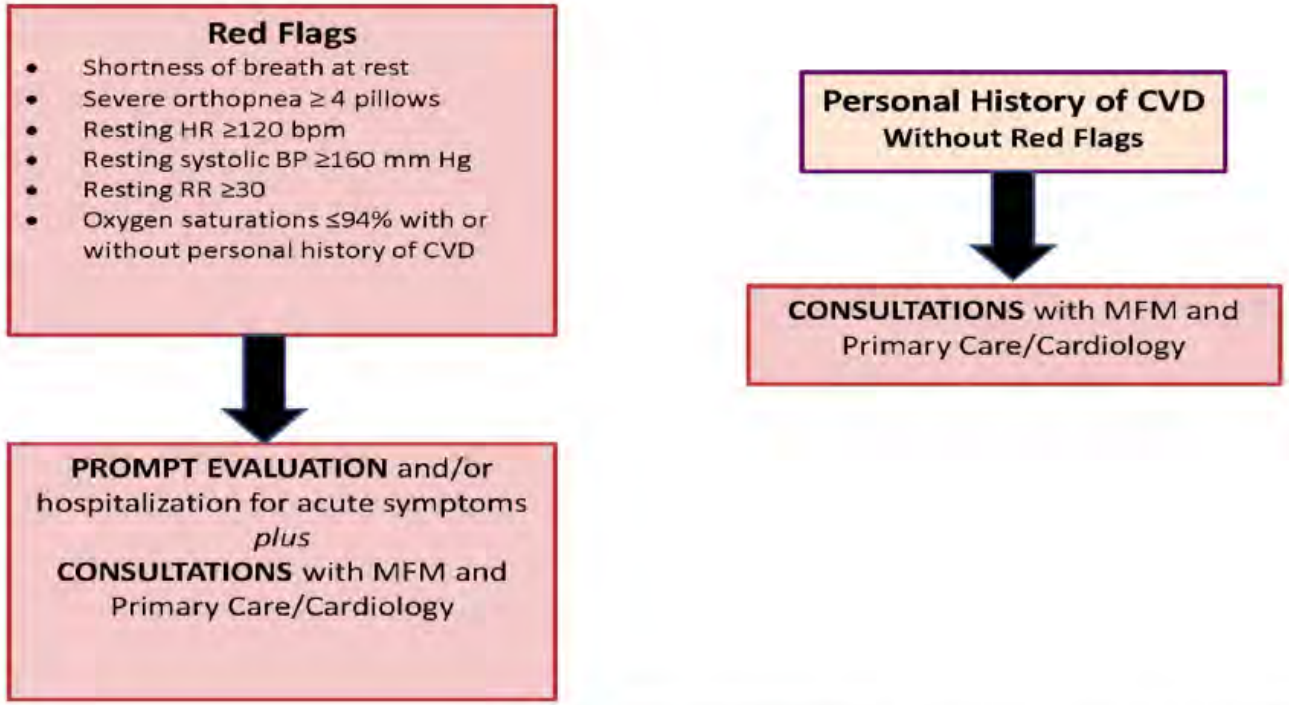
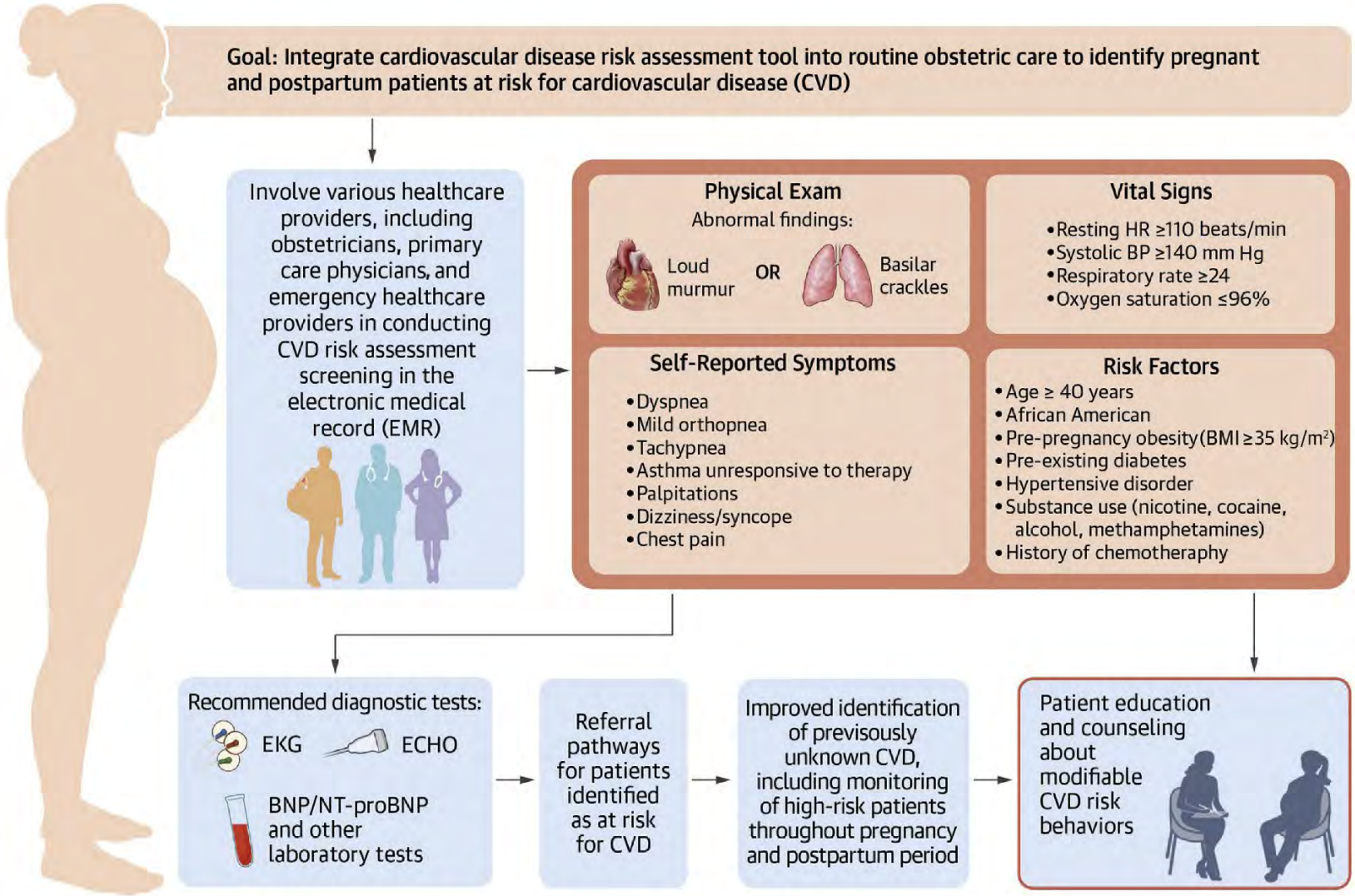
CVD ASSESSMENT ALGORITHM FOR PREGNANT and POSTPARTUM WOMEN



CENTRAL ILLUSTRATION: Universal Cardiovascular Disease Risk Assessment in Pregnancy and Postpartum



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Review

Screening for Cardiovascular Disease in Pregnancy: Is There a Need?

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Abstract: Maternal mortality in the United States has been on the rise. Every year, about 700 women die from pregnancy-related complications. Cardiovascular disease (CVD) accounts for a large majority of pregnancy-related deaths driven by the lack of recognition and delays in diagnosis due to the overlap of normal pregnancy symptoms with those of CVD. Risk factors for CVD including race, advanced maternal age, hypertension, diabetes, obesity, socioeconomic status, and geographic region play an important role in CVD-related deaths. Several risk assessment models are available to stratify women with a known diagnosis of CVD. However, most women who die from CVD during pregnancy or the postpartum period do not have a prior diagnosis of CVD, and cardiomyopathy is an important contributor. The California Maternal Quality Care Collaborative (CMQCC) developed an algorithm to screen all pregnant and postpartum women to allow stratification into low or high risk for CVD. The algorithm has been validated in diverse patient populations. We propose universal CVD screening for all women in the antepartum and postpartum period to identify women at risk and to provide education and awareness for both patients and healthcare providers. This screening tool would work to reduce the increasing rates of severe maternal mortality and morbidity while having a significant impact on healthcare costs in the United States.

Keywords: cardiovascular disease; pregnancy; maternal mortality; cardiomyopathy

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1. Introduction

In the United States, 700 women die annually from pregnancy-related complications [1]. Between 2014 and 2017, cardiomyopathy and other cardiovascular conditions accounted for 27% of all pregnancy-related deaths in the United States [2]. In California, cardiovascular disease (CVD) was responsible for 28% of all deaths among pregnant women between 2008 and 2016, with over half of these deaths due to cardiomyopathy [3]. Data collected through the California Pregnancy Mortality Surveillance System (CA-PMSS) demonstrates CVD has remained the leading cause of pregnancy-related mortality throughout this period (Figure 1). Review of the timing of CVD deaths deserves attention. Only 19% of CVD-related deaths occurred in the antepartum period (19%). The vast majority (>80%) of maternal deaths are encountered in the late postpartum period. The largest number of maternal deaths are seen beyond the first week postpartum, i.e., 6 days postpartum (24%), between 7 and 42 days postpartum (24%), and within 43–365 days postpartum (33%) [3]. Maternal deaths after 42 days postpartum are primarily driven by cardiomyopathy. Maternal mortality represents the tip of the iceberg. The CDC reports that maternal morbidity and mortality has increased 200% from 49.5 in 1993 to 144.0 in 2014 [4]. The etiology is multifactorial, which has led to extended length of hospitalization, increased costs, and higher utilization of healthcare services [5].

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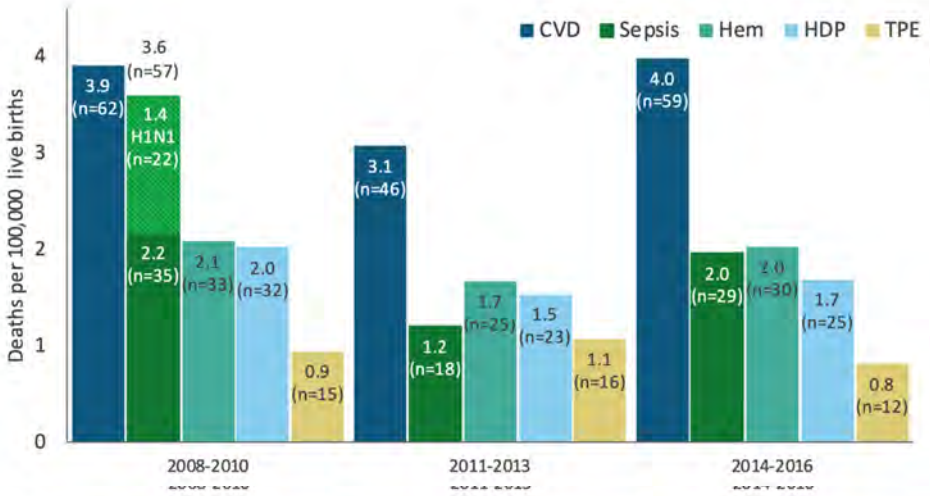

Figure 1. Pregnancy-related mortality ratio by cause, California 2008–2016.
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2. Cardiovascular Changes in Pregnancy
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Pregnancy involves dramatic changes in cardiovascular physiology to promote increased perfusion to the uterus to meet the growing needs of the fetal–placental unit. Pregnancy-related increases in catecholamines, estrogen, and progesterone cause activation of the renin–angiotensin system that augment the cardiac output and plasma volume [6]. Other cardiovascular changes include increases in heart rate, decrease in diastolic blood pressure, increased RBC volume, and a decrease in systemic vascular resistance (Figure 2) [7]. Additionally, these physiologic changes lead to known cardiac structural and functional changes, i.e., increase in left ventricular end diastolic volume as well as ventricular mass demonstrated by echocardiography [6]. This may also result in sign and symptoms in a normal pregnancy that are like that of CVD and, therefore, diagnosis of CVD may be challenging. Not surprisingly, pregnancy is often considered a cardiovascular stress test that may worsen the pre-existing CVD or unmask a previously undiagnosed but well-compensated cardiac condition.
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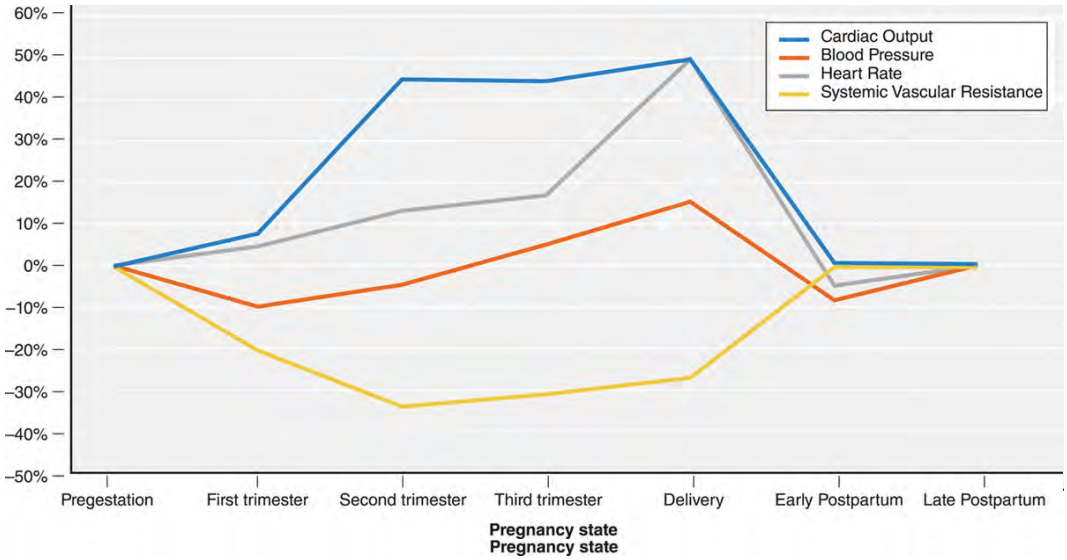

Figure 2. Physiologic changes during pregnancy. Mehta et al. Cardiovascular considerations in caring for pregnant patients, Circulation 2020 [7].
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Pregnancy vs. Cardiovascular Disease

Normal physiological changes in pregnancy lead to signs and symptoms that may be indistinguishable from those of CVD. Common symptoms of pregnancy include palpi-

tations, shortness of breath, fatigue, chest pain, and dizziness. A systematic approach is required to differentiate normal pregnancy symptoms (Table 1). Based on patient-reported symptoms, vital signs, and physical exam findings (Table 1), providers can give reassurance or triage patients for further CVD evaluation with laboratory tests (BNP, troponin) and/or other diagnostic testing (EKG, chest radiography, stress test). It is not surprising that most women who died of CVD during pregnancy and/or the postpartum period were not suspected of having a cardiac diagnosis and symptoms were attributed to an alternate diagnosis. Roughly 84% of pregnant patients who died from CVD presented with symptoms concerning for cardiopulmonary disease. However, only 61.1% of these patients were referred to Cardiology, and, of those, only 7% were referred antenatally. The overlap of signs and symptoms of normal pregnancy with those of CVD further complicates timely diagnosis. About 60.9% of CVD-related maternal deaths were found to be due to delayed response from healthcare providers [8].

Table 1. How to differentiate common signs and symptoms of normal pregnancy versus those that are abnormal and indicative of underlying cardiac disease.

	ROUTINE CARE	CAUTION	STOP
	Reassurance	**Nonemergent Evaluation**	**Prompt Evaluation**
History of CVD	None	None	Yes
Self-Reported Symptoms	None or mild	Yes	Yes
Shortness of breath	No interference with activities of daily living; with heavy exertion only	Yes; with moderate exertion, new onset asthma, persistent cough or moderate/severe OSA	Yes, at rest; paroxysmal nocturnal dyspnea or orthopnea, bilateral chest infiltrates or refractory pneumonia
Chest pain	Reflux-related that resolves with treatment	Atypical	At rest or with minimal exertion
Palpitations	Few seconds, self-limited	Brief, self-limited episode, no light-headedness or syncope	Associated with near syncope
Syncope	Dizziness only with prolonged standing or dehydration	Vasovagal	Exertion or unprovoked
Fatigue	Mild	Mild or moderate	Extreme
Vital Signs	Normal		
HR (bpm)	<90	90–119	≥120
Systolic BP (mm Hg)	120–139	140–159	≥160 (or symptomatic low blood pressure)
RR (per minute)	12–15	16–25	≥25
Oxygen Saturation	>97%	95–97%	<95% (unless chronic)
Physical Exam	Normal		
JVP	Not visible	Not visible	Visible >2 cm above clavicle
Heart	S3 barely audible soft systolic murmur	S3 systolic murmur	Loud systolic murmur, diastolic murmur S4
Lungs	Clear	Clear	Wheezing, crackles, effusion
Edema	Mild	Moderate	Marked

Practice Bulletin 2019, Pregnancy and Heart Disease, ACOG.

A key challenge for the healthcare providers who evaluate pregnant and postpartum women is to differentiate the sign and symptoms of normal pregnancy from those of CVD, particularly beyond the conventional postpartum period up to a year after delivery.

3. Pregnancy-Related Cardiovascular Disease

Pregnancy-related CVD can be classified into two groups: (i) women with known pre-existing CVD and (ii) women without known pre-existing CVD. Women with known CVD include congenital heart disease, cardiomyopathy, valvular heart disease, arrhythmia, pulmonary hypertension, coronary artery disease, etc. [8]. This group of women is typically

managed optimally by maternal fetal medicine specialists and cardiologists. Their mortality risk profile during pregnancy can be estimated using existing cardiovascular risk assessment tools that have been validated. Women without known pre-existing CVD can either develop a new diagnosis of CVD in pregnancy, i.e., peripartum cardiomyopathy, or CVD can be unmasked by pregnancy or a new diagnosis of CVD. This specific population of women is particularly at higher risk during pregnancy as conditions such as hypertension, diabetes, obesity and advanced age often coexist. The number of patients that fall into this category is large. In a review of CVD deaths in California between 2006 and 2006, only 3.1% of deaths due to CVD had a pre-existing CVD diagnosis, while most diagnoses (48.4%) were made postmortem [8]. Additionally, 64.1% of patients who died from pregnancy-related CVD had an underlying medical condition [8]. This suggests that a substantial proportion of these patients experienced either an exacerbation of an underlying condition leading to a CVD-related death or developed new peripartum cardiomyopathy, given that two-thirds of all CVD-related deaths were from cardiomyopathy [8].

It is not yet standard of care for obstetric providers to incorporate a robust screening and management strategy into the prenatal care of pregnant patients without existing cardiovascular disease. Additionally, as mentioned previously, differentiating normal pregnancy symptoms with CVD symptoms remains a challenge for providers. Due to these existing gaps in healthcare, provider misdiagnosis leads to delays in treatment and accounts for 26% of maternal CVD-related deaths, 37% of cardiomyopathy deaths, and 62% of preeclampsia/eclampsia-related deaths [9]. However, since we know that pregnancy increases a woman's risk of developing CVD, a universal screening plan for all pregnant and postpartum women ought to be implemented and clinicians (obstetricians, gynecologists, and cardiologists) need to improve their knowledge of cardiovascular changes and complications in pregnancy in order to prevent adverse maternal outcomes.

4. Risk Factors Including Racial, Geographic, and Socioeconomic Disparities

Several risk factors have been identified as affecting CVD-related maternal mortality. These include race, advanced maternal age, hypertension, diabetes, obesity, geographic region, income, education level, and type of insurance [6,10,11]. Black women have been shown to be at a significant risk of not only CVD-related maternal mortality but also all-cause maternal mortality [3]. In a report from the nine maternal mortality review committees, 48.2% of pregnancy-related deaths were in Black women compared to 30.2% in Hispanic women and 28.4% in White women [12]. In California between 2008 and 2010, the pregnancy-related mortality ratio for Black women was more than three times higher than that of other racial groups [3]. By 2014–2016, this disparity was further widened as the mortality ratio for Black women was four to six times higher than that of other racial groups [3]. Specifically for CVD, Black women are 3.4 times more likely to die from CVD in pregnancy than White women [6]. Black women are more likely to have a delay in diagnosis of peripartum cardiomyopathy resulting in more severe disease (decrease ejection fraction) and poorer prognosis compared to non-Black women [13]. This is suggestive of not just a barrier for Black patients' ability to access care, but also inherent flaws in the healthcare system fostering bias and racism that can result in missed diagnoses [6]. These findings mirror those demonstrated in a review of cardiovascular deaths in California between 2002 and 2006 [8]. Patients who died from CVD were more likely to be Black compared to those that died from non-CVD causes. Obesity, diabetes, and hypertension were also noted to be the most prevalent conditions in women who died from CVD [8].

In the United States between 2016 and 2019, a serial cross-section analysis of maternal birth records demonstrated a large geographic and socioeconomic disparity preventing access to equitable healthcare for pregnant women [11]. Favorable cardiometabolic health (normal BMI, no diabetes or hypertension) in pregnant women declined significantly, with the largest decline being in the Midwest and the South compared to the West and North East regions [11]. Additionally, the higher the prevalence of high school educated women in a region, the less favorable the cardiometabolic health outcomes [11]. This trend can

also be attributed to insurance type as well: the higher the number of women enrolled in Medicaid, the less favorable the cardiometabolic health outcomes [11].

Among the multitude of risk factors seen during pregnancy, of which obesity and hypertension play a major role, and the inequities of health care access faced by racial minorities and persons of lower socioeconomic/education status, there is a stark underdiagnosis of CVD which is likely contributing to the high rates of CVD-related maternal mortality in this country. Consequently, the American College of Obstetricians and Gynecologists (ACOG) endorses universal CVD screening for all women in the antepartum and postpartum period, specifically using the CVD in Pregnancy and Postpartum Toolkit Algorithm [6,14].

5. Universal Cardiovascular Risk Assessment in Pregnancy and Postpartum Period

Pregnant and postpartum patients with CVD fall into two groups: (i) women with known pre-existing CVD and (ii) women without known pre-existing CVD that is either unmasked by pregnancy or a new diagnosis of CVD, i.e., peripartum cardiomyopathy. The existing cardiovascular risk assessment models that stratify women with a known diagnosis of CVD are being routinely used for preconception counseling and during pregnancy. These provide guidance to the healthcare provider to describe the level of risk involved, anticipated complications, level of maternal care requirements and frequency of planned visits with the cardiologist. Commonly used models include Modified WHO classification, CARPREG II, and Zahara predictors that have been validated in various studies [15–17]. While these tools are useful in directing management for patients with specific and pre-existing cardiac lesions, they are not applicable to the general obstetric population. Mortality reviews indicated that most women who die from CVD during pregnancy or the postpartum period do not have a prior diagnosis of CVD. Cardiac diagnosis is not considered in the differential diagnosis in a woman presenting with the normal symptoms of pregnancy such as shortness of breath or fatigue that often leads to delays in recognition and treatment. Early recognition of CVD will help triage women at risk to initiate appropriate timely treatment to prevent maternal morbidity and/or mortality. Most important is a new diagnosis of CVD during pregnancy, i.e., peripartum cardiomyopathy, that presents in the later part of pregnancy or in the postpartum period. Therefore, there is a need for a universal screening tool to assess all pregnant and postpartum patients for their risk of CVD. The proposed CVD screening tool should be easy to administer and applicable to all clinical settings.

The California Maternal Mortality Review Committee put together a tool kit that contains two CVD screening algorithms published by the California Maternal Quality Care Collaborative (CMQCC). The first algorithm (Figure 3) calls for "red flags" identified as the patient's reported severe symptoms or severe vital sign abnormalities, and for patients with known CVD, i.e., prior history of CVD. Presence of any of these three elements guides the clinician to perform further cardiac testing and prompt evaluation. The second algorithm (Figure 4), however, applies to patients without red flags or personal history of CVD. It uses demographics, self-reported symptoms, vital sign abnormalities and abnormal physical examination findings to stratify pregnant/postpartum women into high vs. low risk of CVD. If the patient screens positive for CVD, it warrants further workup with an EKG, BNP, and/or other diagnostic tests. Additionally, consultation with maternal fetal medicine and/or cardiology is recommended [14]. If results are negative, the patient simply receives reassurance and routine obstetric follow up is continued. This second screening algorithm was validated in women who had died of CVD. It was demonstrated that 88% of cases would have been identified as high risk of CVD in asymptomatic women and 93% of symptomatic women that would have prompted further CVD testing [8].

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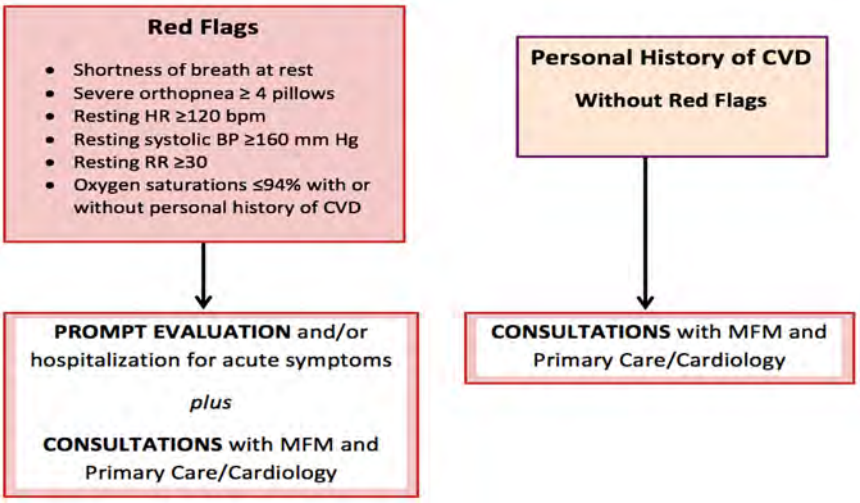

Figure 3. California Maternal Quality Care Collaborative (CMQCC) algorithm to identify red flags in pregnant and postpartum patients that would prompt further cardiovascular disease evaluation.

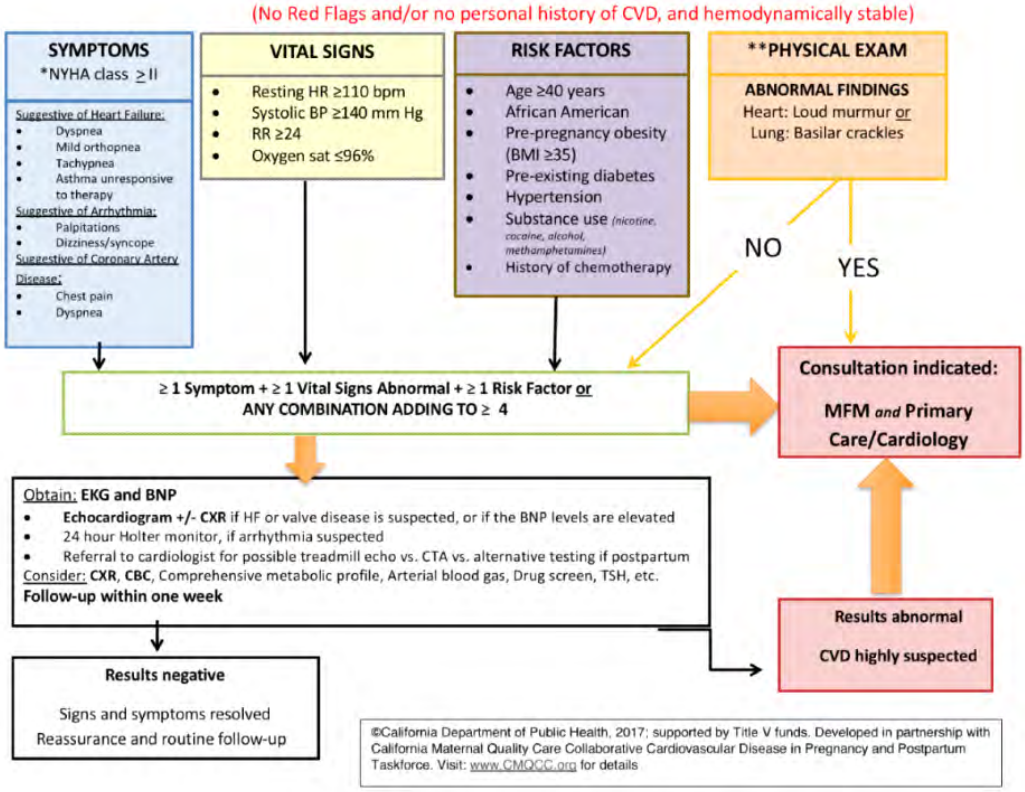

Figure 4. California Maternal Quality Care Collaborative (CMQCC) algorithm to identify pregnant and postpartum patients without red flags or personal history of CVD who are at high or low risk of CVD. * New York Hospital Association Functional Classification. ** Physical exam limited to heart (diastolic or systolic murmur) and lung (crackles, jugular venous distension, cyanosis, clubbing) exam.

CVD Toolkit Application and Future Implications

Blumenthal et.al. reported on prospective screening of pregnant and postpartum women at two large academic centers in California and New York using the CMQCC CVD algorithm. The screening algorithm identified 8% of women at both sites as screen-positive, i.e., at increased risk for CVD. At both sites, combinations of moderate risk factors were the driving force behind positive screens rather than "red flag" signs alone. Between the two sites, New York had a higher screen-positive rate (19%) compared to California (5%).

This may in part be due to the higher proportion of Black women enrolled in the study in New York (35%) compared to that in California (2.7%). Subsequent cardiovascular testing confirmed CVD in 34% of those patients who screened positive for CVD and completed follow up. Of note, a higher proportion of screen-positive patients completed all follow up studies in California compared to New York (70% vs. 27%, respectively). One proposed explanation for this finding was that the screening and testing were performed by the patients' primary providers in California versus a separate research team in New York [18]. This suggests the physician–patient relationship may play a role regarding perceived importance of CVD risk assessment in patients, which is supported by the mortality review by Hameed et al. where both lack of patient knowledge and lack of provider continuity were identified as risk factors contributing to pregnancy-related cardiovascular deaths [8].

The finding that cumulative moderate risk factors rather than "red flags" led to more positive screens reinforces the assertion by Hameed et al. that most of the cardiovascular-related maternal mortality can be attributed to a delayed response and misdiagnosis on the part of the provider, particularly when almost all the moderate risk symptoms in the CVD algorithm are also common symptoms of pregnancy [8]. It is important to note that based on the study by Blumenthal et al., communication between the provider and patient is suggested to aid in achieving a higher chance of workup completion and subsequent identification of true-positive CVD patients. These lessons will be applied as the CVD algorithm is used for universal screening of all antenatal patients at our institution.

Integration of the CVD screening tool in the electronic medical record system is essential for rapid CVD screening in pregnant and postpartum patients. Studies looking to minimize the time spent by the healthcare provider to administer the CVD screen and linking the positive screen to the order sets prompting diagnostic testing and referrals are underway to address this important area of women's heart health. Additional studies are ongoing to optimize the screening algorithm for use on a larger scale.

As previously stated, one of the barriers to CVD-related care is lack of knowledge at the healthcare provider and the patient level. Therefore, a key step in preventing maternal death can be reduced by addressing provider awareness and education surrounding CVD in pregnancy. Additionally, this universal screening tool would improve access to healthcare for pregnant women especially at a lower socioeconomic status and reduce the percentage of misdiagnoses and delay in treatment of CVD. In turn, early diagnosis and treatment of CVD has the potential to reduce healthcare costs in addition to significantly affect maternal mortality and morbidity in the United States [10]. One study evaluating the cost-effectiveness of cardiovascular screening performed by Smith et al. out of Colorado demonstrated a screening tool in combination with community health workers reaching out to individuals to implement interventions resulted in a 0.8% reduction in Framingham risk score in the general population and a 2.0% reduction in an at-risk population. In their cost analyses, they demonstrated not just an increase in quality-adjusted life-years (QALYs) but, more importantly, a significant savings in healthcare costs in both the general population as well as an at-risk population [19]. Given the large proportion of pregnancy-related mortality attributed to cardiovascular disease, these data suggest that an implementation of universal screening may be beneficial to overall healthcare costs in addition to improvement of overall maternal outcomes; however, a secondary analysis of healthcare-related costs would be indicated after implementation of our algorithm.

6. Conclusions

Most of the deaths from CVD in pregnancy are attributed to acquired, as opposed to congenital, heart disease [6]. Maternal mortality reviews estimate that CVD-related deaths could be prevented through early diagnosis and treatment [8]. Moreover, half of the serious cardiac complications are preventable in women with cardiac disease [20,21]. Studies demonstrate that conventional CVD risk factors such as age, hypertension, diabetes, obesity, etc., play a significant role in CVD-related mortality [22]. Identification of these risk factors in conjunction with universal CVD screening to assist in early diagnosis is

essential in efforts to reduce maternal mortality. We propose universal CVD screening for all women in the antepartum and postpartum period to identify women at risk and to provide education and awareness for both patients and healthcare providers.

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CLINICAL GUIDANCE FOR POSTPARTUM PRESENTATIONS TO THE EMERGENCY DEPARTMENT, PRIMARY CARE PROVIDER OR OBSTETRIC PROVIDER

Deirdre Anglin, MD, MPH – University of Southern California

INTRODUCTION

This chapter is intended for clinicians who evaluate women presenting for care in the postpartum period who complain of symptoms of shortness of breath, chest pain, unresolved cough or swelling. Symptoms of cardiovascular disease can occur up to five months postpartum. Women of childbearing age should be questioned about recent pregnancies, in addition to their last menstrual period (LMP). Recommendations are based on the quality improvement opportunity data identified through the California Pregnancy-Associated Mortality Review (CA-PAMR), research literature and expert opinion.

Clinical pearls presented in this document are derived from the quality improvement opportunity data identified in the CA-PAMR, experience of the authors, literature and expert opinion. The level of evidence for current literature on cardiovascular disease in pregnancy is primarily consensus of expert opinion, case control studies, observational or retrospective studies and registries (Code C).[1]

CLINICAL PEARLS

- During pregnancy, symptoms of cardiac disease may be falsely attributed to the common symptoms in a normal pregnancy (i.e., shortness of breath, fatigue. swelling).
- Preexisting cardiovascular disease and/or new-onset peripartum cardiomyopathy may initially present during pregnancy or in the postpartum period.
  - Physiologic changes associated with pregnancy gradually return to baseline by two weeks postpartum[2]
  - Peripartum cardiomyopathy most frequently presents in the first postpartum week, with 75% presenting in first month[3]
  - Pregnant or postpartum women with CVD frequently present with shortness of breath or a new-onset cough.[4]
  - Emergency Department (ED) providers, Primary Care Providers, and Obstetricians should maintain a high index of suspicion for underlying cardiovascular disease when a woman presents with symptoms, signs, and risk factors concerning for heart disease for as long five months postpartum.

HISTORY

When a woman presents in the postpartum period with complaints of shortness of breath, ask if she has experienced:

- Worsened level of exercise tolerance
- Difficulty performing activities of daily living
- Symptoms that are deteriorating
- Chest pain, palpitations, or dizziness
- New-onset cough or wheezing
- Pedal or lower extremity edema and if it is improving or deteriorating
- Unexpected fatigue, i.e., needing to stop frequently when walking
- Inability to lie flat due to shortness of breath, and if this is a change, how many pillows does she use
- Failure to lose weight or unusual weight gain, and how much
- A history of cardiac or pulmonary conditions
- A history of substance use and/or tobacco use
- Has been seen by other providers or in other Emergency Departments since giving birth.

KEY POINTS

- Symptoms related to physiologic changes of pregnancy should be improving in the postpartum period.
- Visits to Emergency Department for dyspnea should raise suspicion for cardiovascular disease.
- Women of childbearing age should be questioned about recent pregnancies, in addition to their last menstrual period (LMP).
- Postpartum dyspnea or new-onset cough is concerning for cardiovascular disease.

PHYSICAL EXAMINATION

Conduct a thorough physical examination, paying particular attention to:

- The vital signs: HR ≥120 bpm, BP ≥160 mm Hg, RR ≥30, and oxygen saturation ≤ 94%
    - Look for the underlying cause of abnormal vital signs
- Lung exam: crackles, wheezing
- Cardiac exam: loud murmur, jugular venous distention
- Extremities: edema, taut shiny skin.

DIFFERENTIAL DIAGNOSIS FOR POSTPARTUM DYSPNEA

- Congestive Heart Failure
- Myocarditis
- Endocarditis
- Pulmonary Embolism
- Pulmonary Hypertension
- Asthma
- Infection
-

WORKUP FOR POSTPARTUM DYSPNEA

- Chest radiograph – *frequently normal in asthma*
- EKG – *may be normal in cardiomyopathy, except for sinus tachycardia*
- CBC, Basic Metabolic Panel, Thyroid Function Test (TSH)
- BNP – *an elevated BNP should raise suspicion for CHF*
- D-dimer – *may normally be elevated in pregnancy, however, may be considered for negative predictive value*
- Toxicology screen - *Substance use (e.g., methamphetamine, cocaine) is a strong risk factor for pregnancy-related cardiovascular disease*
- Echocardiogram: this should be obtained on an emergency basis if the patient has abnormal vital signs or is very symptomatic - *Normal LV ejection fraction does not exclude heart failure, normal RV function does not exclude pulmonary embolism*
- Venous Doppler Ultrasound and/or CT pulmonary angiogram for pulmonary embolism
- Cardiology consultation as needed.

KEY POINTS

- New-onset asthma is rare in adults.
- Bilateral crackles on lung examination are most likely associated with Congestive Heart Failure (CHF).
- Improvement of dyspnea with bronchodilators does not confirm the diagnosis of asthma, as CHF may also improve with bronchodilators. Response to bronchodilators should prompt the consideration of a diagnosis other than asthma.

DISPOSITION

- If considering discharge:
  - Repeat vital signs to ensure they are persistently normal, the symptoms have improved, and the patient is stable for discharge
  - Arrange for early follow-up with primary provider or cardiologist as indicated.
- Admission and cardiology consultation may be indicated for:
  - Persistent symptoms or abnormal vital signs, in particular, HR $\geq$ 120 bpm, BP $\geq$ 160 mm Hg, RR $\geq$ 30, and oxygen saturation $\leq$ 94%
  - Lack of response to treatment
  - Newly-diagnosed cardiomyopathy or pulmonary hypertension.

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LIFETIME RISKS OF HEART DISEASE AFTER PREGNANCY COMPLICATIONS AND SYMPTOMS OF HEART DISEASE

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BACKGROUND

Recent research demonstrates a higher lifetime likelihood of cardiovascular disease (CVD) when women experience complications during pregnancy or postpartum.[1] These complications include gestational diabetes, gestational hypertension, preeclampsia and HELLP (hemolysis, elevated liver enzyme levels, and low platelet levels) syndrome and preterm birth. Hypertensive disorders occur in 5-10% of all pregnant women.[1] Gestational diabetes is diagnosed in up to 14% of all pregnancies.[2]

Many women who have had pregnancy complications are unaware of the long term cardiovascular health impacts. As well, women who develop symptoms of heart disease are unaware of their implication or have difficulties obtaining appropriate assessment. To address these information gaps, two infographics were developed by the CVD Task Force (see Patient Resources section). The first one outlines pregnancy complications and future risk of cardiovascular disease and aims to increase awareness on how women can potentially modify their risk of CVD through lifestyle changes. The second infographic focuses on the signs and symptoms of heart disease in pregnancy and postpartum. Both infographics are available in English and Spanish in .jpg and .pdf formats on the CMQCC website (www.cmqcc.org). The infographics are designed to be posted or displayed in medical clinic offices and/or exam rooms for patients to observe, read and review. They may also be incorporated into digital communications, such as social media or embedded in emails.

HYPERTENSION IN PREGNANCY

Women can enter pregnancy with chronic hypertension or develop hypertension during their pregnancy. New-onset hypertension in pregnancy can further be diagnosed as gestational hypertension, preeclampsia, or preeclampsia with HELLP syndrome.

Gestational Hypertension: Gestational hypertension is diagnosed when a pregnant woman presents with hypertension in the absence of proteinuria after the 20th week of pregnancy.[3] The incidence of gestational hypertension is 6%.[4] Gestational hypertension is managed similarly to preeclampsia and has similar impact on future development of hypertension, but there is not as strong an association with other cardiovascular diseases.[5,6]

Preeclampsia: The American Congress of Obstetricians and Gynecologists (ACOG) have published comprehensive definitions and guidelines on diagnosis and

management of hypertension in pregnancy.[3] Women diagnosed with preeclampsia have double the risk of stroke, cardiac ischemia or venous thromboembolism for up to 20 years after pregnancy.[1] The risk for the development of hypertension is four-fold among women with preeclampsia.[1] For women who develop preeclampsia prior to 34 weeks' gestation (early-onset preeclampsia), the risk of developing these complications is 8-10 times higher than among women who develop preeclampsia after 34 weeks' gestation.[1]

OTHER CONDITIONS

Gestational Diabetes: Gestational diabetes mellitus (GDM) is a complication of pregnancy and is associated with an increased risk of developing CVD.[7-9] The most common risk factors associated with GDM include advanced maternal age, obesity, and excess weight gain during pregnancy, family history of diabetes, previous pregnancy with GDM and hypertension.[2] Women with GDM have a higher risk of developing CVD earlier in their lives.[5,10] Among women diagnosed with GDM, there is a 48% incidence among Hispanic women, 35% among White women, 12% among Asian women and 5.5% among African-American women.[11,12]

Preterm Birth: Preterm birth is defined as birth occurring at less than 37 weeks gestation. In 2012,11.5% of all U.S. births were preterm.[13] A number of preterm births can be attributed to hypertension in pregnancy.[14] Women who experience preterm birth AND preeclampsia have 8-10 times higher CVD mortality in their lifetimes compared to women with normal pregnancies.[1]

RECOMMENDATIONS FOR WOMEN TO DECREASE CVD RISK AFTER PREGNANCY COMPLICATIONS

Women who have had pregnancy complications and are monitored throughout their lifetime can improve their cardiovascular health outcomes and overall health. All women should share their pregnancy and postpartum information with their current and future healthcare providers and ensure their medical records are shared as they receive care throughout their lives. In addition, all providers should ensure women are informed of and understand their pregnancy complications, and stress the importance of the six-week postpartum visit. The postpartum visit occurs on or between 21 and 56 days following the birth and is important for all postpartum women.[15] Women who experienced gestational diabetes should be re-screened for diabetes. Obstetric providers should provide a referral for a 3- or 6-month follow-up visit with a primary care provider to assess future CVD risk.

Postpartum Period: All healthcare providers should educate women with regard to serious signs or symptoms that may be associated with preeclampsia or cardiovascular disease in the first few days or weeks following birth. These include:

- Severe headache
- Shortness of breath – especially when lying down
- Chest pain
- Persistent cough
- Extreme swelling
- Extreme fatigue

Postpartum women (up to five months following birth) should notify their pregnancy provider and/or seek care from the provider or an Emergency Department when experiencing symptoms listed above. Women should be empowered to listen to their body and trust their instincts. It is crucial that women who seek care from an Emergency Department notify providers of their recent birth experience.

Throughout Their Lifetime: At three to six months postpartum, and annually thereafter, women who had any hypertension, preterm birth, preeclampsia, or gestational diabetes should consider a physical examination with their pregnancy provider or primary care provider for assessment of future CVD risk. This visit should include:[1]

- Vital signs – blood pressure, heart rate, respiratory rate, oxygen saturation, weight and BMI
- Consider laboratory studies – fasting blood glucose levels with or without a Hemoglobin A1C, lipid profile to check total/HDL/LDL cholesterol, and triglyceride levels.

Healthcare providers should share this information with women and discuss what these results mean for their health. Women should be encouraged to know their own health-related numbers and how they relate to healthy heart values from the American Heart Association (2017) referenced below:[16]

Health Indicator	Healthy Values (less than)
Blood pressure	< 120/80 mm Hg
Total cholesterol	< 200 mg/dL
HDL cholesterol	< 50 mg/dL
LDL cholesterol	< 100 mg/dL
Triglyceride	< 100 mg/dL
Fasting blood glucose	< 100 mg/dL
BMI	< 25 kg/m^2

Lifestyle Modifications: Lifestyle changes may decrease the incidence or development of cardiovascular disease.[17] As many CVD diagnoses are associated with an increased BMI and waist circumference, steps to maintain a healthy weight are important.[5] Women should be encouraged to have a healthy diet and regular exercise as recommended by their healthcare provider. When compared to women who remained obese, women who

lost weight lowered their incidence of the following conditions in future pregnancies: gestational hypertension from 23.5% to 9.6% and preeclampsia from 20.8% to 12%.[18]

Breastfeeding has added benefits for maternal health. Women whose cumulative lifetime duration of breastfeeding is six-to-twelve months were 10% less likely to develop cardiovascular disease.[19] Breastfeeding has been theorized to decrease the incidence of hypertension through changes that occur to the maternal vasculature and maternal lipid and hormonal values.[20] It also enhances postpartum weight loss.

COMMON MISCONCEPTIONS

A common misconception among providers and the public is that pregnancy-related hypertension and gestational diabetes complications resolve after the baby is born. In fact, women with a history of preeclampsia have twice the risk of stroke, cardiac ischemia or blood clots, and four times the risk of developing chronic hypertension.[21] Of women diagnosed with gestational diabetes, up to 50% may develop Type II diabetes within five years after giving birth.[8,10,11]

KEY POINTS

Women who have experienced preeclampsia are often unaware of their increased lifetime risk for cardiovascular health concerns but are enthusiastic to learn of the association and how they can improve their health.[21]

- Hypertension and diabetes in pregnancy represent a wake-up call for women and those who care for them.
- Healthy lifestyle changes will likely reduce future cardiovascular disease risk by 4-13%.[17]

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Patient Handout:

PREPARING FOR PREGNANCY IF YOU HAVE A HISTORY OF HEART PROBLEMS OR CARDIOVASCULAR DISEASE

Monica Sood, MD – Kaiser Permanente Medical Group Walnut Creek

Do you have a history of heart disease (preexisting heart disease discovered during childhood or adulthood) and are thinking about having a baby?

Planning for a healthy pregnancy
More women who were born with a heart problem are able to get pregnant and have a healthy baby. In most cases, if you were born with a heart problem, you can have a healthy and safe pregnancy and childbirth. However, because of your heart disease, if you get pregnant, you will be considered high-risk.

The first step is to talk to your doctor BEFORE you get pregnant. Your doctor should refer you to a cardiologist and/or a maternal fetal medicine specialist for a preconception counseling appointment. If you had surgery for heart disease as a child, it is important that you see a cardiologist who is an expert in congenital heart disease. In the meantime, it is important to keep using birth control until you have made a plan for pregnancy with your doctor and other specialists.

Preparing for your visit before you become pregnant (preconception)
The preconception counseling appointment is an important visit. You can discuss how your heart disease will affect your pregnancy and how your pregnancy will affect your heart disease. At this visit, the specialist will go over your medical history and help you decide whether pregnancy is right for you. The doctor will also talk to you about what you can do to improve your chances of a safe pregnancy and a healthy baby.

The doctor will ask you about your current and past symptoms, such as chest pain, fast heart beat (palpitations) or if you have a hard time breathing. It may help to keep a diary of your symptoms to show your doctor. You and your doctor can talk about how these symptoms may change when you are pregnant and after you have a baby.

You should bring all of your medical records with you to this visit so the doctor can review your health history. Bring records from any childhood surgeries that you have had. All of this information will help the doctor understand your risks in pregnancy. The information will help you decide whether it is safe for you to get pregnant.

Evaluation of heart disease before you get pregnant
It is very likely that you will be asked to have some tests done before you get pregnant to see if your heart is ready for pregnancy. You may have had tests of your heart in the past, such as an EKG or an echocardiogram, a special ultrasound of the heart. Your doctor will use these tests to help you decide if and when you are ready for pregnancy. If the doctor does not order these tests, it is very reasonable to ask for them especially if they have not been performed in more than one year or if you've experienced new symptoms.

Heart disease medications and pregnancy
Your doctor may want you to change some medications that you currently take to different medications that are safe to take when you are pregnant. There are some medications that are unsafe in pregnancy. Your doctor may switch you off these medications to safer ones even before you become pregnant.

Congratulations on taking the first steps in planning for a healthy pregnancy!

Websites for more information:
Adult Congenital Heart Association: www.achaheart.org
American Heart Association: www.americanheart.org

RECOGNITION & PREVENTION

Introduction: Recognition and Prevention of Cardiac Conditions in Pregnancy and Postpartum (Mississippi)

Cardiovascular disease is the leading cause of pregnancy-related mortality in the United States, and Mississippi reflects this national trend. In recent years the state's maternal mortality ratio has risen to approximately 39.1 deaths per 100,000 live births in the 2018 to 2022 period, which is significantly higher than the national rate. Between 2016 and 2020, Mississippi recorded 167 pregnancy-associated deaths, 39 percent of which were determined to be pregnancy-related.

Within those pregnancy-related deaths, cardiovascular-related conditions (excluding cardiomyopathy, hypertensive disorders of pregnancy, and cerebrovascular accidents) were the most common underlying, contributing, or immediate cause. Eighty percent of pregnancy-related deaths in Mississippi during this period were judged preventable, and more than 90 percent had some chance of a different outcome with earlier recognition, better care, or stronger systems of response.

Racial disparities are striking. Black, non-Hispanic women account for nearly 77 percent of all pregnancy-related deaths despite representing only about 42 percent of births in the state. They experience mortality rates several times higher than White women, reflecting the combined impact of inequitable access to care, structural barriers, and social drivers of health.

Timing is also critical. Nearly half of pregnancy-related deaths occur in the late postpartum period, from 43 days to one year after delivery, a time when women often transition out of frequent contact with the health system and symptoms may be attributed to normal recovery.

This recognition component of Mississippi's AIM Cardiac Conditions in Obstetric Care bundle responds directly to these challenges. It emphasizes universal screening for pregnancy or recent pregnancy at every clinical encounter, the use of structured history taking and validated cardiac risk tools, and vigilance for red-flag symptoms. Just as importantly, it highlights the need for timely escalation, equitable patient education, and standardized pathways of care to ensure that cardiovascular disease in pregnancy and the postpartum period is recognized early and managed effectively.

Key Messages at a Glance

• Cardiovascular disease is the leading cause of maternal death in Mississippi, most deaths are preventable and occur postpartum.

• Systematic recognition strategies, including universal screening, standardized risk assessment, and timely escalation, are critical to saving lives.

• Racial disparities demand culturally responsive, equitable approaches across all care settings.

• Education of patients and providers on urgent maternal warning signs is essential for early recognition and intervention.

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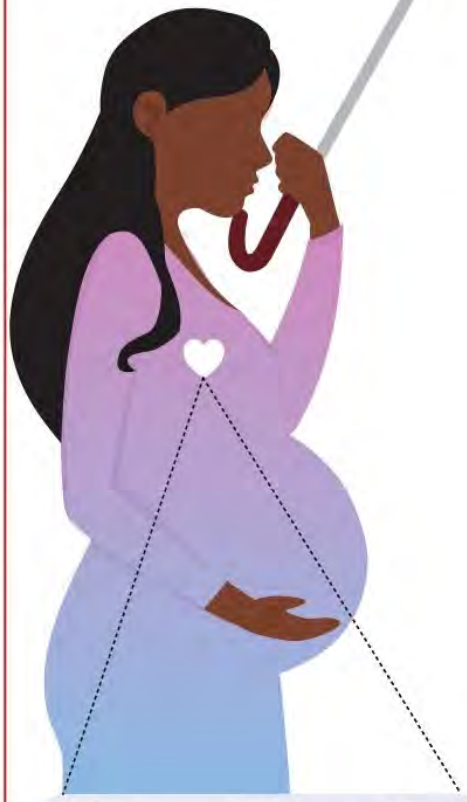
Cardiac Conditions in Obstetric Care Implementation Details

Recognition & Prevention — Every Patient

Recognition Element	Key Points
Screening for community support needs and resources provided	Screening should include: • Medical needs • Mental health needs • Substance use disorder needs • Structural and social drivers of health All provided resources should align with the pregnant or postpartum patient's: • Health literacy • Cultural needs • Language proficiency • Geographic location and access

Pregnancy Heart Team

Extended with specific multidisciplinary teams if indicated



Pre-conception

- Risk assessment mWHO 2.0
- Genetic counselling
- Lifestyle counselling
- Reproductive technology
- Drug review
- Clinical optimization
- Contraception

Pregnancy

Disease-specific

- Regular follow-up and risk assessment
- Regular foetal assessment
- Documented delivery plan

Delivery (plan)

- Timing and mode of delivery
- Foetal and maternal monitoring
- Anaesthesia and pain relief methods
- Drug management and bleeding control
- Device management

Post-partum

- Breastfeeding and lactation
- Contraception
- Maternal cardiac follow-up

Long term

- Identify adverse pregnancy outcome
- Women's Heart Clinic
- Cardiovascular risk factor screening

ESC

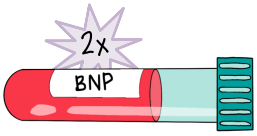
Society for Maternal-Fetal Medicine

Consult Series #73

Diagnosis and management of RIGHT AND LEFT HEART FAILURE during pregnancy and postpartum

Cardiac changes in pregnancy

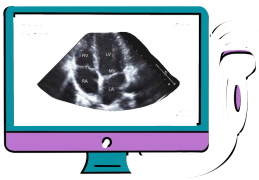
- 30-50% ↑ in blood volume
- Heart rate ↑ by 10-20 bpm
- Systemic and pulmonary vascular resistance ↓
- Vasodilation leads to ↓ in diastolic and systolic blood pressure



B-type natriuretic peptide (BNP) may rise two-fold

May cause elevation in BNP	Preeclampsia Sepsis Cardiomyopathy	Congenital heart disease Pulmonary embolism Critical illness	Renal failure Anemia

Echocardiographic changes in pregnancy



- ↑ left and right ventricular dimension and volume
- ↑ stroke volume
- ↑ cardiac output without a change in the left ventricular ejection fraction

Heart Failure — Clinical syndrome with signs/ symptoms from structural or functional impairment of ventricular filling or ejection of blood

- Heart failure with preserved ejection fraction (HFpEF)
- Heart failure with reduced ejection fraction (HFrEF)
  - Encompasses peripartum cardiomyopathy and dilated cardiomyopathy
  - Primary type of heart failure seen in pregnancy
  - Left ventricular ejection fraction (LVEF) of <40%
  - Pressure overload + Volume overload + Decreased contractility

Preconception counseling

for patient with a history of heart failure (HF)

- Assess functional status
- Review etiology of HF and impact on pregnancy
- Assess for structural defects, prior cardiac events, and the presence or absence of arrhythmias
- Review compatibility of HF medications with pregnancy
- Use a model (see below) for cardiac risk stratification
- Option for pregnancy termination should be available to all patients

ADVISE AGAINST PREGNANCY IF

Persistent LVEF <45% after a diagnosis of peripartum cardiomyopathy in prior pregnancy

LVEF <30% at the time of presentation with peripartum cardiomyopathy

TABLE 1 Relevant echocardiographic parameters, clinical implications, and reasonable next steps for management of abnormal results

Parameter	Normal values in reproductive-aged females	Clinical implication	Next steps
RVSP	<40 mmHg	The tricuspid regurgitant jet velocity is a non-invasive measure of pulmonary artery systolic pressure and quantifies pulmonary hypertension. Elevated levels can be indicative of pulmonary hypertension, fluid overload, or right ventricular dysfunction.[22,23]	Confirmation: 25% of RVSP measures are inaccurate. Consider other echocardiographic and clinical parameters, serial follow-up, and expert consultation. Right heart catheterization may be advised. If confirmed, classification into 5 groups of pulmonary hypertension is recommended (see Table 4). The classification/group usually guides treatment.[22,23]
TAPSE	>1.7 m/s	Assessment of right ventricular function. M-mode is used to measure the vertical movement of the lateral tricuspid valve annulus. Lower values can be indicative of right ventricular dysfunction and failure.[22,23]	Expert consultation: Right ventricular failure or depression can be very morbid and mortal in the context of pregnancy. Swift consultation is advised. Observe other right-sided echocardiographic findings, including right atrial volume and IVC diameter. Medical management could include diuresis, afterload reduction, and inotropy[22,23]
Left atrial volume	22-52 (mL)[24]	Increased size indicates increased filling pressures and fluid overload and can place patients at risk for arrhythmia (i.e., atrial fibrillation).	Expert consultation: Increased left atrial volume can indicate heart failure or obstructive process and left-sided cardiac pathology (i.e., heart failure, mitral stenosis, aortic stenosis,[24,25] hypertrophic cardiomyopathy). Observe other echocardiographic findings. Assess mitral and aortic valves for stenosis or regurgitation, left ventricular failure, etc. Medical management can include diuresis, afterload reduction, beta-blockade for arrhythmia treatment.
Mitral septal E/e'	<13	Increased levels are indicative of increased left ventricular filling pressure and increased pulmonary capillary wedge pressures and can be found in HFpEF[26]	Expert consultation: Increased mitral septal E/e' values >13 can be indicative of increased left ventricular filling pressures, fluid overload, and heart failure[26] Observe other echocardiographic findings such as valvular function, left atrial volume, left ventricular systolic function, and left ventricular wall thickness. Medical management can include treatment of chronic medical conditions (i.e., hypertension), diuresis, and expanding differential diagnosis for chronic cardiac disease and hypertrophic cardiomyopathy.

E, mitral inflow velocity of early diastolic filling; e', tissue Doppler mitral annular velocity; HFpEF, heart failure with preserved ejection fraction; IVC, inferior vena cava; RVSP, Right ventricular systolic pressure; TAPSE, Transannular planar systolic excursion

RISK STRATIFICATION

Modified WHO Classification of Maternal Cardiovascular Risk

Categorizes individuals into risk categories ranging from

I — extremely high risk of maternal mortality or severe morbidity

↓

IV — no detectable increased risk of maternal mortality and no/mild increased risk in morbidity

CARPREG II Risk Predictor

PREDICTOR	POINTS
Prior cardiac events or arrhythmias	3
Baseline NYHA III-IV or cyanosis	3
Mechanical valve	3
Ventricular systolic dysfunction[1]	2
High risk left-sided valve disease/left ventricular outflow tract obstruction[2]	2
Pulmonary hypertension	2
Coronary artery disease[3]	2
High risk aortopathy[4]	2
No prior cardiac intervention[5]	1
Late pregnancy assessment[6]	1

Predicted risk for a primary cardiac event	
0-1 points	5%
2 points	10%
3 points	15%
4 points	22%
>4 points	41%

[1]Left ventricular ejection fraction <55%
[2]Aortic valve <1.5 cm², subaortic gradient >30 mmHg, mitral valve area <2 cm², moderate to severe mitral regurgitation
[3]Angiographically proven coronary obstruction or past myocardial infarction
[4]Marfan syndrome, bicuspid aortopathy with aortic dimension >45 mm, Loeys-Dietz syndrome, vascular Ehlers-Danlos syndrome, prior aortic dissection or pseudoaneurysm
[5]No cardiac repair of congenital lesions, valvular replacement or repair, percutaneous or operative treatment of arrhythmias
[6]First visit after 20 weeks of gestation

RV FAILURE

Causes of right ventricular failure in pregnancy

Acute Right Ventricular Failure	Chronic Right Ventricular Failure
Embolism • Pulmonary thromboembolism • Amniotic fluid embolism • Air or fat embolism Right ventricular infarction	Left heart failure Right-sided valve disease Cardiomyopathies involving the RV Pulmonary hypertension ✳ Chronic thromboembolic disease Interstitial lung disease

✳ Pulmonary hypertension = Mean pulmonary artery pressure >20 mmHg

RV systolic dysfunction

Reduces forward flow to the pulmonary circulation

Decreasing LV stroke volume and cardiac output

Neurohormonal activation promotes renal sodium and water retention

Systemic venous hypertension

Hepatic congestion, ascites, lower extremity edema

RV is sensitive to afterload (accustomed to pumping into low-resistance pulmonary circulation)

Any sudden increase in pulmonary artery pressure (eg pulmonary embolism) may lead to cardiogenic shock

Symptoms of RV failure

Shortness of breath on exertion

Fatigue

Initial diagnostic tests

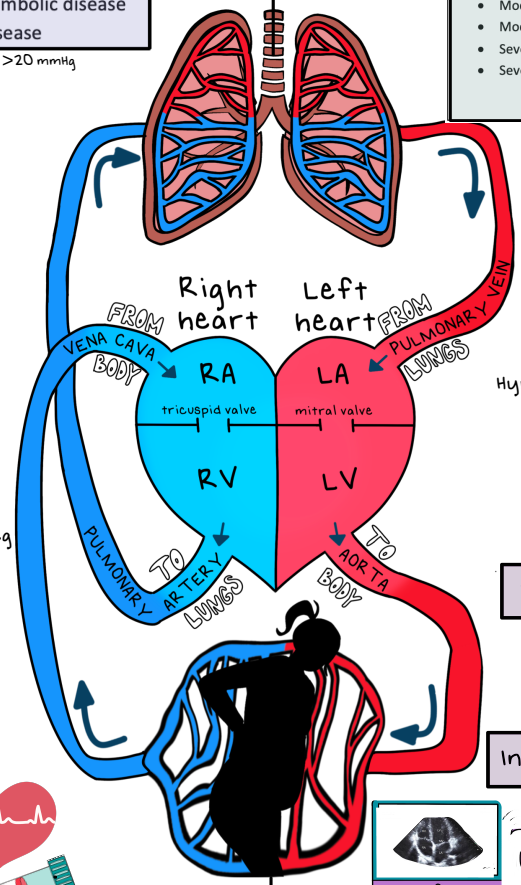
Echocardiogram

EKG

BNP levels

Management

- RV failure due to pulmonary hypertension
  - Counsel on high risk of morbidity and mortality
  - Refer to center with expertise in pulmonary hypertension
  - Oxygen saturations maintained at ≥90% (preferably ≥95%)
  - Maintain intravascular volume
- RV failure due to left heart failure or volume overload
  - Diuretic therapy
- PE and RV infarction
  - Anticoagulation
  - Adequate intravascular volume
- RV failure due to arrhythmias and low cardiac output
  - Based on underlying etiology

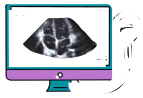


LV FAILURE

Causes of left ventricular failure

Cardiomyopathy • Peripartum cardiomyopathy • Non-ischemic dilated cardiomyopathy • Tachycardia induced cardiomyopathy • Stress (Takotsubo) cardiomyopathy • Hypertrophic cardiomyopathy • Left ventricular non-compaction Progressive valve disease • Moderate to severe aortic stenosis • Moderate to severe mitral stenosis • Severe aortic regurgitation • Severe mitral regurgitation	Acute valve disease • Prosthetic valve thrombosis Arrhythmias • Atrial fibrillation • Atrial flutter • High frequency ventricular ectopy • Ventricular tachycardia Acute coronary syndrome • Coronary artery dissection • Thrombosis Ion channel disorders Myocarditis Acute diastolic dysfunction Preeclampsia with severe range blood pressure

Peripartum cardiomyopathy (PPCM)



Presents on echo with LV enlargement + dysfunction with LVEF <45%

Diagnosis of exclusion, must rule out other causes of heart failure

Consider referral to a genetics provider

Hypertrophic cardiomyopathy (HCM) = LV hypertrophy

Thickening of myocardium >15mm

May lead to LV outflow obstruction, diastolic dysfunction, ischemia, mitral regurgitation

Risk of arrhythmias and sudden death

Often tolerate pregnancy well due to volume expansion

Symptoms of LV failure

Shortness of breath

Cough

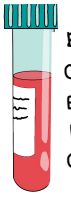
May have chest pain

Initial diagnostic tests

Echocardiogram

EKG

Consider cardiac MRI



BNP levels

Cardiac enzymes

Electrolytes

Renal function

CBC

History and physical examination

Weight gain

Jugular venous distension

Tachycardia

Crackles

S3 or S4

Murmurs

Pedal edema

NYHA functional class

Management

	Acute Left Ventricular Heart Failure	Chronic Left Ventricular Heart Failure
Experts	Cardiology, cardiac surgeon (possible mechanical circulatory support, MCS), intensivist, maternal-fetal medicine, cardiac anesthesiologist, obstetric anesthesiologist	Maternal-fetal medicine, cardiology, heart failure specialist, obstetric anesthesiologist
Resources	Intensive care unit (sub-specialized in cardiac care preferred), MCS capabilities	Outpatient imaging capabilities
Medications	Afterload reduction: hydralazine, nitroprusside Diuresis: furosemide, bumetanide Inotropy: dobutamine, epinephrine	Afterload reduction: hydralazine, isosorbide dinitrate Beta-blockade: metoprolol, carvedilol, bisoprolol Diuretic: furosemide **All other GDMT (goal-directed medical therapy) agents (ACEi, ANRi, mineralocorticoid antagonists) are contraindicated during pregnancy**
Anticoagulation	Mechanical or pharmacological thromboprophylaxis	Consider if EF < 35%
Fetal Monitoring	At least daily if the fetus is considered viable.	Individualized

Refractory heart failure

Candidates for intravenous inotropic therapy, left ventricular assist device, extracorporeal membranous oxygenation, and cardiac transplantation

Require transfer to a high level of care

In most cases, necessitate abortion care or delivery of fetus

Arrhythmia and heart failure

Sustained cardiac arrhythmias can cause HF

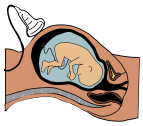
Medical and procedural care for SVT and ventricular arrhythmias in pregnant patients with HF is incredibly nuanced; it is imperative to involve HF and/or EP specialists

Treatment of SVT in HF involves using nodal blocking agents (eg beta-blockers, calcium channel blockers) and diuresis if overloaded

Fetal considerations

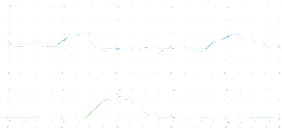
Pregnant individuals with cardiac disease are at increased risk for adverse perinatal outcomes, including small for gestational age birth, lower Apgar scores, and prematurity

A fetal echocardiogram is indicated in the cases of maternal congenital defect



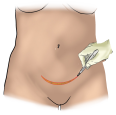
Serial growth ultrasounds should be performed

Recommend continuous fetal heart rate monitoring during anesthesia administration, labor, and delivery



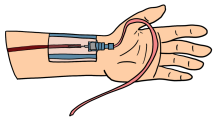
Recommend fetal heart rate monitoring in the case of maternal cardiovascular changes prompting inpatient assessment

Labor and delivery



Cesarean delivery reserved for typical obstetric indications

Telemetry is often utilized for patients at risk for arrhytmias

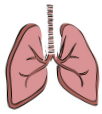


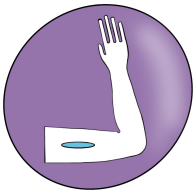
Consider arterial line in patients who may benefit from continuous blood pressure and cardiac output monitoring (Eg critical aortic stenosis, previous peripartum cardiomyopathy with unrecovered function)

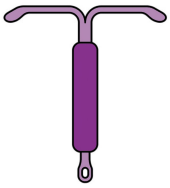
Recommend use of neuraxial anesthesia in most patients with heart failure

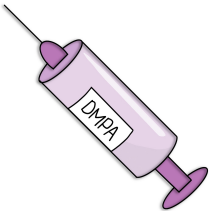
Instances in which to limit or avoid valsalva may include:

- Severe pulmonary hypertension
- LV outflow tract obstruction
- Compromised venous return
- Substantially compromised myocardial contractility









Recommend comprehensive contraceptive counseling taking into consideration medical criteria and patient preferences

Recognition and Prevention — Every Unit

- [ ] Obtain a focused pregnancy and cardiac history in all care settings, including emergency department, urgent care and primary care.
    - [ ] Staff triage (OB and emergency) with skilled nurses for identification of cardiac issues.
    - [ ] Ensure that elements of cardiac history are understood beyond just pregnancy-related assessment.
- [ ] In all care environments assess and document if a patient presenting is pregnant or has been pregnant within the past year.
    - [ ] Build inquiry into all entrance portals for care and ensure gender inclusivity in assessment.
    - [ ] Encourage and inquire about information associated with recent pregnancies to the entire health care team, including physicians and nurses.
- [ ] Assess if escalating warning signs for an imminent cardiac event are present.
- [ ] Utilize standardized cardiac risk assessment tools to identify and stratify risk. Utilize the cardiac risk assessment tools. (Most cases ultimately are risk-assessed individually; however, the tools exist to provide guidance).
    - [ ] mWHO
    - [ ] CARPREG I
    - [ ] CARPREG II
    - [ ] Pregnancy in congenital heart disease: risk prediction and counselling | Heart
- [ ] Conduct a risk-appropriate workup for cardiac conditions to establish a diagnosis and implement the initial management plan.
- [ ] Screen each person for condition-associated risk factors and provide linkage to community services and resources.

Cardiac Conditions in Obstetric Care

Patient Screening Tool

Patients with a known history of heart disease or certain risk factors may be at higher risk of complications during pregnancy and after delivery. Please answer the following questions.

Do you have any of the following:

Yes	No	
☐	☐	Do you see a heart doctor now or did you as a child?
☐	☐	Is it hard to breathe when you lay flat or on your side?
☐	☐	Do you have trouble breathing when resting?
☐	☐	Have you passed out/fainted in the past year?

Have you ever had a:

Yes	No	
☐	☐	Heart attack
☐	☐	Stroke
☐	☐	Surgery
☐	☐	Chemotherapy

Your answers may lead to additional questions or testing after discussion with your care provider.

Provider Follow-Up

This information is intended as clinical guidance and is not intended to be prescriptive. Provider's assessment is imperative.

Additional questions to consider:

If the patient has a cardiologist, who is it, and has the patient seen them recently?

_____

If the patient has shortness of breath or orthopnea, has the patient always had these symptoms or is this new?

_____

If the patient had syncope in the past year, were there any precipitating events?

_____

If the patient says "yes" to any screening questions and/or reports a significant cardiac history and cardiology records are not available:

Consider ordering:

- ☐ Echocardiogram
- ☐ EKG
- ☐ Cardiac event monitor
- ☐ BNP or nt-ProBNP

Consider referral to:

- ☐ Cardiology
- ☐ Maternal-fetal medicine

If patient has a known cardiac history and records are available, see also the "Referral Protocol for Patients with Known Cardiovascular Diagnoses".

If ordering any cardiac testing or referral to cardiology, please **also notify the Cardio-OB Care Coordinator** at _____.

Yes	**No**	
☐	☐	Cardio-OB Care Coordinator notified

Cardiac Conditions in Obstetric Care

Referral Protocol for Patients with Known Cardiovascular Diagnoses

Notify **Cardio-OB Care Coordinator** for patients in ALL cardiovascular risk categories

Contact: _____

WHO I		WHO II		WHO II-III or III		WHO IV	
Cardiology	**MFM**	**Cardiology**	**MFM**	**Cardiology**	**MFM**	**Cardiology**	**MFM**
1-2 visits	-----	Every trimester	Once	Every 8 weeks	Transfer, by 32 weeks or as soon as possible if identified after 32 weeks to allow for delivery planning	Every month	Transfer, immediately to determine safety of continuation of pregnancy
Cardio-OB Team		**Cardio-OB Team**		**Cardio-OB Team**		**Cardio-OB Team**	
-----		Review once		Review monthly		Review monthly	
Delivery location		**Delivery location**		**Delivery location**		**Delivery location**	
Local hospital		Local hospital, per resources and agreement of provider teams (OB, cardiology, and anesthesiology)		Tertiary care, with availability of MFM, cardiology, cardiothoracic surgery, advanced cardiac imaging, pediatric cardiology, and NICU		Tertiary care, with availability of MFM, cardiology, cardiothoracic surgery, advanced cardiac imaging, pediatric cardiology, and NICU	

Cardio-OB Team should include the Cardio-OB Care Coordinator and representatives from cardiology, MFM, obstetrics, anesthesiology, nursing, and pharmacy. Additional team members may include social work, case managers, primary care providers, CT, surgery, neonatology, etc.

Modified World Health Organization (WHO) Classification of Maternal Cardiovascular Risk[1]

WHO I	WHO II	WHO II-III	WHO III	WHO IV

• Small or mild:
  ○ Pulmonary stenosis
  ○ Patent ductus arteriosus
  ○ Mitral valve prolapse
• Successfully repaired simple lesions (atrial or ventricular septal defect, patent ductus arteriosus, anomalous pulmonary venous drainage)
• Atrial or ventricular ectopic beats, isolated
	• Unoperated atrial or ventricular septal defect
	• Repaired tetralogy of Fallot
	• Most arrhythmias (supraventricular arrhythmias)
	• Turner syndrome without aortic dilatation
		• Mild left ventricular impairment (EF >45%)
		• Hypertrophic cardiomyopathy
		• Native or tissue valve disease not considered WHO I or IV (mild mitral stenosis, moderate aortic stenosis)
		• Marfan or other HTAD syndrome without aortic dilatation
		• Aorta <45 mm in bicuspid aortic valve pathology
		• Repaired coarctation
		• Atrioventricular septal defect
			• Moderate left ventricular impairment (EF 30–45%)
			• Previous peripartum cardiomyopathy without residual left ventricular impairment
			• Mechanical valve
			• Systemic right ventricle with good or mildly decreased ventricular function
			• Fontan circulation, if otherwise well and cardiac condition uncomplicated
			• Unrepaired cyanotic heart disease
			• Other complex heart disease
			• Moderate mitral stenosis
			• Severe asymptomatic aortic stenosis
			• Moderate aortic dilatation (40–45 mm in Marfan syndrome or other HTAD; 45–50 mm in bicuspid aortic valve, Turner syndrome ASI 20–25 mm/m, tetralogy of Fallot <50 mm)
			• Ventricular tachycardia
				• Pulmonary arterial hypertension
				• Severe systemic ventricular dysfunction (EF <30%)
				• Previous peripartum cardiomyopathy with residual left ventricular impairment
				• Severe mitral stenosis
				• Severe symptomatic aortic stenosis
				• Systemic right ventricle with moderate or severely decreased ventricular function
				• Severe aortic dilatation (>45 mm in Marfan syndrome or other HTAD, >50 mm in bicuspid aortic valve, Turner syndrome ASI >25 mm/m, tetralogy of Fallot >50 mm)
				• Vascular Ehlers–Danlos
				• Severe (re)coarctation
				• Fontan with any complication

[1] Regitz-Zagrosek V, Blomstrom Lundqvist C, Borghi C, et al. ESC Guidelines on the management of cardiovascular diseases during pregnancy: the Task Force on the Management of Cardiovascular Diseases during Pregnancy of the European Society of Cardiology (ESC). *Eur Heart J*. 2011;32(24):3147-3197. doi:10.1093/EURHEARTJ/EHR218

Cardiac Conditions in Obstetric Care

Referral Protocol for Patients with Known Cardiovascular Diagnoses

Notify **Cardio-OB Care Coordinator** for patients in ALL cardiovascular risk categories

Contact: _____

WHO I		WHO II		WHO II-III or III		WHO IV	
Cardiology	**MFM**	**Cardiology**	**MFM**	**Cardiology**	**MFM**	**Cardiology**	**MFM**
1-2 visits	-----	Every trimester	Once	Every 8 weeks	Transfer, by 32 weeks or as soon as possible if identified after 32 weeks to allow for delivery planning	Every month	Transfer, immediately to determine safety of continuation of pregnancy
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				• Severe symptomatic aortic stenosis
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				• Vascular Ehlers–Danlos
				• Severe (re)coarctation
				• Fontan with any complication

[1] Regitz-Zagrosek V, Blomstrom Lundqvist C, Borghi C, et al. ESC Guidelines on the management of cardiovascular diseases during pregnancy: the Task Force on the Management of Cardiovascular Diseases during Pregnancy of the European Society of Cardiology (ESC). *Eur Heart J*. 2011;32(24):3147-3197. doi:10.1093/EURHEARTJ/EHR218

CARDIOVASCULAR DISEASE ASSESSMENT IN PREGNANT AND POSTPARTUM WOMEN

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Elyse Foster, MD – University of California, San Francisco
Elliott Main, MD – California Maternal Quality Care Collaborative
Abha Khandelwal, MD, MS – Stanford University School of Medicine
Elizabeth Lawton, MHS – CDPH/MCAH

Development of the Algorithm: The CMQCC Cardiovascular Disease in Pregnancy and Postpartum Task Force was charged with developing a toolkit that includes an overview of clinical assessment and management strategies based on risk factors and presenting signs and symptoms. The key components of the Toolkit include an algorithm developed to guide stratification and initial evaluation of symptomatic or high-risk pregnant or postpartum women.

The goal of the algorithm is to assist providers in distinguishing between signs and symptoms of cardiac disease and those of normal pregnancy and to guide clinicians in the triage of further cardiac evaluation, appropriate referrals and follow-up of pregnant and postpartum women who may have cardiovascular disease. Drawing from the literature and analysis of cardiovascular deaths reviewed in the California Pregnancy-Associated Mortality Review (CA-PAMR), the authors created this algorithm based on risk factors, symptoms, vital sign abnormalities, and physical examination findings commonly identified in women who die of various types of cardiovascular disease.

The most severe symptoms and vital sign abnormalities are labeled as “Red Flags” and include shortness of breath at rest, severe orthopnea necessitating four or more pillows, resting heart rate ≥120 beats per minute, resting systolic blood pressure ≥160 mm Hg, resting respiratory rate of ≥30 breaths per minute and an oxygen saturation ≤94%. The presence of Red Flags or a personal history of cardiovascular disease in pregnant or postpartum women should lead clinicians to conduct a prompt evaluation and seek consultations with specialists in maternal fetal medicine and primary care or cardiology. If other less severe symptoms and vital sign abnormalities are identified, then risk factors and physical examination findings may need to be combined to stratify the women who require further work-up or routine follow-up.

Sample Case Presentation

A 25-year-old obese (Body Mass Index (BMI) 38) African-American G2P2 underwent an uncomplicated vaginal delivery 10 days ago. She presents to the urgent care clinic with complaints of fatigue and persistent cough since delivery. She is afebrile with blood pressure of 110/80 mm Hg, heart rate 110 bpm and respiratory rate of 28/minute. Chest X-ray reveals bilateral infiltrates. Oxygen saturation is 94% on room air. The patient is diagnosed with a respiratory infection. Fatigue is attributed to the lack of sleep due to care of the newborn. She is prescribed an antibiotic and sent home. One week later, she presents again with continued symptoms. Antibiotics are switched at this time, and beta agonists are added due to presumptive diagnosis of "new-onset asthma" as evidenced by physical examination findings. Two days later, the patient experiences cardiac arrest at home. Resuscitation attempts are unsuccessful. Autopsy findings were indicative of cardiomyopathy.

This case is representative of similar deaths attributed to cardiovascular disease reviewed by CA-PAMR. Maternal mortality due to cardiac disease primarily revolved around the lack of awareness of CVD at both patient and provider levels, coupled with delays in diagnosis. In most cases, diagnosis was made in the perimortem period or at the time of autopsy.

Further testing should include electrocardiogram (EKG) and B-type natriuretic peptide (BNP). Arrhythmia monitor, echocardiogram, chest X-ray, complete blood count, comprehensive metabolic panel, arterial blood gas, assessment of thyroid function, and drug screen may also be considered. BNP is a readily available test that may help identify asymptomatic women with left ventricular dysfunction and assist in triaging pregnant or postpartum women who present with symptoms. BNP is a neurohormone secreted predominantly by the cardiac ventricles in response to volume or pressure overload. A BNP level of <100 pg/mL is considered normal and the half-life is 20 minutes. Its use has been validated in the diagnosis of systolic and diastolic heart failure.[1,2] BNP levels in pregnancy remain within normal range despite significant volume overload in pregnancy, and the levels are higher in pathologic conditions. An elevated BNP level should trigger an echocardiogram to evaluate cardiac function. Serial measurements of BNP in pregnant women with dilated cardiomyopathy are shown to be predictive of adverse cardiovascular outcomes.[3.] BNP is described in detail on page 13 of the Toolkit.

The TSH screen is essential for the high risk pregnancy by history or with cardiovascular (CV) symptoms; however, because of the cardiovascular risk with

subclinical hypothyroidism and hyperthyroidism and the fact that even high-normal thyroid function may cause cardiovascular problems – all pregnant women with CV problems should get full thyroid function testing.[4] When deciding to conduct thyroid screening (TSH) on all pregnant women and advancing to potentially full diagnostic testing (T3 and T4), one is especially looking for subclinical disease that might need treatment.[4]

Validation of the Algorithm: Pregnant and postpartum women who die from cardiovascular disease represent the most extreme consequence of missed or delayed recognition of cardiovascular disease. Accordingly, any triage algorithm should be able to detect the most serious cases and not return a 'false negative' assessment of cardiovascular disease. To assess how well the triage algorithm would have identified pregnant and postpartum women with the most need of further work-up, we compared the 64 cardiovascular disease deaths identified by CA-PAMR for 2002-2006, using the seven critical risks and abnormalities, including heart rate, systolic blood pressure, respiration rate, oxygen saturation, tachypnea, cough and wheezing. We found that the use of algorithm would have identified 56 out of 64 (88%) cases of CVD. The proportion of women identified increased to 93% when we restricted comparison to the 60 cases of women who were symptomatic or had sufficient documentation with which to compare to the algorithm.[5]

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2. Grewal J, McKelvie R, Lonn E, et al. BNP and NT-proBNP predict echocardiographic severity of diastolic dysfunction. *Eur J Heart Fail.* 2008;10(3):252-259.
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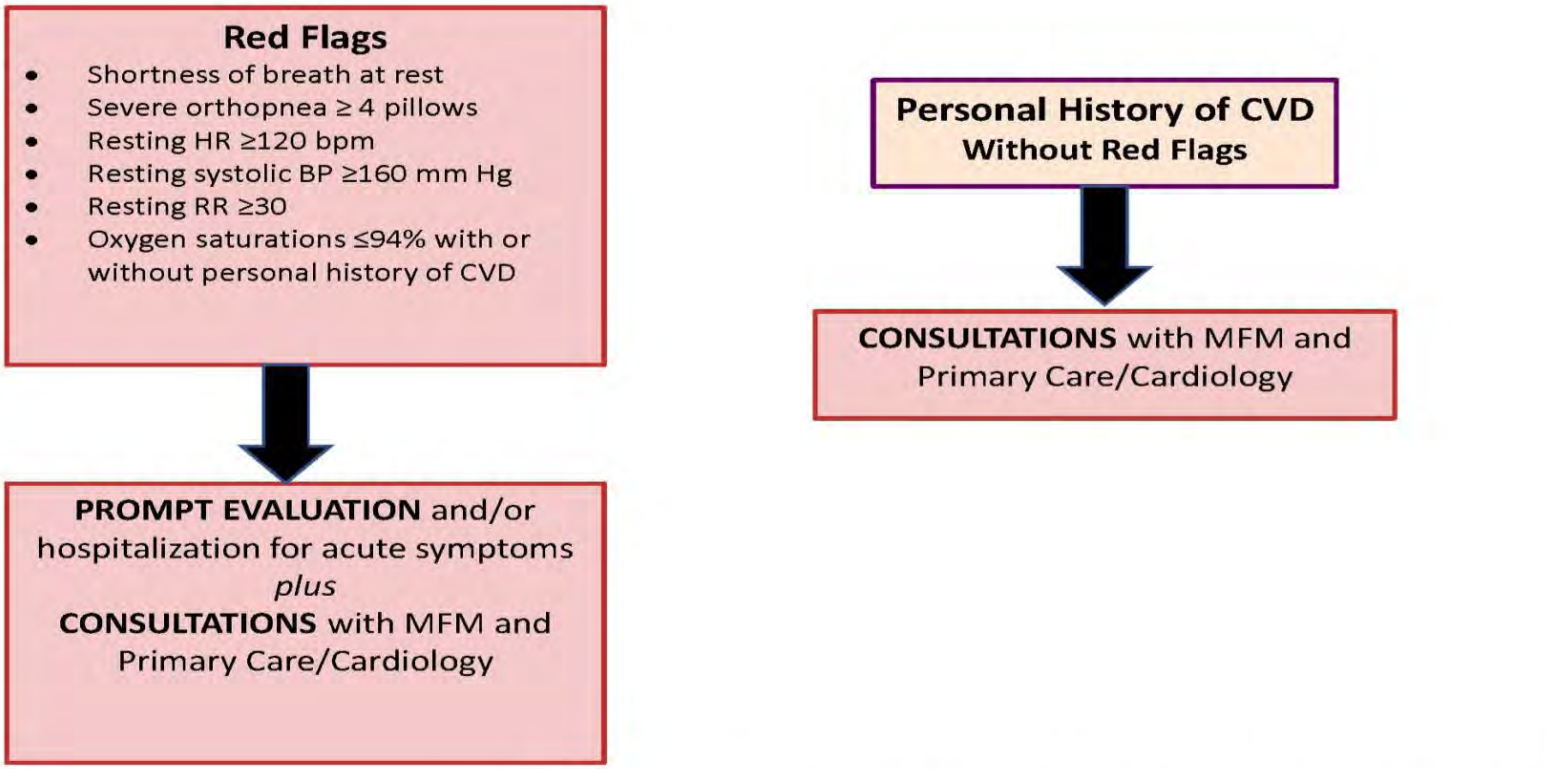
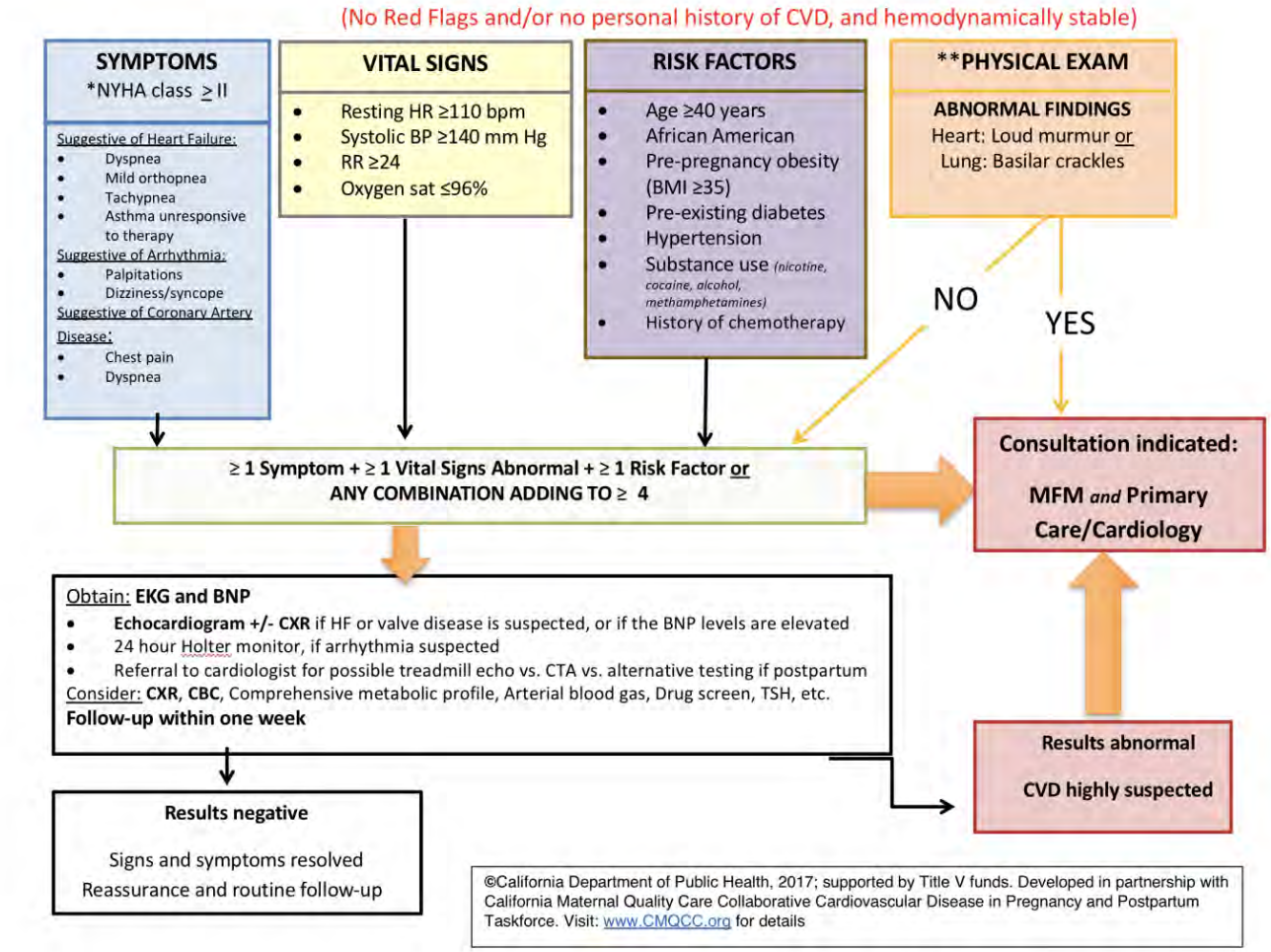
5. Hameed A, Main EK, Lawton E, Morton CH, CA-PAMR Committee. Validation Study of Cardiovascular Disease Assessment Algorithm for Pregnant and Postpartum Women among Pregnancy-Related Cardiovascular Deaths in California, 2002-2006. In: University CMQCCaS, ed. Palo Alto, CA2015.

CVD ASSESSMENT ALGORITHM FOR PREGNANT and POSTPARTUM WOMEN



CARDIOVASCULAR DISEASE ASSESSMENT IN PREGNANT and POSTPARTUM WOMEN



*****New York Hospital Association Functional Classification (shown on algorithm)

Class	Descriptors
I	Asymptomatic, no limitation of physical activity
II	Asymptomatic at rest, symptoms with exertion and heavy physical activity
III	Asymptomatic at rest, symptoms with normal physical activity
IV	Symptomatic at rest, limitation to physical activity

Reference: Used with permission from American Heart Association, Inc. NYHA Functional Classification, American Heart Association, Inc. http://www.heart.org/HEARTORG/Conditions/HeartFailure/AboutHeartFailure/Classes-of-Heart-Failure_UCM_306328_Article.jsp Accessed May 1, 2015

******Physical Examination (shown on algorithm)

Lungs (presence of)	Heart (presence of)
• Adventitious breath sounds, particularly crackles	• Diastolic murmur
• Jugular vein distention	• Loud systolic murmur (III/IV intensity or higher) ○ Functional murmurs generally are of lesser intensity
• Cyanosis (peripheral)	
• Clubbing of extremities	

Reference: Easterling TR and Stout K. *Heart disease in pregnancy, Chapter 37 in Obstetrics: Normal and Problem Pregnancies*, 7th Ed. Eds: Gabbe SG, Niebyl JR, Simpson JL et al. 2017. Elsevier: Philadelphia.

B-TYPE NATRIURETIC PEPTIDE (BNP)

Afshan Hameed, MD – University of California, Irvine Medical Center

INTRODUCTION

This chapter describes B-type Natriuretic Peptide (BNP) and its use as a tool to help clinicians identify asymptomatic individuals with left ventricular dysfunction or assist in triaging patients presenting with symptoms for further diagnostic testing.

ABOUT BNP

BNP is a neurohormone secreted predominantly by the cardiac ventricles in response to volume expansion or pressure overload. BNP acts as the body's defense against volume overload by virtue of its vasodilatory and renin-angiotensin-aldosterone system inhibitory properties that lead to natriuresis and diuresis.

Normal levels: BNP level of <100 pg/mL is considered normal and the half-life is 20 minutes.

Variations in BNP levels: Women tend to have higher level of BNP when compared to men and levels are also elevated in patients with renal insufficiency/failure. However, obesity is associated with lower plasma BNP in comparison to non-obese population.[1]

CLINICAL USES

Diagnosis of Heart Failure (HF):
BNP levels are used routinely in the emergency room for the diagnosis of HF and play a key role in establishing etiology of dyspnea (cardiac vs. pulmonary) in patients presenting with acute shortness of breath.[2,3] In the Breathing Not Properly trial, plasma BNP was markedly elevated in patients with clinically diagnosed HF compared to those without HF (mean 675 pg/mL vs. 110 pg/mL).[4] In general, a BNP value of ≥ 100 pg/mL is diagnostic of HF with a sensitivity and specificity of 90% and 76% respectively. In contrast, a BNP level of < 50 pg/mL has a negative predictive value of 96% in excluding heart failure. BNP has a higher predictive value than other diagnostic tests, i.e., cardiomegaly on chest x-ray, or clinical evaluation including history of HF and rales on physical examination. In a prospective randomized controlled trial, 452 subjects who presented to the emergency room with acute shortness of breath were either assigned BNP bedside assay or received standard clinical assessment. The use of BNP reduced the need for hospitalization, intensive care admission, and time to discharge along with the total cost of in-hospital treatment.[2,5] The American College of Cardiology/American Heart Association guidelines recommend that BNP or NT-proBNP (N-terminal pro-BNP) levels can be useful in the evaluation and risk stratification of patients presenting with symptoms in whom the clinical diagnosis of heart failure is uncertain.[6]

Asymptomatic Left Ventricular Dysfunction:
BNP has been shown to detect asymptomatic left ventricular dysfunction with sensitivity of 88% and specificity of 67% when BNP level of 50 pg/mL is used as a cutoff; it may be used as an initial low-cost modality to identify asymptomatic high risk individuals who would need further diagnostic testing.[7]

Predictor of Adverse Cardiovascular Outcomes:
BNP (>50 pg/mL) has been shown to be the strongest predictor of serious adverse cardiovascular outcomes in older individuals with preserved left ventricular systolic function. BNP level is generally increased in diastolic left ventricular dysfunction and correlates directly with left ventricular hypertrophy.[8,9]

Pregnancy:
Pregnancy is a state of physiologic volume overload. Despite an increase in the left ventricular wall mass and end-diastolic dimensions during normal pregnancy, BNP levels remain stable throughout the gestation and postpartum period. In a longitudinal study of plasma BNP levels during pregnancy, when compared to non-pregnant, age-matched controls, the median level of BNP was noted to be 19 pg/mL during pregnancy vs. 10 pg/mL in the non-pregnant state.[10] BNP levels stay well within normal range during an uncomplicated pregnancy; however, significant elevations are seen in patients with hypertensive disorders including preeclampsia.[11]

- *Preexisting heart disease:* In pregnant women with preexisting dilated cardiomyopathy, serial measurements of NT-proBNP (N-terminal pro-BNP) are shown to be predictive of adverse cardiovascular outcomes.[12] In another study of 66 women with cardiac symptoms, all women who remained event free during pregnancy had BNP < 100 pg/mL.[13]

- *Pregnant women with cardiac symptoms:* BNP may play an important role in evaluation of pregnant women presenting with shortness of breath to determine both systolic and diastolic left ventricular dysfunction. BNP levels correlate with elevated left ventricular filling pressures in symptomatic pregnant women.[14]

SUMMARY

BNP is a simple, readily available, relatively inexpensive test that may assist clinicians in triaging patients who present with symptoms for further diagnostic testing. This test can be of particular value for obstetricians as most women exhibit some degree of fatigue, shortness of breath, palpitation and/or swelling during pregnancy. Adding BNP to routine evaluation of cases with symptoms out of proportion to pregnancy or to those patients presenting with symptoms suggestive of cardiac disease may reduce potential morbidity.

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CLINICAL GUIDANCE FOR POSTPARTUM PRESENTATIONS TO THE EMERGENCY DEPARTMENT, PRIMARY CARE PROVIDER OR OBSTETRIC PROVIDER

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INTRODUCTION

This chapter is intended for clinicians who evaluate women presenting for care in the postpartum period who complain of symptoms of shortness of breath, chest pain, unresolved cough or swelling. Symptoms of cardiovascular disease can occur up to five months postpartum. Women of childbearing age should be questioned about recent pregnancies, in addition to their last menstrual period (LMP). Recommendations are based on the quality improvement opportunity data identified through the California Pregnancy-Associated Mortality Review (CA-PAMR), research literature and expert opinion.

Clinical pearls presented in this document are derived from the quality improvement opportunity data identified in the CA-PAMR, experience of the authors, literature and expert opinion. The level of evidence for current literature on cardiovascular disease in pregnancy is primarily consensus of expert opinion, case control studies, observational or retrospective studies and registries (Code C).[1]

CLINICAL PEARLS

- During pregnancy, symptoms of cardiac disease may be falsely attributed to the common symptoms in a normal pregnancy (i.e., shortness of breath, fatigue. swelling).
- Preexisting cardiovascular disease and/or new-onset peripartum cardiomyopathy may initially present during pregnancy or in the postpartum period.
  - Physiologic changes associated with pregnancy gradually return to baseline by two weeks postpartum[2]
  - Peripartum cardiomyopathy most frequently presents in the first postpartum week, with 75% presenting in first month[3]
  - Pregnant or postpartum women with CVD frequently present with shortness of breath or a new-onset cough.[4]
  - Emergency Department (ED) providers, Primary Care Providers, and Obstetricians should maintain a high index of suspicion for underlying cardiovascular disease when a woman presents with symptoms, signs, and risk factors concerning for heart disease for as long five months postpartum.

HISTORY

When a woman presents in the postpartum period with complaints of shortness of breath, ask if she has experienced:

- Worsened level of exercise tolerance
- Difficulty performing activities of daily living
- Symptoms that are deteriorating
- Chest pain, palpitations, or dizziness
- New-onset cough or wheezing
- Pedal or lower extremity edema and if it is improving or deteriorating
- Unexpected fatigue, i.e., needing to stop frequently when walking
- Inability to lie flat due to shortness of breath, and if this is a change, how many pillows does she use
- Failure to lose weight or unusual weight gain, and how much
- A history of cardiac or pulmonary conditions
- A history of substance use and/or tobacco use
- Has been seen by other providers or in other Emergency Departments since giving birth.

KEY POINTS

- Symptoms related to physiologic changes of pregnancy should be improving in the postpartum period.
- Visits to Emergency Department for dyspnea should raise suspicion for cardiovascular disease.
- Women of childbearing age should be questioned about recent pregnancies, in addition to their last menstrual period (LMP).
- Postpartum dyspnea or new-onset cough is concerning for cardiovascular disease.

PHYSICAL EXAMINATION

Conduct a thorough physical examination, paying particular attention to:

- The vital signs: HR ≥120 bpm, BP ≥160 mm Hg, RR ≥30, and oxygen saturation ≤ 94%
    - Look for the underlying cause of abnormal vital signs
- Lung exam: crackles, wheezing
- Cardiac exam: loud murmur, jugular venous distention
- Extremities: edema, taut shiny skin.

DIFFERENTIAL DIAGNOSIS FOR POSTPARTUM DYSPNEA

- Congestive Heart Failure
- Myocarditis
- Endocarditis
- Pulmonary Embolism
- Pulmonary Hypertension
- Asthma
- Infection
-

WORKUP FOR POSTPARTUM DYSPNEA

- Chest radiograph – *frequently normal in asthma*
- EKG – *may be normal in cardiomyopathy, except for sinus tachycardia*
- CBC, Basic Metabolic Panel, Thyroid Function Test (TSH)
- BNP – *an elevated BNP should raise suspicion for CHF*
- D-dimer – *may normally be elevated in pregnancy, however, may be considered for negative predictive value*
- Toxicology screen - *Substance use (e.g., methamphetamine, cocaine) is a strong risk factor for pregnancy-related cardiovascular disease*
- Echocardiogram: this should be obtained on an emergency basis if the patient has abnormal vital signs or is very symptomatic - *Normal LV ejection fraction does not exclude heart failure, normal RV function does not exclude pulmonary embolism*
- Venous Doppler Ultrasound and/or CT pulmonary angiogram for pulmonary embolism
- Cardiology consultation as needed.

KEY POINTS

- New-onset asthma is rare in adults.
- Bilateral crackles on lung examination are most likely associated with Congestive Heart Failure (CHF).
- Improvement of dyspnea with bronchodilators does not confirm the diagnosis of asthma, as CHF may also improve with bronchodilators. Response to bronchodilators should prompt the consideration of a diagnosis other than asthma.

DISPOSITION

- If considering discharge:
  - Repeat vital signs to ensure they are persistently normal, the symptoms have improved, and the patient is stable for discharge
  - Arrange for early follow-up with primary provider or cardiologist as indicated.
- Admission and cardiology consultation may be indicated for:
  - Persistent symptoms or abnormal vital signs, in particular, HR $\geq$ 120 bpm, BP $\geq$ 160 mm Hg, RR $\geq$ 30, and oxygen saturation $\leq$ 94%
  - Lack of response to treatment
  - Newly-diagnosed cardiomyopathy or pulmonary hypertension.

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Clinicians and Facilities:
RESOURCES WHEN CARING FOR WOMEN WITH ADULT CONGENITAL HEART DISEASE OR OTHER FORMS OF CARDIOVASCULAR DISEASE

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INTRODUCTION

This chapter includes a summary of guidelines published by the American College of Cardiology and the American Heart Association in conjunction with other professional groups that manage adult cardiovascular disease.[1,2] These guidelines are based on scientific evidence reviewed by experts in their field of practice. The purpose of the guidelines is to give clinicians the most current evidence upon which to base management of adults with specific cardiac disease. This synopsis is intended to provide information to clinicians who care for women with cardiac disease about current resources and management strategies. Key components of comprehensive, evidence-based care include resources consisting of diagnostic testing, imaging and experienced multidisciplinary staff. Recommendations for appropriate resources when providing care for adults with cardiac disease are also included.[3]

OB PROVIDERS: ADULT CONGENITAL HEART DISEASE (ACHD) GUIDELINES.[1,2]

- Estrogen-containing oral contraceptives are not recommended for patients with Adult Congenital Heart Disease (ACHD) at risk of thromboembolism such as those with cyanosis, intra-cardiac shunt, severe pulmonary arterial hypertension (PAH) or Fontan repair.
- Patients with ACHD should consult with an ACHD expert before pregnancy to develop a plan for management of labor and the postpartum period.
- Preconception counseling is recommended for women receiving chronic anticoagulation with warfarin.
- Patients with intra-cardiac right to left shunt should have fastidious care of IV lines to avoid air embolus.
- Fetal echocardiography is recommended between 18 and 20 weeks in women with personal history of congenital heart disease.

Table 1, on the next page, is an overview and does not replace evaluation and management by an ACHD physician, which should be pursued in all ACHD patients.[1-3]

Table 1: Adult Congenital Cardiac Lesions: Management and Expected Outcomes in Pregnancy

Lesion	Overview *Note: This does not supplant evaluation and management by an ACHD physician, which should be performed in all ACHD patients.[1-3]
Shunt lesions	
Atrial Septal Defect (ASD)	• Well tolerated in the absence of pulmonary arterial hypertension (PAH). • Repair should be considered in patients with large ASDs prior to pregnancy in the absence of PAH. • Pregnancy is not recommended in patients with ASD and severe PAH or Eisenmenger syndrome due to excessive maternal and fetal mortality.
Ventricular Septal Defect (VSD)	• Small VSDs without PAH and no associated lesions do not have increased CV risk and pregnancy is usually well tolerated. • Prior to pregnancy, repair should be considered in patients with large VSDs in the absence of PAH. • Pregnancy is not recommended in patients with VSD and severe PAH or Eisenmenger syndrome due to excessive maternal and fetal mortality.
Atrioventricular Septal Defects (AVSD)	• Usually well-tolerated post repair in the absence of PAH. • Pregnancy is not recommended in patients with AVSD (repaired or unrepaired) and severe PAH or Eisenmenger syndrome due to excessive maternal and fetal mortality.
Left-sided obstruction	
Aortic Stenosis (AS)	• Mild or moderate stenosis is usually well tolerated in pregnancy. • Vaginal delivery is preferred except in critical AS or if associated with aortic disease (dissection or aneurysm).
Supravalvular or Subvalvular AS	• Those with significant obstruction, coronary involvement or aortic disease should be counseled against pregnancy.
Coarctation of Aorta	• Patients with severe obstruction or aortic aneurysm should have hemodynamic assessment and treatment prior to getting pregnant.
Right-sided obstruction	
Pulmonic Stenosis and Right Ventricular Outflow Tract Obstruction	• Mild to moderate obstruction is well tolerated. • Severe obstruction should be treated prior to pregnancy.
Tetralogy of Fallot (TOF)	• TOF should be repaired prior to pregnancy. In patients with repaired TOF and a competent pulmonary valve, pregnancy is well tolerated in those with good functional capacity and without residual lesions. • Severe symptomatic pulmonary regurgitation should be treated prior to pregnancy in the presence of severe right ventricle (RV) dilatation. Patients should be screened for arrhythmias prior to pregnancy.
Other lesions	
Single Ventricle Lesions Post Fontan Repair	• Successful pregnancy is reported after Fontan repair but arrhythmias, ventricular dysfunction, thrombotic complications and edema have been reported. • Increased risk for spontaneous abortion or premature birth.
Ebstein's Anomaly	• Generally well tolerated in the absence of severe tricuspid regurgitation, arrhythmias and cyanosis; however, there is an increased risk of low birth weight, and fetal loss if significant cyanosis is present. The risk of CHD in offspring is approximately 6%.

Obstetric Providers:

RESOURCES WHEN CARING FOR ADULTS WITH CONGENITAL HEART DISEASE

FOR ADOLESCENTS:

- Adolescents with congenital heart disease (CHD) should have a coordinated, collaborative and comprehensive healthcare transition to adult cardiac specialists with services similar to the level of care they received as children.

FOR ADULTS:

- Each provider of adult congenital heart disease (ACHD) care and each facility where ACHD patients receive care should be in contact with a regional ACHD center of excellence.
- Regional ACHD centers are responsible for the organization of ACHD healthcare including:
    - Staff with expertise in cardiology: physicians, nurses, advanced care providers, anesthesiologists
    - Diagnostic testing and imaging
    - Interdisciplinary care teams for special patient populations including obstetrics and neonatology
    - Mechanisms for consultations, referrals, review of policies and protocols, quality assessment
- Patients with ACHD should possess documents that describe their condition including how to access local healthcare and the regional center.
- Each patient with ACHD should have a primary health care provider who has her current medical records and a consultation arrangement with local and regional ACHD experts.
- Patients with moderate or complex ACHD should be followed by a provider with expertise in that level of ACHD, or their primary provider should be in frequent consultation with an expert in CHD. Plans for referral to a higher level of expert care should be in place in the event the patient's condition becomes unstable.
- Adults with moderate or complex CHD should have the following procedures or evaluations in the regional center of excellence:
    - Diagnostic and interventional procedures
    - Surgery that necessitates conscious sedation or general anesthesia
    - Sudden onset or emergent cardiac or non-cardiac conditions.

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PREGNANCY Society for Maternal-Fetal Medicine

SMFM CONSULT SERIES

Society for Maternal-Fetal Medicine Consult Series #73: Diagnosis and management of right and left heart failure during pregnancy and postpartum

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The Heart Rhythm Society supports this document.

Abstract

Heart failure is a major contributor to maternal morbidity and mortality. Pregnancy is a state of hemodynamic stress, and normal physiologic changes of pregnancy may mimic signs of heart failure. Prepregnancy counseling, multidisciplinary care, and referral to a center with expertise in managing pregnant patients with heart failure can help optimize outcomes. The option for abortion care should be available to all patients with heart failure, regardless of the severity of the disease, and is an essential component of individualized counseling. In this Consult, we provide guidance for managing patients with heart failure with reduced ejection fraction who are continuing pregnancy. The following are Society for Maternal-Fetal Medicine (SMFM) recommendations: (1) we recommend that all patients with right heart failure due to pulmonary arterial hypertension receive counseling about high rates of maternal morbidity and mortality; if pregnancy is pursued, the patient should be referred to a center with expertise in this condition to guide management during pregnancy and postpartum (GRADE 1C); (2) we recommend considering referral to a genetics provider with expertise in heritable cardiac disease for people with peripartum cardiomyopathy (PPCM), particularly when the index of suspicion is high and no other contributing factors are identified (GRADE 1C); (3) we recommend that other causes of heart failure be ruled out before making a diagnosis of PPCM (Best Practice); (4) for acute left ventricular heart failure during pregnancy, we recommend hydralazine or isosorbide dinitrate for afterload reduction and furosemide for diuresis. For acute left ventricular failure postpartum, we recommend afterload reduction with angiotensin-converting enzyme inhibitor (ACEi), angiotensin receptor blocker (ARB), or angiotensin receptor/neprilysin inhibitor (ARNi) unless contraindicated (e.g., renal failure) (GRADE 1B); (5) we recommend against inotropic blockade (i.e., beta-blockers) in the setting of acute decompensated left ventricular heart failure (GRADE 1B); (6) we recommend prophylactic anticoagulation administration

in hospitalized pregnant patients with acute left ventricular heart failure (GRADE 1C); (7) in patients who are pursuing pregnancy or pregnant, we recommend discontinuing spironolactone, ACEi, ARB, and ARNi and continuing beta-blockers (metoprolol, carvedilol, bisoprolol) (GRADE 1C); (8) for pregnant patients with left ventricular failure and ejection fraction < 35%, we recommend pharmacologic thromboprophylaxis during pregnancy and for six weeks postpartum (GRADE 1C); (9) for patients with chronic left ventricular failure, we recommend starting or continuing guideline-directed medical therapy when medically able, in consultation with experts in cardiology (GRADE 1C); (10) we recommend fetal echocardiography when maternal heart failure is a result of an underlying congenital cardiac defect (GRADE 1C); (11) we recommend serial growth ultrasounds in pregnancies complicated by maternal heart failure (GRADE 1C); (12) we recommend continuous fetal heart rate monitoring during anesthesia administration, labor, and delivery for pregnant patients with heart failure (GRADE 1B); (13) in the case of maternal cardiovascular changes prompting inpatient assessment or treatment, we recommend continuous or intermittent fetal heart rate monitoring, taking into consideration the gestational age and any relevant maternal or fetal factors that may impact fetal viability or the maternal clinical status (GRADE 1C); (14) we recommend planned vaginal delivery at term in patients with heart failure in the absence of hemodynamic compromise or obstetric indications for cesarean (GRADE 1C); (15) we recommend the use of neuraxial anesthesia in most patients with heart failure to provide appropriate analgesia and to limit the effects of labor on cardiac parameters (GRADE 1C); (16) we recommend considering a limited or assisted second stage for some patients after input from cardiology about each individual patient's cardiac risk (GRADE 1C); (17) we recommend that postpartum patients with heart failure undergo routine counseling regarding infant feeding. We recommend reviewing all medications for compatibility with breastfeeding and using shared decision-making in the absence of robust data (GRADE 1B).

KEYWORDS
cardiac disease, counseling, echocardiography, heart failure, maternal monitoring, maternal morbidity, maternal mortality, peripartum cardiomyopathy, pulmonary hypertension

1 | INTRODUCTION

Heart failure is a complex clinical syndrome with signs and symptoms that result from any structural or functional impairment of ventricular filling or ejection of blood [1]. The right and left sides of the heart are interdependent yet independent; the "two hearts" model visualizes the right and left chambers as separate entities with the lungs between them [2]. This model helps illustrate the pathophysiology of heart failure and management strategies when one side of the heart is primarily compromised [2]. Diseases of the left heart invariably lead to changes in the right heart over time [3].

2 | CLINICAL QUESTIONS

2.1 | What is the maternal morbidity and mortality associated with heart failure?

It is difficult to calculate the current overall incidence of heart failure in pregnancy, given the varying etiologies of heart failure, limitations of existing data sources, geographic and temporal variation, and differing methodologies of previous analyses. Despite these limitations, heart disease is known to be a leading cause of pregnancy-related deaths in the United States [4–6], and the number of pregnant people with heart disease has increased [7, 8]. Concerning racial disparities persist in maternal

mortality, and a disproportionate percentage of pregnancy-related deaths from cardiovascular conditions occur in non-Hispanic Black individuals [5, 9]. Pregnant and postpartum patients with heart failure are at increased risk for a variety of perinatal adverse outcomes, including maternal mortality [6, 10–12], and should be managed in or referred to an institution with experience caring for pregnant people with cardiac disease.

2.2 | What cardiac changes in pregnancy can potentiate heart failure?

Pregnancy is a state of hemodynamic stress. Physiologic changes of pregnancy increase perfusion conducive to the growth and development of the uteroplacental unit. There is a 30%–50% increase in blood volume and cardiac output by the third trimester, 75% of which has occurred by the end of the first trimester [13]. Heart rate increases steadily by 10–20 beats per minute (bpm) throughout pregnancy but seldom exceeds 100 bpm [14]. Moreover, heart rate varies across gestation with changes in maternal positioning [15, 16]. Systemic and pulmonary vascular resistance decreases due to the vasodilatory effects of progesterone, estrogen, relaxin, and prostaglandins. Vasodilation leads to decreases in systolic and diastolic blood pressure, though the effect on the latter is more pronounced [17]. These physiologic changes may lead to variations in some diagnostic tests commonly used for heart failure evaluation, such as B-type natriuretic peptide (BNP) levels and echocardiography; therefore, results should be interpreted with caution.

However, BNP remains a useful marker for diagnosing and managing heart failure. In normal pregnancy, BNP or its inactive amino-terminal fragment NT-pro-BNP may rise twofold compared to a non-pregnant state while remaining within the normal range [18, 19]. BNP levels are lower in individuals with obesity and may be elevated in those with preeclampsia, congenital heart disease, cardiomyopathy, sepsis, renal failure, pulmonary embolism, critical illness, and anemia [19, 20]. Echocardiographic changes in pregnancy include increased left and right ventricular dimension and volume, stroke volume, and cardiac output without a change in the left ventricular ejection fraction (LVEF) [21]. Table 1 summarizes specific measurements and findings on echocardiography beyond the overall function and ejection fraction (EF) [22–26].

2.3 | How is heart failure defined?

Heart failure is a clinical syndrome resulting from structural or functional abnormalities of the heart that compromise its ability to fill or eject blood normally. It may affect the left ventricle, the right ventricle, or both ventricles. Broadly, there are two types of heart failure: heart failure with reduced EF (HFrEF) and heart failure with preserved EF (HFpEF) [27]. Both types of heart failure (HFrEF and HFpEF) lead to a compromised ability of the heart to fill or eject blood, causing symptoms such as shortness of breath and fatigue [28].

HFrEF is defined by LVEF < 40% and constitutes the primary type of heart failure seen in pregnancy [29]. It includes peripartum cardiomyopathy (PPCM) and dilated cardiomyopathy (DCM). HFrEF is characterized by pressure overload, volume overload, and decreased contractility. In this setting, the adaptive response to maintain perfusion to vital organs leads to ventricular remodeling over time and the onset of shortness of breath and fatigue.

Although HFpEF constitutes a large proportion of heart failure in older adults, it is not frequently identified in pregnancy and is thus not discussed here [30].

2.4 | How should patients with a history of heart failure be counseled before pregnancy?

Prepregnancy counseling in patients with heart failure should involve assessing functional status using the New York Heart Association (NYHA) functional classification (Table 2) [31]; reviewing the etiology of heart failure and its impact on pregnancy; assessing for structural defects, prior cardiac events, and the presence or absence of arrhythmias; and evaluating the compatibility of heart failure medications with pregnancy. Cardiac risk stratification should be based on well-accepted models, such as the Cardiac Disease in Pregnancy Study risk prediction index (CARPREG II, Figure 1) and modified World Health Organization classification (mWHO, Figure 2) [32–34]. Patients with persistent left ventricular dysfunction (LVEF < 45%) after a diagnosis of PPCM in a prior pregnancy or those with EF < 30% [35–37] at the time of presentation with PPCM should be advised against pregnancy. The option for abortion care should be available to all patients with heart failure, regardless of the severity of the disease, and is an essential component of early pregnancy counseling [37].

The scores mentioned above (NYHA, CARPREG II, and mWHO) are not interchangeable; they can be used in an additive fashion to communicate the cardiac status of a pregnant patient to other care providers. NYHA is a scoring system used in non-pregnant and pregnant adults (Table 2), CARPREG II is a scoring system specific to pregnant individuals (Figure 1), and mWHO is a pregnancy-specific classification system (Figure 2). The total CARPREG II score determines the risk for an

TABLE 1 Relevant echocardiographic parameters, clinical implications, and reasonable next steps for management of abnormal results.

Parameter	Normal values in reproductive-aged females	Clinical implication	Next steps
RVSP	< 40 mmHg	The tricuspid regurgitant jet velocity is a non-invasive measure of pulmonary artery systolic pressure and quantifies pulmonary hypertension.	Confirmation: 25% of RVSP measures are inaccurate. Consider other echocardiographic and clinical parameters, serial follow-up, and expert consultation. Right heart catheterization may be advised.
		Elevated levels can be indicative of pulmonary hypertension, fluid overload, or right ventricular dysfunction [22, 23].	If confirmed, classification into the five groups of pulmonary hypertension is recommended (see Table 4). The classification/group usually guides treatment [22, 23].
TAPSE	> 1.7 m/s	Assessment of right ventricular function. M-mode is used to measure the vertical movement of the lateral tricuspid valve annulus.	Expert consultation: Right ventricular failure or depression can be very morbid and mortal in the context of pregnancy. Swift consultation is advised.
		Lower values can be indicative of right ventricular dysfunction and failure [22, 23].	Observe other right-sided echocardiographic findings, including right atrial volume and IVC diameter.
			Medical management could include diuresis, afterload reduction, and inotropy [22, 23].
Left atrial volume	22–52 mL [24]	Increased size indicates increased filling pressures and fluid overload and can place patients at risk for arrhythmia (i.e., atrial fibrillation).	Expert consultation: Increased left atrial volume can indicate heart failure or obstructive process and left-sided cardiac pathology (i.e., heart failure, mitral stenosis, aortic stenosis [24, 25], hypertrophic cardiomyopathy).
			Observe other echocardiographic findings. Assess mitral and aortic valves for stenosis or regurgitation, left ventricular failure, etc.
			Medical management can include diuresis, afterload reduction, beta-blockade for arrhythmia treatment.
Mitral septal E/e' ratio	< 13	Increased levels are indicative of increased left ventricular filling pressure and increased pulmonary capillary wedge pressures and can be found in HFpEF [26].	Expert consultation: Increased mitral septal E/e' values > 13 can be indicative of increased left ventricular filling pressures, fluid overload, and heart failure [26].
			Observe other echocardiographic findings such as valvular function, left atrial volume, left ventricular systolic function, and left ventricular wall thickness.
			Medical management can include treatment of chronic medical conditions (i.e., hypertension), diuresis, and expanding differential diagnosis for chronic cardiac disease and hypertrophic cardiomyopathy.

Abbreviations: E, mitral inflow velocity of early diastolic filling; e', tissue Doppler mitral annular velocity; HFpEF, heart failure with preserved ejection fraction; IVC, inferior vena cava; RVSP, right ventricular systolic pressure; TAPSE, transannular planar systolic excursion.

TABLE 2 New York Heart Association (NYHA) classification [31].

Class	Patient symptoms
I	No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, or shortness of breath.
II	Slight limitation of physical activity. Comfortable at rest. Ordinary physical activity results in fatigue, palpitation, shortness of breath, or chest pain.
III	Marked limitation of physical activity. Comfortable at rest. Less ordinary activity causes fatigue, palpitation, shortness of breath, or chest pain.
IV	Symptoms of heart failure at rest. Any physical activity causes further discomfort.

PREDICTOR	POINTS
Prior cardiac events or arrhythmias	3
Baseline NYHA III-IV or cyanosis	3
Mechanical valve	3
Ventricular systolic dysfunction[a]	2
High risk left-sided valve disease/left ventricular outflow tract obstruction[b]	2
Pulmonary hypertension	2
Coronary artery disease[c]	2
High risk aortopathy[d]	2
No prior cardiac intervention[e]	1
Late pregnancy assessment[f]	1

FIGURE 1 CARPREG II risk predictors. Reprinted with permission from [33]. [a]Left ventricular ejection fraction <55%. [b]Aortic valve <1.5 cm^2, subaortic gradient >30 mmHg, mitral valve area <2 cm^2, moderate to severe mitral regurgitation. [c]Angiographically proven coronary obstruction or past myocardial infarction. [d]Marfan syndrome, bicuspid aortopathy with aortic dimension >45 mm, Loeys-Dietz syndrome, vascular Ehlers-Danlos syndrome, prior aortic dissection or pseudoaneurysm. [e]No cardiac repair of congenital lesions, valvular replacement or repair, percutaneous or operative treatment of arrhythmias. [f]First visit after 20 weeks of gestation. Abbreviation: NYHA, New York Heart Association functional class.

antepartum or postpartum cardiac event. In the primary study, the predicted risk for a primary cardiac event was 5% (0–1 points), 10% (2 points), 15% (3 points), 22% (4 points), and 41% (> 4 points) [33]. The mWHO integrates all known maternal cardiovascular risk factors and groups patients into risk categories ranging from I (shown in yellow, no detectable increased risk of maternal mortality and no/mild increased risk in morbidity) to IV (shown in red, extremely high risk of maternal mortality or severe morbidity). It provides considerations for follow-up care and delivery [34].

2.5 | What are the main causes of *acute* right ventricular failure during pregnancy?

Right ventricular failure is the impaired ability of the right ventricle to perfuse the lungs. The most common cause of right ventricular failure is left-sided heart failure. Under normal circumstances, the right ventricle pumps against low resistance, low pressure, and high compliance pulmonary vasculature that can accommodate a large volume of blood flow without an increase in pulmonary artery pressure [38, 39]. Right ventricular systolic dysfunction reduces forward flow to the pulmonary circulation, decreasing the left ventricular stroke volume and cardiac output. Subsequent neurohormonal activation promotes renal sodium and water retention, causing systemic venous hypertension resulting in hepatic congestion, ascites, and gut and lower extremity edema [40].

TABLE 3 Causes of acute and chronic right ventricular failure in pregnancy.

Acute right ventricular failure	Chronic right ventricular failure
Embolism • Pulmonary thromboembolism • Amniotic fluid embolism • Air or fat embolism Right ventricular infarction	Left heart failure Right-sided valve disease Cardiomyopathies involving the right ventricle Pulmonary hypertension Chronic thromboembolic disease Interstitial lung disease

The right ventricle is sensitive to afterload. It is not capable of generating high systolic pressures under normal circumstances as it is accustomed to pumping into the low-resistance pulmonary circulation; therefore, any sudden increase in pulmonary artery pressure (e.g., from a pulmonary embolism) may lead to cardiogenic shock due to an inability to maintain forward flow [39]. The main causes of acute and chronic right ventricular failure are summarized in Table 3.

2.6 | What are the main causes of *chronic* right ventricular failure?

Chronic heart failure may be asymptomatic in early pregnancy and become symptomatic with peaking of cardiac output as pregnancy progresses. Among the various causes of chronic right heart failure in pregnancy (Table 3), pulmonary hypertension deserves special attention. The Sixth World Symposium on Pulmonary Hypertension defined pulmonary hypertension as mean pulmonary artery pressure > 20 mmHg via right heart catheterization and classified it into five groups (Table 4) [41].

2.7 | How should right ventricular failure be diagnosed during pregnancy?

The symptoms of right ventricular failure may be nonspecific and include shortness of breath on exertion and fatigue [42]. Fluid retention, ascites, and hepatomegaly are more likely in advanced cases of right ventricular failure and may be challenging to discern in pregnancy. Echocardiogram, electrocardiogram, and BNP levels should be considered as the initial diagnostic tests [42]. Right ventricular function, size of the right atrium, collapsibility of

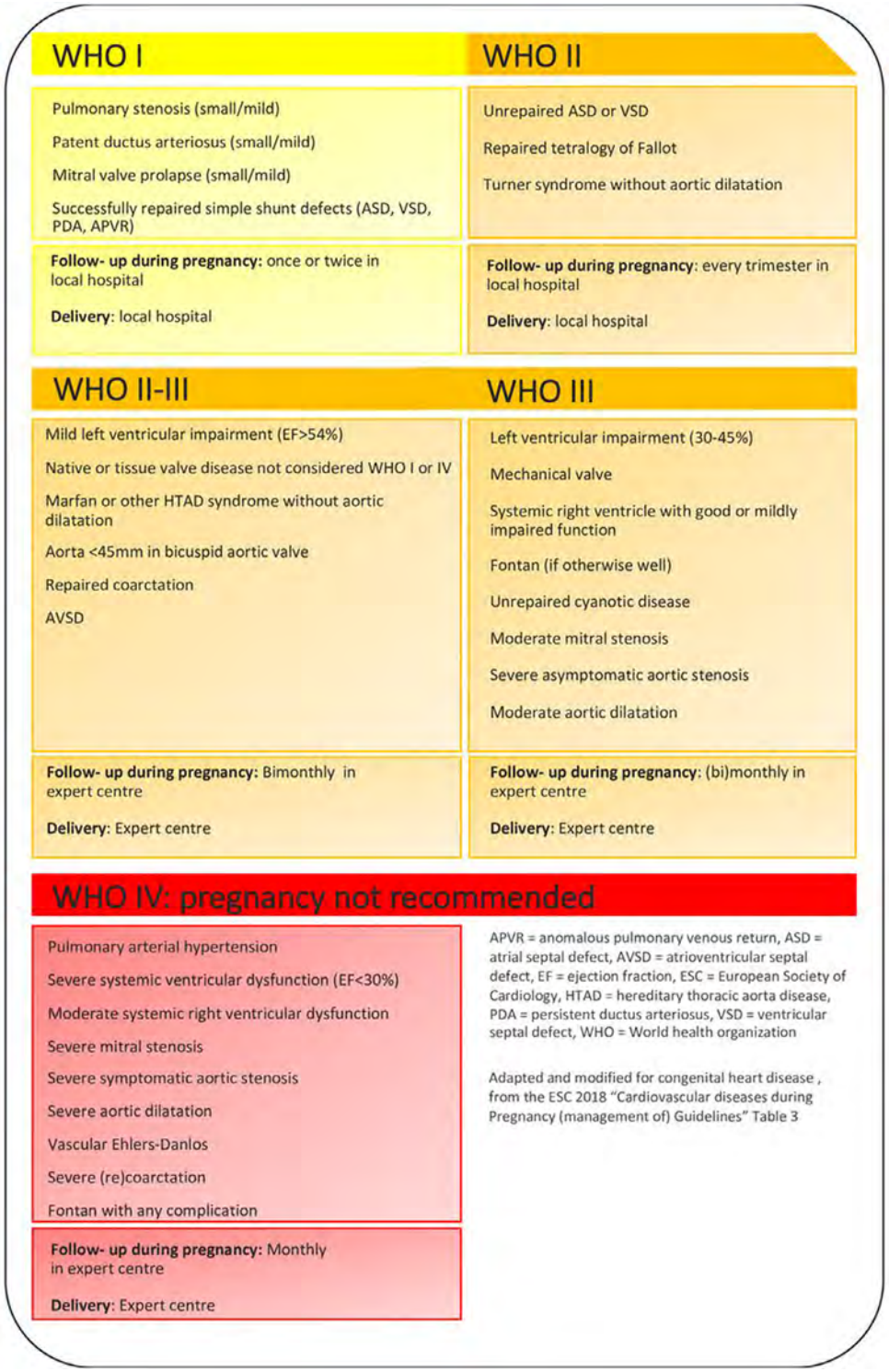

FIGURE 2 Modified World Health Organization classification of maternal cardiovascular risk. Reprinted with permission from [34].

the inferior vena cava, severity of tricuspid regurgitation, and estimation of the pulmonary artery pressure determine the severity of right ventricular dysfunction. Elevated central venous pressure (> 10 mmHg) and evidence of right heart dysfunction are hallmarks of right ventricular failure diagnosis on echocardiography. Right heart catheterization is considered the gold standard for diagnosis but is unlikely to be necessary in most cases. Patients with signs or symptoms concerning for right ventricular heart failure should have a careful physical examination, laboratory assessment, and echocardiography as part of the initial workup, with additional imaging as needed.

TABLE 4 Pulmonary hypertension groups and associated causes [41].

Group 1: Pulmonary arterial hypertension	Idiopathic, genetic, drug-induced, toxin, portal, connective tissue disorder, HIV, calcium channel related, PAH with overt features of venous/capillaries (PVOD/PCH) involvement, persistent pulmonary hypertension of the newborn syndrome
Group 2: Pulmonary hypertension due to left heart disease	Pulmonary hypertension due to left heart failure (reduced and preserved EF), valvular, congenital, or acquired heart disease
Group 3: Pulmonary hypertension due to lung disease and/or hypoxia	Obstructive lung disease, restrictive lung disease, other lung disease with mixed restrictive/obstructive, hypoxia without lung disease, and developmental lung disease
Group 4: Pulmonary hypertension due to pulmonary artery obstructions	Chronic thromboembolic emboli, other pulmonary artery obstructions
Group 5: Pulmonary hypertension with unclear and/or multifactorial mechanisms	Hematologic disorders, systematic and metabolic disorders, Others, complex congenital heart disease

Abbreviations: EF, ejection fraction; LVEF, left ventricular ejection fraction; PAH, pulmonary arterial hypertension; PCH, pulmonary capillary hemangiomatosis; PVOD, pulmonary veno-occlusive disease.
Adapted from [41]

2.8 | How should right ventricular failure be managed during pregnancy?

The varied etiologies of right ventricular failure necessitate individualized management strategies. In the case of preexisting right ventricular failure, prepregnancy pharmacotherapy should be continued with adjustment of medications as needed based on the pregnancy safety profile.

Pregnant patients with right heart failure due to pulmonary hypertension should be thoughtfully counseled about the high risk of maternal morbidity and mortality [32, 43, 44], particularly as abnormal right ventricular systolic function portends a poor prognosis [32, 43–45]. Generally, management involves optimizing tissue perfusion and oxygenation. Oxygen saturations should be maintained at ≥ 90% [46] (preferably ≥ 95%) as the pulmonary vasculature reacts to hypoxia with vasoconstriction, further decreasing perfusion and worsening the existing hypoxemia [47]. Intravascular volume must also be maintained to allow adequate right ventricular output. Most notably, these patients are at substantially increased risk for maternal death in the immediate postpartum period [43, 48–50]. The detailed management of pulmonary hypertension is beyond the scope of this review; all patients with a diagnosis of WHO group 1 pulmonary arterial hypertension should be referred to a center with expertise in pulmonary hypertension [51].

Right ventricular failure due to left heart failure or volume overload is largely managed with diuretic therapy. For patients with pulmonary embolism and right ventricular infarction, anticoagulation therapy and maintenance of intravascular volume are critical to maintain hemodynamic stability. Right ventricular failure due to arrhythmias and low cardiac output should be treated based on the underlying etiology. Patients with right ventricular failure and other indications (e.g., atrial fibrillation, thrombosis) may be candidates for anticoagulation [52]. **We recommend that all patients with right heart failure due to pulmonary arterial hypertension receive counseling about high rates of maternal morbidity and mortality; if pregnancy is pursued, the patient should be referred to a center with expertise in this condition to guide management during pregnancy and postpartum (GRADE 1C)**. Pregnant patients with right heart failure not due to pulmonary hypertension may be managed in conjunction with maternal-fetal medicine subspecialists and cardiologists.

2.9 | What are the main causes of *acute* left ventricular failure in pregnancy?

Common causes of left ventricular failure in pregnancy are outlined in the Box. PPCM is a form of DCM that occurs towards the end of pregnancy or in the months following delivery with no identifiable cause [53]. A 2014 study using the National Inpatient Sample noted that the incidence of pregnancies complicated by PPCM from 2004 to 2011 was 10.3 per 10,000 live births, increasing from 8.5 to 11.8 per 10,000 live births over the eight-year period [7]. This same study noted an overall rate of 13.5% for any major maternal adverse event (in-hospital mortality, cardiac arrest, heart transplant, mechanical circulatory support, acute pulmonary edema, thromboembolism, or implantable defibrillator/permanent pacemaker) in patients with PPCM. There was no temporal increase in this overall rate over the observed eight-year period; however, there was a slight increase in in-hospital mortality (07% to 1.8%), mechanical circulatory support (0.9% to 2.2%), and cardiogenic shock (1.0% to 4.0%) [7]. This study was not designed to address obstetric or neonatal outcomes.

BOX. Causes of left ventricular failure in pregnancy

Cardiomyopathy
- Peripartum cardiomyopathy
- Non-ischemic dilated cardiomyopathy
- Tachycardia-induced cardiomyopathy
- Stress (Takotsubo) cardiomyopathy
- Hypertrophic cardiomyopathy
- Left ventricular non-compaction

Progressive valve disease
- Moderate to severe aortic stenosis
- Moderate to severe mitral stenosis
- Severe aortic regurgitation
- Severe mitral regurgitation

Acute valve disease
- Prosthetic valve thrombosis

Arrhythmias
- Atrial fibrillation
- Atrial flutter
- High-frequency ventricular ectopy
- Ventricular tachycardia

Acute coronary syndrome
- Coronary artery dissection
- Thrombosis

Ion channel disorders

Myocarditis

Acute diastolic dysfunction
- Preeclampsia with severe range blood pressure

PPCM presents on echocardiography with left ventricular enlargement and dysfunction with EF < 45% [54, 55]. Although PPCM is a common cause of left ventricular failure in pregnancy, it is a diagnosis of exclusion, and other reasons for heart failure should be ruled out [37]. These include, but are not limited to, DCM, left ventricular noncompaction, chronic heart failure, arrhythmogenic causes of heart failure, and heart failure from acute coronary syndromes. Notably, up to 22% of individuals with PPCM have co-existing preeclampsia [56, 57]. Management principles for PPCM are the same as those for other etiologies of left ventricular failure.

Animal studies and limited human trials suggest that bromocriptine may benefit left ventricular recovery in PPCM, but this has not been confirmed in larger trials [58]. Bromocriptine is recommended as an addition to standard therapy for PPCM in Europe. Although it is not currently approved by the US Food and Drug Administration (FDA) for this indication in the United States, there is a multicenter study underway to evaluate the benefit of bromocriptine in PPCM [59].

Generally, pregnancy is considered contraindicated in patients with a history of PPCM with residual left ventricular dysfunction (EF < 45%) [60]. Left ventricular dysfunction should be evaluated in the context of (1) the overall health of the patient (i.e., NYHA functional class); (2) prior PPCM history (e.g., severely depressed EF, use of mechanical circulatory support); (3) medications needed to maintain current EF; and (4) the ability to access and receive comprehensive cardiac care [60]. Although PPCM is a diagnosis of exclusion, Ware et al. found that 15% of people diagnosed with PPCM had truncating variants (two-thirds of which were in *TTN*), a prevalence similar to that observed in a population with DCM, a lifelong condition [61]. In another study that included three families with cases of both PPCM and DCM, there were low rates of full recovery of left ventricular function following PPCM (10%). Among this population, 22% of families had pathogenic mutations in cardiomyopathy-related genes (e.g., *TTN*), and 33% had variants of unknown significance, often also in the *TTN* gene [62]. This suggests that a genetic etiology may be present for patients without left ventricular function recovery and/or with a family history of PPCM or DCM. **We recommend considering referral to a genetics provider with expertise in heritable cardiac disease for people with PPCM, particularly when the index of suspicion is high and no other contributing factors are identified (GRADE 1C). We recommend that other causes of heart failure be ruled out before making a diagnosis of PPCM (Best Practice)**.

2.10 | What are the main causes of *chronic* left ventricular failure in pregnancy?

Common causes of chronic left ventricular failure in pregnancy are outlined in the Box. Hypertrophic cardiomyopathy (HCM) is characterized by left ventricular hypertrophy in the absence of another etiology for cardiac hypertrophy [63]. Typically, there is asymmetric thickening of the myocardium ≥ 15 mm, which may lead to left ventricular outflow obstruction, diastolic dysfunction, ischemia, and mitral regurgitation. There is an increased risk of arrhythmias and sudden death [64]. Most patients with HCM tolerate pregnancy well [65] due to the associated volume expansion [66].

2.11 | How is left ventricular failure diagnosed during pregnancy?

Pregnant patients with new decompensated heart failure typically present with shortness of breath and cough, with or without chest pain, as these are some of the

symptoms associated with low cardiac output and pulmonary edema [67]. Pregnant patients with preexisting cardiomyopathy may or may not have a diagnosis before pregnancy. Patients without a previous diagnosis typically decompensate during pregnancy, unmasking the underlying ventricular failure.

Evaluation begins with careful history and physical examination, followed by laboratory testing. Assessment should focus on signs of decompensation, such as weight gain, jugular venous distension, tachycardia, crackles, S3 or S4 heart sounds, murmurs, pedal edema, and functional capacity (i.e., evaluation of NYHA functional class) [68]. Initial diagnostic testing includes electrocardiography and echocardiography. However, cardiac magnetic resonance imaging (MRI) may be considered for patients with congenital heart disease and/or right ventricular dysfunction. For patients with unclear etiologies of heart failure disease, cardiac MRI may help delineate ischemic versus non-ischemic cardiomyopathies and describe myocardial perfusion. It also may help delineate diseases like left ventricular noncompaction in cases where heart failure etiology is not clear [69]. Pertinent laboratory tests include BNP [18], cardiac enzymes (troponins), electrolytes, renal function, and complete blood count.

2.12 | How should acute and chronic left ventricular failure be managed during pregnancy?

System-specific workflows likely exist at each institution to treat and manage cardiac disease in pregnancy. Some institutions have designated pregnancy heart teams, and others may have institutional experts [70, 71]. In the setting of acute congestive heart failure, both maternal-fetal medicine subspecialists and cardiologists should feel confident initiating the initial workup (electrocardiogram, echocardiography, imaging, cardiac biomarkers) and management, including afterload reduction and diuresis. Advanced heart failure specialists or institutional experts may be required for continuation of care, outpatient management, shock, nuanced cases, and cases where referral for surgical or procedural subspecialists is needed.

2.12.1 | Acute left ventricular heart failure

The management of acute left ventricular heart failure is deeply rooted in the etiology of the heart failure itself, and there are some key differences from chronic left ventricular heart failure. The mainstays of treatment for acute left ventricular heart failure are afterload reduction and achieving euvolemia (diuresis if indicated), as many patients are hypervolemic [1]. During pregnancy, afterload reduction is most suitably achieved with hydralazine or isosorbide dinitrate [72] given the restrictions on first-line agents [angiotensin-converting enzyme inhibitor (ACEi), angiotensin receptor blocker (ARB), angiotensin receptor/neprilysin inhibitor (ARNi) [1]] due to known or suspected fetal teratogenicity [73]. Although nifedipine and amlodipine are dihydropyridines and mainly cause vasodilation with minimal effects on chronotropy and inotropy, their use is controversial in the setting of acute heart failure and they are not recommended for heart failure management in pregnancy. For diuresis, loop diuretics such as furosemide can be used safely [74, 75]. In the postpartum period, afterload reduction can be achieved with the above-mentioned first-line agents. Loop diuretics can be continued postpartum, and diuresis can be augmented with spironolactone during this time. Diuresis should be employed until signs of volume overload abate and/or until euvolemia is achieved. In the acute setting, chronotropic and inotropic agents are not advised except for acute coronary syndrome because they can increase ischemia [1, 72]. **For acute left ventricular heart failure during pregnancy, we recommend hydralazine or isosorbide dinitrate for afterload reduction and furosemide for diuresis. For acute left ventricular heart failure postpartum, we recommend afterload reduction with ACEi, ARB, or ARNi unless contraindicated (e.g., renal failure) (GRADE 1B)**.

Identifying the etiology of acute left ventricular failure is as important as initiating treatment. Etiologies for acute left ventricular failure in pregnancy include PPCM, cardiomyopathy secondary to acute myocardial infarction, and heart failure in the setting of hypertensive emergency or increased afterload (i.e., preeclampsia). It is critical to consult with an advanced heart failure and/or cardiology specialist to help delineate a specific etiology of disease. Notably, beta-blockers are typically avoided in patients with acute decompensated heart failure, which may have implications for hypertension management in the setting of preeclampsia. In the inpatient setting, prophylactic anticoagulation, with heparin or low molecular weight heparin, is advised for patients with acute left ventricular failure (particularly for EF $< 30\%$) [1, 76–79]. Whether to continue anticoagulation on discharge is an individualized decision based on the patient's risk and shared decision-making. If outpatient prophylaxis is prescribed, the duration and dosage should be determined with input from the multidisciplinary care team. The data to guide the use of anticoagulants during pregnancy and postpartum in acute heart failure are limited [80]. In the postpartum period, such decisions may be individualized depending on the presence of risk factors for venous thromboembolism. **We recommend against inotropic blockade**

TABLE 5 Management of acute and chronic left ventricular failure [83].

	Acute left ventricular heart failure	Chronic left ventricular heart failure
Experts	Cardiologist, cardiac surgeon (MCS), intensivist, maternal-fetal medicine subspecialist, cardiac anesthesiologist, obstetric anesthesiologist	Maternal-fetal medicine subspecialist, cardiologist, heart failure specialist, obstetric anesthesiologist
Resources	Intensive care unit (sub-specialized in cardiac care preferred), MCS capabilities	Outpatient imaging capabilities
Medications	Afterload reduction: hydralazine, nitroprusside Diuresis: furosemide, bumetanide Inotropy: dobutamine, epinephrine	Afterload reduction: hydralazine, isosorbide dinitrate Beta-blockade: metoprolol, carvedilol, bisoprolol Diuresis: furosemide **All other GDMT agents (ACEi, ANRi, mineralocorticoid antagonists) are contraindicated during pregnancy**
Anticoagulation	Mechanical or pharmacological thromboprophylaxis	Consider if EF < 35%
Fetal monitoring	At least daily if the fetus is considered viable.	Individualized

Abbreviations: ACEi, angiotensin-converting enzyme inhibitors; ANRi, angiotensin receptor-neprilysin inhibitor; EF, ejection fraction; GDMT, guideline-directed medical therapy; MCS, mechanical circulatory support.

(i.e., beta-blockers) in the setting of acute decompensated left ventricular heart failure (GRADE 1B). We recommend prophylactic anticoagulation administration in hospitalized pregnant patients with acute left ventricular heart failure (GRADE 1C).

It is important to acknowledge that pregnant patients can experience HFpEF, previously called diastolic dysfunction [81, 82]. Although HFpEF is a major contributor to cardiac morbidity and mortality, there exists a large knowledge gap about its pathology and natural history in pregnancy, and it is thus beyond the scope of this document. If HFpEF is suspected, expert consultation should be considered.

2.12.2 | Acute decompensated left ventricular failure in pregnancy

Severe decompensated heart failure is a rare event in pregnancy and postpartum but requires swift multidisciplinary action when detected. It is characterized by an often rapid onset of fluid overload, contributing to the heart's inability to deliver oxygenated blood to meet the body's metabolic demands [83]. The cornerstones of therapy in decompensated heart failure are afterload reduction and diuresis, with inotropy and/or vasopressor as needed (Table 5). Pregnant patients with acute heart failure should have monitoring that includes continuous heart rate measurement, pulse oximetry, telemetry, frequent blood pressure assessment, and strict urine output measurements. Frequent cardiac imaging may also be needed. Ultimately, maternal monitoring depends on the severity of the heart failure and the interventions required, such as whether vasopressor and inotropic support are needed or whether the clinical scenario necessitates mechanical circulatory support. To accomplish the necessary medical interventions and monitoring, pregnant patients may require transfer to a higher level of care unit or center, particularly one with heart failure specialists, intensivists, maternal-fetal medicine subspecialists, and obstetric and cardiac anesthesiologists [71, 84].

Patients should be monitored for volume status and signs of pulmonary edema to ensure adequate oxygenation [67]. All patients should have daily weights to monitor their response to diuresis. Fluid intake and output are closely followed with daily or more frequent electrolyte measurements to guide replacement, particularly for potassium and magnesium, as aggressive diuresis may impact renal function and lower blood pressure. Cardiac telemetry monitoring, transthoracic echocardiography, blood pressure monitoring, hourly fluid status, pulse oximetry, and thromboprophylaxis should be initiated in all pregnant individuals with decompensated acute heart failure. Transfer to a center with additional expertise in caring for pregnant patients with heart disease is recommended.

2.12.3 | Chronic left ventricular failure in pregnancy

Thankfully, chronic or long-standing left ventricular failure is still a rarity in pregnancy. Patients with chronic left ventricular systolic failure should first be assessed for the risk of adverse outcomes during pregnancy; in those already pregnant, this discussion should involve the risks associated with continuing pregnancy. Avoidance of pregnancy is strongly recommended in patients with EF < 30%

[84]. If patients choose to pursue or continue pregnancy, a thorough medical history and review of medications should be performed. Although medical societies advocate for the use of guideline-directed medical therapy (GDMT) soon after discharge in left ventricular failure, the initiation of outpatient GDMT for heart failure remains low [85]. GDMT includes ACEi/ARB, beta-blockade, and mineralocorticoid receptor antagonist (i.e., spironolactone) [86]. Timely initiation of these medications reduces worsening heart failure within one year and decreases mortality [87], with 90% survival at one year in optimally treated patients [88]. For people with chronic heart failure who are pursuing pregnancy or are currently pregnant, contraindicated GDMT medications such as ACEi, ARB, ARNi, and spironolactone should be discontinued and replaced with alternatives, such as hydralazine. Beta-blockers should be continued, and the recommended agents in this patient population are metoprolol, carvedilol, and bisoprolol [1]. All three of these medications have adequate safety profiles, and it is not advised to switch to labetalol, despite long-term comfort using labetalol during pregnancy. Outpatient anticoagulation in chronic left ventricular failure is controversial and should be individualized. Outside of pregnancy, anticoagulation is not needed for chronic left ventricular failure alone; in the setting of EF < 35% in pregnancy and postpartum, however, prophylaxis is reasonable [1, 80]. In the inpatient setting, prophylactic anticoagulation, with heparin or low molecular weight heparin, should be considered for all pregnant individuals with heart failure. **In patients who are pursuing pregnancy or are pregnant, we recommend discontinuing spironolactone, ACEi, ARB, and ARNi and continuing beta-blockers (metoprolol, carvedilol, bisoprolol) (GRADE 1C) [32, 89, 90]. For pregnant patients with left ventricular failure and EF < 35%, we recommend pharmacologic thromboprophylaxis during pregnancy and for six weeks postpartum (GRADE 1C) [76–79]. For patients with chronic left ventricular failure, we recommend starting or continuing GDMT therapy when medically able, in consultation with experts in cardiology (GRADE 1C)**.

2.12.4 | Refractory heart failure

Pregnant or postpartum patients with heart failure refractory to standard treatment are candidates for intravenous inotropic therapy, left ventricular assist device (LVAD), extracorporeal membranous oxygenation, and cardiac transplantation. There are reports of LVAD use in pregnancy; however, complications include both thromboembolism and increased bleeding [91]. Cardiac transplantation is a last resort in patients who have exhausted all possible interventions. Any of these interventions will require transfer to a high level of care and, in most cases, will necessitate abortion care or delivery of the fetus, depending on the gestational age and fetal status. Preparations for a preterm delivery may be necessary, including administering antenatal corticosteroids [92–94] and consultation with neonatology as appropriate. Cases of refractory left ventricular heart failure during pregnancy should be managed at a center with expertise in caring for pregnant patients with heart disease and with the appropriate subspecialist support.

2.12.5 | Arrhythmia and heart failure

Sustained cardiac arrhythmias can cause heart failure. Arrhythmias can arise from underlying cardiovascular complications or independently co-exist in acute and chronic heart failure. The most commonly encountered arrhythmias are supraventricular tachycardia (SVT), including atrial fibrillation and atrioventricular nodal re-entry tachycardia (AVNRT), and ventricular tachycardia [95]. Treatment of SVT in heart failure involves nodal blocking agents (e.g., beta-blockers, calcium channel blockers) and diuresis, depending on the volume status, which is usually presumed to be overloaded in acute heart failure. Sodium channel blockers (e.g., procainamide, lidocaine) and potassium channel blockers (e.g., sotalol) can also be used under expert guidance. Electrical cardioversion should be done under the supervision of a heart specialist and/or critical care provider. Anticoagulation during medical and/or electrical cardioversion should be discussed with a multidisciplinary team, and bleeding risks should be assessed [95].

Ventricular arrhythmias, specifically ventricular tachycardia, can lead to sudden cardiac death in patients with heart failure. Ventricular arrhythmias occur at a much higher rate in the setting of reduced EF secondary to myocardial fibrosis, abnormal repolarization, subendocardial ischemia, and ventricular (and atrial) dilation. Anti-arrhythmogenic drugs such as amiodarone and lidocaine can be used in the acute setting with the addition of other blockade agents with expert advice. Electrical cardioversion has a larger role in ventricular arrhythmias, and implantable cardioverter-defibrillators (ICDs) have revolutionized care in the outpatient setting [95]. Medical and procedural care for SVT and ventricular arrhythmias in pregnant patients with heart failure is incredibly nuanced. In these situations, it is imperative to involve heart failure experts and/or electrophysiology specialists when available.

2.13 | What fetal considerations are relevant in pregnancies complicated by maternal heart failure?

Pregnant people with cardiac disease, including heart failure, are at increased risk for adverse perinatal outcomes, including small for gestational age (SGA) birth, lower Apgar scores, and prematurity [10–12]. A first-trimester ultrasound facilitates accurate pregnancy dating and identification of a multifetal gestation, if present [96]. Patients with heart failure are candidates for routine prenatal aneuploidy screening and diagnostic testing. In the case of maternal heart failure resulting from an underlying congenital defect, a fetal echocardiogram is indicated, given the increased risk for congenital heart disease in the fetus [32, 97, 98]. **We recommend fetal echocardiography when maternal heart failure is a result of an underlying congenital cardiac defect (GRADE 1C)** [99].

Several medications in GDMT cannot be used in pregnant or lactating people. ACEi, ARB, aldosterone antagonists, and sodium-glucose cotransporter inhibitors (SGLT2i) are contraindicated in pregnancy due to known or suspected fetal teratogenicity [100–102]. Beta-blockers (e.g., metoprolol, carvedilol, bisoprolol) are standard treatments employed in patients with heart failure and can safely be continued, although they may increase the risk for hypotension, hypoglycemia, bradycardia, and respiratory depression in neonates [32]. A large systematic review from 2014 (49 trials with 4723 participants) of pregnant individuals treated with antihypertensive agents (including beta-blockers) noted no difference in the rates of SGA births. Two additional randomized controlled trials investigating hypertension treatment in pregnancy (3395 pregnant individuals) that included labetalol use found no difference in the rates of SGA births with treatment [103, 104]. Notably, most well-designed studies have not included metoprolol or carvedilol, and some observational studies suggest a possible increase in the rates of SGA births [105, 106]. Given the increased risk for fetal growth restriction and SGA births among pregnant people with heart failure and the possible association with medications used, serial growth ultrasounds should be performed, and antepartum fetal surveillance should be instituted as indicated [107–109]. **We recommend serial growth ultrasounds in pregnancies complicated by maternal heart failure (GRADE 1C)** [110, 111].

Continuous fetal monitoring should be used for appropriate assessment of the fetus during the cardiac challenges of regional or general anesthesia administration, labor, and delivery. Aside from intrapartum management, continuous or intermittent fetal heart monitoring should be considered when changes in the maternal status prompt inpatient evaluation or treatment. This decision should consider gestational age and any relevant maternal or fetal factors that may impact fetal viability or the maternal clinical status. **We recommend continuous fetal heart rate monitoring during anesthesia administration, labor, and delivery for pregnant patients with heart failure (GRADE 1B)** [112–114]**. In the case of maternal cardiovascular changes prompting inpatient assessment or treatment, we recommend continuous or intermittent fetal heart rate monitoring, taking into consideration the gestational age and any relevant maternal or fetal factors that may impact fetal viability or maternal clinical status (GRADE 1C)** [110–114].

2.14 | How are pregnant patients with heart failure managed around the time of delivery?

Delivery planning considerations in patients with heart failure include timing and mode of delivery, laboratory testing, monitoring (e.g., pulse oximetry, telemetry, arterial line, central line), type of anesthesia, thromboprophylaxis, fluid management, endocarditis prophylaxis, and location of postpartum recovery. Planning starts with identifying the care team, including members from obstetrics, maternal-fetal medicine, cardiology, obstetric anesthesiology, cardiac anesthesiology (if needed), nursing, and other disciplines deemed appropriate.

Delivery timing should be based on cardiac stability and obstetric indications. There are no clinical studies on which to base delivery timing recommendations in this specific population. A term delivery should be pursued in an otherwise uncomplicated patient who is well compensated. In some cases, an early-term delivery may be appropriate based on the overall clinical considerations.

Vaginal delivery is generally preferred in patients with ventricular failure unless avoidance of labor and expeditious delivery is in the best interest of the patient due to hemodynamic compromise. Cesarean delivery is reserved for typical obstetric indications; compared to vaginal delivery, it is associated with increased likelihood of blood loss, general anesthesia, thromboembolism, infection, and bleeding complications, particularly for those on anticoagulation [115]. In some patients, labor may be well tolerated, particularly with the aid of neuraxial anesthesia, but there may be reasons to avoid Valsalva, or prolonged Valsalva. Although the Valsalva maneuver is associated with substantial hemodynamic alterations [116] (sudden rise and then fall in systolic blood pressure, decrease in venous return, heart rate fluctuations), many pregnant individuals with cardiac disease can tolerate Valsalva with or without operative vaginal delivery [117]. Instances in which to

limit or avoid Valsalva during the second stage may include some cases of severe pulmonary hypertension, left ventricular outflow tract obstruction, compromised venous return, or substantially compromised myocardial contractility. In these cases, an assisted second stage with an operative delivery can be considered with insight from a heart failure specialist about each individual patient's cardiac risk.

In most cardiac patients, neuraxial analgesia and anesthesia are considered safe and may be desirable to limit fluctuations in cardiac output associated with catecholamine surges and to facilitate rapid obstetric interventions (such as cesarean delivery) if needed [118]. For patients at risk for arrhythmias in the peripartum period, telemetry is often utilized. An arterial line should be considered in patients who may benefit from continuous blood pressure and cardiac output monitoring during the peripartum period (e.g., critical aortic stenosis, previous PPCM with unrecovered function) [118]. Any obstetric patient is at risk for hemorrhage. No uterotonic is absolutely contraindicated for use in patients with heart failure but some carry additional cardiovascular risk. For example, ergot alkaloids (e.g., methergine) induce vasoconstriction and may cause increased afterload and cardiac ischemia [119]. Obstetric hemorrhage should be managed per unit protocols with consideration of the potential effect of each uterotonic based on individual patient factors. **We recommend planned vaginal delivery at term in patients with heart failure in the absence of hemodynamic compromise or obstetric indications for cesarean (GRADE 1C). We recommend the use of neuraxial anesthesia in most patients with heart failure to provide appropriate analgesia and to limit the effects of labor on cardiac parameters (GRADE 1C). We recommend considering a limited or assisted second stage for some patients after input from cardiology about each patient's cardiac risk (GRADE 1C)**. Pregnant patients at risk for requiring mechanical circulatory support in the peripartum period should be delivered at an appropriately resourced tertiary care center.

2.15 | How should patients with heart failure be managed in the immediate postpartum period?

Postpartum patients with heart failure require close monitoring due to substantial and rapid changes in the cardiovascular system during this time [120, 121]. The largest change in intravascular volume occurs during the second and third stages of labor and immediately postpartum, placing patients at risk for volume overload and arrhythmia exacerbation. Risk for compromise in the postpartum period largely depends on the etiology of heart failure, maternal status prior to delivery, and delivery events. Importantly, many maternal cardiovascular deaths and severe morbidity occur after discharge from the delivery hospitalization [122–124]. For this reason, efficient bridging of care is critical to aid in a safe maternal transition to cardiac care in the postpartum period. Postpartum patients can be transitioned to medications they could not take antenatally (i.e., ACEi, ARB, and mineralocorticoid receptor antagonists). Close maternal monitoring is needed in the immediate postpartum period with an individualized inpatient hospitalization plan for each patient; some patients may require monitoring for more than 48 hours after delivery [125]. Strong partnerships with the appropriate care teams can promote a safe transition to cardiac care, particularly after the immediate postpartum period.

2.16 | What are considerations for breastfeeding in postpartum people with heart failure?

Pregnant individuals with heart failure should receive routine counseling about infant feeding. Each patient's medication should be reviewed to confirm compatibility with breastfeeding (sometimes called chestfeeding). In the absence of robust data to guide counseling, shared decision-making should be pursued, taking into account the benefits of breastfeeding and possible risks [126, 127]. Notably, ACEi agents are regarded as safe for breastfeeding and should not be withheld in this setting because they represent an essential aspect of GDMT therapy [128–130]. Patients requiring therapeutic anticoagulation in the postpartum period should be made aware that warfarin is compatible with breastfeeding and poses no risk to the infant [131]. Direct oral anticoagulants (DOACs), however, are not recommended while breastfeeding due to insufficient safety data and the availability of effective alternatives. There may be theoretical concerns related to decreased breast milk production with diuretic use; however, the benefits of prompt initiation of GDMT outweigh these concerns. Currently, SGLT2i agents are not recommended for breastfeeding as animal studies have shown excretion into breastmilk [132]. **We recommend that postpartum patients with heart failure undergo routine counseling regarding infant feeding. We recommend reviewing all medications for compatibility with breastfeeding and using shared decision-making in the absence of robust data (GRADE 1B)**.

Summary of recommendations[a]

Number	Recommendation	GRADE
1	We recommend that all patients with right heart failure due to pulmonary arterial hypertension receive counseling about high rates of maternal morbidity and mortality; if pregnancy is pursued, the patient should be referred to a center with expertise in this condition to guide management during pregnancy and postpartum.	1C
2	We recommend considering referral to a genetics provider with expertise in heritable cardiac disease for people with PPCM, particularly when the index of suspicion is high and no other contributing factors are identified.	1C
3	We recommend that other causes of heart failure be ruled out before making a diagnosis of PPCM.	Best Practice
4	For acute left ventricular heart failure during pregnancy, we recommend hydralazine or isosorbide dinitrate for afterload reduction and furosemide for diuresis. For acute left ventricular heart failure postpartum, we recommend afterload reduction with ACEi, ARB, or ARNi unless contraindicated (e.g., renal failure).	1B
5	We recommend against inotropic blockade (i.e., beta-blockers) in the setting of acute decompensated left ventricular heart failure.	1B
6	We recommend prophylactic anticoagulation administration in hospitalized pregnant patients with acute left ventricular heart failure.	1C
7	In patients who are pursuing pregnancy or pregnant, we recommend discontinuing spironolactone, ACEi, ARB, and ARNi and continuing beta-blockers (metoprolol, carvedilol, bisoprolol).	1C
8	For pregnant patients with left ventricular failure and EF < 35%, we recommend pharmacologic thromboprophylaxis during pregnancy and for six weeks postpartum.	1C
9	For patients with chronic left ventricular failure, we recommend starting or continuing GDMT therapy when medically able, in consultation with experts in cardiology.	1C
10	We recommend fetal echocardiography when maternal heart failure is a result of an underlying congenital cardiac defect.	1C
11	We recommend serial growth ultrasounds in pregnancies complicated by maternal heart failure.	1C
12	We recommend continuous fetal heart rate monitoring during anesthesia administration, labor, and delivery for pregnant patients with heart failure.	1B
13	In the case of maternal cardiovascular changes prompting inpatient assessment or treatment, we recommend continuous or intermittent fetal heart rate monitoring, taking into consideration the gestational age and any relevant maternal or fetal factors that may impact fetal viability or the maternal clinical status.	1C
14	We recommend planned vaginal delivery at term in patients with heart failure in the absence of hemodynamic compromise or obstetric indications for cesarean.	1C
15	We recommend the use of neuraxial anesthesia in most patients with heart failure to provide appropriate analgesia and to limit the effects of labor on cardiac parameters.	1C
16	We recommend considering a limited or assisted second stage for some patients after input from cardiology about each individual patient's cardiac risk.	1C
17	We recommend that postpartum patients with heart failure undergo routine counseling regarding infant feeding. We recommend reviewing all medications for compatibility with breastfeeding and using shared decision-making in the absence of robust data.	1B

[a]See "Supporting Information" for evidence summary table.

Society for Maternal-Fetal Medicine Grading of recommendations assessment, development, and evaluation (GRADE) system [133][a]

Grade of Recommendation	Clarity of Risk and Benefit	Quality of Supporting Evidence	Implications
1A. Strong recommendation, high-quality evidence	Benefits clearly outweigh risks and burdens, or vice versa.	Consistent evidence from well-performed, randomized controlled trials, or overwhelming evidence of some other form. Further research is unlikely to change confidence in the estimate of benefit and risk.	Strong recommendation that can apply to most patients in most circumstances without reservation. Clinicians should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.
1B. Strong recommendation, moderate-quality evidence	Benefits clearly outweigh risks and burdens, or vice versa.	Evidence from randomized controlled trials with important limitations (inconsistent results, methodologic flaws, indirect or imprecise), or very strong evidence of some other research design. Further research (if performed) is likely to have an impact on confidence in the estimate of benefit and risk and may change the estimate.	Strong recommendation that applies to most patients. Clinicians should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.
1C. Strong recommendation, low-quality evidence	Benefits appear to outweigh risks and burdens, or vice versa.	Evidence from observational studies, unsystematic clinical experience, or randomized controlled trials with serious flaws. Any estimate of effect is uncertain.	Strong recommendation that applies to most patients. Some of the evidence base supporting the recommendation is, however, of low quality.
2A. Weak recommendation, high-quality evidence	Benefits closely balanced with risks and burdens.	Consistent evidence from well-performed randomized controlled trials or overwhelming evidence of some other form. Further research is unlikely to change confidence in the estimate of benefit and risk.	Weak recommendation; best action may differ depending on circumstances or patients or societal values.
2B. Weak recommendation, moderate-quality evidence	Benefits closely balanced with risks and burdens; some uncertainty in the estimates of benefits, risks, and burdens.	Evidence from randomized controlled trials with important limitations (inconsistent results, methodologic flaws, indirect or imprecise), or very strong evidence of some other research design. Further research (if performed) is likely to influence confidence in the estimate of benefit and risk and may change the estimate.	Weak recommendation; alternative approaches likely to be better for some patients under some circumstances.
2C. Weak recommendation, low-quality evidence	Uncertainty in the estimates of benefits, risks, and burdens; benefits may be closely balanced with risks and burdens.	Evidence from observational studies, unsystematic clinical experience, or randomized controlled trials with serious flaws. Any estimate of effect is uncertain.	Very weak recommendation, other alternatives may be equally reasonable.
Best practice	Recommendation in which either (i) there is an enormous amount of indirect evidence that clearly justifies strong recommendation (direct evidence would be challenging, and inefficient use of time and resources, to bring together and carefully summarize) or (ii) recommendation to the contrary would be unethical.		

[a]Adapted from Guyatt et al [134].

Guidelines referenced

Organization	Title	Year of Publication
American College of Obstetricians and Gynecologists	ACOG Practice Bulletin No. 227: Fetal Growth Restriction: [107]	2021
American Heart Association, American College of Cardiology, Heart Failure Society of America	2022 AHA/ACC/HFSA Guideline for the Management of Heart Failure: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines [1]	2021
American Heart Association	Use of Medication for Cardiovascular Disease During Pregnancy: JACC State-of-the-Art Review [89]	2022
American Institute of Ultrasound in Medicine	AIUM practice guideline for the performance of fetal echocardiography [98]	2011
European Society of Cardiology	2018 ESC Guidelines for the management of cardiovascular diseases during pregnancy [32]	2018
National Heart, Lung, and Blood Institute and Office of Rare Diseases	Peripartum cardiomyopathy: National Heart, Lung, and Blood Institute and Office of Rare Diseases (National Institutes of Health) workshop recommendations and review [54]	2000

2.17 | Which contraceptive options may be used in patients with heart failure?

Individualized, patient-centered reproductive planning is essential for patients with heart failure because of the increased maternal and fetal morbidity and mortality in this population [10–12]. Potential adverse effects of contraceptive options, including fluid retention, hypertension, and thromboembolic risk, should be taken into consideration. If cesarean delivery is planned and future fertility is not desired, patients should be counseled about the option for concurrent permanent sterilization. The 2024 US Medical Eligibility Criteria for Contraceptive Use [135] lists the implant and progestin-only pill as category 1 (no restrictions for use) for patients with a history of PPCM who have NYHA class I or II functional status. Intrauterine devices (both copper and levonorgestrel) and depot-medroxyprogesterone acetate are listed as Category 2 (method generally can be used, although careful follow-up might be required). Combined hormonal contraceptives, however, are listed as Category 4 (unacceptable health risk if the method is used) in the first 6 months following PPCM and Category 3 (requires careful clinical judgment and access to clinical services) after 6 months. These recommendations are due to the fluid retention associated with combined hormonal contraceptives and the possible increased risk for arrhythmias. For patients with a history of PPCM who have NYHA class III or IV functional status, the implant, intrauterine devices, and progestin-only pills are Category 2, depot-medroxyprogesterone acetate is Category 3, and combined hormonal contraceptives are Category 4. Although recommendations are not listed for other etiologies of heart failure, it is reasonable to use these recommendations as guidance. For patients with heart failure who desire future fertility, comprehensive contraceptive counseling should take into consideration medical criteria and patient preferences. For patients with heart failure interested in permanent methods, surgical sterilization should be considered.

2.18 | What are the known health disparities in right and left ventricular failure during pregnancy?

Among pregnant and non-pregnant adults with heart failure, health disparities by patient race and socioeconomic status are well-documented [136–140]. Providers' practice differences attributed to implicit bias are also reported, affecting procedural and medical management (i.e., GDMT) [141]. Among pregnant patients, the data largely derive from cases of PPCM but demonstrate a similar pattern of worse clinical outcomes among those identifying as Black, with strong associations based on disadvantaged socioeconomic status [142–144]. Although disparities data are limited in the setting of pregnancy and heart failure, race and ethnicity likely affect diagnosis, treatment, and escalation of care. Providers and institutions should be vigilant and work towards reducing disparities and providing equitable care, for example, by standardly collecting accurate race, ethnicity, and language data in conjunction

with other measures of social determinants of health [145].

3 | CONCLUSION

The management of pregnancies complicated by heart failure requires understanding the etiology and severity of the heart failure, as well as whether the heart failure is primarily right- or left-sided. In addition to maternal-fetal medicine and cardiology (sub)specialists, some particularly high-risk patients, such as those with heart failure due to pulmonary arterial hypertension or severely depressed systolic function, will likely require additional expertise specific to their conditions. Many of the medical cornerstones of heart failure management can be continued during pregnancy, with a few notable exceptions. Labor, delivery, and particularly postpartum represent times during which patients may be at high risk for decompensation, such that delivery at a center with experience in caring for these patients is recommended. Given the risk of complications even after discharge following delivery, a seamless transition to cardiac care is critical for these patients.

Although our understanding of heart failure in pregnancy continues to improve, research gaps remain. The management of PPCM, specifically whether bromocriptine is effective in the immediate time frame and whether GDMT is beneficial in the long term, is an active area of interest. Further knowledge gaps include the most effective imaging modalities to predict future cardiac health in those with heart failure and the impact of maternal heart failure on the cardiovascular health of offspring. Finally, the advance of cardiac genetics is likely to become an important component in the care of patients with heart failure, including in pregnancy.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

The use of this information is voluntary, and clinicians should be familiar with and comply with all applicable laws and regulations.

All authors and committee members have filed a disclosure of interests delineating personal, professional, business, or other relevant financial or nonfinancial interests in relation to this publication. Any substantial conflicts of interest have been addressed through a process approved by the Society for Maternal-Fetal Medicine (SMFM) Board of Directors. SMFM has neither solicited nor accepted any commercial involvement in the specific content development of this publication.

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RESPONSE

Response

In this section, we will discuss the **RESPONSE** section: The steps to follow when a cardiac event has taken place.

For Every Event the following elements should be in place:

- Facility-wide standard protocols with checklists and escalation policies for management of cardiac symptoms.
- Facility-wide standard protocols with checklists and escalation policies for management of people with known or suspected cardiac conditions.
- Coordinate transitions of care including the discharge from the birthing facility to home and transition from postpartum care to ongoing primary and specialty care.
- Offer reproductive life planning discussions and resources, including access to a full range of contraceptive options in accordance with safe therapeutic regimens.
- Provide patient education focused on general life-threatening postpartum complications and early warning signs, including instructions of who to notify if they have concerns, and time and date of a scheduled postpartum visit.

Element 1:

- Facility-wide standard protocols with checklists and escalation policies for management of **cardiac symptoms**.
    - Resource: Handout 1: Cardiovascular Checklist

Element 2:

- Facility-wide standard protocols with checklists and escalation policies for management of people with **known or suspected cardiac conditions**.
    - Create system wide protocols needed for transfer, in accordance with maternal level of care with defined roles, triggers, treatment algorithms, referrals and follow up, which should be embedded in the EHR
        - See algorithms in Recognition and Prevention Section
    - Designate provider to take the lead on patient and family communication during a crisis and use an interpreter when appropriate
    - Create individualized plans for discharge from emergency department or postpartum using specific criteria and with follow-up plans
    - Resources: Response Handouts 2-4
        - Handout 2- Cardiovascular Considerations in Caring for Obstetric Patients: https://www.ahajournals.org/doi/10.1161/CIR.0000000000000772

        - Handout 3- Ensuring a Heart Healthy Pregnancy: https://www.bidmc.org/about-bidmc/wellness-insights/heart-health/2020/01/ensuring-a-heart-healthy-pregnancy
        - Handout 4- Maternal Cardiac Teams: https://www.urmc.rochester.edu/conditions-and-treatments/cardio-obstetrics-program

Element 3:

- Coordinate transitions of care including the discharge from the birthing facility to home and transition from postpartum care to ongoing primary and specialty care.
    - Provide shared EHR across settings
    - Maintain a list of Cardiologists willing to care for pregnant and postpartum patients and PCPs who are comfortable with cardiac conditions
    - Standardize handoff systems for care transitions
        - Handout 5- Impact of Communication and Patient hand-off tool SBAR on patient safety: A Systemic Review https://bmjopen.bmj.com/content/bmjopen/8/8/e022202.full.pdf

Element 4:

- Offer reproductive life planning discussions and resources, including access to a full range of contraceptive options in accordance with safe therapeutic regimens
    - Maintain understanding of how new laws may affect access in your state
    - Offer reproductive life planning discussions and resources, including access to a full range of contraceptive options in accordance with safe therapeutic regimens.
    - Considerations may include:
        - Using shared medical decision-making
        - Congruence with patient's goals and values
        - Safety for health conditions
            - Handout 6- Guidelines for Contraception with Cardiovascular Disease (from California Maternal Quality Care Collaborative) https://www.cmqcc.org/resource/guide-contraception-information-women-cardiovascular-disease

        - Contraceptive options
            - Handouts 7-8- English and Spanish Versions of the "How well does Birth Control Work?" page in the flip chart

    - Full flip chart in English and Spanish https://beyondthepill.ucsf.edu/resource/birth-control-whats-important-to-you-flip-chart/

- Birth spacing and pregnancy intention
- Chest or breastfeeding
- Other parenting choices as prioritized by the pregnancy or postpartum person

Element 5:

- Provide patient education focused on general life-threatening postpartum complications and early warning signs, including instructions of who to notify if they have concerns, and time and date of a scheduled postpartum visit.
    - Review of warning signs/symptoms
        - Handout 9: Cardiovascular Disease Patient Handout, English
        - https://www.cmqcc.org/files/CVD_Risk_Infographic.pdf
    - Handout 10: Cardiovascular Disease Patient Handout, Spanish
        - https://www.cmqcc.org/files/CVDRiskInfographic_Sp_letter.pdf
    - Handout 11: Cardiovascular Disease Signs and Symptoms, English
        - https://www.cmqcc.org/files/Signs-Symptoms-Print-Friendly.pdf
    - Handout 12: Cardiovascular Disease Signs and Symptoms, Spanish
        - https://www.cmqcc.org/files/CVD_Signs_Symptoms_SPAN.pdf
    - Handouts 13-17- Urgent Maternal Warning Signs in Many languages
        - Link to each of the Maternal Warning Signs PFDs with more languages: https://www.cdc.gov/hearher/hcp/toolkit/warning-signs-educational-materials.html
    - Reinforcement of the value of outpatient postpartum visits
    - Summary of delivery events

- All education provided should be:
    - In appropriate lay terminology
    - In appropriate lay terminology
    - Aligned with the postpartum person's health literacy, culture, language, and accessibility needs
- Include a designated support person for all teaching with patient permission (or as desired) and use teach back to confirm understanding of education and care plans

CVD ASSESSMENT ALGORITHM FOR PREGNANT and POSTPARTUM WOMEN

Red Flags

- Shortness of breath at rest
- Severe orthopnea ≥ 4 pillows
- Resting HR ≥120 bpm
- Resting systolic BP ≥160 mm Hg
- Resting RR ≥30
- Oxygen saturations ≤94% with or without personal history of CVD

↓

PROMPT EVALUATION and/or hospitalization for acute symptoms
plus
CONSULTATIONS with MFM and Primary Care/Cardiology

Personal History of CVD Without Red Flags

↓

CONSULTATIONS with MFM and Primary Care/Cardiology

Circulation

AHA SCIENTIFIC STATEMENT

Cardiovascular Considerations in Caring for Pregnant Patients

A Scientific Statement From the American Heart Association

ABSTRACT: Cardio-obstetrics has emerged as an important multidisciplinary field that requires a team approach to the management of cardiovascular disease during pregnancy. Cardiac conditions during pregnancy include hypertensive disorders, hypercholesterolemia, myocardial infarction, cardiomyopathies, arrhythmias, valvular disease, thromboembolic disease, aortic disease, and cerebrovascular diseases. Cardiovascular disease is the primary cause of pregnancy-related mortality in the United States. Advancing maternal age and preexisting comorbid conditions have contributed to the increased rates of maternal mortality. Preconception counseling by the multidisciplinary cardio-obstetrics team is essential for women with preexistent cardiac conditions or history of preeclampsia. Early involvement of the cardio-obstetrics team is critical to prevent maternal morbidity and mortality during the length of the pregnancy and 1 year postpartum. A general understanding of cardiovascular disease during pregnancy should be a core knowledge area for all cardiovascular and primary care clinicians. This scientific statement provides an overview of the diagnosis and management of cardiovascular disease during pregnancy.

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On behalf of the American Heart Association Council on Clinical Cardiology; Council on Arteriosclerosis, Thrombosis and Vascular Biology; Council on Cardiovascular and Stroke Nursing; and Stroke Council

Cardiovascular disease (CVD) is the leading cause of pregnancy-related mortality in the United States and has gradually increased over time (from 7.2 to 17.2 deaths per 100 000 live births from 1987–2015).[1] The rise in maternal mortality has been attributed to increasing numbers of women at advanced maternal age undertaking pregnancy, comorbid preexisting conditions such as diabetes mellitus and hypertension, and the growing number of women with congenital heart disease surviving to childbearing age.[1,2] Racial and ethnic disparities in pregnancy-related mortality are significant, peaking among black non-Hispanic women followed by American Indian/Alaskan Native non-Hispanic women, Asian/Pacific Islander non-Hispanic women, white non-Hispanic women, and Hispanic women (42.8, 32.5, 14.2, 13.0, and 11.4 deaths per 100 000 live births, respectively).[1]

Early and specialized multidisciplinary care in the antepartum, peripartum, and postpartum time frames is essential to improve cardiovascular outcomes and to reduce maternal mortality up to the first year postpartum (Figure 1). The cardio-obstetrics team (also referred to as the pregnancy heart team)[3,4] should provide a comprehensive review of maternal cardiovascular risk, obstetric risk, and fetal risk and outcomes. This includes expectant management and prepregnancy counseling on cardiac medication safety throughout pregnancy and lactation phases. The cardio-obstetrics team is often made up of obstetricians, cardiologists, anesthesiologists,

Key Words: AHA Scientific Statements ■ cardiovascular disease ■ maternal mortality ■ obstetrics ■ pregnancy

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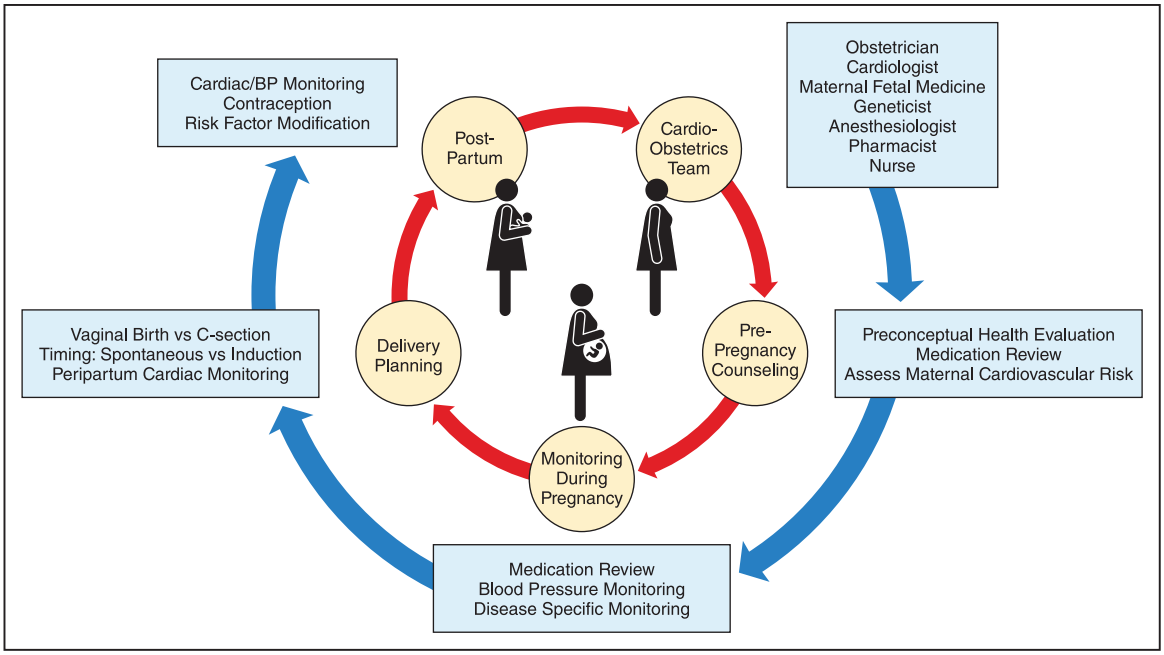

Figure 1. Cardio-obstetrics team in the management of women before pregnancy, during pregnancy, and postpartum.
BP indicates blood pressure.

maternal fetal medicine specialists, geneticists, neurologists, nurses, and pharmacists who jointly develop a comprehensive strategy for management of CVD during pregnancy, delivery, and postpartum.

This scientific statement provides an overview of CVD during pregnancy, exclusive of congenital heart disease and sudden cardiac arrest, which are addressed in recent American Heart Association (AHA) scientific statements on these specific topics.[5,6] In addition, this scientific statement highlights the need for a cardio-obstetrics team for the management of CVD in women during a high-risk pregnancy.

PHYSIOLOGICAL CHANGES DURING PREGNANCY

Predictable and expected hemodynamic and structural changes occur during pregnancy (Data Supplement

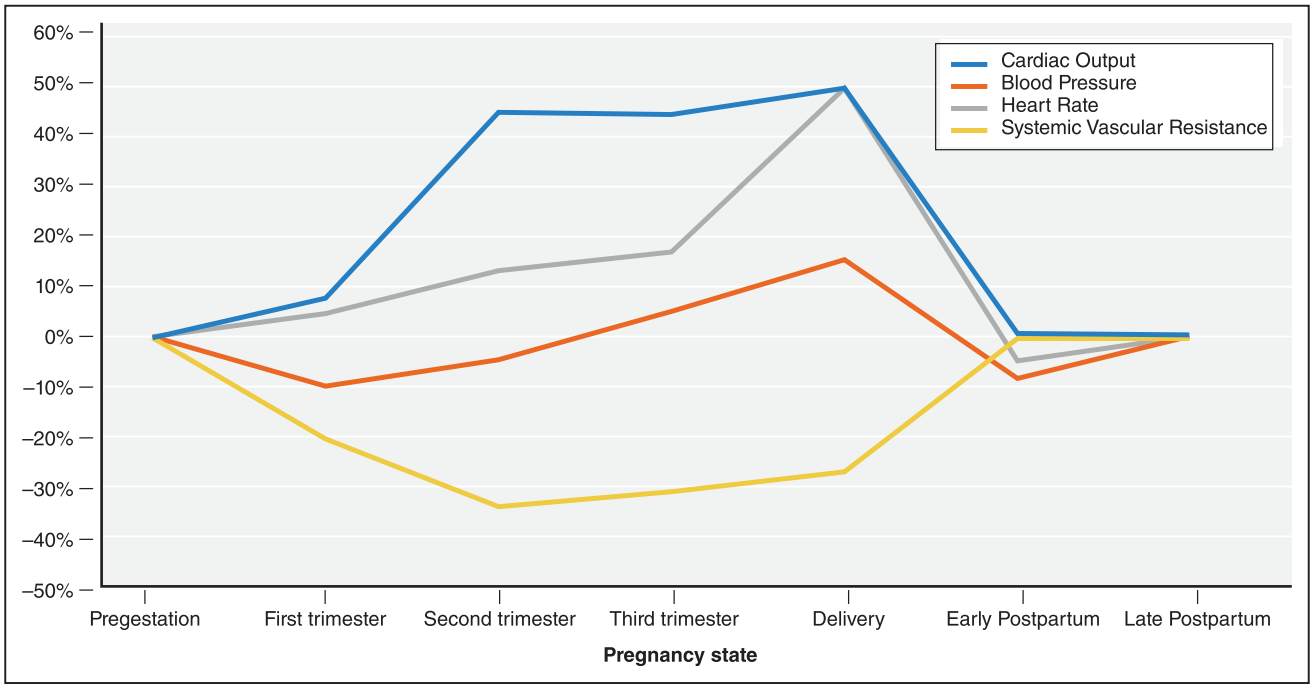

Figure 2. Physiological changes during pregnancy, including variation in cardiac output, blood pressure, and heart rate.[4,7]

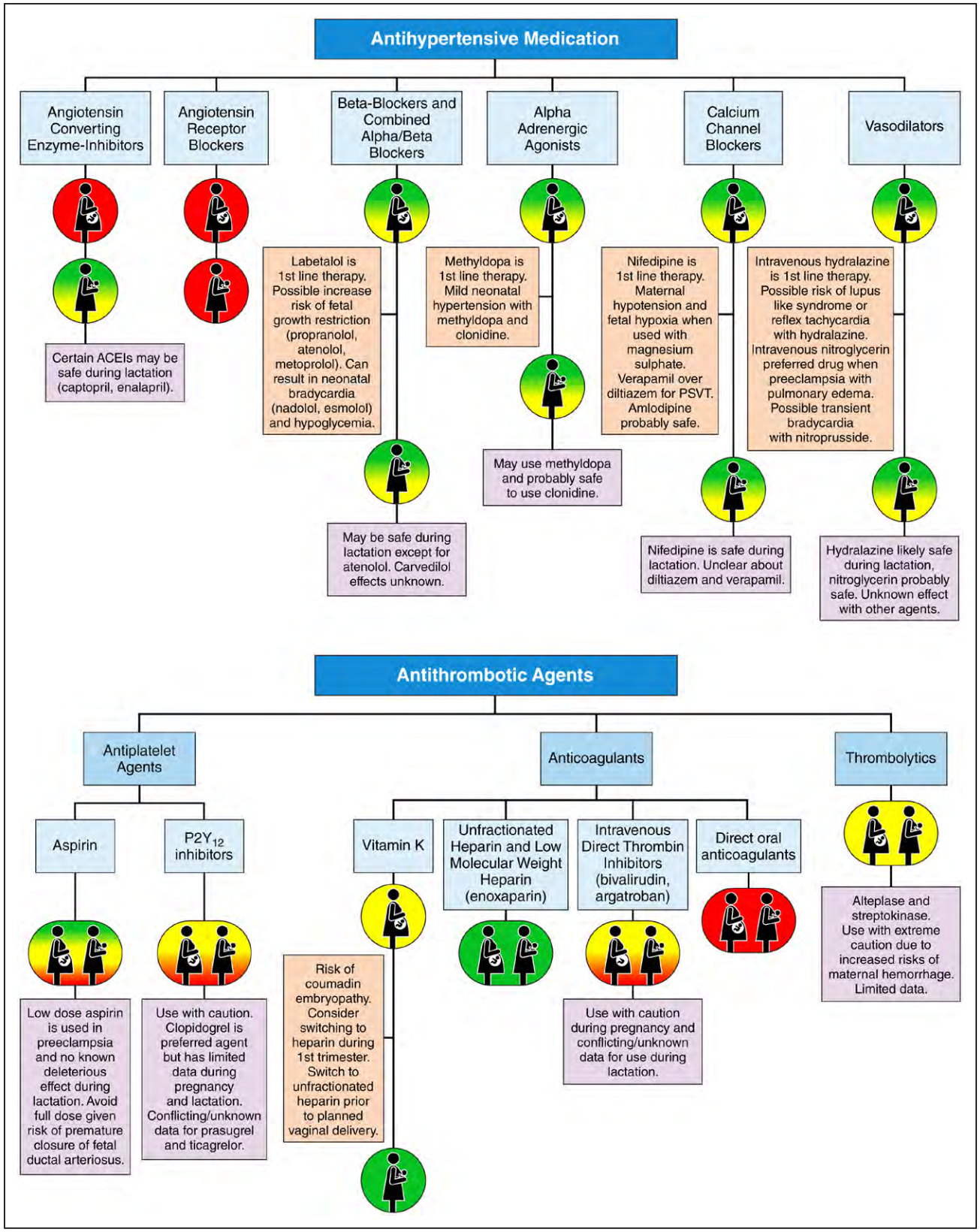

Figure 3. Antihypertensive medications and anticoagulants used during pregnancy.[3,5,9–12]
Boxes with various shades: Red shows contraindicated medications; yellow, use-with-caution medications; and green, relatively safe medications. ACEI indicates angiotensin-converting enzyme inhibitor; and PSVT, paroxysmal supraventricular tachycardia.

Table 1 and Data Supplement Figure 2).[4,7] Along with structural changes of the left ventricle (LV) in pregnancy, activation of the renin-angiotensin-aldosterone system and hormonal fluctuations contribute to the increase in plasma volume, rise in cardiac output, and decline in systemic vascular resistance. Significant fluid shifts at delivery lead to labile peripartum blood pressure, often rising before delivery and then falling within week.[4,7]

PREPREGNANCY COUNSELING

CVD is the leading cause of indirect maternal mortality, and women with CVD should receive counseling on both maternal and fetal risks before conceiving. These women should be cared for by a specialized cardio-obstetrics team (Figure 1) with experience in managing high-risk women with CVD during pregnancy.[8] Preconception counseling is important to ensure that estimates of individual risk are considered when women begin family planning. This counseling permits the high-risk cardio-obstetrics team to include the patient in shared decision-making and to outline anticipated or potential events during pregnancy and management strategies at every stage of the process. In preconception planning, all medications should be reviewed to ensure safety during pregnancy (Figure 3).[3,5,9–12] For example, angiotensin-converting enzyme inhibitors and angiotensin receptor blockers are teratogenic and should be replaced with medications known to have a better safety profile in pregnancy. A comprehensive clinical review of a woman's overall health before conception should include reviewing the need for supplemental folic acid and monitoring nutritional status.[13]

The modified World Health Organization (WHO) classification is often the preferred method to estimate individual maternal cardiovascular risk in women with CVD who are contemplating pregnancy (Data Supplement Table 2).[14] Several risk models that estimate maternal cardiovascular risk have been evaluated, but the WHO classification remains the only prospectively validated method for risk assessment. Nonetheless, most models have included several factors known to increase maternal cardiovascular risk, including prior CVD event, history of arrhythmia, prior heart failure, poor functional class, resting cyanosis, use of anticoagulant therapy, and presence of a mechanical valve. In most models of maternal cardiovascular risk estimation, several conditions are felt to be of high/prohibitive risk to continue with pregnancy, including pulmonary arterial hypertension, severe ventricular dysfunction, severe left-sided heart obstruction, and significant aortic dilatation with underlying connective tissue disease.[3] Women with these conditions are often advised to avoid pregnancy. However, it is not uncommon for women to present pregnant, and at that point, the high-risk cardio-obstetrics team must work together to come up with the best way to mitigate maternal cardiovascular and obstetric risk and fetal risk moving forward.

MEDICAL CONDITIONS DURING PREGNANCY

Hypertensive Disorders in Pregnancy

Hypertensive disorders of pregnancy (HDP) are common in the United States, occurring in 912 per 10 000 delivery hospitalizations.[15] HDP are classified into 4 categories by the American College of Obstetricians and Gynecologists (ACOG): preeclampsia/eclampsia, gestational hypertension, chronic hypertension, and chronic hypertension with superimposed preeclampsia[11,12] (Data Supplement Figure 1). Preeclampsia is defined hypertension (systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg in women after 20 weeks of gestation who were previously normotensive) along with evidence of proteinuria. The salient features of preeclampsia with severe features and associated risk factors are highlighted in Data Supplement Table 3.[16] Preeclampsia is important because women with preeclampsia have a 71% increased risk of CVD mortality, a 2.5-fold increased risk of coronary artery disease, and a 4-fold increased risk of heart failure compared with normal cohorts.[17]

A recent joint presidential advisory from the ACOG and AHA highlighted the need for a multidisciplinary management strategy incorporating lifestyle and behavioral modifications, including diet, exercise, and smoking cessation, as well as electronic medical record–based standardized algorithms targeting cardiovascular risk factors.[18] Several studies have proposed that regular exercise during pregnancy may improve vascular function and prevent preeclampsia.[19,20] Moderate exercise has been studied to evaluate the prevention of preeclampsia. However, large randomized controlled trials evaluating the potential reversal of endothelial dysfunction leading to improved outcomes have still not been done.[21] For women with high-risk conditions (chronic hypertension, previous preterm preeclampsia, preterm birth at <34 weeks of gestation, diabetes mellitus), low-dose aspirin may be considered and should be started in the late first trimester.[3,11,12]

Expeditious triage and treatment within 30 to 60 minutes of confirmed severe hypertension (blood pressure ≥160/110 mm Hg and persistent for 15 minutes) should be initiated to reduce the risk of maternal heart failure, myocardial ischemia, stroke, or renal disease.[11] For severe hypertension, treatment with intravenous labetalol or intravenous hydralazine is typically recommended. However, if intravenous access has not been established, immediate-release oral nifedipine may be administered (Data Supplement Figure 2).[11] Intravenous

nitroglycerin is the preferred drug when preeclampsia is associated with pulmonary edema. For the prevention of eclampsia and treatment of seizures, intravenous magnesium sulfate is recommended. However, there is a potential synergy with calcium channel blockers, which can result in hypotension.[3,11]

Less severe hypertension can be managed with labetalol, nifedipine, and methyldopa, which are commonly used as first-line antihypertensive medications. Hydrochlorothiazide can be used as a second-line agent in patients with developing hypertension.[3,12] In a meta-analysis of 49 trials in pregnant women with mild to moderate hypertension (systolic blood pressure of 140–169 mm Hg and diastolic blood pressure of 90–109 mm Hg), antihypertensive medications reduced the risk of developing severe hypertension, but it was no better than placebo at preventing maternal complications (preeclampsia, death) or neonatal outcomes (preterm birth, babies who were small for gestational age, or neonatal/perinatal death).[22] One large multicenter international trial of women with preexisting or gestational hypertension compared fetal and maternal complications of patients with less tight and those with tight blood pressure control. In this trial, there were no significant differences in adverse perinatal outcomes or overall maternal complications between the blood pressure control groups. However, there was a significantly higher frequency of severe maternal hypertension in the less tight blood pressure control group.[23] Several consensus and guideline statements in this area are published, but there is no clear consensus on the optimal blood pressure threshold to initiate antihypertensive treatment or to target blood pressure in women with nonsevere HDP.[3,11,12,24,25]

Maternal risk stratification is needed to help guide patient care, including timing of delivery, and may help improve cardiovascular outcomes. One such model is the fullPIERS model (Preeclampsia Integrated Estimate of Risk), which was developed to identify predictors of adverse maternal outcomes in women who were admitted with preeclampsia or developed it after admission. Predictors included gestational age, symptoms of chest pain or dyspnea, oxygen saturation levels, platelet count, and serum creatinine and aspartate transaminase concentrations. In this multivariate model, blood pressure did not independently predict adverse maternal outcomes, and it was largely felt to be the only element for which an easy intervention is possible.[26]

For women with HDP requiring antihypertensive therapy, early outpatient blood pressure surveillance during the first 1 to 2 weeks postpartum is encouraged. Antihypertensive therapy should be continued in postpartum patients with persistent hypertension (≥150/100 mm Hg). Blood pressure control continues to be an important consideration in the postpartum period because even those women who are not treated with antihypertensive medications during pregnancy may warrant close surveillance, monitoring, and initiation of medications in the postpartum time frame. An important recognition is that severe hypertension or superimposed preeclampsia also may develop for the first time in the postpartum period; therefore, early ambulatory visits in the first 1 to 2 weeks after delivery or home blood pressure monitoring may be prudent. Medication in the first few weeks postpartum should be adjusted to maintain a systolic blood pressure not higher than 150 mm Hg and a diastolic blood pressure not higher than 100 mm Hg. For those women with persistent hypertension beyond 6 weeks to 3 months postpartum, blood pressure management should be initiated as per the current American College of Cardiology/AHA guidelines and on an individualized basis.[12,24]

Hypercholesterolemia in Pregnancy

Total cholesterol, triglycerides, and low-density lipoproteins levels rise steadily during pregnancy and reach peak levels at the time of delivery. However, neither triglycerides nor total cholesterol exceeds 250 mg/dL in normal pregnancies.[27] After delivery, major lipoprotein levels decline over the next 3 months to near prepregnancy levels (Data Supplement Figure 3). According to the 2018 multisociety guideline on the management of blood cholesterol, estimation of atherosclerotic CVD risk and documentation of baseline low-density lipoproteins with a lipid panel are recommended for adults who are ≥20 years of age and not on lipid-lowering therapy.[28] However given the variation in lipids during pregnancy, it is preferable to screen for dyslipidemia before pregnancy according to the National Lipid Association's recommendations for patient-centered management of dyslipidemia.[29]

The 2 most common conditions in which lipids should be addressed during pregnancy are severe hypertriglyceridemia and familial hypercholesterolemia; however, pharmacological treatment is limited because of fetal risks. Pregnancy-related complications such as preeclampsia and gestational diabetes mellitus are associated with triglyceride levels >250 mg/dL.[27] A heart-healthy lifestyle (diet, exercise, weight management) is recommended for all patients. Those with very high triglyceride levels (>500 mg/dL) are at risk for pancreatitis and may benefit from pharmacological agents (omega-3 fatty acids with or without fenofibrate or gemfibrozil) during the second trimester. The risk for premature atherosclerosis is elevated in patients with familial hypercholesterolemia, and during pregnancy, this risk may be further exacerbated by supernormal atherogenic lipoproteins while the patient is off statin therapy. Statins are contraindicated during pregnancy, and all women who are on any lipid-lowering agents should review with their physician the safety of treatment during pregnancy and whether to discontinue treatment

before pregnancy. Current treatment options for pregnant women with familial hypercholesterolemia include bile acid sequestrants, which lack systemic circulation, and, as last resort, low-density lipoprotein apheresis in severe cases (Data Supplement Figure 4).[28,29]

Ischemic Heart Disease in Pregnancy

Ischemic heart disease during pregnancy constitutes a rare but potentially fatal condition. The risk of acute myocardial infarction (MI) is 3- to 4-fold higher in pregnant women compared with their nonpregnant counterparts. The incidence is between 2.8 and 8.1 cases per 100 000 deliveries, with mortality rates of 4.5% to 7.3%.[30–32] Although atherosclerosis accounts for <50% of patients,[33] pregnancy-related spontaneous coronary artery dissection and MI with nonobstructive coronary arteries are prevalent causes (Data Supplement Figure 5) of acute MI in pregnancy.[34] The third trimester and postpartum are the highest-risk periods.[32,34]

A multidisciplinary team approach should be adopted,[4] and the treatment strategy is guided by the clinical presentation. In patients with atherosclerotic ST-segment– elevation MI, timely coronary reperfusion by percutaneous coronary intervention (PCI) is recommended.[35] Fetal radiation protection with lead shielding and radiation reduction measures should be implemented.[36] If PCI is not readily available, thrombolysis is very rarely used and has been administered with extreme caution because of the risk of maternal hemorrhage.[37,38] An invasive approach is also recommended in patients with non–ST-segment–elevation MI who are unstable or have high atherosclerotic burden. Stable patients at low risk can be managed conservatively.[39]

Angiography is the gold standard for the diagnosis of ischemic heart disease in pregnancy (Data Supplement Figure 6). In the case of atherosclerotic plaque rupture or coronary thrombosis, PCI with stent implantation is recommended.[35,40] Because pregnant women were generally excluded from stent trials, scarce evidence is available for this population. Post-PCI low-dose aspirin is considered safe throughout pregnancy, and clopidogrel may be used with caution for the shortest duration possible. Other antiplatelet agents should be avoided.[9]

Pregnancy-related spontaneous coronary artery dissection is a challenging diagnosis in clinical practice (Data Supplement Table 4).[41] Similar to the general population, conservative management with inpatient monitoring is recommended for most patients,[42] with a high rate of lesion recovery within months of its occurrence.[43,44] Radial forces generated by balloon inflation or stent expansion may broaden the dissection, resulting in procedural failure.[43–45] PCI should be performed only in a patient presenting with left main coronary artery dissection, hemodynamic instability, recurrent chest pain, or ongoing ischemia.[42,43] Although pharmacotherapy in this clinical scenario is not well established, antiplatelet agents combined with β-blockers (ie, labetalol) represent the most accepted regimen.[3,45,46] MI with nonobstructive coronary arteries should be considered a working diagnosis warranting further investigation. The recent AHA scientific statement on MI with nonobstructive coronary arteries offers a comprehensive diagnostic algorithm.[47] Treatment should be tailored to the underlying pathophysiology.

Pregnancy in women with preexisting coronary artery disease is considered to be very high risk. The probability of developing ischemic complications is ≈10%, and only 21% of women have a completely uncomplicated pregnancy.[48] In those patients with prior spontaneous coronary artery dissection, LV dysfunction, and signs of residual ischemia, consultation and shared decision-making with the cardio-obstetrics team are essential when these women are counseled about the increased cardiovascular risks with future pregnancy.[39] Women with a history of these conditions who become pregnant should be monitored very closely.

Cardiomyopathies in Pregnancy

The diagnosis and management of cardiomyopathy during pregnancy are challenging because both dilated cardiomyopathy and peripartum cardiomyopathy (PPCM) may represent a condition within a spectrum of similar pathophysiology. Therefore, it is important to exclude reversible causes of left ventricular dysfunction (eg, myocarditis, hypertension, underlying valve disease, toxin-induced, ischemia).[49] PPCM is defined as new-onset cardiomyopathy with systolic dysfunction (LV ejection fraction <45%) without a reversible cause presenting near the end of pregnancy or in the postpartum period in a woman without known heart disease and is a significant cause of maternal morbidity and mortality.[50] The prognosis for women with PPCM is strongly linked to LV ejection fraction at presentation. The IPAC study (Investigations of Pregnancy Associated Cardiomyopathy) followed up 100 women with PPCM with echocardiography during the first postpartum year and determined that recovery of LV function occurred almost exclusively within the first 6 months postpartum, with little subsequent change. In addition, major cardiovascular events (heart transplantation, LV assist device, or death) occurred almost exclusively in women with an ejection fraction of <30%.[51] Treatment of heart failure during pregnancy is directed at controlling volume status (eg, diuretics), afterload reduction (eg, nitrates, hydralazine), rhythm control (eg, β-blockers, digoxin), and anticoagulation if necessary (Data Supplement Figure 7). Many causes of PPCM have been proposed, and animal models of suppression of prolactin production have been shown to prevent the development of PPCM. Bromocriptine, which

suppresses prolactin production, has been shown to be associated with improvement in LV function[52] and may be considered as adjunctive treatment in women with PPCM according to the 2018 European Society of Cardiology guidelines for the management of CVD during pregnancy.[3] Appropriate contraception choices and risk in future pregnancies of recurrent PPCM must be discussed early in the management of these women.[53]

The management of pregnant women with other forms of cardiomyopathies is often determined by the individual's physiology and the severity of the condition. For example, some women with hypertrophic cardiomyopathy tolerate pregnancy well. However, up to 23% of women experience heart failure or arrhythmia-related complications during pregnancy, most commonly in the third trimester or postpartum.[54] Treatment should be tailored for specific indications (eg, β-blockers for LV outflow tract obstruction or arrhythmias). Diuretics must be used cautiously for volume overload because many of these women need to maintain preload in the setting of LV outflow tract obstruction.[55] Particular attention must be paid in the early postpartum period, when dramatic fluid shifts and changes in afterload may worsen underlying hemodynamics.

Arrhythmias in Pregnancy

Data gathered between 2000 and 2012 in 57 million pregnancies have shown a rise in the number of pregnancy-related hospitalizations for arrhythmias, a finding that has been felt to be related to increasing numbers of women pursuing pregnancy at advanced maternal age, particularly in women 41 to 50 years of age.[56] Pregnant black women have an increased frequency of any arrhythmia compared with women in other ethnic groups.[57] Palpitations caused by sinus tachycardia and atrial and ventricular ectopy are usually self-limited and benign and require no pharmacological treatment.[58] More complex arrhythmias require a cardio-obstetrics team approach, and management strategies may include initiation or titration of antiarrhythmic therapy or consideration of an electrophysiological study and radiofrequency ablation.

Sustained arrhythmias are more frequent in patients with underlying structural heart disease or thyroid or electrolyte disturbances. Stable supraventricular tachycardia treatment should be no different in pregnant patients, and if vagal maneuvers fail, then intravenous adenosine may be used.[59] Wolff-Parkinson-White syndrome can worsen during pregnancy[60]; intravenous procainamide can be used for wide-complex tachyarrhythmia.[61] Catheter ablation for atrial arrhythmias may be needed if medical therapy fails, ideally with minimal radiation exposure.[62,63]

New-onset atrial fibrillation in pregnancy usually indicates underlying heart disease and should be treated on an inpatient basis by a cardiologist.[64] If the patient is unstable, direct cardioversion is recommended over chemical cardioversion because it is highly safe and effective. Digoxin, β-blockers, and calcium channel blockers can be used for rate control; however, amiodarone should be avoided. If necessary, catheter ablation can be used for atrial flutter refractory to medication, avoiding/limiting fluoroscopy if possible and preferably delaying the ablation until the second trimester. For stroke prevention in patients with valvular heart disease or high stroke risk, vitamin K antagonists can be used after the first trimester, whereas low-molecular-weight heparin (LMWH) should be accompanied by periodic evaluation of anti–factor Xa.[64]

Prepregnancy counseling in women with congenital long-QT syndrome is advised to discuss the significantly increased risk of malignant tachyarrhythmias, and these women require β-blockade throughout pregnancy.[65] Recent American and European practice guidelines for the management of patients with ventricular arrhythmias outline nuances of management of this condition (Data Supplement Table 5).[66,67] Because there are no trials, registry data, or systematic analyses, data on the safety of antiarrhythmic drugs are limited. In patients with severely symptomatic bradycardia, a pacemaker is indicated regardless of pregnancy status.

Synchronized cardioversion is used if there is hemodynamically significant supraventricular tachycardia, atrial fibrillation, and ventricular tachyarrhythmia, similar to nonpregnant patients.[68] In the event of hemodynamic compromise, treatment is similar to that in a nonpregnant patient with direct unsynchronized cardioversion.[69] There are limited human reports on pharmacological therapy for the treatment of sustained ventricular tachycardia in hemodynamically stable patients; in general, intravenous procainamide and lidocaine are considered safe.[70] Data Supplement Table 6 summarizes antiarrhythmic treatment options for pregnant patients according to underlying arrhythmia.

Valvular Heart Disease in Pregnancy

Valvular heart disease pathologies in women of childbearing age are most commonly congenital but may include rheumatic, acquired, and native degenerative causes. Many young women have undergone preconception valvular repair or replacement. Regardless of pathogenesis and prior treatment, women with a history of valvular heart disease should undergo preconception evaluation by the cardio-obstetrics team. Safety and potential risks should be discussed before pregnancy, including in those with mechanical prosthetic valves or moderate to severe native regurgitant or left-sided stenotic valvular lesions and those with associated ventricular dysfunction or pulmonary hypertension. Frequency of monitoring, composition of the care team,

delivery planning, and management during pregnancy are determined on the basis of patient risk.[2,5,71–76] The recently published ACOG guidelines recommend the estimation of risk and subsequent management with the modified WHO classification (Data Supplement Table 2).[4,77] Ideally, severe valvular heart disease should be treated before conception. Clinical judgment prevails in each case; however, consideration should be given to performing valvular repair/replacement with a bioprosthesis to minimize the need for therapeutic anticoagulation during pregnancy.[4,78]

Left-sided stenotic valvular lesions are associated with the highest-risk valve lesion in pregnancy. A summary of the clinical features is presented in Data Supplement Table 7. Symptoms may develop in previously asymptomatic patients because increased blood volume, higher heart rate, and diminished cardiac output exaggerate stenotic physiology. Pregnancy-related hemodynamic changes lead to expected physiological augmenting of derived velocity, and imaging specialists must be aware of these normal changes when interpreting studies performed throughout pregnancy. Mitral stenosis, most commonly from rheumatic heart disease, is associated with increased maternal and fetal morbidity and mortality. Untreated mitral stenosis can lead to heart failure with pulmonary edema, atrial arrhythmias, cerebrovascular events, and death.[77,79,80] Although the cardiovascular risk profile of mitral stenosis in pregnancy has changed over time, the risks escalate with increasing severity of stenosis.[81] β-1–Selective β-blockers along with activity restriction are the primary treatment recommendations for patients with mitral stenosis who either are symptomatic or have significant pulmonary hypertension. Percutaneous mitral commissurotomy can be performed in pregnant (preferably after 20 weeks of gestation) patients with mitral stenosis with severe symptomatic heart failure or significant pulmonary artery hypertension despite optimal medical management.[3] While typically associated with better outcomes than mitral stenosis, severe aortic stenosis can also be associated with increased maternal cardiovascular risk during pregnancy, including heart failure, arrhythmias, and rarely death.[82] Adverse fetal outcomes include prematurity and fetal growth restriction, with the highest risk again occurring in those with more severe aortic stenosis. The management of women who are contemplating pregnancy or who are already pregnant is guided largely by the severity of aortic stenosis and whether symptoms are present.[83]

Valvular regurgitant lesions are generally well tolerated in pregnancy. These lesions are less likely to cause complications because diminished afterload is present as a result of low-resistance placental circulation and an expected decrease in systemic vascular resistance. However, the presence of ongoing symptoms despite optimal medical therapy before pregnancy should lead to consideration of valvular repair or replacement before conception.[84,85] Even if stable throughout pregnancy, women with valvular regurgitant lesions may be at risk for developing pulmonary edema postpartum when systemic vascular resistance abruptly increases in the setting of high total body volume.[86]

Pregnancy in women with mechanical prosthetic heart valves is associated with increased risk of fetal and maternal morbidity and mortality.[4,75,76,78] Maternal risks include increased mortality, valve thrombosis–associated valvular dysfunction, heart failure, stroke, and maternal hemorrhage. Risks to the fetus include increased mortality, teratogenicity, and hemorrhage.[75,78,87] The optimal strategy for maintenance of anticoagulation during pregnancy in women with prosthetic heart valves remains controversial. Given the known dose-dependent teratogenicity, the 2014 AHA/American College of Cardiology Guideline for the Management of Patients with Valvular Heart Disease and the 2018 European Society of Cardiology Guideline for the Management of CVD During Pregnancy recommend continuing warfarin if therapeutic anticoagulation can be maintained at a dose ≤5 mg/d.[3,85] If the dose of warfarin required to maintain therapeutic anticoagulation exceeds 5 mg/d or the patient prefers to avoid warfarin, suggested alternatives include dose-adjusted LMWH (guided by weekly peak and consideration of trough anti–factor Xa levels, targeting a range of 0.8–1.2 U/mL) or dose-adjusted continuous unfractionated heparin (UFH). Warfarin can be resumed safely in the second trimester and then transitioned to dose-adjusted continuous UFH in anticipation of delivery. Brief cessation of anticoagulation is required before delivery. With regard to labor and delivery, the use of epidural anesthesia is contraindicated in the anticoagulated patient. The American Society of Regional Anesthesia and the Society for Obstetric Anesthesia and Perinatology recommend holding intravenous UFH for 4 to 6 hours and LMWH for 24 hours before the administration of epidural anesthesia.[88,89] The 2018 European Society of Cardiology guidelines for the management of CVD during pregnancy recommend planned delivery in women with mechanical valves. These women should be hospitalized and placed on intravenous UFH or LMWH with close monitoring at 36 weeks, and at ≈36 hours before planned delivery, they should be on intravenous UFH, which is recommended to be discontinued 4 to 6 hours before delivery. Intravenous UFH can be restarted as early as 4 to 6 hours after delivery, depending on the type of delivery and whether there were bleeding complications.[3] Cesarean section should be performed in women who go into labor while therapeutically anticoagulated with warfarin because of the risk of fetal hemorrhage associated with vaginal delivery.[3,5]

Aortic Disease and Pregnancy

Aortopathy in the pregnant woman carries substantial cardiovascular risk (modified WHO pregnancy risk category of III–IV, Data Supplement Table 2) because of the combination of hemodynamic changes and hormonally driven structural effects on the integrity of vascular/connective tissue.[90,91] Heritable fibrillinopathies, bicuspid valve–associated aortopathy, and Turner syndrome are a few of the many causes of aortopathy, which results in aneurysms and dissection in women of childbearing age. The heritability and syndromic features of genetic aortopathies are heterogeneous, as is the risk of pregnancy-associated maternal cardiovascular morbidity and mortality (Data Supplement Figure 8). Unfortunately, this contributes to the challenging nature of caring for these women in pregnancy.

Several published guidelines address prophylactic aortic root replacement to avoid spontaneous dissection.[84,85,92–95] However, data in pregnancy are less clear and may include consideration of absolute diameter and the ratio of cross section to height (Data Supplement Table 8). In general, a multipronged approach to women with aortopathy is required during the antepartum, peripartum, and postpartum periods with clinical

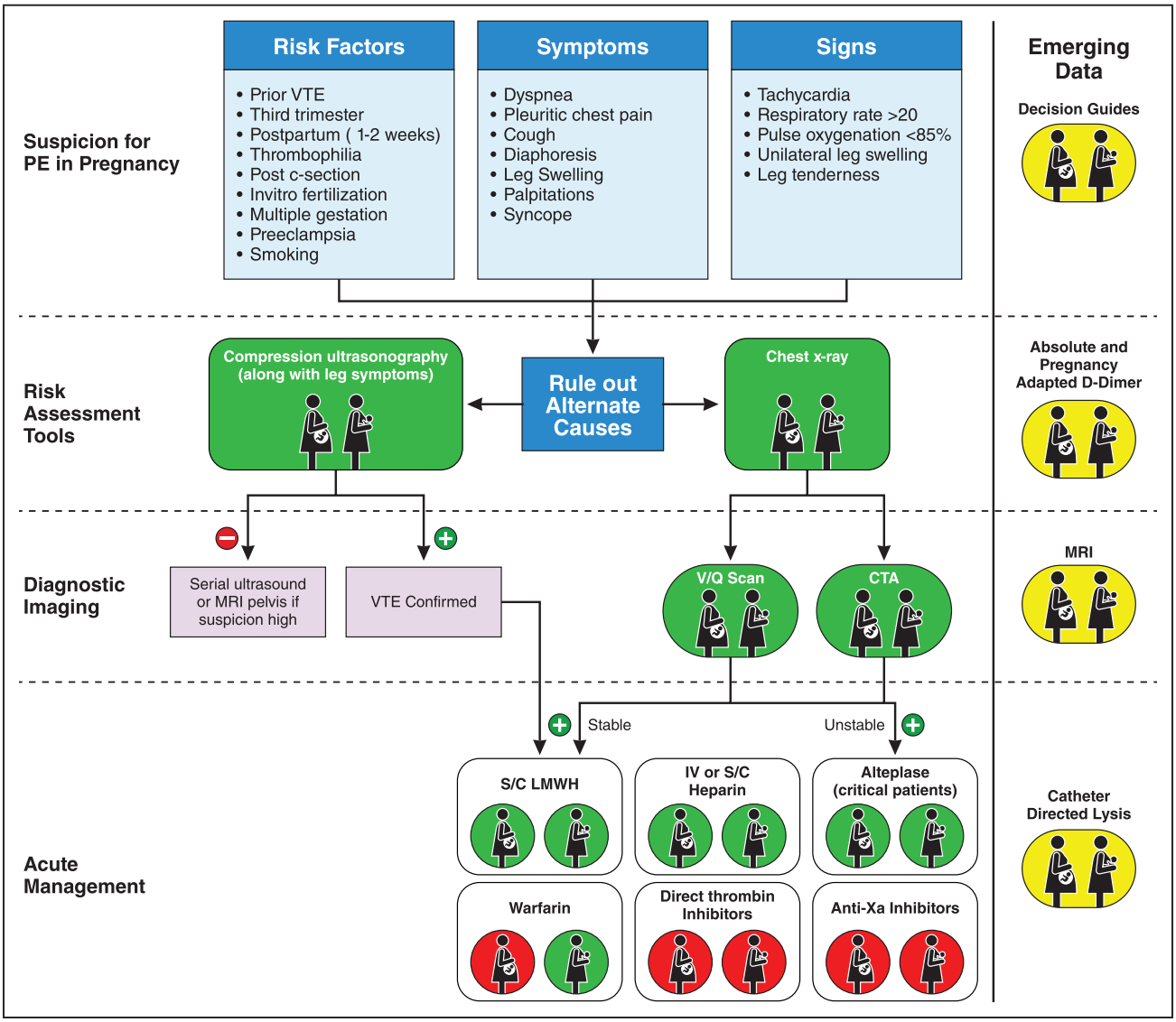

Figure 4. Proposed algorithm for the diagnosis of pulmonary embolism (PE) during pregnancy.[3,99–116]
Guidelines for diagnosing PE during pregnancy are limited and based on low-level evidence derived primarily from data from small observational trials. Acquired or inherited thrombophilia include lupus anticoagulant, shortened activated partial thromboplastin time, factor V Leiden, prothrombin variations, familial proteins C and S, and antithrombin deficiency. Other population-based risk factors include age; presence of autoimmune conditions, sickle cell disease, or obesity; history of cancer; or bed rest for >72 hours. Absolute cutoff for D-dimer is typically <500 μg for most commercial assays, and the adjusted cutoff may be <500 or <1000 μg or dependent on gestation.[101–103,108] Given the high risk of hemorrhage with systemic thrombolytics, particularly in the postpartum period, catheter-based thrombolysis may be considered as an alternative.[112] In stable patients, low-molecular-weight heparin (LMWH) is preferred over unfractionated heparin given the longer half-life, similar efficacy and safety, and lower risk of thrombocytopenia and osteoporosis.[97] CTA indicates computed tomographic angiography; IV, intravenous; MRI, magnetic resonance imaging; S/C, subcutaneous; V/Q, ventilation/perfusion; and VTE, venous thromboembolism.

evaluation of blood pressure and echocardiographic assessment of aortic dimensions. Consideration of pharmacological therapy with β-blockers for strict blood pressure control is recommended. Echocardiographic evaluation of the aorta should be performed during pregnancy (may be reasonable every 12 weeks in low-risk women with mildly dilated aorta and warranted every month in women with severely dilated aorta or at high risk of dissection) and at 6 months after delivery.[3] The cardio-obstetrics team approach would also include consideration of intervention if appropriate, multidisciplinary delivery planning, and postpartum follow-up (Data Supplement Figure 9), including when surgical replacement of the aorta is recommended (Data Supplement Table 8). During pregnancy, Stanford type A dissection is a surgical emergency that would necessitate cardiothoracic surgical intervention to rapidly deliver the fetus and repair the dissection. Conservative medical management, including strict blood pressure control, is recommended for stable type B aortic dissections.[3]

Deep Venous Thrombosis and Pulmonary Embolism in Pregnancy

Venous thromboembolism (VTE), referring to deep venous thrombosis (DVT) and pulmonary embolism (PE), is 4 to 5 times more common during pregnancy. However, the absolute risk of VTE during pregnancy remains low at 0.3% for PE and 1.2% for DVT, with the majority (70%) occurring in the postpartum period.[96,97] Accordingly, low rates of pregnancy-related PE have been reported in emergency department evaluations.[98]

DVT commonly presents with extremity pain or swelling and is diagnosed with compression ultrasonography. However, DVT in pregnancy is often proximal (iliac or iliofemoral) and predominantly left-sided.[96] Therefore, if ultrasonography is negative and clinical suspicion remains high, serial ultrasonography measurements in 3 to 7 days or magnetic resonance imaging of the pelvis should be considered.[3,99]

The diagnosis of PE is challenging because the presentation often overlaps with symptoms common during normal pregnancy (Figure 4). It therefore requires a high index of suspicion, particularly in the presence of risk factors such as a history of VTE or thrombophilia. One-third of patients with PE do not have any symptoms.[100] The initial evaluation for PE should include ECG, chest x-ray, and blood tests to rule out alternative causes such as ischemia, anemia, or infection. A clinician may weigh risk factors and presentation (Figure 4) to estimate pretest probability in order to guide the need for testing or early up-front therapy before obtaining imaging results.[3,99–116] However, there is no consensus on this approach. Recently, pregnancy-adapted decision algorithms have been proposed with promising early data, but they require validation in larger studies.[102–104]

D-dimer testing to rule out PE during pregnancy has remained controversial (Data Supplement Table 9). D-dimer physiologically increases with each trimester, leading to low specificity[101,105,117] and even, in rare cases, false negatives.[118,119] Emerging data support a negative predictive value of ≈100% for high-sensitivity D-dimer assay in low-risk patients, especially during the first and early second trimesters.[103,106,107,120] Further work is needed to determine normal levels for each week of gestation.[105,108]

A definitive diagnosis of PE requires imaging such as lung scintigraphy (ventilation/perfusion scan) or coronary tomographic angiography. The choice of diagnostic test should be based on institutional protocols, availability, and shared decision-making that involves a discussion of maternal and fetal risks with the patient (Data Supplement Table 10).[121] Coronary tomography and ventilation/perfusion scans have similar sensitivity, yet coronary tomographic angiography is often more readily available and more efficient with lower interobserver variability than the ventilation/perfusion scan in an emergency department setting. However, selection of the most appropriate test is often guided by local expertise and the level of radiation exposure.[108,122,123]

Once diagnosed, all VTE should be treated with antithrombotic therapy (Table 1). Intravenous UFH is recommended for acute PE and for DVT with large clot burden, for hemodynamic instability, and when surgery or delivery is anticipated. In stable patients, LMWH is preferred over UFH. Approximately 4% of pregnant patients with VTE experience cardiac arrest. Thrombolysis is recommended for patients with hemodynamic instability or massive PE.[37] Inferior vena cava filters may be considered only in cases in which anticoagulation is contraindicated or has failed.[124]

Cerebrovascular Disease in Pregnancy

Pregnancy introduces specific cerebrovascular risk factors uncommon in an otherwise healthy young-adult female population. Cerebrovascular risk is highest in the third trimester and within 6 weeks postpartum (puerperium) and includes ischemic stroke, cerebral venous thrombosis (CVT), intracerebral hemorrhage, reversible cerebral vasoconstriction syndrome (RCVS), and posterior reversible encephalopathy syndrome (PRES). In the United States, combined ischemic and hemorrhagic stroke risk is estimated to occur in 30 per 100 000 pregnancies.[125]

In a recent meta-analysis, the arterial ischemic stroke rate in pregnancy was 12.2 per 100 000 (separating arterial and venous thrombosis).[125] There are multiple risk factors for ischemic stroke in pregnancy, including hypertension, sickle cell disease, systemic lupus erythematosus, and migraines. Pathogenetic factors for stroke in

Table 1. Anticoagulation for Thromboembolic Events During Pregnancy

Drug	Teratogenic	Crosses Placenta	Compatibility with Breastfeeding	Antepartum Indications	Postpartum indications	Therapeutic Doses
Warfarin	Yes	Yes	Probably compatible	Atrial fibrillation/flutter, after first trimester (bridge with LMWH during first 6–12 wk of gestation)	DVT/PE	Individualized starting dose and adjusted to INR (goal 2.0–3.0 typically but may be higher with certain conditions such as mechanical valves)
Direct thrombin inhibitors (dabigatran)	Insufficient data	Yes	Avoid	Avoid	DVT/PE	150 mg twice a day
Anti–factor Xa inhibitors (rivaroxaban, apixaban, edoxabab, betrixaban)	Insufficient data	Yes	Avoid	Avoid	DVT/PE	Rivaroxaban 15 mg twice a day Apixaban 10 mg twice a day Edoxaban 60 mg once a day Betrixaban 160 mg once a day
UFH	No	No	Probably compatible	DVT/PE	DVT/PE	80 U/kg intravenous bolus followed by 18 $U \cdot kg^{-1} \cdot h^{-1}$ Subcutaneous 10 000 units every 12 h Therapeutic target aPTT is 1.5–2.5 times the control 6 h after injection (aPTT is at least 2 times the laboratory control in mechanical valves)
LMWH	No	No	Probably compatible	Atrial fibrillation/flutter, DVT/PE	Preferred	Enoxaparin 1 mg/kg subcutaneous every 12 h Deltaparin 200 U/kg once a day Tinzaparin 175 U/kg once a day Target is 0.6–1.0 U/mL anti–factor Xa level 4 h after last injection for twice-daily dosing regimen; may be higher for once-daily dosing injections (if mechanical valve present, then target anti–factor Xa level is 0.8–1.2 U/mL 4–6 h after dosing)
Fondaparinux	Insufficient data	Yes	Probably compatible	In cases of heparin allergy DVT/PE	In cases of heparin allergy DVT/PE	5 mg (body weight <55 kg) 7.5 mg (body weight 55–100 kg) 10 mg (body weight >100 kg)
Thrombolysis alteplase	No	No	No information	Massive PE or limb-threatening DVT	Massive PE or limb-threatening DVT	Intravenous 100 mg

aPTT indicates activated partial thromboplastin time; DVT, deep venous thrombosis; INR, international normalized ratio; LMWH, low-molecular-weight heparin; PE, pulmonary embolism; and UFH, unfractionated heparin.

Adapted from American College of Obstetricians and Gynecologists and American Society of Hematology guidelines.[109,113]

pregnancy include hypercoagulability, paradoxical embolism via patent foramen ovale, amniotic fluid embolism, arterial dissection, and cardioembolic phenomena resulting from PPCM.[125,126] Hypercoagulability in pregnancy is mediated by increased von Willebrand factor, factor VIII, plasminogen activators 1 and 2, and fibrinogen, as well as protein C resistance, reduced protein S concentration, and platelet aggregation caused by hyperprolactinemia, compressive and hemodynamic venous stasis, and endothelial trauma during delivery.[126] Elevated blood pressures are not the only cause of acute strokes in pregnancy. In fact, rates of cerebral hemorrhage are low in women with preeclampsia, including those with sustained severe hypertension. Another contributory cause of stroke in women with preeclampsia is endothelial dysfunction, which leads to proteinuria and edema and, as a result, injury to the normal blood-brain barrier system.[126,127]

Intravenous thrombolysis in acute ischemic stroke of the pregnant patient is still considered a relative contraindication in the absence of disabling deficits; however, retrospective studies have found it to be safe. In the setting of a disabling ischemic stroke, thrombolysis should be considered.[128] Patients with an indication for anticoagulation or antiplatelet therapy should follow the aforementioned pharmacological recommendations for ischemic stroke prevention during pregnancy and postpartum.[129–131]

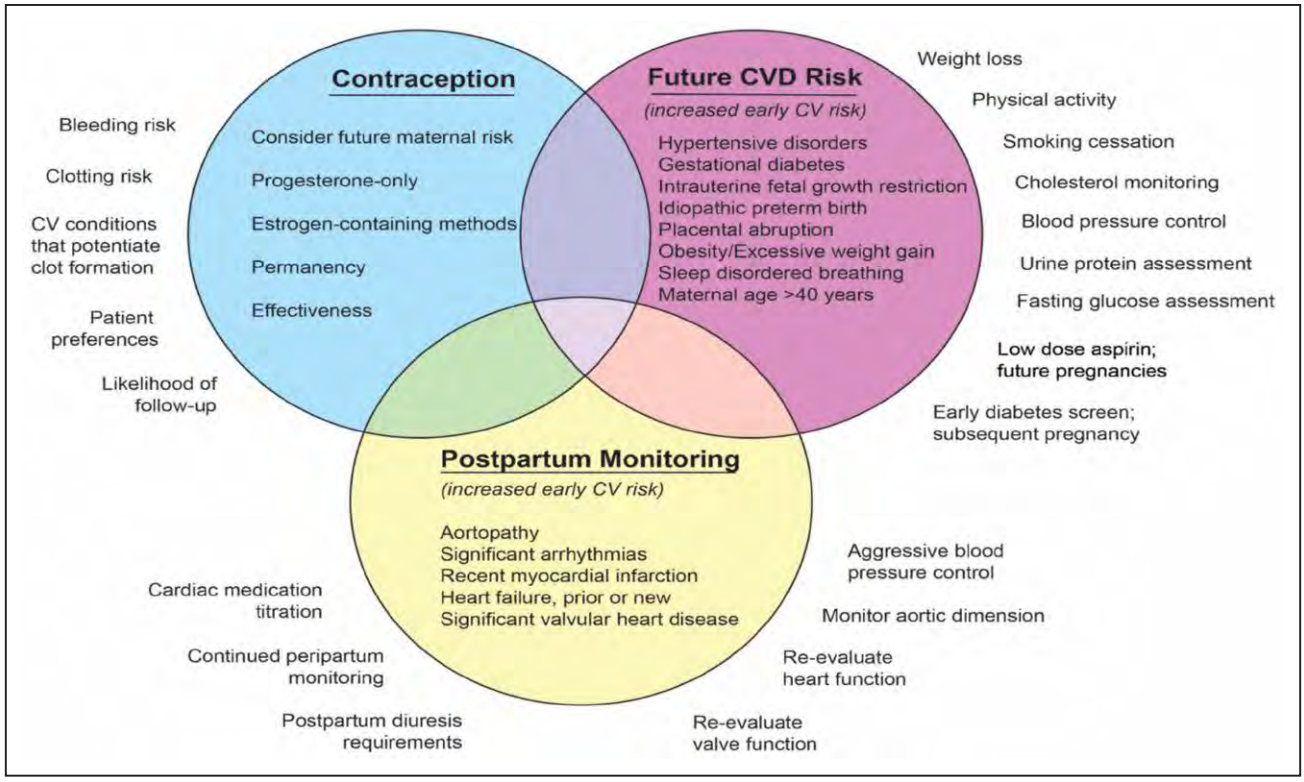

Figure 5. Postdelivery follow-up and late cardiovascular (CV) risk.
CVD indicates cardiovascular disease.

CVT rates pooled in a recent meta-analysis were 9.1 per 100 000 pregnancies, with pregnant and postpartum women making up 20% of adult patients with CVT.[125,132] In a recent retrospective case-control study of 813 cases and 6296 controls, CVT was associated with the puerperium, not with pregnancy.[133] The choice of anticoagulant for CVT should be guided by stage of pregnancy and breastfeeding status.[129]

Intracerebral hemorrhage and nonaneurysmal subarachnoid hemorrhage risk is also increased during pregnancy and puerperium, especially in the setting of preeclampsia and eclampsia. In a meta-analysis, the intracerebral hemorrhage rate was 12.2 per 100 000 pregnancies.[125] Risk factors for puerperium intracerebral hemorrhage include age >35 years, black race, preexisting hypertension, gestational hypertension, preeclampsia and eclampsia, coagulopathy, and tobacco use.[134] Intracerebral aneurysms and vascular malformations pose increased risk during pregnancy.[128,134] Prepregnancy counseling in patients with known vascular malformations should include vascular neurology and neurosurgical evaluation with lesion-specific monitoring.

Both RCVS and PRES are associated with preeclampsia and eclampsia and are considered to be secondary to dysfunctional cerebral autoregulation.[135] RCVS typically presents with a thunderclap headache (reaching peak intensity within ≤1 minute). Compared with nonpregnant populations, PRES tends to present with a higher prevalence of headaches and less encephalopathy in pregnant women. RCVS and PRES can occur at the same time and can manifest with convexity nonaneurysmal subarachnoid hemorrhage. Treatment for RCVS may include calcium channel blockade (nifedipine) and magnesium. PRES is treated with hypertension management.[135]

Neurological emergencies may warrant the use of computed tomography and contrast dye; however, when able/indicated, magnetic resonance imaging and angiography are the preferential modalities to avoid radiation and contrast dye exposure. Given the breadth of cerebrovascular disease that presents during pregnancy and the puerperium, it is important to thoroughly evaluate neurological symptoms in pregnancy and to seek expert consultation (Data Supplement Figure 10).

TIMING AND MODE OF DELIVERY

Contemporary approaches to labor and delivery favor spontaneous labor and vaginal birth for the majority of women with heart disease in pregnancy.[3,5,136] Cesarean delivery is known to carry increased risk of infectious morbidity and thrombotic complications and increased blood loss.[137] In general, cesarean delivery should be reserved for obstetric indications such as breech presentation, failure to progress in labor, elective repeat cesarean delivery, and fetal heart rate abnormalities. Induction of labor may be recommended for care coordination for women planning to deliver at a tertiary care center that may not be close to home. There is evidence that induction of labor may

be protective against cesarean delivery and other obstetric morbidity and therefore should be used to facilitate care planning as needed.[138,139] Induction agents are generally safe in women with CVD. The cardio-obstetrics team will determine delivery plans, including determination of which patients should not deliver vaginally or require assisted second stage of labor.[4] Many hemodynamic changes occur during labor and delivery, particularly in the second stage of labor during Valsalva. For the highest-risk gravidas, it may be appropriate to allow passive descent of the fetal head during the second stage and assist with either forceps or vacuum for delivery when the head reaches the perineum. Cesarean delivery for the indication of cardiac disease should be reserved for the most decompensated women for whom delivery needs to be achieved in the shortest time possible and for women who are fully anticoagulated with vitamin K antagonists in order to protect the fetus from hemorrhagic complications.

The timing of delivery may be a contentious topic because the care team is often weighing maternal, obstetric, and fetal risks, and should include input from the cardio-obstetrics team. The ACOG recommends elective induction of labor for pregnant women with cardiac disease between 39 and 40 weeks of gestation in patients who do not have spontaneous onset of labor or clinical indications for preterm delivery. The timing of delivery for women with active, maternal, or fetal conditions is highly variable according to the underlying medical problem.[4] The ACOG literature does not provide specific information about delivery timing in WHO class IV maternal cardiac conditions; thus, these decisions are frequently made on a case-by-case basis by the high-risk cardio-obstetric team.[140]

POSTPARTUM FOLLOW-UP

The peripartum admission offers an excellent time to discuss the possibility of future pregnancy, contraception, follow-up needs, and the likelihood of late cardiovascular risk. Unique considerations exist prospectively in each of these areas and are often directly related to the specific type of underlying CVD (Figure 5).

Ideally, contraceptive plans have been made in the antepartum period, but if not, contraception should be discussed and offered before discharge. Many long-acting reversible contraceptives such as the intrauterine device or progesterone-only subdermal implants can be used in the immediate postpartum period. Thrombogenic conditions (complex congenital heart disease, cyanotic heart disease, VTE risk), rheumatological conditions, and bleeding risk (women on dual antiplatelet therapy, cyanotic heart disease) need to be carefully considered during the selection of the type of contraception offered. The Centers for Disease Control and Prevention Medical Eligibility Criteria for Contraceptive Use is the trusted resource to consult in the evaluation of contraception safety and appropriateness

Table 2. Approach to Contraceptive Use in Women With CVD

Condition	Subcondition	IUD	Implant	DMPA	POP	CHC
DVT/PE	Remote, not receiving anticoagulation	R	R	R	R	U
	Acute	R	R	R	R	U
	History, receiving ≥3 mo of anticoagulation	R	R	R	R	U
	Family history (first-degree relative)	R	R	R	R	R
High blood pressure in pregnancy	History in prior pregnancy	R	R	R	R	R
Hypertension	Controlled	R	R	R	R	U
	SBP >140–159 mm Hg, DBP >90–99 mm Hg	R	R	R	R	U
	SBP >160 mm Hg, DBP >100 mm Hg	R	R	U	R	U
	Vascular disease	R	R	U	R	U
IHD	Current	Variable depending on whether IHD is present before vs after contraception. Copper IUD safe. For progesterone-IUD, implants, DMPA, and POP, risk likely outweighs benefit. CHC should be avoided.				
Multiple cardiovascular risk factors	Tobacco, diabetes mellitus, hypertension, older age, dyslipidemia	R	R	U	R	U
PPCM	Normal/mild systolic dysfunction	R	R	R	R	U
	Moderate to severe systolic dysfunction	R	R	R	R	U
Valvular heart disease	Uncomplicated	R	R	R	R	R
	Complicated*	R	R	R	R	U

CHC indicates combined hormonal contraception; CVD, cardiovascular disease; DMPA, depot medroxyprogesterone acetate; DBP, diastolic blood pressure; DVT, deep venous thrombosis; IHD, ischemic heart disease; IUD, intrauterine device; PE, pulmonary embolism; POP, progestin-only pill; PPCM, peripartum cardiomyopathy; R, reasonable (benefit outweighs risk); SBP, systolic blood pressure; and U, unreasonable (risk outweighs benefit).

*Defined as a condition that places the woman at an increased risk as a result of pregnancy.

Adapted from Curtis et al.[141]

in the context of general underlying medical conditions, including CVD (Table 2).[141]

In general terms, specific types of maternal CVD affect immediate and postdischarge monitoring requirements. Early after delivery, women with preexisting or new heart failure, significant arrhythmia, severe valve disease, aortopathy, or recent MI will require continued invasive monitoring until postdelivery hemodynamic stability is achieved. In some cases such as patients with aortopathy or the development of new PPCM, risk continues throughout the fourth trimester and beyond. These women require specialized long-term cardiovascular follow-up.

Adverse pregnancy outcomes such as preterm birth and HDP, including gestational hypertension and preeclampsia, gestational diabetes mellitus, and small for gestational age, are a group of interrelated disorders that share common pathways and are thought to be caused by placental dysfunction and oxidative stress.[142] These adverse pregnancy outcomes are associated with increased risk of future CVD (hypertension, ischemic heart disease, stroke)[17,143–146] and are included in the 2018 multisociety guideline on the management of blood cholesterol as cardiovascular risk–enhancing conditions.[28] These patients warrant follow-up in the fourth trimester, at which time aggressive risk factor modification should be undertaken and future risk should be discussed with the patient.[4]

CONCLUSIONS

CVD is the primary causative condition related to the maternal mortality in the United States. Advancing maternal age and preexisting comorbid conditions (including congenital heart disease) have contributed to the increased rates of maternal mortality. Preconception counseling and early involvement of the multidisciplinary cardio-obstetrics team are warranted in order to provide a comprehensive review of maternal and fetal risks associated with pregnancy. In women with a high-risk pregnancy, a cardio-obstetrics team is essential to prevent maternal morbidity and mortality during the length of the pregnancy and postpartum.

ARTICLE INFORMATION

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

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*Modest.

†Significant.

Reviewer Disclosures

Reviewer	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
Juan M. Gonzalez	University of California, San Francisco	None	None	None	None	None	None	None
Rupa Mehta-Sanghani	Rush University Medical Center	None	None	None	None	None	None	None
Erin D. Michos	Johns Hopkins University School of Medicine	None	None	None	None	None	None	None
Nandita S. Srividya Scott	Massachusetts General Hospital	None	None	None	None	None	None	None

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Ensuring a Heart-Healthy Pregnancy

Heartmail

FEBRUARY 01, 2020

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Although cardiovascular disease is the leading cause of death in the United States, it has not been widely recognized that many types of heart disease can and do affect women of childbearing age. But that is rapidly changing.

Collaborating with specialists in BIDMC's Division of Maternal and Fetal Medicine and in the Department of Anesthesia, Feinberg and colleagues in the Women's Cardiovascular Health program provide a highly specialized treatment approach for women with underlying cardiovascular issues who want to become pregnant as well as for women who develop cardiac problems during pregnancy. "By working together, we can identify potential problems and carefully coordinate care before, during and after a woman's pregnancy and delivery," says Feinberg.

Before Pregnancy: Have a Preconception Evaluation

For many patients, cardiac care begins before conception.

"A preconception cardiac evaluation is always recommended for women with underlying cardiovascular disease of any type," says Feinberg. Women who were born with congenital heart defects or have valve disease, coronary artery disease, as well as women who have arrhythmias or heart failure, should schedule an appointment for a cardiac evaluation before they become pregnant.

This comprehensive evaluation may include genetic assessment and evaluation of a woman's exercise capacity, as well as risk assessments for both mother and fetus. In addition, specific cardiac testing may be included.

Women who are becoming pregnant at later ages as well as women with a family history of heart disease or underlying risk factors can also benefit from a preconception evaluation.

"The average age of first-time mothers has steadily risen over the past several decades," says Melissa Spiel, DO, a Maternal and Fetal Medicine specialist at BIDMC who treats women with high-risk pregnancies . "With age comes a higher risk of heart complications, especially when compounded by preexisting conditions such as hypertension, diabetes and obesity. These may lead to a number of pregnancy complications, including a dangerous condition called preeclampsia."

By identifying possible issues prior to pregnancy, she adds, specialists can help mothers-to-be to avoid potentially serious problems.

During and After Pregnancy: Awareness and Prevention

Because many common symptoms of heart disease and heart attack are similar to symptoms encountered in mid-to-late-stage pregnancy, cardiovascular issues can be particularly difficult to identify.

complaints during pregnancy," says Spiel. "But it shouldn't be automatically assumed that these are just normal pregnancy symptoms." If these are not going away or are progressing , women should contact their doctor or health care provider and arrange to be seen right away.

Pregnancy puts a strain on a woman's cardiovascular system and by the third trimester, the amount of blood in a mother's body increases by as much as 50 percent, meaning the heart must work harder to pump blood. It's also normal for heart rate to increase.

"These normal changes during pregnancy can complicate preexisting cardiovascular conditions and, in some cases, can lead to the development of new cardiovascular issues," says Feinberg, adding that recent research has shown that women who have high blood pressure, preeclampsia, eclampsia or gestational diabetes during first pregnancies are more likely to develop long-term heart disease.

"It's important to identify and treat women who are at risk of problems before they develop lifelong cardiac disease," says Feinberg. "Ideally, taking care of your heart before conception can be key to healthy outcomes during pregnancy. Managing weight and underlying conditions such as high blood pressure or high cholesterol can significantly reduce the risk of problems and help ensure that mother and baby stay safe and healthy."

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Cardio Obstetrics Program

Overview

UR Medicine has a unique multidisciplinary program for pregnant people with cardiac disease. The Cardio Obstetrics Program at UR Medicine is the only program of its kind in Upstate New York.

Although having a baby is an exciting time, having cardiac disease can put both parent and baby at risk for complications before and during delivery. There are normal changes that the body undergoes during pregnancy to support the developing baby; however, for those with cardiac disease, these changes can put additional strain on the heart.

Individuals with cardiac conditions who are considering pregnancy or who are pregnant should be cared for by a team of specialists. This can help reduce risks of heart disease and provide families with the support and treatment they need during the extraordinary, but often difficult, months of pregnancy.

What to Expect from the Cardio Obstetrics Program

Women with cardiac conditions are followed under the UR Medicine Cardio Obstetrics Program. This integrative, multidisciplinary team of physicians and care providers includ those from the following Divisions and Departments:

- Adult Cardiology

- Adult Congenital Heart Disease
- Cardiac Anesthesia
- Cardiac Intensive Care
- High-Risk Obstetrics
- Obstetric Anesthesia
- Pediatric Cardiology

Every other month, the Cardio Obstetrics Team (including extended members such as care coordinators and inpatient nursing) reviews every patient with complex heart disease who is pregnant. This ensures the cardiac and inpatient teams are fully prepared to manage your overall pregnancy care and delivery care.

Care Coordination

Our outpatient provider teams will help with coordinating appointments, answering questions, and keeping you and your family informed of planned services and test results.

Reproductive Genetics

Our integrated office offers reproductive genetics services, which can help determine if a specific cardiac disease can be passed on to your child. We will also explain the screening options for common pregnancy concerns.

Level II OB/GYN Ultrasound and Fetal Echocardiogram

Pregnant individuals with structural heart differences are at higher risk for their child having structural heart differences. We offer AIUM certified Level II OB/GYN ultrasound including fetal echocardiography, assuring fetal assessment and fetal monitoring is available on-site. This allows the team to have all the information available to help guide pregnancy management. We also work collaboratively with our Pediatric Cardiology colleagues and our NICU to provide comprehensive care for our patients.

Pregnancy Planning

Planned pregnancies are healthy pregnancies. If you have pre-existing cardiac disease and are considering your reproductive options our team is happy to discuss pregnancy risks and make sure you enter pregnancy as healthy as possible.

Contraceptive Services

Cardiac disease can limit the options for contraception. Our team works closely with the UR Medicine Complex Contraception Clinic to ensure you have a full range of counseling and options.

What Sets Us Apart?

In addition to providing complex cardiac care, UR Medicine Maternal-Fetal Medicine offers referrals and care coordination for all aspects of reproductive care. We also offer easy access to a Behavioral Health Specialist to ensure our patients' mental health needs are supported.

UR Medicine Maternal-Fetal Medicine's obstetrics ultrasound unit is certified by the American Institute of Ultrasound in Medicine to perform Level 2 ultrasounds—these are more in-depth ultrasound evaluations for your infant(s). Our experienced Registered Diagnostic Medical Sonographers and state-of-the-art equipment including 3D/4D capabilities help diagnose effectively. We offer fetal assessment and fetal monitoring on-site at both of our office locations, giving our providers access to all the needed information available.

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Impact of the communication and patient hand-off tool SBAR on patient safety: a systematic review

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ABSTRACT

Objectives Communication breakdown is one of the main causes of adverse events in clinical routine, particularly in handover situations. The communication tool SBAR (situation, background, assessment and recommendation) was developed to increase handover quality and is widely assumed to increase patient safety. The objective of this review is to summarise the impact of the implementation of SBAR on patient safety.

Design A systematic review of articles published on SBAR was performed in PUBMED, EMBASE, CINAHL, Cochrane Library and PsycINFO in January 2017. All original research articles on SBAR fulfilling the following eligibility criteria were included: (1) SBAR was implemented into clinical routine, (2) the investigation of SBAR was the primary objective and (3) at least one patient outcome was reported.

Setting A wide range of settings within primary and secondary care and nursing homes.

Participants A variety of heath professionals including nurses and physicians.

Primary and secondary outcome measures Aspects of patient safety (patient outcomes) defined as the occurrence or incidence of adverse events.

Results Eight studies with a before–after design and three controlled clinical trials performed in different clinical settings met the inclusion criteria. The objectives of the studies were to improve team communication, patient hand-offs and communication in telephone calls from nurses to physicians. The studies were heterogeneous with regard to study characteristics, especially patient outcomes. In total, 26 different patient outcomes were measured, of which eight were reported to be significantly improved. Eleven were described as improved but no further statistical tests were reported, and six outcomes did not change significantly. Only one study reported a descriptive reduction in patient outcomes.

Conclusions This review found moderate evidence for improved patient safety through SBAR implementation, especially when used to structure communication over the phone. However, there is a lack of high-quality research on this widely used communication tool.

Trial registration none

Strengths and limitations of this study

- This systematic review was conducted in accordance with the Cochrane Collaboration standards using a validated tool for quality assessment of the identified studies.
- Five well-known databases as well as the references of the included studies were searched using an open search strategy.
- Reliability of the study selection, data extraction and rating of the study quality was ensured using two independent reviewers.
- Studies in which SBAR (situation, background, assessment and recommendation) was part of a larger quality improvement initiative and outcomes that did not measure the incidence of adverse events were not included in this review.
- The heterogeneity of the studies impeded to test for publication bias or to perform a meta-analysis.

INTRODUCTION

Patient safety is crucial for the delivery of effective, high-quality healthcare[1] and is defined by the World Alliance for Patient Safety of WHO as 'the reduction of risk of unnecessary harm associated with healthcare to an acceptable minimum'.[2] To illustrate the impact of patient safety on healthcare quality, the incidence of adverse events is commonly cited. Following the definition of Brennan *et al*,[3] adverse events are injuries that are caused by medical conduct resulting in prolonged hospitalisation and/or disability at the time of discharge. The Joint Commission reported that poor communication is a contributing factor in more than 60% of all hospital adverse events they reviewed.[4] Poor communication is found in many different healthcare settings and is especially prominent in patient hand-offs and settings where fast and effective management is indispensable. Such settings include the perioperative period,[5] the intensive care unit (ICU)[6] and the emergency department.[7] The components and processes of communications are complex and prone to misunderstanding.[8] To overcome these barriers, communication strategies are desirable, which take little time and effort to

Table 1 SBAR communication technique, adapted table [16 18 63 64]

		Questions	Description	Example
S	Situation	What is going on with the patient? What is the situation you are calling/ communicate about?	First, the speaker presents the situation, by identifying himself, stating the patient's name and briefly describing the problem	*'Dr Preston, I'm calling about Mr Lakewood, who's having trouble breathing'*
B	Background	What is the background or context on this patient?	The speaker then provides the background, such as the patient's diagnosis or reason for admission, medical status and relevant history. The patient's chart is reviewed and questions the other care provider may have are anticipated	*'He's a 54 year old man with chronic lung disease who has been sliding downhill, and now he's acutely worse'*
A	Assessment	What is the problem?	Then specific information on vital signs, recent laboratories and other quantitative or qualitative data related to the patient's current state are provided. This section can include a provisional diagnosis or clinical impression	*'I don't hear any breath sounds in his right chest. I think he has a pneumothorax'*
R	Recommendation	What is the next step in the management of the patient?	An informed suggestion for the continued care of the patient has to be made by the speaker. The immediate need is explained clearly and specifically, including what is necessary to address the problem	*'I need you to see him right now. I think he needs a chest tube'*

The tool is available for download from the website of the Institute for Healthcare Improvement.[9]

complete, deliver comprehensive information efficiently, encourage interprofessional collaboration and limit the probability of error.[9–11] The SBAR (situation, background, assessment, recommendation) instrument (see table 1) and its derivatives ISBAR, SBAR-R, ISBARR and ISOBAR fulfil this need and are widely used in different healthcare facilities as a communication and hand-off tool both intraprofessionally and interprofessionally.[12–15] By virtue of a clear structure, SBAR calls for the provision of all relevant information, organised in a logical fashion.[16] Furthermore, it enables a preparation before the communication process,[16 17] and because sender and receiver share the same mental model, understanding and awareness are expected to be higher.[18] Besides, it reduces inhibitions especially in hierarchical context by encouraging the sender to provide a personal assessment and suggestion of the situation ('Recommendation').[19] The SBAR tool is regarded as a communication technique that increases patient safety and is current 'best practice' to deliver information in critical situations.[16 20]

A number of studies have investigated 'soft' outcomes such as employee satisfaction[21 22] and interdisciplinary communication[19 23] in relation to SBAR. Positive resonances of employees after the introduction of SBAR were reported[24–28] with improvements of the communication perception and interdisciplinary teamwork[29–33] as well as the quality of the communication.[34–40] Especially in patient hand-off, the quality of the communication and the completeness of transferred information was increased after the implementation of SBAR.[41–44] Furthermore, less time was needed for the patient hand-off in several studies.[40 42 45]

However, the actual effect of SBAR on patient outcome is unclear. The wide adoption of SBAR (or any other communication strategy) without proven benefit may paradoxically limit improvements because a problem presumably solved will be less addressed. Thus, the purpose of this systematic review is to summarise the available evidence for and evaluate the impact of the implementation of SBAR in clinical settings on patient safety as measured by the incidence of adverse events.

METHODS

Search strategy

A systematic search for articles published on SBAR was performed in PUBMED, EMBASE, CINAHL, Cochrane Library and PsycINFO via OvidSP. The search was conducted in January 2017. It was augmented by a review of the references of all articles included. Search terms used in all electronic medical databases were SBAR, ISBAR, SBAR-R, ISBARR and ISOBAR (combined as text words with the Boolean operator 'OR'). The detailed search strategy is provided in online supplementary appendix A. No restrictions were applied in terms of time, language or type of article. No review protocol exists.

Eligibility criteria

All original research articles on SBAR fulfilling the following eligibility criteria were included:

- SBAR was implemented into clinical routine,
- The investigation of SBAR was the primary objective of the study (as opposed to, for example, SBAR as part of a larger quality improvement initiative),

- At least one patient outcome was reported (eg, mortality or secondary ICU admission). In accordance with the definition of WHO,[2] aspects of patient safety (patient outcomes) were defined through outcome parameters measuring the occurrence or incidence of adverse events.

Exclusion criteria were:

- Articles that only describe the SBAR tool but provide no evaluation data on patient outcome,
- Studies that report a larger project in which SBAR was not the main intervention under investigation (because in such studies the attribution of any effect to SBAR is impossible),
- Studies that only report, survey outcomes or team perceptions.

Selection of studies

Studies were evaluated in two steps: (1) Two trained reviewers (JJ, MM) reviewed all abstracts and titles for eligibility. (2) If the eligibility of an article could not be clearly determined, the article was included for further full-text evaluation in a second step.

In case of dissent, the reviewers solved the divergence by consensus or, if necessary, by involving a third reviewer (MR).

Data extraction

The following data were extracted out of the included articles using a predefined form in Microsoft Excel for Mac 2011 (V.14.7.2; Microsoft, Redmond, Washington, USA): characteristics of the study (study setting, study design and information to evaluate the risk of bias; see below), characteristics of the study population and possible control group (type and number of trained people), characteristics of the intervention (type and duration) and outcome data on patients' safety including time/period of measurement). To ensure high accuracy and completeness of the data extraction by MM and JJ, data extraction was checked by KK.

Quality assessment

Methodological quality of the studies included was assessed with the '*Quality Assessment Tool for Quantitative Studies*' developed by the Effective Public Health Practice Project Canada.[46] The tool is recommended by the Cochrane Collaboration[47] as it evaluates the full range of quantitative study designs. It has been evaluated for inter-rater reliability, content and construct validity.[48] The identified studies were assessed on 18 criteria in six domains (selection bias, study design, confounders, blinding, data collection methods, as well as withdrawals and drop-outs). Studies were rated as 'strong', 'moderate' or 'weak' in each domain. An accompanying algorithm consolidates the six ratings into an overall score.

Two reviewers (JJ, MM) independently assessed the quality of each study. The final assessment of each study was determined by consensus between the two reviewers and, if necessary, by involving a third reviewer (WEH).

Data synthesis

The intraclass correlation coefficient (ICC) using Stata's *ICC* command with a two-way mixed-effects model was calculated to quantify the rater agreement on study inclusion as well as on quality ratings of the studies included.

The heterogeneity of reported study designs, outcome measures, settings and forms of SBAR interventions does not allow to pool data across the studies that met the inclusion criteria. Characteristics and results of the studies are presented in a narrative form.

Patient and public involvement

No patients were involved in the design, recruitment or conduct of the study. The results of this review will not be disseminated to patients included in the trials of the review.

RESULTS

Systematic review process

Article identification and inclusion is depicted in figure 1. The literature search identified 1053 articles. Seven hundred and one (701) articles remained after exclusion of duplicates; 607 articles were excluded after reviewing the titles and abstracts. Of the remaining 94 articles analysed in full text, 11 articles were included into this review. The rater agreement on inclusion was ICC 0.90 (95% CI 0.86 to 0.94). No additional studies were identified through screening of the references of the included articles.

Quality assessment

Rater agreement on the studies quality ratings was excellent (ICC 0.85, 95% 0.78 to 0.90).

The randomised controlled trial (RCT) by Field *et al*[49] was rated as 'strong' and one controlled trial by Randmaa *et al*[37] as 'moderate' in the overall study quality, while the remaining nine studies were rated as 'weak' (figure 2).

Three studies were rated as strong in the study design category as they were controlled clinical trials.[37 49 50] Eight studies used a before–after study design resulting in a weak rating in the study design category.

Except for the study by Christie and Robinson,[41] in which the selected individuals were not described in sufficient detail, the study quality regarding selection bias was rated as 'moderate'.

The study by Field *et al*[49] used a RCT as a design with facility as a randomisation unit. Thus, by study design, the results were controlled for potential (known and unknown) confounders such as infrastructure, patient safety culture and management.

No other study controlled for confounders in the study design or analysis (weak rating).

While main outcomes, study objectives and the applied SBAR intervention were described in all studies, blinding was not described in any but one of the studies (9.1%), resulting in a 'moderate' rating in this category. In one of the controlled trials,[49] the reviewers who rated the patient

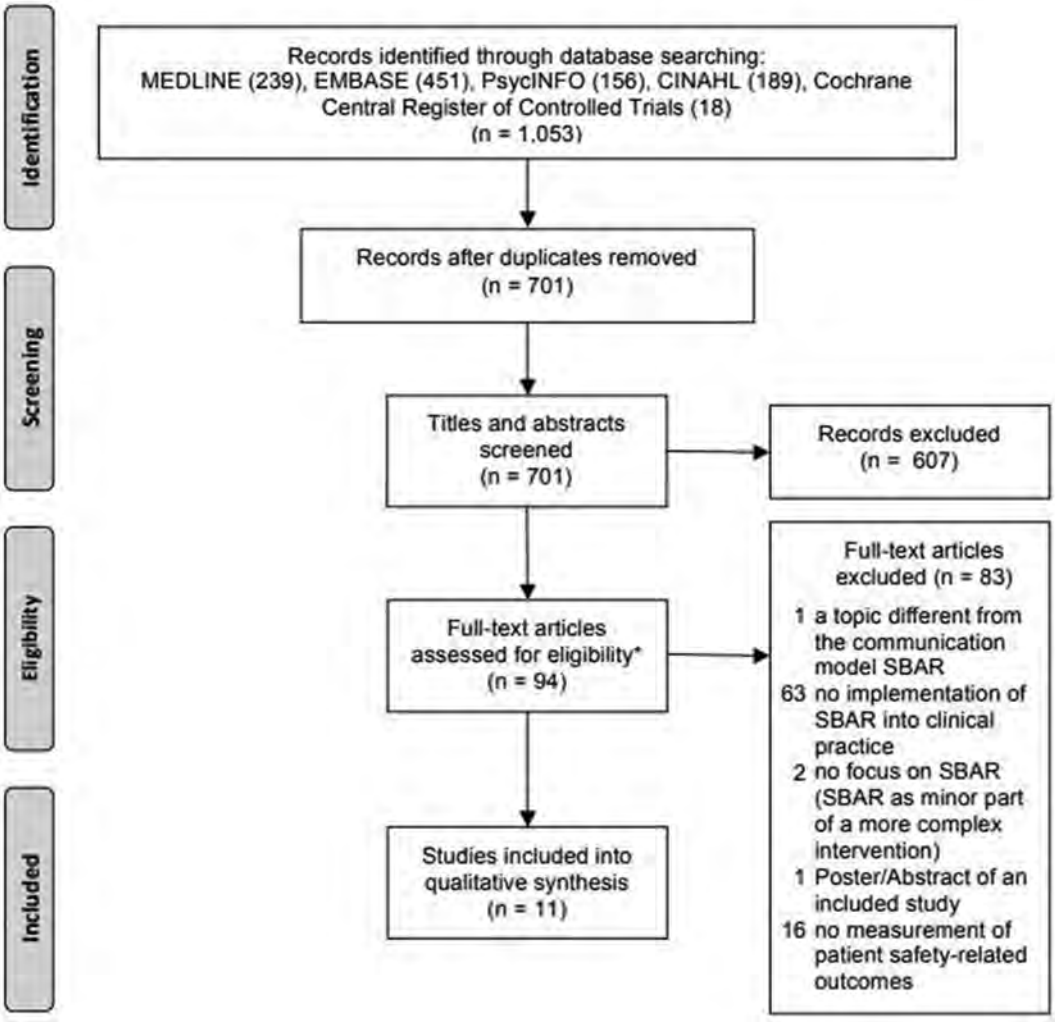

Figure 1 Flowchart of the systematic review process. SBAR, situation, background, assessment, recommendation. *No additional studies were identified through screening of the references of the included articles.

safety outcome were blinded in regard to the intervention (strong rating).

Overall, there was a lack of reporting on statistical tests[51–54] and number of persons that were trained.[41 49 51 53–55] Sample size calculations to ensure sufficient power were not reported in any of the studies.

Study setting and study characteristics

Eight of the analysed studies (72.7%) used a before–after intervention design,[41 51–57] while in two studies (18.2%) a non-RCT[37 50] and in one study (9.2%) a RCT[49] were reported.

All identified articles were published in recent years (2006–2016). Eight (72.7%) of the 11 studies were conducted in North America,[49–54 56 57] and the remaining three (27.3%) were performed in Europe.[37 41 55]

The studies focused on three different study sites: (1) hospitals in seven studies (63.6%),[37 41 50 51 53–55] (2) a rehabilitation centre (geriatric/musculoskeletal unit) in one study[52] (9.2%) and (3) nursing homes in three studies (27.3%).[49 56 57] Four of the studies that introduced the SBAR tool into a hospital setting restricted the intervention to specific units (anaesthesiological,[50] surgical[37] or medicosurgical[54 55]) while three trials introduced the SBAR tool to all departments.[41 51 53] Nurses were trained in the use of SBAR in all studies. In five studies (45.5%), additionally other clinical staff, for example, physicians, were trained also.[37 41 50–52] The number of staff members trained ranged from 38[50] to 155[37], but was not specified in five studies[41 49 51 53 55] (online supplementary appendix B).

The study period was mainly dependent on the time period that the patient outcomes were measured and ranged between 2[50] and 24 months[37 56] and was not specified in two studies.[41 53]

Intervention targets

A detailed description of the wide range of implementation strategies of SBAR in the studies included is provided in online supplementary appendix C.

In two studies (18.2%), the aim of the intervention was to improve team communication in general[51 52] while five studies (45.5%) focused on patient hand-offs either between nurses or interprofessional.[37 41 53 54] The four

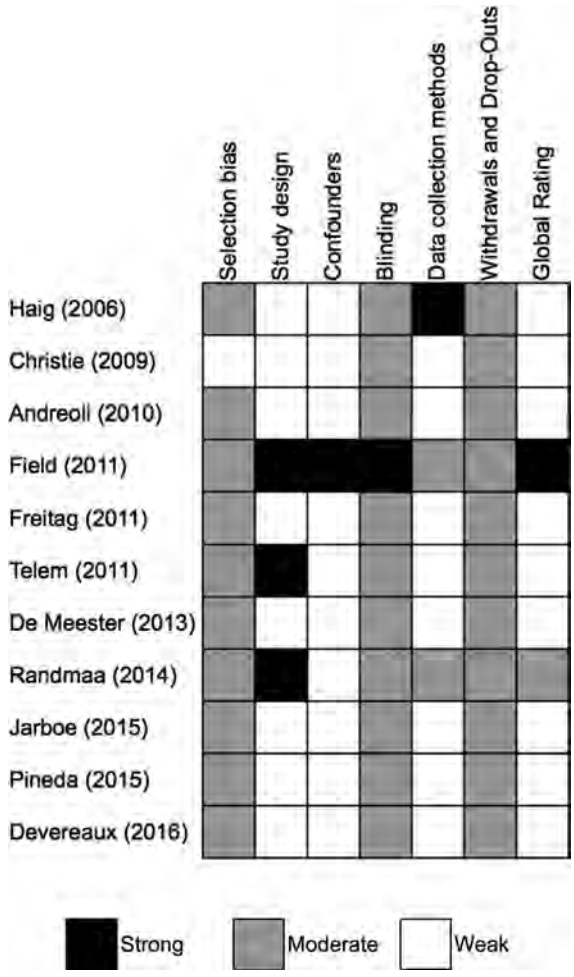

Figure 2 Quality assessment of the included studies.

remaining studies (36.4%) aimed to improve communication in a particular situation such as telephone calls between nurses and physicians for anticoagulation management[49] or in case of patient deterioration.[55–57]

Implementation strategies were educational programmes (seven studies[41 49 51 52 54–56]), organisational/human support (seven studies[37 41 49 51–54]) and interactive teaching (seven studies[37 41 50 52 53 55 56]) including group discussions and role play. Additional SBAR trigger tools (poster, pocket cards, telephone stickers) were used in six studies (54.5%).[37 41 49 51–53]

Patient outcome

All studies included assessed the effect of SBAR implementation on the outcome of inpatients, none the outcome of outpatients. The patient outcomes and outcome measurements varied widely over the identified studies (online supplementary appendix D). Three studies (27.3%) measured general patient outcomes such as adverse patient/drug events,[41 50 51] while the remaining eight studies (72.7%) used specific adverse event outcomes such as anticoagulation-related[49] and patient fall–related adverse events[52–54] as well as unplanned events such as ICU admissions,[55] death/cardiac arrests[41 55] and transfer to hospitals.[56 57] Other patient outcomes included methicillin-resistant *Staphylococcus aureus* (MRSA) bacteraemias[41] and catheter-associated urinary tract infection rates.[53]

The duration of measurement of the patient outcomes in the pre/controlled phase respectively the post/intervention phase ranged from 1 month[50 54] to 12 months[37] and was not reported in three studies.[41 52 53] Three of the studies[37 51 55] controlled the use of SBAR by staff survey or review of medical records and identified high use rates within daily routine.

Effect of SBAR on patient outcomes

Overall summary

The main study characteristics and the effects of SBAR on the studied patient outcomes are summarised in table 2.

In total, 26 different patient outcomes were measured. Of these, eight outcomes measured in five studies[37 49 54 55 57] significantly improved and 11 patient outcomes measured in four before–after studies[41 51–53] are described as improving without the report of a statistical test. Six outcomes did not change significantly. One study descriptively reported an increase of adverse events,[52] and none found a significant reduction of patient safety. The reported results of the studies are shown in detail in online supplementary appendix D.

Team communication in general

While one of the two before–after studies that focused on team communication in general[51] found a reduction of adverse patient as well as of drug events, a study that focused on falls in a rehabilitation centre[52] found mixed results with a decrease in major falls, but an increase in the incidence of overall falls. Both studies did not provide a statistical analysis of their results.

Patient hand-off

All but one[50] of the five studies[37 41 50 53 54] that focused on patient hand-offs reported an improvement of patient safety. Two before–after studies focused on patient hand-off between nursing shifts.[53 54] A reduction in the number of patient falls was reported in both studies. In addition, restrained patients rate and catheter-associated urinary tract infection rate decreased about one-third in one of these studies.[53] Both studies that focused on patient hand-offs between physicians and nurses reported an improvement in patient safety–related outcome.[37 41]

In their controlled clinical trial, Randmaa *et al*[37] reported that the critical incidence reporting system (CIRS) events due to communication breakdowns in the department of anaesthesiology of two clinics decreased significantly from 31% to 11%. The before–after study performed in a hospital by Christie and Robinson[41] found a reduction in hospital mortality (−11%), MRSA bacteraemias (−83%), adverse events (−65%) and cardiac arrests (−8%) after SBAR implementation (no further statistical analysis reported).

The controlled clinical by Telem *et al*[50] evaluated the effect of SBAR versus no-SBAR training on patient

Table 2 Study characteristics and outcomes sorted by effect on patient safety, study design and year

Study	Design	Setting	How SBAR was used	Patient outcome defined as	Effect
Field *et al*[49] 2011	RCT	Nursing home	Telephone communication from nurse to doctor—anticoagulation management	INR values within the target range	▲
Randmaa *et al*[37] 2014	CCT	Hospital	Patient hand-off—physician and nurses	CIRS events (communication errors)	▲
De Meester *et al*[55]* 2013	BAS	Hospital	Telephone communication from nurse to doctor—deteriorating/status change of a patient	(1) Unexpected death and (2) ICU admission	▲
Pineda[54] 2015	BAS	Hospital	Patient hand-of f—nurses	Patient falls	▲
Devereaux *et al*[57] 2016	BAS	Nursing home	Telephone communication from nurse to doctor—deteriorating/status change of a patient	(1) 30-day readmissions, (2) transfers to hospital and (3) avoidable hospitalisations	▲
Haig *et al*[51] 2006	BAS	Hospital	Team communication in general	(1) Adverse patient and (2) drug events	▵
Andreoli *et al*[52] 2010	BAS	Rehabilitation clinic	Team communication in general	(1) Falls severity (four levels), (2) near-miss reporting	▵
Freitag and Carroll[53] 2011	BAS	Hospital	Patient hand-off—nurses	(1) Inpatient fall rate, (2) restrained patients rate and (3) catheter-associated UTI	▵
Christie and Robinson[41] 2009	BAS	Hospital	Patient hand-off— physician and nurses	(1) Hospital mortality, (2) adverse events, (3) cardiac arrests, (4) MRSA bacteraemias	▵
Field *et al*[49] 2011	RCT	Nursing home	Telephone communication from nurse to doctor—anticoagulation management	Preventable AE related to warfarin therapy	○
Telem *et al*[50] 2011	CCT	Hospital	Patient hand-off—physician	Sentinel events	○
De Meester *et al*[55] 2013	BAS	Hospital	Telephone communication from nurse to doctor—deteriorating/status change of a patient	Call of cardiac arrest team	○
Jarboe[56] 2015	BAS	Nursing homes	Telephone communication from nurse to doctor—deteriorating/status change of a patient	(1) Overall number of transfers to acute care hospitals, (2) types of transfers by clinical condition criteria, (3) transfers resulting in hospitalisation	○
Andreoli *et al*[52] 2010	BAS	Rehabilitation clinic	Team communication in general	Falls incidence	▽

If a study reported outcomes with different effects on patient safety, the study results are listed separately.
▲, statistically significant evidence for improvement; ▵, descriptive evidence for improvement (no statistical test reported); ○, no significant evidence of a change; ▽, descriptive reduction of patient safety.
*And nursing hand-off (between shifts).
AE, adverse event; BAS, before–after study; CCT, clinical controlled trial; CIRS, critical incident reporting system; ICU, intensive care unit; INR, international normalised ratio; MRSA, methicillin-resistant *Staphylococcus aureus*; RCT, randomised controlled trial; SBAR, situation, background, assessment and recommendation; UTI, urinary tract infection.

hand-offs by physicians on surgical wards. The number of identified sentinel events was not statistically different between the study groups. One sentinel event was reported over the whole study period.

Telephone communication between nurse and physician

Three trials tried to increase the quality of telephone communication between nurse and physician when nurses reported deterioration or other status changes of patients.[55–57] Two studies reported significant improvements in the study patient outcome under investigation while the study of Devereaux *et al*[57] could not find a significant change.

Field *et al*[49] showed a statistically significant improvement in the management of anti-coagulated patients in nursing centres using a randomised controlled design: the international normalised ratio (INR) value of patients

was 4.5% more time within the therapeutic range in the intervention homes than in control homes (95% CI 3.1% to 8.7%). They further reported a non-significant reduction of adverse warfarin-related events in the intervention homes (OR 0.9, 95% CI 0.5 to 1.4).

De Meester *et al*[55] (before–after study) reported that the number of unexpected death was significantly decreased from 0.99 to 0.34 per 1000 admissions (p<0.001), while ICU admissions increased (13.1 to 14.8 per 1000 admissions) without a significant difference in the frequency with which a cardiac arrest team was called.

Devereaux *et al*[57] studied transfers from nursing homes to acute care hospitals using a before–after trial and found a significant reduction in 30-day readmissions (0.12 vs 0.04, p=0.012) and avoidable hospitalisations (0.15 vs 0.05, p=0.007). Jarboe[56] used a similar setting, but a longer study period (20 months vs 6 months) and could not find significant differences with regard to preventable patient transfers (p=0.927) or emergent patient transfer (p=0.565).

DISCUSSION

Summary of main results

The present systematic review assesses the effect of the implementation of the widely adopted communication strategy SBAR on patient-related outcomes. Because communication breakdowns have been repeatedly identified as a major source of adverse events and medical error,[4 58 59] implementation of a strategy such as SBAR seems a valid remediation approach.

Eleven studies, eight with a before–after design and three controlled trials, met the inclusion criteria. SBAR was implemented through different strategies in three different clinical settings (hospitals, rehabilitation centre and nursing homes) and with a broad range of objectives to improve (1) team communication in general, (2) intradisciplinary and interdisciplinary patient hand-offs, and (3) communication in telephone calls from nurses to physicians. In total, 26 different patient outcomes were measured. Eight significantly improved, 11 were described as improving (but no further statistical test were reported), six outcomes did not change significantly and one study reported a descriptive reduction in patient outcomes. Study outcomes with statistical evidence for improvement included INR values within the target range[49] and unplanned transfers to hospitals[57] in nursing homes, as well as CIRS events due to communication errors,[37] patient falls,[54] unexpected death and ICU admissions[55] in hospitals. The overall study quality was high or moderate in two studies only; all other studies showed a weak study quality.

Quality of the evidence

The strongest evidence identified in our review comes from a single RCT investigating the effect of SBAR implementation in nursing homes on anticoagulation management of patients under warfarin.[27] However, because warfarin is increasingly substituted by direct oral anticoagulants less difficult to dose,[60] the relevance of this finding may cease over time. Furthermore, adverse events related to warfarin therapy, the primary outcome parameter in this study, did not differ significantly between the intervention and control group. We found further evidence that the use of SBAR in telephone communication to inform the physician of a deteriorating patient leads to (1) a significant decrease in unexpected death[22] and (2) a significant reduction in transfers to hospitals, 30-day readmissions and avoidable hospitalisations from nursing homes.[21] Therefore, SBAR implementation in telephone communication seems to positively affect patient outcome. However, one study conducted in a similar setting[56] (nursing home, unplanned hospital admission) but with a longer study period could not find any significant difference between the preimplementation and postimplementation phase in the patient outcomes. One explanation for the differences in the findings might be that the use of SBAR (not reported in the two studies) decreased over time, thus the effect vanished.

Study periods were short at least in two trials[50 54] (2 months only). As a consequence, only one sentinel event in one controlled clinical trial[50] over the study period was reported.

Power calculations were missing in all studies. Thus, the lack of significant differences between the groups in these studies could not be interpreted adequately. Furthermore, in almost half of the reported outcomes, no statistical tests were performed. Notably, no study in our review found a significant *increase* in the occurrence of adverse events after to the implementation of SBAR, but Andreoli *et al*[52] descriptively reported an increase in fall incidence while the fall severity was reduced at the same time. This study's findings illustrate the difficulty with most of the studies findings included in the review. Some might argue that the implementation of SBAR in patient fall reporting has just led to an increased awareness regarding patient falls. Consequently, the reporting of patient falls and especially of less severe falls increased, resulting in a decrease of the patient fall severity overall.

It has been previously argued that downstream targets of educational interventions (such as the implementation of a specific communication strategy) are often difficult to assess due to possible dilution of the effect of any intervention.[61 62] Indeed, implementation of SBAR may only directly affect communication among health professionals, which in turn may or may not affect healthcare conduct, which then may result in altered patient outcome. Arguably, there are many other effective agents along this path that may dilute the effect of SBAR implementation on patient outcome. We would argue that because it has been possible in the past to relate adverse events to communication breakdowns,[7 58 59] it should just as well be possible to demonstrate the effect on patient safety of interventions targeted at remediating such communication breakdowns.

One reason for the current failure to demonstrate such effects may be that studies investigating the effect of SBAR on patient outcome are mostly of limited quality and yield heterogeneous results. Many studies identified were before–after studies. It is thus difficult to differentiate between changes attributed to the implementation of SBAR and changes attributable to other factors that had changed over time, such as increased awareness. Process measures in regard to parameters of communication were not measured in any of the included studies, but several not included studies suggest an improvement of communication through the implementation of SBAR.[34–40] The lack of process measures within the included studies reduces internal validity and impedes the interpretation of the present results with regard to causation. Consequently, the unreflected adoption of SBAR may paradoxically limit improvements in healthcare communication because once a problem appears to be solved, less research will be conducted on it.

Limitations

This systematic review has some limitations. Efforts were undertaken to identify all relevant trials to evaluate the impact of SBAR implementation in clinical practice on patient safety. Five well-known databases as well as the references of the studies that met the inclusion criteria were searched using an open search strategy. No grey literature was searched, thus trials could have been missed. Further, we did not contact any author to ask for raw data to perform additional statistical analysis. Publication bias could not be assessed leading to an important source of bias. The heterogeneity of the data impeded a meta-analysis. This systematic review was conducted in accordance with the Cochrane Collaboration standards using a validated tool for quality assessment of the identified studies. Reliability of the study selection, data extraction and rating of the study quality was ensured using two independent reviewers. We did not differentiate the broad range of adverse events or sentinel events, but subsume them under patient safety/outcome in order to provide a first insight into the relationship between SBAR and patient safety. The inclusion criteria were restricted to trials that reported at least one 'hard' patient outcome parameter to evaluate SBAR's impact on patient safety. Evidence of improvement of potentially 'soft' outcomes such as an increase in employee satisfaction[21 22] and interdisciplinary communication[19 23] with improvements of the communication perception, interdisciplinary teamwork,[29–33] completeness[41–44] and efficiency[40 42 45] of the communication were not reported in this review. Last, trials in which SBAR was a minor component of a complex intervention only were not included in this review. These trials may contain potential evidence for an improvement of patient safety through the implementation of SBAR.

Implications for practice and research

Five of the studies[37 49 54 55 57] including the two moderate/high-quality studies found significantly improved patient safety outcomes. Four other before–after studies[41 51–53] reported descriptive improved patient outcomes. On the one hand, these findings emphasise the potential importance of implementation of SBAR in the clinical practice to improve (1) telephone communication from nurse to doctors in critical situations, (2) general patient hand-off as well as (3) team communication in general. However, the quality of the evidence is low and four studies[49 50 55 56] reported no significant changes of other relevant outcomes and even a descriptive increase of patient falls also.[52] Best evidence was found in telephone communication between nurses and physicians. This should raise awareness and demands future high-quality research as the unreflected adoption of SBAR may paradoxically limit improvements in healthcare communication because once a problem appears to be solved, less research will be conducted on it.

CONCLUSION

In summary, many authors claim that SBAR improves patient safety. There is some evidence of the effectiveness of SBAR implementation on patient outcome, but this evidence is limited to specific circumstances such as communication over the phone. Especially high-quality studies are lacking. Future studies are needed to further demonstrate the benefit of SBAR in terms of patient safety and keep raising the awareness of communication errors. SBAR might be an adaptive tool that is suitable for many healthcare settings, in particular when clear and effective interpersonal communication is required.

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GUIDE TO CONTRACEPTION INFORMATION FOR WOMEN WITH CARDIOVASCULAR DISEASE

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INTRODUCTION

Hypertension and cardiac disease in pregnancy are the leading causes of maternal morbidity and mortality. Pregnancy can affect the course of cardiovascular disease and potentially endanger the health of the mother. In return, cardiac disease in women can affect fetal well-being and overall health of the pregnancy. Patients with cardiovascular disease including hypertension, congenital heart defects, arrhythmia and heart failure should be educated about contraceptive choices to improve overall health and to successfully achieve their reproductive plan, which may include preventing unwanted pregnancy.[1-4]

INCREASED RISKS DUE TO PREGNANCY IN PATIENTS WITH CARDIOVASCULAR DISEASE INCLUDE:

- Worsening hypertension
- Prolonged hospitalization
- Preeclampsia
- Fetal growth restriction
- Premature delivery
- Myocardial infarction
- Stroke
- Heart failure
- Death

METHODS OF CONTRACEPTION

Non-hormonal methods are the preferred contraception in patients with cardiovascular disease, given the minimal risk of thromboembolism with their use.

- Barrier methods
- Copper IUD
- Tubal ligation
- Trans-cervical tubal occlusion
- Partner vasectomy.

Hormonal methods containing estrogen products and depot medroxy-progesterone acetate injection should be used with caution in patients who have multiple risk factors or a history of cardiovascular disease.[5] Table 9 shares current guidelines for suggested contraception in patients with CVD.

- Combined Hormonal Contraceptives (CHC): Pill, Patch or Ring
- Progestin only form: Pill, Injection, Implant, or IUD

Table 9: Current Guidelines for Suggested Contraception in Patients with Cardiovascular Disorders

	Peripartum Cardio-myopathy	Valvular Disease on no anticoagulation	Valvular Disease on anticoagulation	Congenital Cardiac Defect
Combined Hormonal Contraceptives: Pill, Patch, Ring **Risks include** thromboembolism, stroke, myocardial infarction, lipid abnormalities **Risk of unintended pregnancy:** User dependent up to 9/100	Based on individual patient profile in consultation with cardiologist	Based on individual patient profile in consultation with cardiologist	AVOID	Based on individual patient profile in consultation with cardiologist
Progestin only **Risk of unintended pregnancy:** User dependent up to 9/100	Recommended	Recommended	Recommended	Based on individual patient profile in consultation with cardiologist
Progestin Injection **Risks include** fluid overload **Risk of unintended pregnancy:** 6/100	Recommended	Recommended	Recommended	Based on individual patient profile in consultation with cardiologist
Progestin Implant **Risk of unintended pregnancy:** Less than 1/100	Recommended	Recommended If mechanical valve, antibiotic prophylaxis	Recommended If mechanical valve, antibiotic prophylaxis	Based on individual patient profile in consultation with cardiologist
Copper IUD **Contraindicated in:** Allergy to copper; Wilson's disease **Risk of unintended pregnancy:** Less than 1/100	Recommended	Recommended	Recommended If mechanical valve, antibiotic prophylaxis	Based on individual patient profile in consultation with cardiologist
Levonorgestrel IUD **Risk of unintended pregnancy:** Less than 1/100	Recommended	Recommended	Recommended If mechanical valve, antibiotic prophylaxis	Based on individual patient profile in consultation with cardiologist

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HOW WELL DOES BIRTH CONTROL WORK?

What's your chance of getting pregnant in a year?

Really, really well

Implant

Works as birth control... Up to 5 years

Hormonal IUD

Up to 8 years

Copper IUD

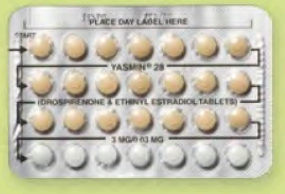
Up to 12 years

Sterilization

Forever

Less than 1 in 100

Really well



Pill

For it to work best, use it... Every day

Patch

Every week

Ring

Every month

Shot

Every 3 months

6-9 in 100, depending on method

Pretty well

Pulling Out

Fertility Awareness

Can be used alone or with another method for STI protection.

Internal Condom

Condom

For each of these methods to work, you or your partner have to use it every time you have sex.

12-24 in 100, depending on method

More than 85 in 100 without birth control.

¿QUÉ TAN BIEN FUNCIONAN LOS ANTICONCEPTIVOS?

¿Qué riesgo tengo de quedar embarazada en un año?

★★★★★ **Muy, muy bien**

El implante

Hasta 5 años

El DIU con hormonas

Hasta 8 años

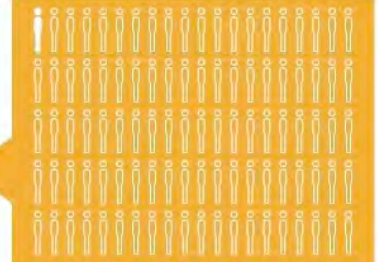
El DIU de cobre

Hasta 12 años

Esterilización

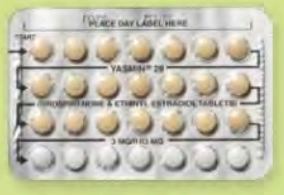
Para siempre

Funciona como un método de anticonceptivo...



Menos de 1 de cada 100

★★★★ **Muy bien**



La pastilla

Cada día

El parche

Cada semana

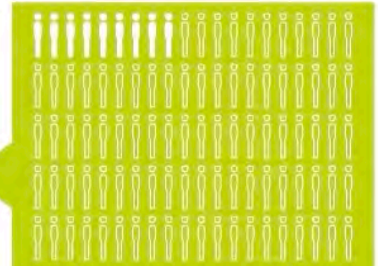
El anillo

Cada mes

La inyección

Cada 3 meses

Para que funcione mejor, úsalo...



Entre 6 y 9 de cada 100, dependiendo del método.

★★★ **Bastante bien**

Eyacular fuera

Conocimiento de la fertilidad

Se puede usar sólo o junto con cualquier otro método para proteger de las ITS.

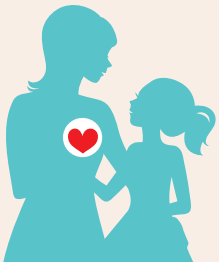
El condón interno

El condón externo

Para que estos métodos funcionen, debes usarlos cada vez que tengas relaciones sexuales.

Entre 12 y 24 de cada 100, dependiendo del método

Más de 85 de cada 100 sin anticonceptivos.



DID YOU HAVE COMPLICATIONS DURING PREGNANCY?

You may be at a higher risk for heart disease over your lifetime

Which pregnancy complications can increase your risk for heart disease as you age?

HIGH BLOOD PRESSURE

5-10% of all pregnant women

GESTATIONAL DIABETES

7-14% of all pregnancies

PRETERM BIRTH

11.5% of babies were born preterm in 2012.

Can include:

- **Gestational hypertension**
- **Preeclampsia**
  once known as Pregnancy Induced Hypertension (PIH) and Toxemia
- **Eclampsia**
- **HELLP syndrome**

If you had **PREECLAMPSIA**, you have **2x** the risk of stroke, heart muscle damage, or blood clot and **4x** the risk of developing high blood pressure for the rest of your life!

Mothers who had gestational diabetes are more likely to have the condition again in a future pregnancy.

If you had **GESTATIONAL DIABETES**, you are **50%** more likely to develop Type II diabetes within 5 years, putting you at higher risk for heart disease.

Babies born before 37 completed weeks of pregnancy are preterm, or premature.

Women with **PRETERM BIRTH AND PREECLAMPSIA** have an **8-10x** higher chance of death from heart disease.

If you had complications in pregnancy, you can lower your risk:

New Mothers

- **See your health care provider 3-6 months after birth** to check your overall physical health. Discuss your pregnancy and any complications you experienced.
- **Get a copy of your pregnancy and post-delivery medical records** to share with your providers for the rest of your life. Don't wait – records may be destroyed.
- **Breastfeed** as long as possible. Women whose total lifetime breastfeeding is 6-12 months were 10% less likely to develop heart disease (and it's good for baby too).

If you had one of these complications, speak with your provider when planning your next pregnancy to optimize your health.

REMEMBER!

It's a MYTH that ALL pregnancy related high blood pressure and gestational diabetes complications go away after the baby is born!

Mothers With Kids Over One Year

- **Get annual checkups and be screened for heart disease.** At this visit, your provider should check your overall physical condition.
- **Ask your provider** what your test results mean and how you can lower your heart disease risk.

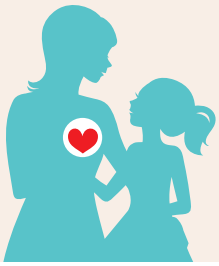
These screening numbers show desirable results.

Blood Pressure	< 120/80 mm hg	Fasting Blood Glucose	< 100 mg/dl
Total Cholesterol	< 200 mg/dl	Body Mass Index	< 25 kg/m2

- **Try a mobile app** to automatically retrieve and **store your medical records,** so you always have them handy.
- **Eat healthy!** A diet low in salt, fat, cholesterol and sugar can help you lower your risk for obesity, diabetes and heart disease.
- **Maintain a healthy weight.** Body Mass Index (BMI) is an estimate of body fat based on height and weight. Less than 25 is healthy.
- **Get active for 30 minutes a day,** or as recommended by your provider.
- **If you smoke, make a plan to quit.** Your provider may have resources to support you.
- **Take medications as directed.** Sometimes a healthy diet and exercise is not enough to lower your risk for heart disease, so your provider may prescribe medications to help.

Get more information and stay heart healthy.
www.cmqcc.org

SISTER TO SISTER The Women's Heart Health Foundation
CMQCC CALIFORNIA MATERNAL QUALITY CARE COLLABORATIVE
California Department of PublicHealth



¿TUVO COMPLICACIONES DURANTE SU EMBARAZO?

Usted puede correr mayor riesgo de enfermedades del corazón por el resto de su vida

¿Cuáles son las complicaciones del embarazo que pueden aumentar el riesgo de enfermedades del corazón con el paso de los años?

PRESIÓN ARTERIAL ALTA

5-10% de todas las mujeres embarazadas

Puede incluir:

- **Hipertensión gestacional**
- **Preeclampsia**, anteriormente conocida como hipertensión inducida por el embarazo o toxemia
- **Eclampsia**
- **Síndrome HELLP** (por sus siglas en inglés) que incluye hemólisis, enzimas hepáticas elevadas y un conteo bajo de plaquetas.

Si tuvo PREECLAMPSIA, tiene 2 veces más riesgo de tener un ataque al cerebro, daño en los músculos del corazón o un coágulo de sangre, y 4 veces más riesgo de desarrollar presión arterial alta por el resto de su vida.

DIABETES GESTACIONAL

7-14% de todos los embarazos

Las madres que tuvieron diabetes gestacional tienen más probabilidad de volver a tenerla en un futuro embarazo.

Si usted tuvo DIABETES GESTACIONAL, tiene 50% más probabilidad de desarrollar diabetes tipo II dentro de 5 años, lo que aumenta su riesgo de enfermedades del corazón.

NACIMIENTO PREMATURO

11.5% de todos los bebés nacieron prematuros en el 2012

Los bebés que nacen antes de las 37 semanas completas de embarazo son prematuros.

Las mujeres con PARTO PREMATURO Y PREECLAMPSIA tienen de 8-10 veces más probabilidad de morir por enfermedades del corazón.

Si tuvo alguna complicación en su embarazo, usted puede disminuir su riesgo:

Nuevas mamás

Consulte con su proveedor de atención médica de 3 a 6 meses después del parto para que le evalúa su salud física general. Cuéntele sobre su embarazo y cualquier complicación que haya tenido.

Obtenga una copia de los registros médicos de su embarazo y posparto para poder compartir con sus proveedores el resto de su vida. No espere para hacerlo, ya que pueden destruir los registros.

Amamante el mayor tiempo posible. Las mujeres que han amamantado por un total de **6 a 12 meses de toda su vida tienen 10% menos probabilidad** de desarrollar enfermedades del corazón (y también es bueno para el bebé).

Si usted tuvo una de estas complicaciones, consulte con su proveedor de atención médica al planear su siguiente embarazo para mantenerse lo más saludable posible.

Mamás con niños mayores de un año

Hágase un chequeo anual y pruebas de detección para las enfermedades del corazón. En su visita anual, su proveedor debe evaluarle su condición física en general.

Pregúntele a su proveedor qué significan los resultados de sus pruebas y cómo puede reducir su riesgo de las enfermedades del corazón.

Estos son los resultados deseables de las pruebas de detección:

Presión arterial	< 120/80 mm hg	Glucosa en la sangre, en ayunas	< 100 mg/dl
Colesterol total	< 200 mg/dl	Índice de masa corporal	< 25 kg/m^2

Pruebe una aplicación móvil que pueda automáticamente recuperar y almacenar sus registros médicos para que siempre los tenga a la mano.

¡Coma sano! Una dieta baja en sal, grasa, colesterol y azúcar puede ayudar a reducir el riesgo de obesidad, diabetes y enfermedades del corazón.

Mantenga un peso saludable. El índice de masa corporal (IMC) es un cálculo de la grasa corporal que se basa en la estatura y el peso. Lo saludable es tener un índice menor de 25.

Manténgase activa por 30 minutos al día o lo que le recomiende su proveedor.

Si fuma, haga un plan para dejar de fumar. Su proveedor puede tener recursos para ayudarle.

Tome los medicamentos siguiendo las indicaciones. A veces, no es suficiente seguir una dieta saludable y hacer ejercicio para reducir el riesgo de las enfermedades del corazón. Por eso, quizás su proveedor le recete medicamentos que le pueden ayudar.

¡RECUERDE!

Es un MITO que TODA presión arterial alta relacionada con el embarazo y TODAS las complicaciones de la diabetes gestacional desaparecen después de que nace el bebé.

Obtenga más información y mantenga su corazón sano.
www.cmqcc.org (en inglés)

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Signs & Symptoms of Heart Disease

During Pregnancy and Postpartum

Heart disease is the leading cause of death among women in the U.S. who are pregnant or gave birth in the last 5 months (postpartum).

Symptoms to watch for in late pregnancy and up to five months postpartum:

- Extreme swelling or weight gain
- Extreme fatigue
- Fainting
- Persistent cough
- Chest pain or fast heart beat
- Severe shortness of breath (especially when lying down)

NOTE: While some of these symptoms are common in late pregnancy, they may be a sign of heart disease especially if they are severe and do not go away after treatment.

If you have any of these symptoms and they don't go away:

- Contact your OB, midwife, family medicine doctor, or your primary care provider
- Describe your symptoms clearly and explain how sick you feel
- If your symptoms arise postpartum, be sure to tell the provider that you recently had a baby
- If your provider says your symptoms are normal, ask what symptoms should cause you to call or come back

Go to the Emergency Department

If you have persistent chest pain or severe shortness of breath, or otherwise feel extremely sick. If possible, take someone with you.

Any woman can develop heart disease in pregnancy or postpartum, but you are at higher risk if you:

- Have prior heart disease
- Are over 40 years old
- Have preeclampsia or high blood pressure (hypertension)
- Are African-American (4X greater risk and 8-10X more likely to die of heart disease)
- Are obese

Bottom line

- Trust your instincts when you feel something is wrong
- When you see a healthcare provider, bring your partner, friend or family member who can support you and help explain these symptoms are not normal for you
- Seek a second opinion if you don't feel listened to or your symptoms are not taken seriously

Get online support and information: www.myheartsisters.com | www.womenheart.org

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California Department of PublicHealth

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Señales & Síntomas de enfermedades del corazón *durante el embarazo y posparto*

En los Estados Unidos, las enfermedades del corazón son la principal causa de muerte en las mujeres que están embarazadas o que han dado a luz en los últimos 5 meses (posparto).

Esté atenta a los siguientes síntomas hacia el final de su embarazo y hasta 5 meses después de dar a luz:

- Tos persistente
- Fatiga extrema
- Desmayos
- Hinchazón extrema o aumento de peso
- Dolor en el pecho o latido rápido del corazón
- Mucha dificultad para respirar (especialmente cuando está acostada)

NOTA: Aunque algunos de estos síntomas son comunes al final del embarazo, también pueden ser una señal de una enfermedad del corazón, especialmente si son graves y no desaparecen después de tener un tratamiento.

Si usted tiene cualquiera de los síntomas anteriores y éstos no desaparecen:

- Comuníquese con su obstetra, partera, médico general o proveedor de atención médica principal.
- Descríbale claramente sus síntomas y dígale lo mal que se siente.
- Si sus síntomas aparecen después del parto, asegúrese de que su médico sepa que usted dio a luz hace poco.
- Si su médico u otro proveedor de atención médica le dice que sus síntomas son normales, pregúntele cuáles síntomas requieren que usted le llame de nuevo o vuelva a su consultorio.

Vaya a la sala de emergencias si usted tiene un dolor de pecho persistente, mucha dificultad para respirar, o se siente extremadamente enferma por alguna otra razón. De ser posible, trate de que alguien le acompañe.

Cualquier mujer puede desarrollar una enfermedad del corazón durante el embarazo o el posparto, pero usted corre un riesgo más alto si:

- Ya tenía una enfermedad del corazón
- Tiene más de 40 años
- Es afroamericana (4 veces más riesgo y 8 a 10 veces más probabilidad de morir de una enfermedad del corazón)
- Tiene preeclampsia o presión arterial alta (hipertensión)
- Es obesa

Conclusión

- Confíe en sus instintos si siente que algo anda mal.
- Cuando consulte a su proveedor de atención médica, vaya con su pareja, amigo o amiga o algún familiar que le pueda apoyar y ayudarle a explicar a su médico que estos síntomas no son normales para usted.
- Busque una segunda opinión si siente que su proveedor de atención médica no le escucha o que no toma en serio sus síntomas.

Obtenga apoyo e información en el internet: www.myheartsisters.com | www.womenheart.org | www.womenheart.org/espanol

CMQCC CALIFORNIA MATERNAL QUALITY CARE COLLABORATIVE
www.cmqcc.org

California Department of PublicHealth

El financiamiento para el desarrollo de este infográfico proviene de una subvención federal en bloque del Título V de la Ley de Seguro Social destinada a la salud materno infantil del Departamento de Salud Pública de California; la División de Salud Maternal, Infantil y Adolescente, y la Universidad de Stanford.

Pregnant now or within the last year?

Get medical care right away if you experience any of the following symptoms:

Headache that won't go away or gets worse over time

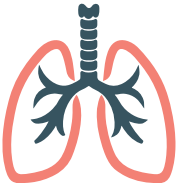
Dizziness or fainting

Changes in your vision

Fever of 100.4ºF or higher

Extreme swelling of your hands or face

Thoughts of harming yourself or your baby



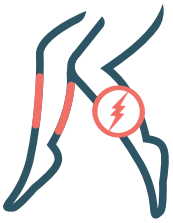
Trouble breathing

Chest pain or fast beating heart

Severe nausea and throwing up

Severe belly pain that doesn't go away

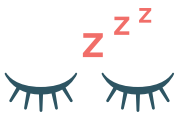
Baby's movement stopping or slowing during pregnancy



Severe swelling, redness or pain of your leg or arm

Vaginal bleeding or fluid leaking *during* pregnancy

Heavy vaginal bleeding or discharge *after* pregnancy



Overwhelming tiredness

These could be signs of very serious complications. If you can't reach a healthcare provider, go to the emergency room. Be sure to tell them you are pregnant or were pregnant within the last year.

Learn more at
cdc.gov/HearHer

HEAR®
HEAR HER CONCERNS

This list of urgent maternal warning signs was developed by the Council on Patient Safety in Women's Health Care.

¿Embarazada ahora o lo estuvo dentro del último año?

Obtenga atención médica de inmediato si tiene cualquiera de estos síntomas:

Dolor de cabeza intenso que no desaparece o empeora con el tiempo

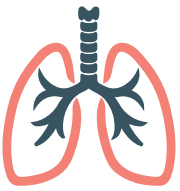
Mareos o desmayos

Cambios en la visión

Fiebre de 100.4 °F o más alta

Hinchazón extrema de las manos o la cara

Pensamientos acerca de hacerse daño o hacerle daño a su bebé



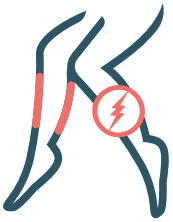
Dificultad para respirar

Dolor en el pecho o latidos cardiacos acelerados

Náuseas y vómitos intensos

Dolor abdominal fuerte que no desaparece

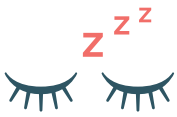
Movimientos del bebé que cesan o disminuyen durante el embarazo



Hinchazón, enrojecimiento o dolor en una pierna

Sangrado o pérdida de líquido vaginales *durante* el embarazo

Sangrado vaginal abundante o pérdida de líquido vaginal que huele mal *después* del embarazo



Cansancio extremo

Estos podrían ser signos de complicaciones graves. Si no puede comunicarse con un proveedor de atención médica, necesita ir a una sala de emergencias. Asegúrese de mencionar que está embarazada o lo estuvo en el último año.

Infórmese más en
cdc.gov/Escúchela

HEAR® ESCÚCHELA

Esta lista fue creada por el Consejo para la Seguridad del Paciente en la Atención de la Salud de la Mujer

حامل الآن أو خلال السنة الماضية؟

احصلي على الرعاية الطبية على الفور إذا تعرضتِ لأي من الأعراض التالية:

صداع لا يزول أو
يزداد سوءًا بمرور الوقت

دوار أو إغماء

تغيرات في الرؤية

حمى تبلغ **100.4**
فهرنهايت أو أعلى

تورم مفرط
في يديكِ أو وجهكِ

أفكار خاصة
بإيذاء نفسكِ أو طفلكِ

صعوبة في التنفس

ألم في الصدر أو
سرعة في ضربات القلب

غثيان شديد
وقيء

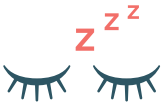
ألم شديد في البطن
لا يزول

حركة الطفل توقفت أو
تباطئت أثناء الحمل

تورم شديد،
إحمرار أو ألم
في ساقكِ أو ذراعكِ

نزيف مهبلي
أو تسرب سائل
أثناء الحمل

نزيف أو إفراز مهبلي
كثيف
بعد الحمل



تعب
كاسح

قد تكون هذه أعراض لمضاعفات خطيرة للغاية. إذا تعذر عليكِ الوصول إلى مقدم رعاية صحية،
فانتقلي إلى غرفة الطوارئ. احرصي على إخبارهم بأنكِ حامل أو كنتِ حاملاً خلال السنة الماضية.

تعرفي على المزيد على www.cdc.gov/HearHer

HEAR
سماع مخاوفها

هذه اللائحة للعلامات التحذيرية العاجلة الخاصة بالأم وضعها المجلس المعني بسلامة المريض في الرعاية الصحية للسيدات (Council on Patient Safety in Women's Health Care).

Quý vị đang mang thai hoặc đã mang thai vào năm ngoái?

Hãy tìm kiếm chăm sóc y tế ngay lập tức nếu quý vị gặp bất kỳ triệu chứng nào sau đây:

Đau đầu không khỏi hoặc càng ngày càng nặng

Chóng mặt hoặc ngất xỉu

Thay đổi thị lực

Sốt 100,4˚F trở lên

Sưng tấy bàn tay hoặc mặt

Có suy nghĩ làm hại chính mình hoặc con quý vị

Khó thở

Đau ngực hoặc tim đập nhanh

Buồn nôn và nôn mửa dữ dội

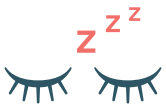
Đau bụng dữ dội mà không biến mất

Chuyển động của em bé ngừng hoặc chậm lại trong thai kỳ

Sưng tấy, đỏ hoặc đau chân hoặc cánh tay

Chảy máu âm đạo hoặc rỉ dịch trong thai kỳ

Chảy máu hoặc tiết dịch âm đạo nhiều sau thai kỳ



Quá mệt mỏi

Đây có thể là dấu hiệu của các biến chứng rất nghiêm trọng. Nếu quý vị không thể liên hệ với nhà cung cấp dịch vụ chăm sóc sức khỏe, hãy đến ngay phòng cấp cứu. Hãy nhớ cho họ biết rằng quý vị đang mang thai hoặc đã mang thai vào năm ngoái.

Tìm hiểu thêm tại www.cdc.gov/HearHer

CDC

HEAR
HÃY NGHE NHỮNG LO NGẠI CỦA CÔ ẤY

Danh sách các dấu hiệu cảnh báo khẩn cấp dành cho bà mẹ này được phát triển bởi Hội đồng Kiểm soát An toàn Bệnh nhân Trong Chăm sóc Sức khỏe Phụ nữ.

Enceinte actuellement ou au cours de la dernière année ?

Demandez immédiatement des soins médicaux si vous détectez certains des symptômes suivants :

Maux de tête qui persistent ou empirent avec le temps

Vertiges ou évanouissements

Altérations de la vision

Fièvre à 38 °C (100,4 °F) ou supérieure

Gonflement extrême de vos mains ou de votre visage

Pensées nuisibles pour vous-même ou votre bébé

Difficultés à respirer

Douleur thoracique ou palpitations cardiaques

Nausées et vomissements importants

Douleurs abdominales sévères qui persistent

Disparition/ ralentissement des mouvements du bébé pendant la grossesse

Gonflement, rougeur ou douleur importante aux jambes ou aux bras

Saignements ou pertes vaginales en cours de grossesse

Saignements ou sécrétions vaginales importantes après la grossesse

Fatigue excessive

Ils peuvent être révélateurs de très graves complications. Si vous ne parvenez pas à contacter un professionnel de santé, rendez-vous aux urgences. Indiquez-leur que vous êtes enceinte ou que vous l'avez été au cours de la dernière année.

En savoir plus sur www.cdc.gov/HearHer

CDC

HEAR
ÉCOUTER SES PRÉOCCUPATIONS

La liste des signes d'alerte d'urgence maternelle a été établie par le Council on Patient Safety in Women's Health Care.

REPORTING & SYSTEMS LEARNING

Reporting and Systems Learning

In this section we will discuss the Reporting and Learning Systems for this bundle. The results to this section will change overtime as you implement the bundle into your hospital and begin to improve on the care delivery of each patient. The three components of reporting and learning for EVERY UNIT are as follows:

- For pregnant and postpartum people at high risk for a cardiac event, establish a culture of multidisciplinary planning, admission huddles and post-event debriefs.

- Perform multidisciplinary reviews of serious complications (e.g. ICU admissions for other than observation) to identify systems issues.

- Monitor outcomes and process data related to cardiac conditions, with disaggregation by race and ethnicity due to known disparities in rates of cardiac conditions experienced by Black and Indigenous pregnant and postpartum people.

Element 1:

- For pregnant and postpartum people at high risk for a cardiac event, establish a culture of multidisciplinary planning, admission huddles and post-event debriefs.
    - Establish standardized briefing documentation to capture successes and determine actionable follow-up
    - Maintain awareness of how disparaging labels like “frequent flyer,” “non-compliant,” etc. can undermine care and trust in the system
    - Identify improvement champions in each setting
        - Handout 1: Integrated Approach to Reduce Perinatal Adverse Events: Standardized Processes, Interdisciplinary Teamwork Training, and Performance Feedback. https://pmc.ncbi.nlm.nih.gov/articles/PMC5134347/

Element 2:

- Perform multidisciplinary reviews of serious complications (e.g. ICU admissions for other than observation) to identify systems issues.
    - Have formal review following serious cardiac event to assess alignment with standard policies and procedures (with appropriate updates) and to identify opportunities for improvement (including identification of discriminatory practices)

- Handout 2: Obstetric Team Debriefing Form https://health.usf.edu/publichealth/chiles/fpqc/~/media/4EDEC762F5C6429ABBFD92898C5A725F.ashx

Element 3:

- Monitor outcomes and process data related to cardiac conditions, with disaggregation by race and ethnicity due to known disparities in rates of cardiac conditions experienced by Black and Indigenous pregnant and postpartum people.
    - Archive debriefing documentation for OB cardiac conditions events and review systematically with unit-specific and QI leadership teams
    - Establish unit-specific and QI leadership teams to review and address quality and safety issues
        - Handout 3: pre-identification of high-risk pregnancies to Improve Triaging at the Time of Admission and Management of Complications in Labor Room: A Quality Improvement Initiative https://pmc.ncbi.nlm.nih.gov/articles/PMC9207917/

Cardiac Bundle Core Data Collection Plan:

- **State and Surveillance Measures**
    - CCOC SS1: Severe maternal morbidity among patients with cardiac conditions- report by race, ethnicity and payor
        - **Denominator**: All qualifying pregnant and postpartum people during their birth admission with cardiac conditions
        - **Numerator:** Among the denominator, those who experienced severe morbidity (not blood transfusion)- See CCOC code list on page 9 of data collection plan- link listed below)
    - CCOC SS2: Pregnancy related deaths due to cardiac conditions- report by race, ethnicity and payor
        - **Denominator:** Live births among state residents
        - **Numerator:** Pregnancy related deaths due to cardiac conditions

- **Outcome Measures**
    - CCOC O1: Cesarean birth rate- report by race, ethnicity and payor
        - **Denominator:** Among people with cardiac conditions, those with live births who have their first birth ≥ 37 completed weeks gestation and have a singleton in vertex (Cephalic) position
        - **Numerator:** Among the denominator, those with a Cesarean birth

- CCOC O2: Preterm birth rate among those with cardiac conditions- report by race, ethnicity and payor
    - **Denominator:** Singleton live births among people with cardiac conditions
    - **Numerator:** Among the denominator, preterm live births (<37 weeks gestation)

- **<u>Process Measures</u>**
    - ALL P1: Provider and Nursing Education on Respectful Care
        - At the end of this reporting period, what cumulative proportion of OB clinicians have received in the last 2 years an education program on Respectful care of some sort, report in estimated 10% increments, rounding up.

    - CCOC P1: Standardized pregnancy risk assessment for people with cardiac conditions- report by race, ethnicity and payor
        - **Denominator:** Patients with cardiac conditions diagnosed prior to their birth admission
        - **Numerator:** Among the denominator, those who received a pregnancy risk classification using a standardized cardiac risk assessment tool by time of their birth admission

    - CCOC P2: Multidisciplinary Care Plan for people with cardiac conditions- report by race, ethnicity and payor
        - **Denominator:** Patients with cardiac conditions diagnosed prior to their birth admission
        - **Numerator:** Among the denominator, those who had a multidisciplinary care plan for birth established by time of their birth admission

    - CCOC P3: Provider and nursing education on cardiac conditions- report to the nearest 10%, rounding up
        - At the end of this reporting period, what cumulative proportion of OB clinicians have received education on signs and symptoms of potential cardiac conditions in pregnant and postpartum people in the last 2 years?

- CCOC P4: Emergency Department Provider and Nursing education on Cardiac conditions- report to the nearest 10%, rounding up
    - At the end of this reporting period, what cumulative proportion of ED clinicians have received education on signs and symptoms of potential cardiac conditions in pregnant and postpartum people in the last 2 years?

- **<u>Structure Measures</u>**
    - ALL S1: Patient Event Debriefs- Rate progress (1, not yet started – 5, fully in place) towards putting and keeping the structure measure fully in place.
        - Has your department established a standardized process to conduct debriefs with patients after a severe event?

    - ALL S4: Patient education materials on urgent postpartum warning signs- Rate progress (1, not yet started – 5, fully in place) towards putting and keeping the structure measure fully in place.
        - Has your department developed/ curated patient education materials on urgent postpartum warning signs that align with culturally and linguistically appropriate standards?

    - ALL S5: Emergency Department screening for current or recent pregnancy- Rate progress (1, not yet started – 5, fully in place) towards putting and keeping the structure measure fully in place.
        - Has your ED established or continued standardized verbal screening for current pregnancy and pregnancy in the past year as part of its triage process?

    - CCOC S1: Multidisciplinary Heart Team- Rate progress (1, not yet started – 5, fully in place) towards putting and keeping the structure measure fully in place.
        - Has your facility established a multidisciplinary pregnancy heart team, which may be comprised of a team of consultants appropriate to your hospital's level of maternal care, to respond to known or potential cardio obstetric emergencies?

    - CCOC S2: Multidisciplinary Case Reviews for CCOC bundle- Rate progress (1, not yet started – 5, fully in place) towards putting and keeping the structure measure fully in place.

        - Has your facility established a process to conduct multidisciplinary systems-level reviews of serious complications experienced by pregnant and postpartum people with cardiac conditions?

- **Optional Measures**
    - CCOC OP 1: Cardiovascular Disease (CVD) Assessment Among Pregnant and Postpartum Women
        - **Denominator:** All birth admissions, whether from sample or entire population
        - **Numerator:** Among the denominator, those with documentation of a cardiovascular disease assessment using a standardized tool

Core Data Collection Plan resource:

- See the link below for the full core data collection plan for this cardiac conditions in Obstetric Care bundle. The final, optional collection piece will remain optional.
    - https://saferbirth.org/wp-content/uploads/Cardiac-Conditions-in-Obstetrical-Care-Patient-Safety-Bundle-2.pdf

HSR Health Services Research

DOI: 10.1111/1475-6773.12592
PATIENT SAFETY & MEDICAL LIABILITY

Integrated Approach to Reduce Perinatal Adverse Events: Standardized Processes, Interdisciplinary Teamwork Training, and Performance Feedback

William Riley, James W. Begun, Les Meredith, Kristi K. Miller, Kathy Connolly, Rebecca Price, Janet H. Muri, Mac McCullough, and Stanley Davis

Objective. To improve safety practices and reduce adverse events in perinatal units of acute care hospitals.

Data Sources. Primary data collected from perinatal units of 14 hospitals participating in the intervention between 2008 and 2012. Baseline secondary data collected from the same hospitals between 2006 and 2007.

Study Design. A prospective study involving 342,754 deliveries was conducted using a quality improvement collaborative that supported three primary interventions. Primary measures include adoption of three standardized care processes and four measures of outcomes.

Data Collection Methods. Chart audits were conducted to measure the implementation of standardized care processes. Outcome measures were collected and validated by the National Perinatal Information Center.

Principal Findings. The hospital perinatal units increased use of all three care processes, raising consolidated overall use from 38 to 81 percent between 2008 and 2012. The harms measured by the Adverse Outcome Index decreased 14 percent, and a run chart analysis revealed two special causes associated with the interventions.

Conclusions. This study demonstrates the ability of hospital perinatal staff to implement efforts to reduce perinatal harm using a quality improvement collaborative. Findings help inform the relationship between the use of standardized care processes, teamwork training, and improved perinatal outcomes, and suggest that a multiplicity of integrated strategies, rather than a single intervention, may be essential to achieve high reliability.

Key Words. High reliability, perinatal outcomes, quality improvement collaborative, standardized care processes, in situ simulation team training

Labor and delivery pose substantial risk for unintended harm to mothers and newborns. Perinatal complications are reported from 3 to 10.7 percent of all deliveries, ranging from catastrophic events, including maternal or infant death, to less severe conditions such as third- and fourth-degree perineal laceration (Mann et al. 2006; Nielsen et al. 2007; Kozhimannil et al. 2013; Goffman et al. 2014; New Jersey Hospital Association 2014). A number of approaches have been undertaken to improve perinatal safety, including (1) didactic training (Mann et al. 2006; Nielsen et al. 2007; Pratt et al. 2007); (2) simulation training (Miller et al. 2008; Fransen et al. 2012); (3) standardizing care (Cherouny et al. 2005; Mazza et al. 2007; Damon et al. 2013); or (4) a combination of these strategies (Ellis et al. 2008; Pettker et al. 2009; Guise et al. 2010; Phipps et al. 2012; Wagner et al. 2012; Goffman et al. 2014).

Communication breakdown and poor teamwork are major risks in perinatal units (Simpson and Knox 2003), associated with 70 percent of perinatal injury (The Joint Commission 2004) and increasing the risk of error 10-fold (Reason 1995) while accounting for approximately 55 percent of all active failures in a hospital setting (Riley et al. 2010a,b,c). Overall, it is estimated that 30 percent of obstetrical complications are preventable (Goffman et al. 2014), and growing evidence suggests that applying reliability principles to health care has the potential to reduce flaws in care processes and increase the consistency with which appropriate care is delivered leading to improved patient outcomes (Burke et al. 2004; Benneyan, Resar, and Scoville 2006; Riley et al. 2010a,b,c). These strategies are aimed toward achieving high reliability, defined as defect-free operations for long periods of time in a hazardous environment (Roberts 1990; Reinertsen and Clancy 2006).

This study reports the results of a quality improvement collaborative, called the Premier Perinatal Safety Initiative (PPSI), consisting of 14 hospitals

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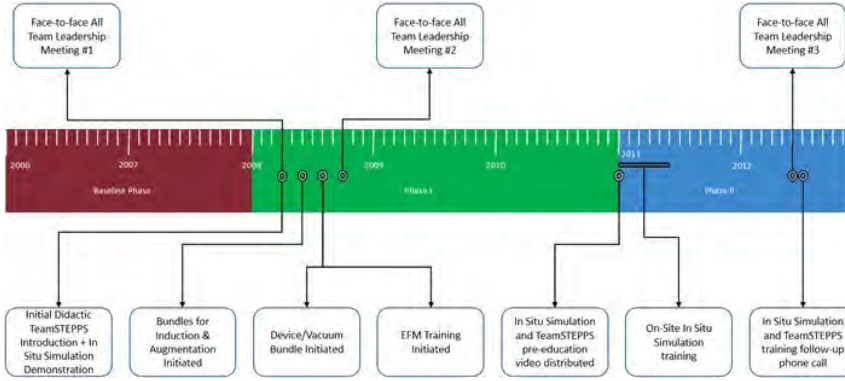
in 12 states, to reduce perinatal harm. One intervention was implemented to reduce variation in perinatal care processes and two interventions were introduced to improve nontechnical skills, and the cognitive and interpersonal abilities that supplement technical clinical competency (Flin, O'Connor, and Crichton 2008).

Materials and Methods

This 7-year study was a quasi-experimental, prospective quality improvement collaborative (QIC) consisting of a 5-year intervention period (January 1, 2008 to December 31, 2012) and a 2-year baseline period (January 1, 2006 to December 31, 2007) for which data were retrospectively collected. The project implemented three interventions: (1) standardization of evidence-based care; (2) interdisciplinary teamwork training; and (3) routine education with performance feedback. We utilized a 7-year horizon to evaluate the long-term impact of the interventions as well as to examine the interplay among diverse and unaffiliated hospitals. While rapid cycle projects are preferred in QICs, it has been the experience of the Institute for Healthcare Improvement that at least 18–24 months are required before culture change results in sustainable, reliable improvements in perinatal care and outcomes (Bisognano, Cherouny, and Gullo 2014). The intervention period entailed two phases: Phase 1 (January 1, 2008 to December 31, 2010) funded by American Excess Insurance Exchange (AEIX); and Phase 2 (January 1, 2011 to December 31, 2012) funded by the Agency for Healthcare Research and Quality (AHRQ). The Phase 1 intervention consisted of the initiation of evidence-based standardized care processes, didactic team training, monthly educational webinars, quarterly performance feedback, two all team in-person meetings, and periodic technical assistance coaching. Through this sequence, we engaged in continuous performance assessment, feedback, and tests of change using rapid cycle improvement. The Phase 2 intervention introduced intensive interdisciplinary in situ simulation training at each hospital, while continuing all Phase 1 activities. Figure 1 depicts the project timeline.

We instituted a set of technical and nontechnical interventions, similar to other complex interventions to improve care in real time in an applied clinical context (Pronovost et al. 2006, 2010; Bion et al. 2013). We expected that the application and maintenance of multiple interventions affecting the reliability of processes and individual cognitive and interpersonal skills over an

Figure 1: Premier Perinatal Safety Initiative Intervention Timeline



Notes. The timeline depicts the dates of meetings and intervention implementation that occurred during the 7-year project. On-site *in situ* simulation training occurred from January to June 2011.

extended time period would be necessary to produce sufficient behavior change to affect outcomes. All interventions except in situ simulation training extended over a 5-year period (2008–2012). The in situ simulation training occurred during year 4 (2011).

We used a train-the-trainer method to sequentially train a team from each hospital, which in turn trained staff at their respective perinatal units. The interdisciplinary trainer team from each hospital, comprised of a physician and a nurse, participated directly in all the interventions. The study was reviewed and ruled exempt by the University of Minnesota Institutional Review Board (IRB). Individual hospitals participating in the study processed IRB approval with their own IRBs as needed. The National Perinatal Information Center (NPIC), as the data partner, obtained IRB approval from a hospital outside of the study group.

Hospital Selection

In 2008, AEIX insured 90 hospitals in 19 health care systems. Sixteen of those health care systems had one or more hospitals providing obstetrical services; the other three systems had no obstetrical service line. An invitation to become involved in the PPSI was sent to these 16 health care systems, representing a total of 67 hospitals providing obstetrical services. Thirteen of the 16 systems accepted the offer, and each of the participating systems enrolled one hospital in the PPSI with funding by AEIX to cover costs of participation. In

addition, three health care systems elected to enroll a second hospital at their own expense. The health care systems selected the specific hospital(s) that participated in the study. The research team was not involved in the final selection of invited hospitals.

These 16 hospitals represent a range of birth volume, academic status, hospital size, and geographic location, creating a diverse mix of participants. Of the 16 hospitals participating in Phase 1, 14 continued through Phase 2. We report findings for those 14 hospitals. Compared to the 14 continuing hospitals, the two hospitals that were excluded had slightly lower adverse event outcome measures. One of the hospitals that withdrew from the study closed its obstetrical unit at the end of Phase 1. This decision was made by the hospital and was unrelated to their participation in this intervention. The other hospital team discontinued participation due to competing priorities for staff time and resources. The organization reported that it could not provide the needed staff time for the data collection (the hospital location, category, and number of deliveries are reported in the online appendix). Given this selection methodology, it is possible the 16 hospitals that volunteered for the study from the population of 67 hospitals may be more motivated to improve their obstetrical outcomes. This motivation could arise from concerns about quality, or from an existing culture of improvement. In any event, these hospitals may not be representative of the typical hospital in terms of motivation to improve.

Interventions

Standardized Care Processes. A care bundle is a set of evidence-based practices that have been demonstrated to improve patient outcomes when performed collectively and reliably. We introduced three standardized care processes: (1) elective induction bundle; (2) augmentation bundle; and (3) vacuum extraction bundle. Each bundle has 4–5 specific behavioral interventions (Table 1). The bundles share a common objective of standardizing processes and reducing practice variation. Originally developed by the Institute for Healthcare Improvement in 2005, the bundles have been applied in a number of perinatal care settings (Cherouny et al. 2005; Mazza et al. 2007; Institute for Healthcare Improvement 2012). When perinatal care bundles were initially developed a decade ago, the majority of birth trauma events were associated with oxytocin use, and the packages for elective induction and augmentation of

Table 1: Three Perinatal Care Bundles and Bundle Elements

Elective Induction	*Augmentation*	*Vacuum Extraction*
Gestational age ≥39 weeks	Documentation of estimated fetal weight	Alternative labor strategies considered
Or documented medical indication for induction if less than 39 weeks gestation	Normal fetal status	Informed consent discussed and documented
Normal fetal status prior to onset of oxytocin	Pelvic exam prior to onset of oxytocin	Estimated fetal weight, fetal position, and station known
Pelvic exam prior to onset of oxytocin	Recognition and management of tachysystole	Maximum application time and number of pop-offs predetermined
Recognition and management of tachysystole		Cesarean and resuscitation team available at delivery

labor were based on consensus recommendations to reduce variation in these care processes (Cherouny et al. 2005).

Consistency in the chart audit process was stressed with all teams. Each team developed different tools, such as forms or fields in their electronic medical records, for documentation of each bundle element. Each team assigned a key contact who was accountable for the data collection of the bundles for their respective team ensuring the audits were completed and the data entered into the online data reporting site for the project. The teams managed tachysystole two ways, by reviewing: (1) the fetal monitoring strips for the presence of tachysystole, or (2) the information entered by the nursing care provider on a tracking form for the bundle element.

Teamwork Training. We used didactic content and in situ simulation to support the creation of highly reliable teams at intervention hospitals. Both training modalities were based on a condensed TeamSTEPPS curriculum, derived from research (Miller et al. 2008), focused on four behavioral markers that identify high reliability team performance: (1) situation awareness; (2) closed-loop communication; (3) SBAR communication; and (4) shared mental model. These critical behaviors reflect the cumulative leadership performance of a critical incident team (Riley et al. 2008). This dual teamwork training strategy was structured to introduce learning, provide opportunities to practice the learning, and reinforce nontechnical team behaviors over an extended time. The didactic training was implemented in Phase 1 through face-to-face

meetings, monthly webinars, a 30-minute video, and a 2-hour presentation prior to the in situ simulation on-site training.

The in situ simulation strategy, shown to be a superior training modality for improving teamwork (The Joint Commission, 2006, 2007; Jewll and McGiffert 2009, Sorra et al. 2009), was introduced in a demonstration format during Phase 1. This was followed, in Phase 2, by a 3-day site visit to each perinatal unit where on-site in situ simulation training was provided. Five simulation scenarios were developed: postpartum hemorrhage, uterine rupture, abruption, shoulder dystocia, and resuscitation of the hypovolemic newborn. Each in situ simulation training consisted of three phases: (1) a briefing to set the stage; (2) the simulation experience; and (3) a facilitated debriefing. Videotapes of the simulations were used during the debriefing for critical review and experiential learning. Using the train-the-trainer model for sustainability, the trainers at each hospital received extensive coaching and monitoring from two project team members (an obstetrician and a obstetrical nurse). The in situ simulation training was then provided to all labor and delivery, neonatal, operating room, anesthesia, lab, blood bank, respiratory therapy, and ancillary staff over the course of a year. Following the on-site train-the-trainer 3 days in situ simulation experiential training, each of the 14 sites conducted additional interdisciplinary in situ simulation offerings for 1 year. The goal of the study was to reach 100 percent participation of the staff. Each site had autonomy in conducting the simulations as well as choice in participation. Overall, 45.7 percent of clinical staff participated in at least one simulation (1,768 staff participating, including LNP, RN, and MD). Staff participation rates in the 14 hospitals ranged from 10 to 92 percent. For overall saturation, 9 percent of all departmental staff participated in at least two simulations, while 4 percent participated in at least three. Labor units were involved with 33 percent of the simulation scenarios, delivery teams were involved in 49 percent of the simulations, and neonatal (NICU) teams were involved with 18 percent of the scenarios. A phone audit with nursing leader of each site was done 1 year after the on-site in situ simulation train-the-trainer experiential education. Twelve hospitals (86 percent) reported scheduling conflicts and 11 hospitals (79 percent) reported physician buy-in to be key repetitive challenges to full simulation participation. Turnover of key personnel leading the in situ simulation effort was also reported with a 36 percent nurse manager turnover.

Education and Performance Feedback. Education was provided on a variety of contemporary teamwork and clinical topics including electronic fetal

monitoring (EFM). The EFM training included standardized language developed by the National Institute of Child Health and Human Development (Macones et al. 2008; American College of Obstetricians and Gynecologists 2010), using an institutional web-based education program Advanced Practice Strategies Advanced Fetal Monitoring & Assessment provided through Healthstream (Healthstream 2012). In addition, five physicians and five registered nurses responsible for fetal monitoring interpretation at each site were offered licenses to complete a more advanced online training with required competency test out. Overall 93 percent (n = 130 of 140) of the clinical staff successfully completed the advanced training, including 89 percent (n = 62 of 70) of the physicians and 97 percent (n = 68 of 70) of the registered nurses.

Performance feedback was provided to all teams using 60 monthly webinars, conference calls, and e-mails to benchmark their progress. Topics included overall compliance with the standardized processes (monthly), outcomes (quarterly), coaching to deal with change management barriers (ad hoc), and education regarding best practices (monthly), as well as an online website with numerous resources to support ongoing learning. These team webinars were also used to share learnings from other teams in the collaborative such as how to enhance bundle compliance, team communication, and resistance to change.

Quality Improvement Collaborative

We used a QIC to support the implementation of all three interventions. The QIC is a well-used approach by the health system to improve performance (Mittman 2004; Lindenauer 2008) and involves teams in a series of meetings to learn best practices from faculty knowledgeable about the content as well as quality improvement (Lindenauer 2008). QICs typically consist of interdisciplinary teams from numerous organizations willing to share experiences and to use quality improvement methods and techniques (Simon 2009).

Outcome Measures

We collected data on eight outcome measures selected from the National Perinatal Information Center database of coded discharge data submitted by hospitals. The eight measures were selected for their likely responsiveness to the intervention. Four measures (AHRQ PSI 1, 5, 7, and 16) were dropped from detailed analysis due to small numbers of

observations. Three of the four remaining outcome measures are related: Adverse Outcome Index (AOI), Weighted Adverse Outcome Score (WAOS), and Severity Index (SI). The three indices were formulated by consensus development conferences in the early 2000s (Mann et al. 2006). The AOI is the number of delivered mothers or infants with an adverse event, divided by the number of deliveries. Ten types of adverse events (e.g., uterine rupture, maternal blood transfusion) are included in the index. Although the AOI has been widely used, it has been subject to limited methodological scrutiny. Potential drawbacks of the AOI include being heavily influenced by high-volume adverse events and reliance on expertise of hospital coding and provider documentation (Foglia et al. 2015). The WAOS sums the weights for each of the adverse events that occurred and divides by the number of total deliveries. The SI sums the weights for each adverse event that occurred and divides by the number of patients that had an adverse event. The fourth outcome measure, AHRQ PSI 17-birth trauma, is a measure of a potential adverse event or complication experienced by a patient that could be prevented by system changes at the provider or organizational level (Agency for Healthcare Research and Quality 2013, 2014). We did not include PSI 18 and PSI 19, obstetrical trauma with and without instruments, for two reasons: (1) the predominant injuries reported for PSI 18 and PSI 19 are third- and fourth-degree perineal lacerations, both of which are already included in the AOI; and (2) there is considerable disagreement regarding laceration interpretation and coding issues associated with PSI 18 and PSI 19.

Data Collection

Care Bundles. The use of standardized processes (bundle compliance) was measured by chart audit using the IHI method (Cherouny et al. 2005). Data for the bundles were compiled in monthly retrospective chart audits by hospital staff, who audited 20 charts for each bundle per month. If fewer than 20 pertinent events occurred in a given month, all charts from that month were included. All items for bundle compliance were coded "yes" or "no," with no credit for bundle compliance given unless all elements of the bundle were performed and documented. Each hospital uploaded all bundle metrics from the chart audits to an online bundle report module. A secure site was maintained by the research team and the data were uploaded for all three bundles each month along with birth log data. Bundle compliance rates were reported to

each perinatal team quarterly, including blinded performance relative to other intervention hospitals.

Outcome Measures. Each participating hospital collected monthly administrative data on all perinatal discharges for the 7-year period. Each quarter, the NPIC collected, processed, validated, and reported the outcome measures. Staff members at each hospital submitted data on births and adverse events electronically.

Statistical Methods. We used a run chart analysis to assess the process behavior of the standardized care bundles over the 7-year period. A run chart is a statistical process control technique that uses a time ordered sequence of consecutive observations to evaluate process behavior by identifying common cause variation and special cause variation. We also used run chart analysis to longitudinally analyze the AOI, WAOS, and SI in this study. Pre-post analyses using two-tailed *t*-tests were conducted for the outcome variables.

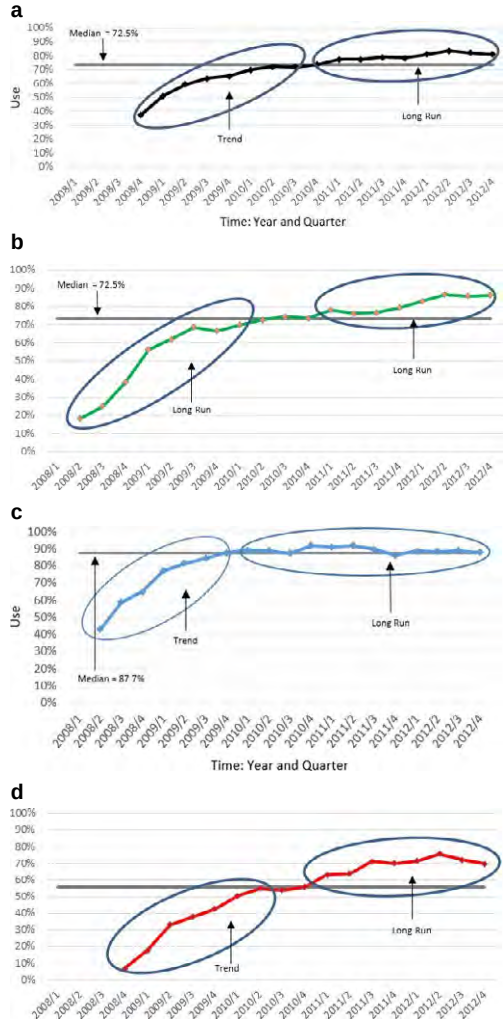
RESULTS

There were a total of 342,754 deliveries in the 14 hospitals, consisting of 107,472 births during the 2-year baseline period and 235,282 deliveries during the 5-year intervention period. Overall, a total of 1,883 (45.7 percent) perinatal staff at the 14 hospitals participated in the in situ simulation training; we did not record the number of staff participating in didactic training.

Standardized Processes

The use of the three standardized care processes, as well as the composite, across the 14 perinatal units is shown in Figure 2. The augmentation and induction care bundles were implemented Quarter 2-2008 through Quarter 4-2012, while the vacuum bundle was implemented Quarter 3-2008 through Quarter 4-2012. Use of the induction care bundle increased 113 percent (from 39 to 90 percent), with an increasing trend noted for the initial eight quarters, indicating special cause variation ($p < .003$) followed by common cause variation during the final 12 quarters, indicating a stable process. The augmentation

Figure 2: (a–d) Run Chart Analyses of Perinatal Care Bundles Compliance: (a) Composite, (b) Augmentation, (c) Induction, and (d) Vacuum



Notes. The compliance of the augmentation, vacuum, and induction standardized care bundles, as well as the composite compliance of all three bundles. Median compliance is noted in each graph, and periods of special cause are noted.

care bundle increased 377 percent (from 17 to 85 percent), with two long runs ($p < .003$). The vacuum bundle increased 900 percent (from 7 to 70 percent), with two long runs noted ($p < .003$). The composite standardized use of care

bundles increased 116 percent (from 37 to 80 percent), with two long runs ($p < .003$). The rate and magnitude of change, as well as overall performance levels, vary in each of the three care processes.

Outcomes

Table 2 shows a comparison of the baseline period with Phase 2 of the intervention for the four outcome measures. Overall, the AOI decreased 14.4 percent ($p = .032$), while there was no significant change in PSI 17, the WAOS, or SI. The run chart in Figure 3 shows the overall process behavior for the AOI over the 7 years (Quarter 1-2006 through Quarter 4-2012). Two occurrences of special cause are noted: (1) from Quarter 1-2006 to Quarter 1-2008 ($p < .003$) during the baseline period and (2) from Quarter 1-2010 to Quarter 4-2012 at the end of the project ($p < .003$). Common cause variation is observed between the two process shifts.

COMMENT

This prospective quasi-experimental study was conducted to improve performance of hospital obstetrical care and reduce preventable perinatal harm. The findings demonstrate the ability of hospital perinatal units to implement interventions over a sustained time period to reduce perinatal harm using a QIC.

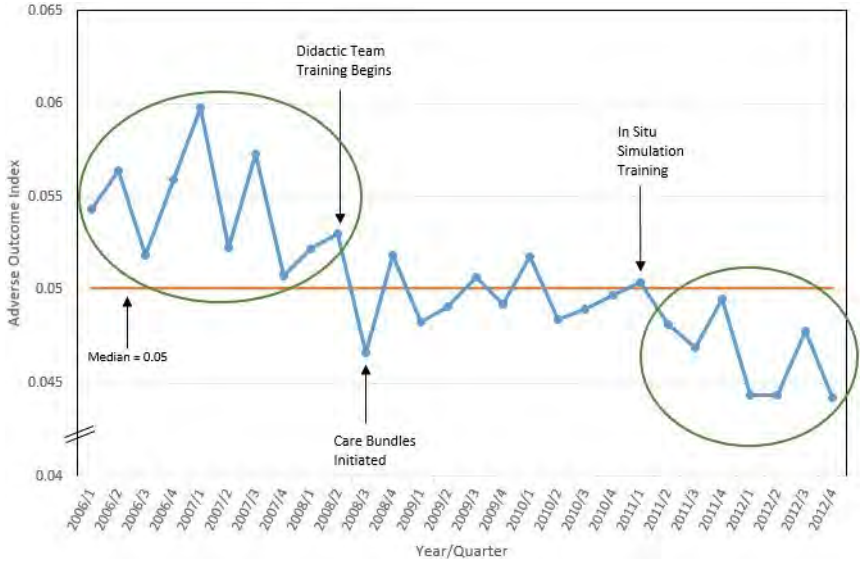
The hospital perinatal unit staff substantially increased the use of standardized processes for each evidence-based care bundle. Of note are the differences between bundle compliance as well as the rate of change over time. While the vacuum extraction bundle moved the farthest, it had the lowest final compliance level of the three bundles. Full compliance with one or more

Table 2: Results of *T*-tests for Four Outcome Measures: Baseline Period Compared to Phase 2

Measure	*Baseline Period* (2006–2007)*	*Phase 2* (2011–2012)*	*Change (%)*	*p-value*
Adverse outcome index	0.055	0.047	−0.008 (−14.5)	.032
Weighted adverse outcome score	1.192	1.081	−0.111 (−9.3)	.100
Severity index	21.88	22.62	0.738 (3.4)	.460
Patient safety indicator 17	0.0019	0.0016	−0.0003 (−15.8)	.163

*Quarterly outcomes were averaged for each hospital, then averaged for all 14 hospitals.

Figure 3: Run Chart of the Composite Adverse Outcome Index of Fourteen Hospitals (January 2006–December 2012)



Notes. The run chart shows the effects of the interventions on the adverse outcome index. Intervention launches are indicated. Two periods of special cause are noted.

bundles was achieved by several perinatal units for one or more quarters, although none of the 14 perinatal units reached 100 percent bundle compliance in the same quarter. We also undertook extensive teamwork training using two training methods (didactic training and in situ simulation training) as well as common EFM interpretation and communication. The findings indicate that the AOI, an important measure of the incidence of perinatal harm, decreased 14 percent. The decrease in the AOI largely occurred only after the first quarter of 2011, at which point bundle compliance rates had all improved beyond their median rates, and at which time in situ simulation training was conducted. The AOI improvement logically could be related to either of those events, their combination, or some unmeasured event. It is possible that the in situ simulation training provided a necessary boost in commitment to decreasing adverse events, and that improved bundle compliance alone would not have produced the effect. While it is possible that the changes in our outcome measures could have been attained without these interventions, secular comparisons suggest otherwise. A population-based study in

British Columbia found no significant change in the AOI or WAOS over the 2004–2013 period, while the SI decreased significantly (Hutcheon et al. 2015). Likewise, nationwide data from the National Perinatal Information Center during the same period of this study indicate that AOI and WAOS increased during the same time period, while the SI remained unchanged. Similarly, PSI 17 incidence rates increased during the period 2009–2013 (Ledneva et al. 2015). To infer the causal relationships between the interventions and improved outcome, we follow the Pawson and Tilley (1997) CMO model, context + mechanisms = outcome, which has been promoted to accelerate the improvement of systems of care and clinical practice (Berwick 2008).

The interventions did not produce significant improvements in the other three outcome measures—the WAOS, SI, and AHRQ PSI 17-birth trauma. One potential interpretation of these seemingly heterogeneous intervention effects is that the outcome indexes measure separate concepts. For example, AOI measures the incidence of adverse perinatal outcomes in a population; WAOS measures the severity of total perinatal injury in an entire population; and SI measures the severity of perinatal injury in the subpopulation of patients who incur injury. Given that the AOI decreased significantly whereas the WAOS and SI did not, our findings suggest that the rate of perinatal harm decreased while the severity of harm, when injury did occur, remained unchanged. However, the lack of a reduction in total severity of injury could be interpreted that there was no change in the severity of injury for patients who were injured.

There is growing understanding that preventable perinatal injury is highly related to large variability in care processes and poor execution of nontechnical skills (Simpson and Knox 2003; Salas, Gregory, and King 2011; Resar et al. 2012). The findings from the present study help inform the relationship between the use of standardized care processes, teamwork training, and improved perinatal outcomes. Process behavior is best understood by examining time ordered sequences in a key quality metric. Using a run chart analysis, our first statistically significant change in the AOI occurred when special cause variation lasting over 2 years (January 2006–March 2008) was followed by almost 3 years of common cause variation (September 2008–January 2011) immediately after the introduction of the standardized care processes. Such standardization of practices is the foremost building block to be addressed before other solutions to unsafe care are introduced (Amalberti et al. 2005).

It is likewise noteworthy that a second pattern of special cause occurred immediately after introduction of the in situ simulation training, suggesting

that nontechnical skills are also necessary to ensure safe patient care (Paisley, Baldwin, and Paterson-Brown 2001; Yule et al. 2008; Bisognano, Cherouny, and Gullo 2014). The second occurrence of special cause in the AOI run chart analysis occurred following the introduction of extensive in situ simulation training and also persisted almost 3 years, until the end of the study (March 2011–December 2012).

While the hospital staff in this study underwent extensive teamwork training over an extended time frame and dramatically increased the use of standardized care processes, it is not clear whether there is a threshold level at which point this care standardization impacted care outcomes. Most studies to improve perinatal outcomes are conducted in one hospital or system, implement a limited set of interventions, involve a small number of deliveries, and/or last a short duration. The findings from this study are especially relevant because of the large number of births (342,754) analyzed over a 7-year time frame using several interventions across 14 widely distributed hospitals, including both employed physicians and private hospital staff. Some perinatal events are so rare that examining a trend requires thousands of cases (Wagner et al. 2012), and the magnitude of this study enhances face validity of the findings.

Several precautions are in order when drawing conclusions regarding the causal relationship between the quality improvement interventions and change in performance (Bion et al. 2013). While findings from this study suggest training in technical and nontechnical interventions to improve patient safety combined with performance feedback resulted in a reduction in perinatal harm, this conclusion requires a nuanced interpretation. Although our discussion regarding industry trends indicates that these findings are not associated with any known secular trends, it is never the less possible these findings do reflect a secular trend. Next, these interventions were undertaken during a period of sustained activity on a national level to improve perinatal safety (Crofts et al. 2007; Clark et al. 2008; Draycott et al. 2008; Hansen and Arafeh 2012). Finally, the methodology applied in this study reflects a larger discussion currently underway in the science of improvement regarding the appropriateness of randomized controlled trails in contrast to other methods to accelerate improvement in clinical settings (Berwick 2008).

Limitations

The data for this analysis come from 14 hospitals who responded to an invitation to participate in a QIC to reduce perinatal harm. To establish causality,

an ideal study would randomly select participating sites and randomize them to intervention or control groups. Because of the potential that hospitals volunteering to participate were somehow different than those not volunteering to participate (e.g., differing levels of motivation to change or underlying leadership characteristics), we cannot establish a true causal link between the intervention and outcomes observed. However, the review of secular trends helps mitigate this potential threat to validity. We did not control for any related or competing interventions occurring in the perinatal units during this study. Another limitation of this study design was the inability to separate the effects of the multiple interventions on perinatal outcomes (standardized care processes, didactic, or in situ simulation training). The extent of in situ simulation training varied substantially in the participating hospitals. The in situ simulation participation data were collected retrospectively, and we do not have sufficient information regarding the uptake of the in situ simulation experience from the participants to assess this impact directly. It is unknown what amount of intervention with perinatal staff is necessary to produce desired outcomes. It is also unknown, given the lack of empirical data, the extent to which limited physician engagement, poor leadership, and turnover in nursing leadership plays in achieving and sustaining high reliability. During the course of this study, there was a 36 percent turnover of nurse managers. There is always a potential for leadership turnover to have a disruptive impact on perinatal unit performance. This potential impact was not addressed in the study. Finally, it is difficult to compare effectiveness of outcomes among studies because there is no commonly accepted time frame to measure adverse perinatal outcomes (Bailit 2007), and a variety of time intervals are used to report rates including monthly, quarterly, and annually. To address this concern, we used statistical process control analysis based on process shifts to assess change over time as reflected by special cause variation.

CONCLUSION

High reliability is especially necessary in perinatal units, where the consequences of errors are high, but the frequency of occurrence is low (Baker, Day, and Salas 2006). The findings from this study contribute to a slowly accumulating body of evidence regarding methods and approaches to reduce unintended perinatal injury. Perinatal teams work in complex systems where the best countermeasure to preventable harm consists of an

interdisciplinary team of experts (McIntyre and Salas 1995; Burke et al. 2004; Miller et al. 2008) using standardized care processes (Cherouny et al. 2005; The Joint Commission 2006; Jewll and McGiffert 2009; Resar et al. 2012) and supplemented by extensive teamwork training (Neily et al. 2010; Weaver et al. 2010; Shannon 2011; Resar et al. 2012) to improve the reliability of obstetrical work. These findings suggest that a multiplicity of integrated strategies, rather than a single intervention, may be essential to achieve high reliability. We propose the following recommendations for future research. First, assess the individual impact of the three interventions and their possible synergistic relationship. Second, consider teamwork training penetration (the percent of staff that participate in training) and saturation (the number of times that staff members train). Third, determine the extent of the uptake of the in situ simulation training from the participants and its impact on perinatal safety.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.
Table S1. Intervention (n = 14).

Obstetric Team Debriefing Form

Remember: Debriefing is meant to be a learning experience and a way to address both human factors and systems issues to improve the response for next time. There is to be no blaming/finger-pointing.

Type of event: _____ Date of event: _____

Location of event: _____ Person completing form: _____

Members of team present: (circle all that apply)
Primary RN, Primary MD, Charge RN, Resident(s), Other RNs
Anesthesia personnel, Neonatology personnel, MFM leader, Patient Safety Officer
Nurse Manager, OB/Surgical tech, Unit Clerk, Antepartum team (RNs, PA, Fellow, Resident)

Thinking about how the obstetric event was managed…

Identify what went well (Check if yes)
☐ Communication
☐ Role clarity (leader/supporting roles identified and assigned)
☐ Teamwork
☐ Situational awareness
☐ Decision-making
☐ Other: _____

Identify opportunities for improvement: **"human factors"** (Check if yes)
☐ Communication
☐ Role clarity
☐ Teamwork
☐ Situational awareness
☐ Decision-making
☐ Human error
☐ Other: _____

Identify opportunities for improvement: **"systems issue"** (Check if yes)
☐ Equipment/supplies/accessibility
☐ Medication
☐ Blood products availability
☐ Inadequate support (in unit or other areas of the hospital)
☐ Delays in transporting the patient (within hospital or to another facility)
☐ Staffing
☐ Other: _____

For identified issues, please fill in table below…

Issue	Actions to be Taken	Person Responsible

DO NOT place any patient identification on this form.

BMJ Open Quality

Preidentification of high-risk pregnancies to improve triaging at the time of admission and management of complications in labour room: a quality improvement initiative

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ABSTRACT

Complications can occur anytime during pregnancy and childbirth. Pregnancies associated with high-risk factors have a higher-than-normal risk for fetomaternal complications. Bhagwan Mahavir hospital is a public sector hospital catering to low-risk and high-risk pregnant women (PW) in the labour room (LR)). The obstetrics and gynaecology team observed that at times the LR team failed to identify high-risk pregnancy (HRP) during admission in LR and to manage complications timely and efficiently. Therefore, the team started a quality improvement (QI) project in January 2019 with the aim to admit preidentified HRP in LR from existing 0% to 80% in 3 months.

The QI team followed the point-of-care quality improvement methodology to conduct this improvement process. They identified HRP in the outpatient department (OPD) during their antenatal care (ANC) visits, mentioned an HRP number on their ANC cards, and did risk stratification with yellow and red stickers into moderate and severe HRP respectively. Preidentified HRP were attended, admitted and managed on priority in the LR. The team achieved its aim in the ninth week of the QI initiative and sustaining to date. The team also measured and analysed the type of HRP identified in OPD, complications occurring around the process of childbirth in LR, maternal near-miss, maternal death and PW referred out from LR. They observed a 6.5%-point reduction (68.93%) in the median complication rate of major life-threatening complications following this improvement process.

This new intervention facilitated the team in early initiation of management of HRP in OPD, their triaging in LR, preparedness towards managing complications, involvement of support staff, PW and their relatives in the patient care, and redistribution of human resources according to priority area. The lessons learnt are generalisable and can be used in other facilities with similar settings.

WHAT IS ALREADY KNOWN ON THIS TOPIC?

⇒ All pregnancies especially high-risk pregnancies (HRP) are at potential risk of complications during pregnancy and childbirth.
⇒ Early identification, risk stratification and management of HRP improve pregnancy outcomes.

WHAT THIS STUDY ADDS?

⇒ The team followed the point-of-care quality improvement methodology with available human resources to identify HRP and used colour codes for risk stratification.
⇒ This intervention helped the team in early identification and management of HRP in antenatal clinic, their triaging in labour room, preparedness towards managing complications and redistribution of human resources according to priority area.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY?

⇒ The lessons learnt are generalisable and can be used in other facilities with similar settings to improve patient care at different levels without additional human resources or financial support.

PROBLEM

Pregnancy and childbirth are considered physiological processes and most pregnancies and childbirth worldwide are uneventful. However, all pregnancies are at risk anytime during pregnancy, childbirth and thereafter. Complications can occur anytime during pregnancy and childbirth, which in turn can affect the health and the overall survival of the mother and the fetus. Almost 15% of all pregnant women (PW) can develop potentially life-threatening complications which might require skilled care with some requiring major intervention for survival.[1]

Bhagwan Mahavir (BM) hospital is a 250-bedded secondary care public sector hospital in the north-west district of Delhi, India. It caters to low and lower-middle socioeconomic populations from the surrounding area. This hospital provides round-the-clock essential and emergency obstetrics and newborn care services in the labour room

(LR). The median delivery per month is 317. The LR receives PW from its antenatal care (ANC) OPD, nearby primary healthcare centres and PW referred from other secondary care and private sector hospitals. The PW delivering at LR consists of both low-risk and high-risk pregnancy (HRP). The LR team manages most of the HRP and refers them to a tertiary care centre only in cases of pregnancy associated with medical disorders like cardiac disease, chronic renal disease, acute renal failure, etc requiring super specialised treatment, with disseminated intravascular coagulopathy requiring massive blood and blood component transfusion, with an extremely premature baby, and baby requiring in-utero treatment. This hospital has an emergency and an elective operation theatre, 10-bedded neonatal intensive care unit (NICU) adjacent to LR, a 12-bedded common ICU and a blood bank. The blood bank does not prepare blood components hence arranges from nearby tertiary care centres.

In LR, one postgraduate senior resident (SR), one undergraduate junior resident (JR) doctor and two staff nurses (SN) in a shift provide all the services. These include labour monitoring, conducting vaginal and caesarean section (CS) delivery and other emergency operative services, and follow-up of mothers after delivery. All deliveries, including vaginal deliveries, are conducted by doctors. SN does not conduct vaginal delivery in this hospital. When the SR goes to OT for any surgical procedure, LR is left with the JR and the SN. In such a situation, before implementation of this quality improvement (QI) process, many a time the JR on duty could not identify an HRP and failed to provide appropriate care around birth to a high-risk PW. There was no process of triaging of PW in the LR. The HRPs were not preidentified or screened during ANC visits. The LR team was failing to anticipate and manage complications timely and efficiently especially in the absence of SR on duty in the LR. The preparedness to manage complications timely and efficiently was poor as they were unanticipated. This was an important concern and a challenge to provide quality healthcare services and safe delivery to the PW attending LR of BM hospital and to give them a good childbirth experience.

In the meantime, the obstetrics and gynaecology (OBGYN) department of BM hospital got the opportunity to participate in a hub and spoke model of a QI project.[2] As a participant, the OBGYN team decided to address this problem through QI methodology and started a QI project with an aim to admit preidentified HRP in LR from existing 0% to 80% in 3 months (from 1 January 2019 to 31 March 2019).

BACKGROUND

All pregnancies are at potential risk of complications during pregnancy and childbirth. The WHO has reported that almost 830 women die daily because of complications during the antenatal period and childbirth.[3] There are five main reasons for the death of PW such as severe haemorrhage, maternal infections, unsafe abortion, hypertension-related disorders of pregnancy such as pre-eclampsia and eclampsia, and medical complications such as cardiac conditions, HIV/AIDS or diabetes complicating or complicated by pregnancy.[3]

An HRP is associated with an actual or potential risk to the mother or the fetus. HRP is defined as pregnancy with pre-existing or current conditions that put the mother, the fetus, and the newborn baby at higher-than-normal risk for complications during or after the pregnancy and childbirth.[4] These include very young and older women and those with previous or current medical and obstetric complications.[3] The chances of pregnancy-related complications are more in HRPs.[5 6] The presence of comorbidities among PW significantly increase the risk of progression to severe maternal morbidity (SMM).[7] A systematic review of SMM found that the most common preventable factors in SMM cases were provider-related, specifically, a failure to identify 'high-risk' status and delays in diagnosis and treatment.[8]

Worldwide, 10%–30% of pregnancies are estimated to be 'at-risk'. In India, about 20%–30% of pregnancies belong to the high-risk category.[9 10] Identification and management of HRP initially and throughout pregnancy improve pregnancy outcomes for the mother and the newborn.[9–13] Hence, all pregnancies need to be evaluated for associated high risks through routine ANC provided by healthcare professionals. Early identification of HRP flags PW who need clinical attention.[14] The prognosis of the HRP also depends on its severity. HRP has been categorised into mild, moderate and severe HRP according to the associated high-risk factors. Several risk scoring systems and risk stratification using colour codes have been used to categorise HRP.[15–17] The risk factors are based on past obstetric history, present pregnancy, medical and surgical illnesses, and each factor is assigned a score proportional to the degree of risk.[18]

BASELINE MEASUREMENT

A consultant and an SR from the OBGYN team collected the baseline data regarding HRP delivery and complications from the available records in LR. The birth register included records of all deliveries conducted in BM hospital including complications. In the birth register, the diagnosis included all the important key variables like parity, number of fetuses, gestational age, fetal presentation and any associated high risk. They collected the number of HRP delivered in LR in the last month (Decmber 2018). This was 32% of the total delivery. The median complication rate of major life-threatening complications like antepartum haemorrhage (APH), postpartum haemorrhage (PPH) and severe pre-eclampsia/eclampsia during pregnancy and childbirth in the last 6 months of the year 2018 was 9.43%.

The OBGYN team decided to record the percentage of preidentified HRP admitted in LR out of total HRP delivery as the process measure. Another process measure

was to record all preidentified HRP in ANC OPD to know the type of HRP coming to BM hospital.

As an outcome measure, the team decided to keep a record of the percentage of major life-threatening complications (APH, PPH, severe pre-eclampsia/eclampsia), maternal near-miss, and maternal death to observe any improvement in these indicators following implementation of this QI initiative.

The number of PW referred out to tertiary care centre from LR was taken as the balancing indicator to assess the impact on the referral of PW.

DESIGN

The OBGYN team followed the Point of Care Quality improvement (POCQI) methodology[19] to conduct this improvement process. An external QI coach from Nationwide Quality of Care Network, India, and a QI trained consultant oriented the doctors and SN posted in the department about the QI methodology. A QI team was formed involving consultants, resident doctors, and SN from LR and OPD. The QI team conducted brainstorming sessions and used process flow chart and fishbone analysis to analyse the problem of HRP being admitted in LR without being preidentified and to find out possible change ideas to bring an improvement.

Process flow chart showed that at the time of admission duty doctors were not screening the PW according to HRP. They were not highlighting the PW as HRP which they identified during history taking and examination. There was no communication between duty doctors and SN regarding HRP admitted in LR. JR and SN were not giving handover of HRP specifically during their shift change. After delivery HRP were shifted to the ward and discharged without being highlighted. Thus, the HRP were identified, managed and discharged mostly at the level of SR and consultants. There was no involvement of JR, SN and support staff in the management of HRP leading to unanticipated fetomaternal complications.

Fishbone analysis of the problem (figure 1) showed that there was no awareness among doctors and SN about the importance of highlighting HRPs during admission in the hospital and the involvement of JR, SN and other support staff in the management as a team. There was no process or policy to triage PW at the time of admission in LR, to identify HRP in OPD during their ANC visits and to highlight HRP during hospital stay.

The QI team decided to orient the staff of OPD and LR, especially the JR and SN about HRP, the importance of their preidentification and their role in the management of an HRP. Also, to identify HRP in OPD during ANC visits, to give them an HRP number on ANC card and to record all HRPs in the HRP register. SR and JR in LR to look for the HRP number on each ANC card at the time of admission for triaging and to mark it as HRP in the case sheet. The SN to write the HRP number from the case sheet in the admission and birth register along with the diagnosis. To record the complications occurring in any PW admitted in LR, including the low risk, in the complication register as before. The team designed this process to initiate the specific treatment of an HRP early in OPD and to refer timely to a higher centre if needed. Also to facilitate the LR team in triaging the HRPs during admission by looking at the HRP number in the ANC card, recording the number of preidentified HRP delivered in LR, and giving hand over of HRPs during shift change.

The SR in the team from OPD and LR will collect the data for analysis from OPD and LR, respectively. The team

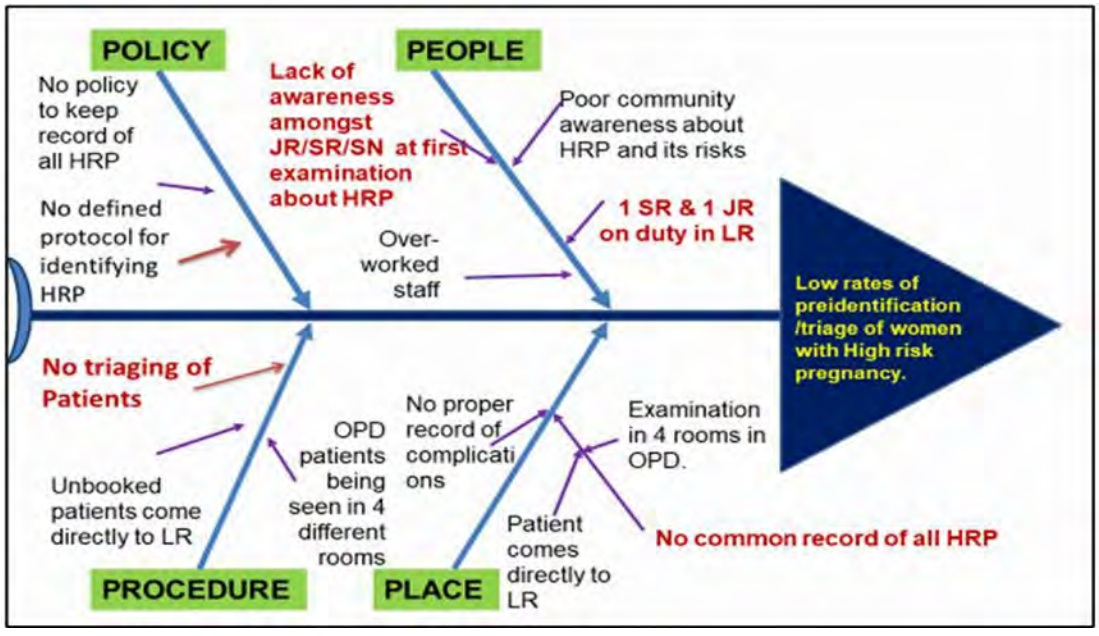

Figure 1 Fishbone analysis of the problem. HRP, high-risk pregnancy; JR, junior resident; LR, labour room; OPD, outpatient department; SN, staff nurse.

decided to analyse data for the percentage of preidentified HRP admitted in LR weekly. The denominator would be the total number of HRP delivery conducted in the facility. The team further decided to analyse the data for the type of HRP identified in OPD, complications occurring around the process of childbirth in LR, maternal near-miss, maternal death and PW referred out from LR on monthly basis. The team met weekly to evaluate the progress and to identify ways to improve the preidentification of HRP and their management.

STRATEGY

The QI team arranged orientation sessions and invited the doctors and SN posted in OPD and LR to orient them about HRP, the importance of early identification of HRP in ANC OPD, triaging of PW in LR at the time of admission, their role in the management of an HRP and the basics of QI methodology. These sessions were conducted repeatedly to orient all staff posted in the department.

The team started the QI intervention in the ANC OPD. In BM hospital, ANC OPDs are conducted on every alternate day (Monday/Wednesday/Friday). There are four OPD rooms. In each room one consultant and one SR attends the PW coming to the OPD. They kept a list of HRP in all OPD rooms to identify HRP based on their clinical history and examination. The consultant supervised that SR is correctly picking up all HRP. A similar list was kept in LR also. The LR team followed these preidentified HRPs to facilitate triaging in LR and to calculate the percentage of preidentified HRP admitted. All PW attending the ANC OPD and admitted in LR for delivery were included in the study. The PW admitted in LR were from own ANC OPD (booked PW) and directly coming to LR for the first time (unbooked PW). Consultants, resident doctors and SN working in LR and OPD were involved in the documentation and monitoring of data, conducting plan–do–study–act (PDSA) cycles, and execution of change ideas after testing them. Later, the team also involved support staff, a nursing orderly (NO) from OPD and, a security guard (SG) from LR in the team. The support staffs were explained about the ongoing improvement process and their role in the management of HRP. The team conducted a series of PDSA cycles in the OPD and LR to test the change ideas as described in table 1.

Through PDSA cycles 1–3 in OPD, the QI team streamlined the process of identification of HRP in OPD and giving an HRP number. PDSA cycles 4–6 helped the team in triaging the HRPs in LR. In PDSA 7, the team redistributed the available human resources and posted one additional SR in LR to support the LR team.

The SR in the team from OPD and LR collected weekly data for the total number of deliveries, the total number of HRP delivery and the total number of preidentified HRP admitted in LR. For the first 6 months, the team collected and analysed the data weekly and thereafter at the monthly intervals in the sustenance phase.

They also collected monthly data of HRP identified in OPD, major life-threatening complications, maternal near-miss, maternal death and PW referred out from LR. The data were entered in a Microsoft Excel spreadsheet for compilation, analysis and comparison. The team used run charts to display and interpret the serial measurement of process and outcome indicators and to study the impact of changes. They analysed the data whenever there was a shift in the median.[20 21]

To sustain this improvement process, the QI team had representatives of all the stakeholders and frontline staff including the support staff. The POCQI learner's manual[19] was kept handy and the team members revised the concepts of POCQI whenever required. The external QI coach and the QI trained consultant were there to support and guide the team. The members build up a good rapport with each other in the team. The doctors in the team understood the importance of communication with SN and support staff. The team met regularly to identify ways to improve and sustain the QI project. Successes were celebrated and failures were discussed in these QI meetings. The team members, especially the support staff, were appreciated for their efforts. This helped the team to continue the work with the same enthusiasm and motivation. They shared the successful change ideas with other staff of the department and invited their inputs for further improvement and sustenance. The successful change ideas tested in PDSA cycles were implemented in the routine processes as the new way of working. The new doctors and staff joining the department were oriented about this improvement process at the earliest. The stickers were not very costly and were procured online with imprest money. The leaders at all levels were kept in the loop and informed since starting and no leaderships issues were encountered. Eventually, this system change has become the routine of providing services in the facility. The SRs are collecting and analysing the data monthly along with other monthly censuses as per their roster under the supervision of consultants.

Patient and public involvement

Patients and/or the public were not involved in the design, conduct or reporting, of this report. The objective of the study was to provide quality care to HRPs and their triaging to reduce complications during pregnancy, childbirth and thereafter.

RESULTS

The total delivery in LR between January 2019 and June 2021 was 9347. During this period, the median HRP delivery was 33% out of which 34% were severe HRP delivery and 66% were moderate HRP delivery.

The QI team achieved its aim in the ninth week of the QI initiative and sustaining to date. The average preidentified HRP was 38% in the first 4 weeks, 64% in the next 4 weeks and 87% in the ninth week. Run chart

Table 1 Plan-Do-Study-Act (PDSA) cycles

	Plan	Do	Study	Act
PDSA-1- 2 January 2019–4 January 2019	OPD doctors to identify HRP in ANC visits and to write HRP number with red colour in their ANC cards. To note the HRP number with diagnosis in the HRP register in all four OPD rooms. To explain the PW and their relatives about associated high-risk and the purpose of giving an HRP number.	Two ANC OPDs as planned.	This change idea worked partially. It helped in the identification of HRP and in generating information about HRP status to the PW but led to the duplication of HRP numbers as the doctors gave the numbers in all four OPD rooms on the same day.	Identification of HRP and giving an HRP number was important to highlight an HRP in LR. Hence this change idea was adapted with partial modification as PDSA-2.
PDSA-2- 7 January 2019)	To keep one common HRP register in one OPD room (room no. 212) for HRP number and to send all identified HRP from other rooms to room no. 212.	One ANC OPD as planned.	This new intervention led to the confusion among high-risk PW to go to another OPD room again to get an HRP number. Doctors from other OPD rooms also felt that this was increasing the visiting time of a PW.	Team decided to involve one nursing orderly (NO) in the process.
PDSA-3 9 January 2019	The team explained the new intervention to the NO and instructed her to help the high-risk PW to get the HRP number from room no. 212.	One ANC OPD	The NO from the team assisted the high-risk PW to get HRP number without much difficulty. The process was not taking much time either as the OPD rooms are adjacent to each other.	The idea worked well and was adopted as it is. Other NOs posted in OPD were also explained about the new process and involved. The team recorded all HRP identified in OPD in one HRP register thereafter.
PDSA-4- 7 January 2019–13 January 2019	Doctor/ Staff Nurse on-duty in LR to look for HRP numbers in the ANC cards. They had to attend such PW on priority and mark them as HRP in their case sheet. Staff nurse to note down the HRP number in the admission and birth register.	One week in LR	With preidentification of HRP in OPD and HRP number mentioned in ANC card, the LR team found it easy to attend HRP on priority and to manage them in LR during observation and childbirth. They highlighted HRPs in LR and were prepared for any anticipated complications. SN recorded details of HRPs in the registers. LR team helped each other to successfully carry on the new processes.	The change idea worked well and was adopted as it is. The same process was continued. However, till the end of the first 4 weeks, the team could not achieve its target. The team evaluated the reasons for unidentified HRP in the next 4 weeks and found the reasons as- unbooked HRP coming directly to LR for admission, late-onset HRP among booked PW, and missed HRP in OPD. The team decided to give HRP number in LR to unidentified HRPs and conducted PDSA cycle-5.
PDSA-5- 1 March 2019–7 March 2019	To identify and highlight HRP in unbooked PW and in a booked PW coming with late-onset HRP at the time of admission in LR. To give HRP number in LR as HRP-LR and in OPD as HRP-OPD.	One week in LR	The QI team observed that among the unidentified HRP, some were missed out in OPD but the majority were unbooked HRP or with delayed onset HRP in booked PW.	This intervention helped the team to achieve its aim and to admit more than 80% HRP in LR with preidentification. However, in subsequent weeks the team members from LR observed that the number of preidentified HRP in LR is increasing and some of them do not require urgent attention. The QI team decided to categorise HRP in PDSA-6.
PDSA-6- 6 May 2019–8 May 2019	The team planned to colour code the ANC card with yellow and red stickers to mark them as pregnancy with moderate and severe HRP respectively. They developed a list to categorise all HRP into two categories and procured one-inch round stickers online. Stickers and a list of HRP for putting yellow/red stickers kept in all OPD rooms and LR to maintain uniformity in colour coding the ANC cards. To give priority to HRPs with red stickers.	As planned in two ANC OPD	Putting a sticker on the ANC cards of some selected PW led to questions about it. However, when explained properly it helped in bringing awareness among patients and their relatives about HRP. The process of procurement of stickers was easy and cost-effective.	The change idea worked well and adopted as it is. HRP with red stickers were given priority in the LR. During data analysis the team observed that a good number of deliveries in LR are HRPs and required additional help.

Continued

Table 1 Continued

	Plan	Do	Study	Act
PDSA-7- 1 July 2019–7 July 2019)	To post one additional senior resident (SR) to support the LR team in conducting CS delivery and other emergency surgical procedures between 14:00 and 21:00 hours and to assist the LR team as and when required. To observe the effect of posting one additional SR in LR duty on other routine works.	One week	This change idea gave very good results. The SR on duty in LR had not to leave the LR for operative procedures and was present full time to monitor the labouring patient in LR and to conduct and supervise PW undergoing vaginal birth. JR and SN in LR also felt supported. The additional SR focused on surgical procedures properly. The other routine services were managed despite posting one SR for LR duty.	This idea helped the team to utilise the human resources more judiciously. LR services were well monitored and supervised now. The team adopted this change idea and started posting an SR on 14:00–21:00 hours duty routinely to support the LR team.

ANC, antenatal care; HRP, high risk pregnancy; JR, junior resident; LR, labour room; NO, nursing orderly; OPD, outpatient department; PW, pregnant women; QI, quality improvement; SN, staff nurse; SR, senior resident.

showing percentrage of preidentified HRP admitted in LR (figure 2).

The team plotted the month-wise data of percentage of major life-threatening complications from June 2018 onwards on a run chart. The median complication rate before implementation of the QI project was 9.43%. After implementation, in the first 6 months, the median was 8.02%. June 2019 onwards the team observed a shift in the data and calculated the median again which was 2.93%. There was a 6.5%-point reduction (68.93%) in the median complication rate of major life-threatening complications following this improvement process. Run chart showing percentage decrease in major life-threatening complications in LR (figure 3).

There were no significant changes in the percentage of maternal near-miss, maternal death and referral data. Run chart showing percentage of referral during the study period (figure 4).

Table 2 is showing percentage of these indicators along with the percentage of major complications.

From January 2019 to June 2021, 5822 HRP were identified in ANC OPD and LR. Out of a total of 5822 preidentified HRP, 3545 (60.89 %) were moderate and 2277 (39.11%) were severe HRP. A total of 3843 (66.01%) HRP were identified in OPD and 1979 (33.99%) in LR. Online supplemental table 3 includes a list of HRP identified in OPD and LR. Common HRP were previous CS without short birth interval (16.88%), hypothyroidism (9.72%), mild/moderate anaemia (8.69%), Rh-negative pregnancy without isoimmunisation (7.04%), severe anaemia (5.82%), breech/ malpresentation (5.65%), hypertensive disorder in pregnancy (4.59%), etc.

Lessons and limitations

Pregnancy is a physiological process and one of the best experiences of a woman in her life. This is the expectation and right of a woman to have a positive childbirth experience. At the same time, all healthcare workers aim to provide quality healthcare services to a PW coming to the facility. For the same reason, the OBGYN team started this QI project in BM hospital.

Preidentification of HRP helped in the early initiation of investigations and specific treatment and prevented the worsening of certain modifiable HRP. HRP requiring

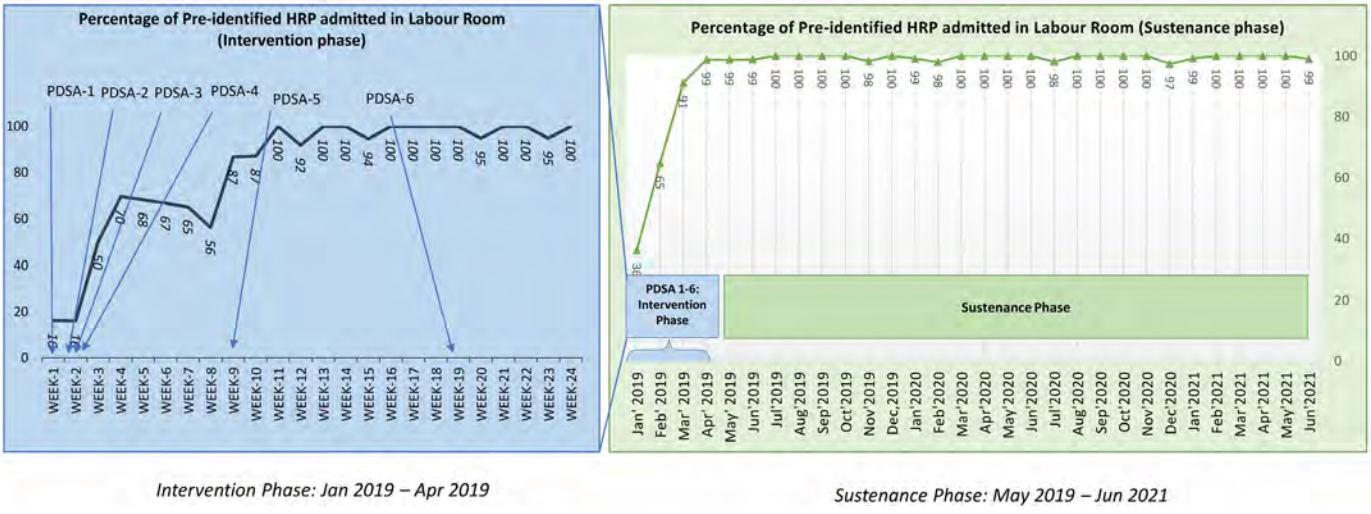

Figure 2 Run chart showing % of preidentified HRP admitted in LR. HRP, high-risk pregnancy; LR, labour room; PDSA, plan–do–study–act.

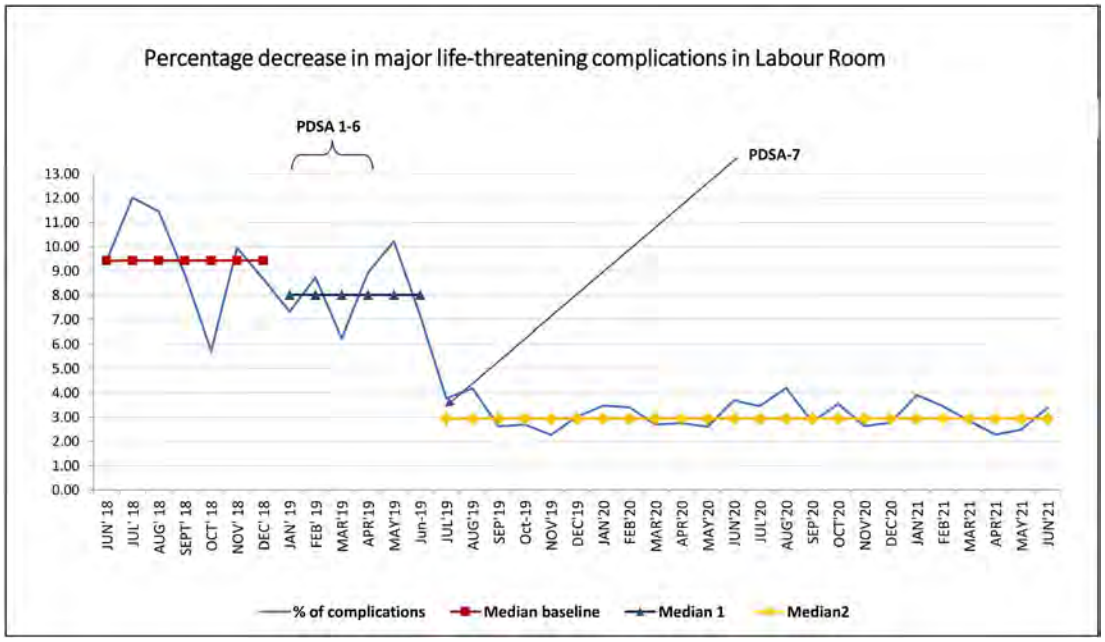

Figure 3 Run chart showing % decrease in major life-threatening complications in LR. LR, labour room; PDSA, plan–do–study–act.

super specialised treatment were referred to a tertiary care centre timely. Initially identifying all HRP in OPD took time as PW used to come for their ANC visits at different schedules and some of them were near expected date of delivery (EDD) and got admitted in LR without being preidentified in OPD. Gradually preidentified HRP started coming to LR for admission. The HRP number and red/yellow sticker on the ANC card helped the LR team especially JR and SN, to triage and highlight HRP during their treatment in LR. Colour coding of ANC cards also helped the support staff to identify HRP and to inform the duty doctors in case of a busy LR. Preidentified HRP were attended, admitted and managed on priority. This helped the facility to provide timely and better services to HRP and to prevent potential maternal complications. Complications were anticipated timely and managed well. Preparedness towards managing complications was better than before. The team observed a 6.5-point reduction in the rate of major life-threatening complications in LR following this QI initiative.

Further, this improvement process helped the team to assess the magnitude of HRP dealt with in the facility, to redistribute the available human resources according to priority area, and to involve staff at all levels. JR and SN were oriented and trained to triage HRP during admission and prioritise their management in LR. The NO and SGs were explained to identify HRP by looking at coloured stickers on ANC cards and to help them in getting HRP number and triaging. One additional SR posted in LR shared the responsibility of the LR team and allowed them to focus on providing care to PW admitted in LR. Additionally, the SN in LR were encouraged to conduct vaginal delivery for low-risk PW. The QI team also met the higher authorities of the hospital to

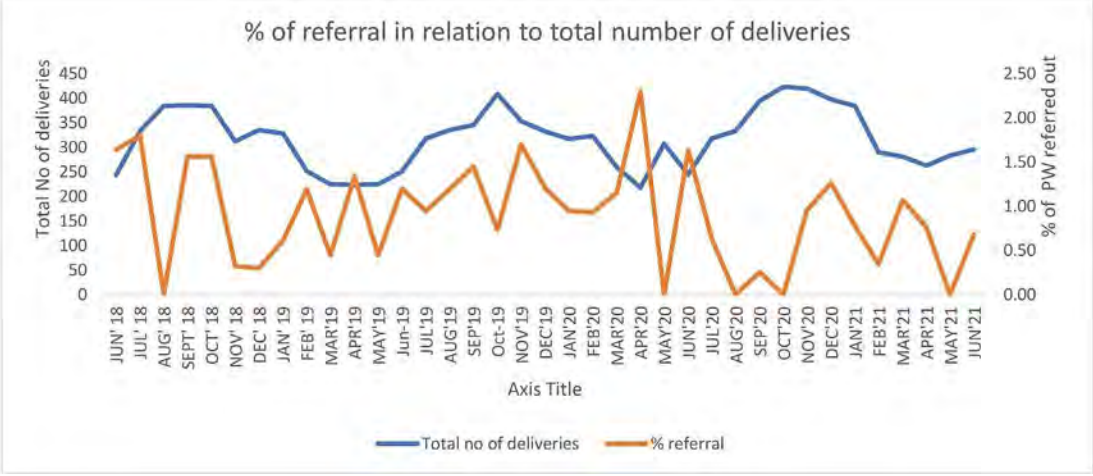

Figure 4 A run chart showing percentage referred out. PW, pregnant women.

Table 2 Percentage of outcome indicators

Month	Total delivery	% Referral	% Near-miss	% Maternal death	% APH	% PPH	% Severe pre-eclampsia	% Eclampsia	% Total complications
January 2018	422		1.18	0.24	0.71	3.08	4.03	0.71	8.53
February 2018	290		0.69	0	0	3.79	5.52	0.69	10
March 2018	301		1.99	0	1.33	4.32	5.32	0	10.96
April 2018	245		4.49	0	0	4.49	5.31	0	9.8
May 2018	301		2.33	0	0.66	4.65	6.98	1.66	13.95
June 2018	244	1.64	3.69	0	0	2.87	5.33	1.23	9.43
July 2018	333	1.8	3.3	0	0.9	5.41	5.71	0	12.01
August 2018	384	0	1.82	0.26	0.26	4.43	6.51	0.26	11.46
September 2018	385	1.56	2.86	0	0.78	3.9	3.64	0.52	8.83
October 2018	384	1.56	1.3	0	0.26	2.34	3.13	0	5.73
November 2018	312	0.32	3.21	0.32	0	4.17	4.81	0.96	9.94
December 2018	335	0.3	0.9	0.3	0.3	4.78	3.58	0	8.66
January 2019	328	0.61	0.3	0.3	0.3	3.66	3.35	0	7.32
February 2019	252	1.19	1.59	0	0.79	3.57	4.37	0	8.73
March 2019	225	0.44	0.44	0	0.89	2.22	3.11	0	6.22
April 2019	224	1.34	2.68	0.45	0.89	2.68	4.91	0.45	8.93
May 2019	225	0.44	4.89	0.44	4.44	2.67	3.11	0	10.22
01 June 2019	251	1.2	3.98	0.4	1.2	3.59	2.39	0	7.17
July 2019	318	0.94	3.14	0	0.31	1.89	1.57	0	3.77
August 2019	335	1.19	3.58	0	0.6	1.79	1.49	0.3	4.18
September 2019	345	1.45	0.87	0	0	1.74	0.87	0	2.61
October 2019	408	0.74	1.72	0	0.25	1.47	0.98	0	2.7
November 2019	353	1.7	1.7	0	0.28	1.42	0.57	0	2.27
December 2019	332	1.2	1.81	0.3	0	2.41	0.6	0	3.01
January 2020	317	0.95	1.58	0	0	1.58	1.26	0.63	3.47
February 2020	323	0.93	0.93	0.93	0.62	1.24	1.55	0	3.41
March 2020	260	1.15	2.31	0	0.38	1.15	0.77	0.38	2.69
April 2020	218	2.29	1.83	0.46	0	1.83	0.92	0	2.75
May 2020	307	0	1.3	0	0	2.28	0.33	0	2.61
June 2020	245	1.63	1.22	0.41	0	2.04	1.63	0	3.67
July 2020	318	0.63	1.89	0.31	0	2.52	0.94	0	3.46
August 2020	333	0	0.9	0	0	2.7	1.2	0.3	4.2
September 2020	394	0.25	1.02	0	0	1.78	1.02	0	2.79
October 2020	423	0	1.65	0	0	2.13	1.42	0	3.55
November 2020	419	0.95	0	0	0.72	1.43	0.48	0	2.63
December 2020	397	1.26	0	0	0	1.26	1.51	0	2.77
January 2021	384	0.78	0	0	0.52	2.34	1.04	0	3.91
February 2021	290	0.34	0.34	0	0	2.41	1.03	0	3.45
March 2021	281	1.07	0.36	0	0.36	1.78	0.36	0.36	2.85
April 2021	263	0.76	1.52	0.38	0	1.14	1.14	0	2.28
May 2021	283	0	1.06	0	0.35	1.41	0.71	0	2.47
June 2021	296	0.68	2.36	0	0.34	2.03	1.01	0	3.38

APH, antepartum haemorrhage; PPH, postpartum haemorrhage.

make some policy changes to involve SNs in conducting vaginal deliveries.

The record of HRP identified helped the team to understand the type of HRP attending BM hospital and their risk stratification. The HRP list ensured the preidentification of all HRP and colour coding of ANC cards correctly. This list also helped the newly joined SR, JR and SN to identify the HRP and to carry on this QI initiative successfully. Any missing HRP and late-onset HRP were identified in subsequent antenatal visits in the OPD and LR.

Giving HRP numbers and colour coding of ANC cards helped in bringing awareness among support staff, patients and their relatives. They used to ask the reason for giving a number and putting a sticker on some of the PWs' ANC cards. This allowed the team to involve them in patient care. PW and their relatives were aware of their HRP status and were well prepared. The team also encouraged them to share the information with other PW and family members to spread awareness about HRP and their role in managing such pregnancies.

Thus, a simple QI intervention allowed the team to improve patient care at different levels. The lessons learnt are generalisable and can be used in similar settings. Risk stratification using colour codes can also be implemented at the level of primary health centres for timely intervention and referral to higher centres.

However, despite being a simple methodology, there were challenges too in sustaining this QI project.

Because of the rapid turnover of SRs and JRs in the LR, reorientation of the new LR team and the newly posted SG and NO about this improvement process remained a challenge. The QI team involved their respective senior colleagues and directed them to orient all recruits about the working of this improvement process at the earliest. SR, JR and SN helped each other and the SG and NO to learn the process. The team leader and head of the department ensured that all recruits are aware of this new process and helped them to understand POCQI methodology and HRP whenever required.

Another challenge was to conduct periodic QI meetings. To overcome this challenge, in the first 6 months the team met weekly on a relatively free day in the afternoon and conducted the meetings even in the presence of one consultant, one SR and one SN. The weekly data and the discussions in the meeting were updated on the WhatsApp group for the benefit of the other members who could not attend the meeting. Later these meetings were arranged along with the routine monthly census reporting meeting of the department. The QI team met separately as and when required.

The success was also dependent on good communication and coordination between duty doctors and SNs posted in LR. Although the stickers are very cost-effective, regular procurement of yellow and red stickers is another limiting factor of this QI initiative.

The major limitation of this QI initiative is the team did not analyse the effect of the implementation of this intervention process on neonatal morbidity and mortality. The team plans to carry forward this process with the inclusion of neonatal health indicators as outcome measures.

CONCLUSIONS

In public sector hospitals, it is a major challenge to provide quality health services to PW with limited human resources. QI methodology has provided an opportunity to improve health services with available resources. In this QI initiative, with a simple intervention the team improved patient care at different levels. They adopted similar processes to improve other areas of patient care in the same as well as other departments of the facility. Other facilities with similar settings can also adopt this methodology to improve their healthcare services without any additional human resources or financial support.

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RESPECTFUL, SUPPORTIVE & PATIENT-CENTERED CARE

Respectful and Supportive Care

The incidence of cardiovascular disease among pregnant women is rising in the United States. There is a racial disparity for the major cardiovascular events during pregnancy, which is demonstrated by the following study in Handout 1:
https://www.ahajournals.org/doi/epub/10.1161/JAHA.120.017832

The Respectful and supportive care section has 3 elements: It suggests that every unit/provider/team member:

- Screen for structural and social drivers of health that might impact clinical recommendations or treatment plans and provide linkage to resources that align with the pregnant or postpartum person's health literacy, cultural needs, and language proficiency.
- Engage in open, transparent, and empathetic communication with pregnant and postpartum people and their identified support network to understand diagnoses, options, and treatment plans.
- Include each pregnant or postpartum person and their identified support network as respected members of and contributors to the multidisciplinary care team

Element 1:

- Screen for structural and social drivers of health that might impact clinical recommendations or treatment plans and provide linkage to resources that align with the pregnant or postpartum person's health literacy, cultural needs, and language proficiency
    - Ensure that providers have the information and resources to screen for social drivers of health
        - Handout 2: CMS Accountable Health Communities Health-Related Social Needs Screening Tool: https://www.cms.gov/priorities/innovation/files/worksheets/ahcm-screeningtool.pdf
    - Educate clinicians on providing respectful care by engaging in the lifelong learning of cultural humility, understanding that individuals cannot learn all aspects of any culture including their own

        - Handout 3: The Cycle to Respectful Care - A Qualitative Approach to the Creation of an Actionable Framework to Address Maternal Outcome Disparities: https://pubmed.ncbi.nlm.nih.gov/34066381/
        - Training webinar series on Trauma Informed Care will be offered, coming Spring 2026. Stay Tuned.

Element 2:

- Engage in open, transparent and empathetic communication with pregnant and postpartum people and their identified support networks to understand diagnoses, options and treatment plans.
    - Clarify goals and values for pregnancy that are essential to include in a patient's treatment plan
    - Refer patients who have experienced significant cardiac events for trauma follow-up care and consider referral to a support group (such as SCAD Alliance)
    - Include patient's support network contact information in EHR

Element 3:

- Include each pregnant and postpartum person and their identified support network as respected members of and contributors to the multidisciplinary care team
    - Ensure that a qualified network of interpreters is identified and utilized to support and facilitate patient communication
        - Training on shared decision making: https://www.ahrq.gov/sdm/index.html
        - Handout 4: Fact Sheet on The SHARE Approach Training: https://www.ahrq.gov/sites/default/files/wysiwyg/sdm/share-approach/share-fact-sheet.pdf

Journal of the American Heart Association

ORIGINAL RESEARCH

Disparities in Cardiovascular Disease Outcomes Among Pregnant and Post-Partum Women

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BACKGROUND: The incidence of cardiovascular disease among pregnant women is rising in the United States. Data on racial disparities for the major cardiovascular events during pregnancy are limited.

METHODS AND RESULTS: Pregnant and post-partum women hospitalized from January 2007 to December 2017 were identified from the Nationwide Inpatient Sample. The outcomes of interest included: in-hospital mortality, myocardial infarction, stroke, pulmonary embolism, and peripartum cardiomyopathy. Multivariate regression analysis was used to assess the independent association between race and in-hospital outcomes. Among 46 700 637 pregnancy-related hospitalizations, 21 663 575 (46.4%) were White, 6 302 089 (13.5%) were Black, and 8 914 065 (19.1%) were Hispanic. The trends of mortality and stroke declined significantly in Black women, but however, were mostly unchanged among White women. The incidence of mortality and cardiovascular morbidity was highest among Black women followed by White women, then Hispanic women. The majority of Blacks (62.3%) were insured by Medicaid while the majority of White patients had private insurance (61.9%). Most of Black women were below-median income (71.2%) while over half of the White patients were above the median income (52.7%). Compared with White women, Black women had the highest mortality with adjusted odds ratio (aOR) of 1.45, 95% CI (1.21–1.73); myocardial infarction with aOR of 1.23, 95% CI (1.06–1.42); stroke with aOR of 1.57, 95% CI (1.41–1.74); pulmonary embolism with aOR of 1.42, 95% CI (1.30–1.56); and peripartum cardiomyopathy with aOR of 1.71, 95 % CI (1.66–1.76).

CONCLUSIONS: Significant racial disparities exist in major cardiovascular events among pregnant and post-partum women. Further efforts are needed to minimize these differences.

Key Words: cardiovascular mortality ■ disparities in care ■ health inequities ■ pregnancy

The United States is witnessing an increasing maternal mortality rate that increased from as low as 9.8 per 100 000 live births at the start of the cenury to 26.4 in 2015 then declined to 17.4 in 2018.[1–3] The Global Burden of Disease study estimates that in 2015, the United States had a maternal mortality rate of 26.4 per 100 000 live births which is significantly higher compared with other high sociodemographic index countries, with a mortality rate of 15.0 per 100 000 live births, close to 4-fold the rate in Canada or Western Europe; 7.3, and 7.2 per 100 000 live births, respectively. Furthermore, it is higher than East Asia and comparable with central Asia with rates of 18.8 and 28.4 per 100 000 live births, respectively.[4] Moreover, US maternal mortality has shown a startling rise with an annual percent change of +1.8 compared with an observed decline globally, in high-sociodemographic index countries,

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CLINICAL PERSPECTIVE

What Is New?

- There are known disparities in maternal morbidity and mortality outcomes in the United States, however, the maternal cardiovascular outcomes have limited data evaluating racial disparities.
- Pregnant and postpartum women in the United States of Black origin, as well as other minority groups, have worse cardiovascular outcomes compared with women of White origin even when adjusting for socioeconomic factors and medical comorbidities.

What Are the Clinical Implications?

- Compared with White women, Black women had a higher risk of mortality, myocardial infarction, stroke, pulmonary embolism, and peripartum cardiomyopathy with odds ratio of 1.45, 1.23, 1.57, 1.42, and 1.71, respectively.

Nonstandard Abbreviation and Acronyms

NIS	Nationwide Inpatient Sample

and low- sociodemographic index counties; –1.5, –2.1, and –1.0, respectively. Thus, a better understanding of the underlying etiologies causing this rise is warranted to halt and potentially begin to reverse the inclining trends.[4]

Multiple studies attempted to understand the perplexing numbers reported in the United States with studies showing that maternal mortality and morbidities with geographic and economic factors playing a significant role. Studies showed differences from one state to another, with California reporting a decline while the rates in Texas doubled, between different socioeconomic groups, with Black women having considerably higher rates compared with White pregnant women, and based on the level of access to medical care with studies showing that uninsured and rural populations suffer from worse outcomes.[5–8] A possible cause may be related to data capturing and collection as some states collect information related to pregnancy, childbirth, and the puerperium in vital statistics related to mortality while other states have not implemented routine collection of pregnancy-related information.[9]

Cardiovascular morbidity and mortality in pregnant women are a matter of concern with heart disease, stroke, and pregnancy-related complications ranking amongst the top 10 leading causes of death in women aged 20 to 44 years.[10] The US Department of Health and Human Services set a goal of eliminating health disparities and achieving equity as a part of healthy people 2020 initiative, and understanding the disparities in cardiovascular pregnancy-related health outcomes plays a pivotal role in alleviating the healthcare disparities and achieving equity between different groups, most importantly different racial groups.[11]

A better understanding of the socioeconomic determinant, traditional cardiovascular risk factors in pregnancy, and racial factors are warranted as policymakers attempt to implement interventions to counter the stern trends noted.[12] The current study aims to explore disparities in cardiovascular disease in pregnancy and its associations with race, socioeconomic status, or medical comorbidities. The findings from this study may shed further light on actionable plans that can be targeted by policy makers as well as healthcare administrators to improve healthcare systems, equity, and access to health care, and reduce financial and social burden of pregnancy-related cardiovascular morbidity and mortality in the United States.

METHODS

Data Source and Study Population

Using the Nationwide Inpatient Sample (NIS) database between January 2007 and December 2017, we identified any pregnancy or post-partum–related hospitalization. The NIS is made publicly available by the Agency for Healthcare Research and Quality for the Healthcare Cost and Utilization Project.[13] The NIS represents the largest publicly available all-payer database and contains discharge-level administrative data on inpatient diagnoses and procedures from a stratified sample of ≈ 20% of US hospitals through 2012. Starting from 2012, the NIS represents a sample of 20% of discharges from all hospitals. The NIS provides a weight variable for establishing an estimate of national statistics in the design of a complex survey sample using a stratum variable and a clustering variable. Women who were hospitalized during pregnancy, labor, and the post-partum period for pregnancy-related causes were identified by using the appropriate administrative codes (Table S1). The need for an institutional review board approval was waived for this study because of the anonymized and de-identified nature of the publicly available data.

Patient and Hospital Characteristics

Baseline characteristics included demographics (age, race, length of hospital stay, elective admission to the hospital, patient disposition, primary payer information, and percentile of home income by residential zip code as provided by Healthcare Cost and Utilization Project), and medical/pregnancy-related comorbidities were identified with the corresponding *International Classification of Diseases, Ninth Revision,*

Clinical Modification (*ICD-9-CM*) (until September 2015) and *International Classification of Diseases, Tenth Revision, Clinical Modification* (*ICD-10-CM*) codes (starting from October 2015) (Table S1). The hospital-related characteristics included bed size, location, hospital region, and teaching status.

Outcome Measure

The primary outcome of the study was the difference in in-hospital mortality and cardiovascular events, defined as acute myocardial infarction (AMI), stroke, pulmonary embolism (PE), and peripartum cardiomyopathy between the different racial group. Cardiovascular events were chosen as they could be fatal and catastrophic for the mother and the family and play a major role in maternal mortality rates. The null hypothesis of the current study was that no difference in mortality and cardiovascular morbidity existed between pregnant women of different ethnicities in the United States. The secondary pre-specified outcomes included the temporal trends of in-hospital mortality and cardiovascular morbidity by race, and adjusted odds ratio of adverse events by race. Further subgroup analyses were performed based on patient baseline comorbidities and socioeconomic status.

Statistical Analysis

The patient baseline characteristics and demographics, as well as outcomes, were compared between different races/ethnicities. Categorical variables were compared with the Mantel Haenszel Chi-square test, and continuous variables were compared with ANOVA testing. The linear Chi-square test was used to evaluate current temporal trends of outcomes and risk factors. The rates were expressed as a percentage, or per 100 000 pregnancy-related hospitalizations, as appropriate. We used bivariate and multivariate regression models to estimate odds of outcomes by race, and adjusted for insurance information and socioeconomic status. All statistical analyses were performed by using the weighted values, hospital clusters, and strata of observations as provided by the NIS to measure national estimates. Statistical analyses were conducted using RStudio software (RStudio, Boston, Massachusetts). *P* values were corrected using Bonferroni correction to avoid multiple comparisons causing type I error. A 2-sided value of $P<0.05$ was set for statistical significance. Odds ratios and the 95% CIs were used.

RESULTS

Population Demographics

Among 46 700 637 hospitalizations of pregnant or post-partum women, 46.4% were White, 13.5% were Black, 19.1% were Hispanic, 4.8% were Asian/Pacific Islander, 0.7% were Native American, 4.3% other races/multiple races, and 11.2% unknown race (results not shown). Black and Hispanic pregnant and post-partum women were younger with 39.9% and 34.8%, respectively aged between 18 and 24 years compared with 25.9% of White women. Approximately 1 in 200 pregnancies in Hispanic and Black women were aged <18 years compared with 1 in 500 pregnancies in White women.

Further information on demographics for each race is shown in Table 1.

Black women had higher prevalence of cardiovascular risk factors including hypertension, heart failure, cardiomyopathy, atrial fibrillation, diabetes mellitus, and obesity compared with White women while Hispanic women tended to have lower prevalence. Further information on baseline comorbidities for each race is shown in Table 1. Table S2 provides further information about hospital and demographics characteristics.

Hospital Complications and Cardiovascular Events

Black women had a higher risk of bleeding, cardiac tamponade, cardiac arrest, acute kidney injury, and sepsis compared with other races/ethnicities.

Further information on complications for each race is shown in Table 2.

Compared with White women, Black women had the highest in-hospital mortality with adjusted odds ratio (aOR) of 1.45, 95% CI (1.21–1.73); AMI with aOR of 1.23, 95% CI (1.06–1.42); stroke with aOR of 1.57, 95% CI (1.41–1.74); PE with aOR of 1.42, 95% CI (1.30–1.56); and peripartum cardiomyopathy with aOR 1.71, 95% CI (1.66–1.76) when adjusted for socioeconomic status, access to health care, and medical comorbidities. Hispanic women had aOR of mortality 1.23, 95% CI (1.02–1.49); AMI with aOR of 1, 95% CI (0.84–1.19); stroke with aOR of 1.23, 95% CI (1.10–1.38); PE with aOR of 0.66, 95% CI (0.58–0.74); and peripartum cardiomyopathy with aOR of 0.69, 95% CI (0.67–0.72). Pacific Islander/Asian women had aOR of mortality 2.00, 95% CI (1.53–2.61); AMI with aOR of 0.77, 95% CI (0.56–1.07); stroke with aOR of 1.08, 95% CI (0.90–1.31); PE with aOR of 0.34, 95% CI (0.25–0.45); and peripartum cardiomyopathy with aOR of 1.11, 95% CI (1.08–1.15) (Table 3).

Temporal Trends

Over the study duration, the incidence of in-hospital mortality in Black women decreased (from 38.1 in 2007 to 21.9 in 2017 per 100 000 hospitalizations) as well as the rates of stroke (from 85.5 in 2007 to 54.2 in 2017 per 100 000 hospitalizations). But the rates of

Table 1. Baseline Demographics of Included Patients, Baseline Medical Comorbidities, and Pregnancy-Related Comorbidities

	White (n = 21 663 575)	Black (n = 6 302 089)	Hispanic (n = 8 914 065)	Asian/Pacific Islander (n = 2 251 824)	
	46.4%	13.5%	19.1%	4.8%	*P* Value
Age group, (%)					<0.001
Under 18 y	0.2%	0.5%	0.5%	0.1%	
18–24 y	25.9%	39.9%	34.8%	11.1%	
25–29 y	29.6%	27.4%	28.0%	26.3%	
30–34 y	27.9%	19.4%	22.1%	36.3%	
35–39 y	13.2%	10.0%	11.6%	21.1%	
40–44 y	2.8%	2.5%	2.8%	4.7%	
≥45 y	0.3%	0.3%	0.2%	0.4%	
Income					<0.001
0–25th percentile	21.4%	48.6%	36.8%	12.5%	
26th–50th percentile	25.9%	22.6%	25.5%	16.2%	
51st–75th percentile	26.6%	17.6%	23.1%	25.0%	
76th–100th percentile	26.1%	11.3%	14.6%	46.3%	
Primary payer					<0.001
Medicare	0.9%	1.7%	0.5%	0.3%	
Medicaid	31.9%	62.3%	63.6%	26.9%	
Private insurance	61.9%	30.7%	28.3%	65.3%	
Self-pay	1.9%	2.9%	5.4%	5.5%	
No charge	0.1%	0.2%	0.4%	0.1%	
Other	3.4%	2.2%	1.8%	2.0%	
Comorbidities					
Known cardiovascular risk factors	0.8%	1.2%	0.5%	0.6%	<0.001
Hypertension	2.3%	5.8%	2.1%	1.8%	<0.001
Heart failure	0.1%	0.4%	0.1%	0.1%	<0.001
Cardiomyopathy	0.1%	0.2%	0.0%	0.0%	<0.001
Congenital heart disease	0.1%	0.1%	0.1%	0.1%	<0.001
Atrial fibrillation	0.0%	0.1%	0.0%	0.0%	<0.001
Valvular disease	0.3%	0.3%	0.1%	0.2%	<0.001
Dyslipidemia	0.2%	0.2%	0.2%	0.3%	<0.001
Diabetes mellitus	1.0%	2.0%	1.5%	1.0%	<0.001
Obstructive sleep apnea	0.1%	0.2%	0.0%	0.0%	<0.001
Obesity	8.8%	14.6%	10.2%	4.5%	<0.001
Smoking	4.9%	4.0%	1.7%	1.8%	<0.001
Alcohol abuse	0.1%	0.2%	0.1%	0.0%	<0.001
Drug abuse	3.2%	3.6%	1.3%	0.4%	<0.001
Peripheral vascular disorders	0.0%	0.0%	0.0%	0.0%	<0.001
Rheumatoid arthritis/collagen vascular diseases	0.4%	0.4%	0.3%	0.3%	<0.001
Deficiencies anemia	6.9%	13.3%	9.4%	8.3%	<0.001
Chronic blood loss anemia	11.6%	21.5%	15.2%	13.6%	<0.001
Chronic pulmonary disease	5.0%	7.9%	3.7%	2.7%	<0.001
Pregnancy-related complications					
Gestational hypertension	4.3%	4.3%	2.8%	2.2%	<0.001
Preeclampsia	3.7%	5.1%	3.8%	2.6%	<0.001
Eclampsia	0.1%	0.2%	0.1%	0.1%	<0.001
Gestational diabetes mellitus	2.3%	3.3%	3.3%	4.3%	<0.001
Hospitalization during delivery and puerperium	90.1%	84.3%	88.7%	93.6%	<0.001
C-section	30.2%	30.7%	29.9%	30.9%	<0.001

Table 2. Patients' Complications and Cardiovascular Outcomes

	White (n = 21 663 575)	Black (n = 6 302 089)	Hispanic (n = 8 914 065)	Asian/Pacific Islander (n = 2 251 824)	
	46.4%	13.5%	19.1%	4.8%	*P* Value
Complications					
Bleeding	0.7%	1.0%	1.0%	0.9%	<0.001
Cardiac arrest	0.0%	0.0%	0.0%	0.0%	<0.001
Acute kidney injury	0.1%	0.2%	0.1%	0.1%	<0.001
Sepsis	0.2%	0.2%	0.2%	0.2%	<0.001
Outcomes					
In-hospital mortality	0.01%	0.03%	0.01%	0.01%	<0.001
Acute myocardial infarction	0.01%	0.02%	0.01%	0.01%	0.015
Stroke	0.04%	0.07%	0.04%	0.03%	<0.001
Pulmonary embolism	0.02%	0.04%	0.01%	0.01%	<0.001
Peripartum cardiomyopathy	0.1%	0.3%	0.1%	0.1%	<0.001

AMI (from 24.2 in 2007 to 36.4 in 2017 per 100 000 hospitalizations), PE (from 29.3 in 2007 to 60.7 in 2017 per 100 000 hospitalizations), and peripartum cardiomyopathy increased (from 236.4 in 2007 to 296.2 in 2017 per 100 000 hospitalizations), *P*-trend <0.001 (Figure and Table S3).

Subgroup Analyses

Among women with diabetes mellitus, Black women had mortality, AMI, stroke, and PE rates of 129.8, 171.0, 203.7, and 120.5 per 100 000 hospitalizations compared with White women with rates of 67.6, 121.2, 131.1, and 65.3 per 100 000 hospitalizations, respectively, *P* value <0.001.

Among patients with history of known cardiovascular disease Black women had mortality, AMI, stroke, and PE rates of 0.7%, 1.3%, 1.5%, and 0.6% compared with White women with rates of 0.3%, 0.8%, 1.0%, and 0.3%, respectively, *P* value <0.001.

When comparing White women with below-median socioeconomic status to Black women with similar socioeconomic status, Black women had higher odds of AMI, stroke, and PE outcomes with OR of 2.26 (2.08–2.46), 1.87 (1.78–1.96), and 1.74 (1.63–1.85), respectively. When Black women with highest socioeconomic quartile status were compared with White women of the lowest quartile, Black women had persistently higher odds of AMI, stroke, and PE outcomes with OR of 1.62 (1.34–1.97), 2.38 (2.18–2.6), and 1.35 (1.19–1.54), respectively. When comparing White women with no affordable access to health care, as defined by self-paying as insurance, to Black women with private insurance, Black

Table 3. Baseline Comorbidities*, Socioeconomic Status, and Access to Health Care Adjusted Odds Ratio of Mortality and Cardiovascular Morbidity

	In-hospital mortality		Acute Myocardial Infarction		Stroke		Pulmonary Embolism		Peripartum Cardiomyopathy	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Race/ethnicity										
White women	Reference		Reference		Reference		Reference		Reference	
Black women	1.45 (1.21–1.73)	<0.001	1.23 (1.06–1.42)	0.006	1.57 (1.41–1.74)	<0.001	1.42 (1.30–1.56)	<0.001	1.71 (1.66–1.76)	<0.001
Hispanic women	1.23 (1.02–1.49)	0.031	1 (0.84–1.19)	0.979	1.23 (1.10–1.38)	<0.001	0.66 (0.58–0.74)	<0.001	0.69 (0.67–0.72)	<0.001
Pacific Islander or Asian women	2 (1.53–2.61)	<0.001	0.77 (0.56–1.07)	0.119	1.08 (0.90–1.31)	0.401	0.34 (0.25–0.45)	<0.001	1.11 (1.08–1.15)	<0.001

*Adjusted for comorbidities; including age, diabetes mellitus, cardiomyopathy, obesity, hyperlipidemia, heart failure, hypertension, smoking, pre-eclampsia/eclampsia, gestational hypertension, gestational diabetes mellitus, and cesarean section, socioeconomic status (income levels), and access to health care (healthcare insurance). OR indicates odds ratio.

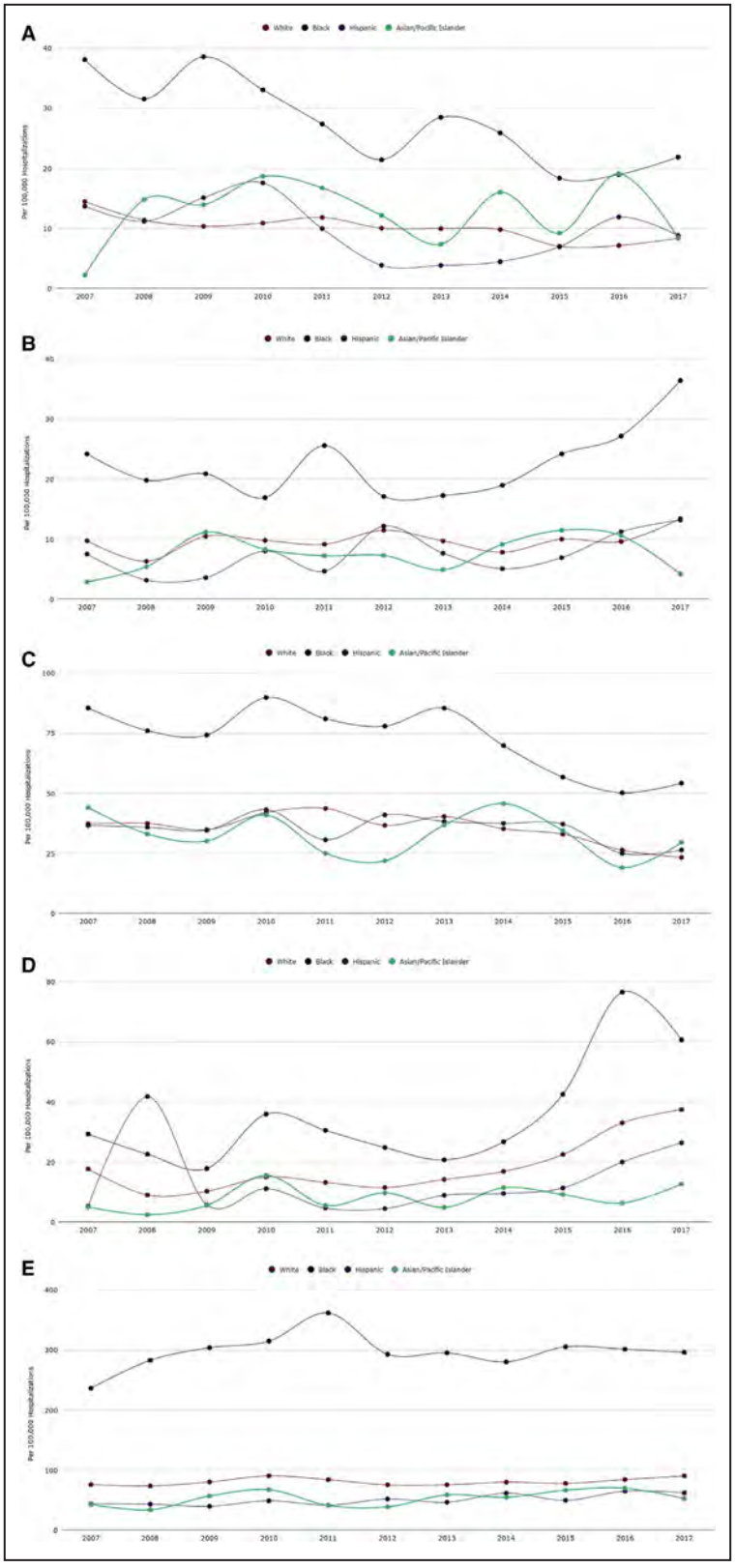

Figure. Temporal trends of incidence of mortality and cardiovascular events in pregnant and post-partum women by race/ethnicity.
A, In-hospital mortality, **B**, acute myocardial infarction, **C**, stroke, **D**, pulmonary embolism, and **E**, peripartum cardiomyopathy

women persistently had worse AMI, and stroke outcomes with OR of 1.32 (1.01–1.71), 1.61 (1.38–1.87), but better PE outcome of 0.77 (0.66–0.90).

DISCUSSION

In this nationwide analysis of pregnancy-related hospitalizations from 2007 to 2017, we aimed to characterize the racial and socioeconomic disparities among pregnant and post-partum women on in-hospital mortality, and cardiovascular events. We found that racial disparities that persisted after adjusting for socioeconomic factors and access to health care. Our study showed that Black women are at a significant risk of mortality and cardiovascular events with certain cardiovascular events, AMI and PE increasing over the study duration disproportionately compared with White women. Many studies entreat socioeconomic differences as the leading contributor to racial disparities as the average Black female has a lower household income, educational attainment, and access to health care.[14–18] While our findings substantiate those observations, we observe persistent disparities with further adjustment for socioeconomic factors, which was observed in studies evaluating racial disparities in pregnancy and infant outcomes with documented racial differences within the same socioeconomic strata. Our study found startling worse pregnancy-related cardiovascular events among high socioeconomic status Black women when compared with low socioeconomic status White women. These disparities appear to have been persisted since the 1990s with Singh et al. reporting that infants born to Black women of higher socioeconomic status suffered from worse outcomes compared with White women of lower socioeconomic status.[19] Thus, those findings are alarming as long-standing disparities appear to be more complex and persistent than to be attributed to socioeconomic factors. Another attributable factor was identified as a lack of access to affordable health care resulting in delayed or inadequate medical care,[20] either prenatal or perinatal care, however; our findings indicate that Black women remained at higher risk when adjusted for insurance type, as a proxy to access to health care, and found a startling increase in myocardial infarction and stroke in Black women with private insurance; OR of 1.32 and 1.60, compared with White women without insurance. Those findings are troubling and alarming as they show persistently worse outcomes in Black women with the highest income and insurance levels when compared with White women with the lowest levels. Our findings indicate that most Black pregnant women were of below-median income (71.2%) and insured by Medicaid (62.3%) compared with White pregnant women who were of above-median income (52.7%) and had private insurance (61.9%). However, the percentage of uninsured Black women significantly trended down over the study period from 4.3% in 2007 to 2.3% in 2017, highlighting increased insurance access. However, those findings are not without drawbacks, as private insurance coverage for Black women declined from 33.1% to 29.9%, and Medicaid insurance trended up from 57.9% to 64.0% which sheds light at reduced and limited access to employer-funded insurance yet highlight increasing state efforts to provide coverage as 34 states expanded Medicaid to improve eligibility criteria for pregnant women increasing the income threshold for Medicaid coverage from 134% of the federal poverty level to >200%.[21,22]

Our results show a disparity in the prevalence of risk factors contributing to potential mortality and morbidity during pregnancy. Significant risk factors previously associated with poor pregnancy outcomes are trending up in Black women and significantly higher than White women. Prior history of cardiovascular disease was found in 1.1% of Black women compared with 0.7% in White women. Obesity in Black women went up from 4.1% in 2007 to 13.8% in 2017 and was overall 8.9% compared with 4.9% in White women. Depression and smoking in Black women increased ≈ 3-fold and 11-folds over the study duration as well, highlighting significant differences in risky maternal behaviors, psychologic, and medical comorbidities that are likely driving the persistent gap in outcomes. Further studies highlighted similar findings and attempted to understand the underlying causes that may cause such disparities. A number of studies highlighted the disparities in food access in Black women with more food deserts in predominantly Black neighborhoods and restricted access to healthy nutritional options worsening obesity and malnutrition.[23,24] Another interesting study that focused on Black women of school age found a disturbingly increased consumption of sweetened beverages and low step count, particularly in low-income women during summertime; no school provided nutrition or mandated activities that highlight a concerning increase in obesity prevalence.[25] To understand the potential reasons why Black women may be at an increased risk of poor dietary habits, Acheampong et al. conducted a study with that question in mind and found that Black women had sufficient awareness of healthy food options; however, the most constant limitation was unaffordability of nutritious food elements.[26] Our results show increasing depression in pregnant women, and poor outcomes have been shown to be related to increased maternal psychological distress, depression, and anxiety with studies showing elevated norepinephrine and cortisol elevation in stress that may contribute to worse

cardiovascular outcomes. Further studies have shown that anxiety and stress were correlated with altered immune function and increased risk of infections and overall increased morbidity and mortality.[27]

Our results show that the outcomes in Black women seem to be improving over the study duration; however, the outcomes are consistently worse compared with White women. However, Hispanic pregnant women appear to have a persistent pattern of poor cardiovascular outcomes and are projected to overtake Black women as the population at the highest risk of adverse cardiovascular morbidity and mortality in the next few years. Those findings are concerning as Hispanic women are the most substantial portion of minority births in the United States with the highest birth rate and constitute the fastest-growing minority in the United States.[28] Thus, further understanding of potential causes and possible interventions to reduce cardiovascular morbidity and mortality are warranted. Several studies looked into cardiovascular risk factors in Hispanic women and found concerning findings of increased prevalence of cardiovascular risk factors as the incidence of type 2 diabetes mellitus was increased in Hispanic women as well as Hispanic women being at a higher risk of entering pregnancy being overweight or obese, as well as gain an excessive amount of weight during pregnancy.[29,30] More studies investigated those findings and found significant differences in dietary habits with increased levels of processed meats, soft drinks, fatty food consumption in the Hispanic population, which reinforce the importance of dietary modifications and understanding of different nutritional ingredients. Another identified concern was food insecurity, which raises levels of anxiety and depression in addition to the established poor nutritional status.[31] Those identifiable risk factors are essential to intervene to lower cardiovascular morbidity and mortality in the fastest-growing minority in the United States.

The burden of pregnancy on the US economy and healthcare expenditure increased by 67% over the past 2 decades from 149.56 USD per capita in 2000 to 248.83 USD per capita in 2017.[32] Thus, pregnancy-related costs cause a significant burden on the US economy, and as the Institute of Medicine estimates that most of the pregnancy-associated expenses are directly related to medical care, we underestimate the financial burden associated with poor neonatal health, long-term morbidity in mothers, and loss of productivity in the workforce in a young population. Moreover, in light of an estimated burden of cardiovascular disease on women to be 1.1 trillion USD in 2035,[33–35] interventions directed at reducing cardiovascular events can help alleviate immense indirect costs that burden the US economy. Programs targeted at reducing racial disparities should consider cultural factors affecting certain behaviors and disease prevalence as culturally tailored interventions influence behaviors in a more favorable way preventing modifiable risk factors. Further studies are needed to provide a cost-benefit analysis demonstrating the impact of primary and secondary preventive measures on direct and indirect financial costs associated with cardiovascular events and mortality in pregnancy.

The findings of this study should be interpreted with certain limitations. This is a retrospective, non-randomized study with inherent limitations intrinsic to the retrospective nature of the study. Our study is derived from an administrative database relying on *ICD-9* and 1 *ICD-10* codes. It is thus subject to coding errors, in addition to that, administrative codes were designed for billing purposes and lack granularity of details in regard to the severity of the disease. In addition to that, the NIS database lacks crucial clinical and demographic information such as patient educational level, size of household, imaging data, and medications. NIS provides significant inpatient information; however, it lacks follow-up beyond the index hospitalization, and that limits peripartum follow up as well as the lack of timing of admission after delivery. In addition to that, obtaining further information on temporal follow-up of the same patient through multiple hospitalizations during 1 or multiple pregnancies is not possible because of the de-identified nature of the data set. Despite these limitations, our study is derived from a national representative sample and provides a large sample size with generalizable results to the US population.

CONCLUSIONS

Significant racial disparities exist in regard to in-hospital mortality and major cardiovascular events among pregnant and post-partum women. AMI and PE rates are trending up significantly in all racial groups, particularly in Black women. Our current observations and estimates provide policy makers as well as healthcare administrators with needed evidence to allocate funds to social and medical programs that can help reduce health disparities and inequities in pregnant women.

ARTICLE INFORMATION

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Disclosures

None.

Supplementary Material

Table S1–S3

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SUPPLEMENTAL MATERIALS

Table S1. Pregnancy related diagnosis codes.

Diagnosis	ICD-9-CM code	ICD-10-CM code
Antepartum	V22.x, V23.x, V28.x, V30.x - V37.x, V39.x, V91.x, 630-633, 638, 640-679 with fifth code as '3', without mention of a labor and delivery or post-partum ICD-9 code.	O00-O08 - Pregnancy with abortive outcome O09 - Supervision of high-risk pregnancy O10-O16 - Edema, proteinuria and hypertensive disorders in pregnancy, childbirth and the puerperium O20-O29 - Other maternal disorders predominantly related to pregnancy O30-O48 - Maternal care related to the fetus and amniotic cavity and possible delivery problems O60-O77 - Complications of labor and delivery O80-O82 - Encounter for delivery O85-O92 - Complications predominantly related to the puerperium O94-O9A - Other obstetric conditions, not elsewhere classified
Labor	Procedure Codes: 72.x - 74.x Diagnosis Codes: V27.x, V30.x00, V30.x01, V31.x00, V31.x01, V32.x00, V32.x01, V33.x00, V33.x01, V34.x00, V34.x01, V35.x00, V35.x01, V36.x00, V36.x01, V37.x00, V37.x01, V39.x00, V39.x01	
Postpartum	V24.x, V27.x, 634-637, 639, 640-679 with fifth code as '1', '2', '4', without mention of a labor and delivery code.	
Pregnancy, Unspecified time	640-679 with fifth code as '0' OR with both antepartum and post-partum codes present without mention of a labor and delivery code	
Gestational Hypertension	642.3x	O13.x
Pre-eclampsia/ Eclampsia	642.4x, 642.5x, 642.6x, 642.7x	O14.x, O15.x
Gestational Diabetes	648.0x	O24.4x
Cesarean Section	Procedure Codes: 74.x, Diagnosis Codes: 669.7	O82, 10D00Z0, 10D00Z1, 10D00Z2

Other comorbidities diagnosis codes:

Diagnosis	ICD-9-CM code	ICD-10-CM code
AMI	410	I21, I22
STEMI	410.0, 410.1, 410.2, 410.3, 410.4, 410.5, 410.6, 410.8	I21.0, I21.1, I21.2, I21.3, I22.0, I22.1, I22.8, I22.9
NSTEMI	410.7	I21.4, I22.2
Unspecified AMI	410.9	I21.9, I21.A1, I21.A9
Prior myocardial infarction	412	I25.2
Prior PCI	V45.82	Z95.5, Z98.61
Prior CABG	V45.81, 414.02, 414.03, 414.04, 414.05	I25.700, I25.708, I25.709, I25.71, I25.72, I25.73, I25.76, I25.79, I25.810, I25.812, Z95.1
Prior pacemaker	V45.01	Z95.0
Prior cerebrovascular disease	438, V12.54	I699.1, Z86.73
Mitral valve disease	394.0, 394.1, 394.2, 746.5, 746.6	I05.0, I05.1, I05.2, I34.0, I34.2, Q23.2, Q23.3

Tricuspid valve disease	397.0, 424.2, 746.1	I07.0, I07.1, I07.2, I36.0, I36.1, I36.2, Q22.4
Atrial fibrillation	427.31	I48.0, I48.1, I48.2, I48.91
Atrial flutter	427.32	I48.3, I48.4, I48.92
Chronic pulmonary disease	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Carotid disease	433.1	I65.2
Peripheral vascular disease	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Renal failure	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Liver disease	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Malignancy	140-165, 170-176, 179-195, 199-209	C00–C97
Rheumatoid arthritis/collagen vascular disease	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Hypothyroidism	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Coagulopathy	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Deficiency anemia	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Chronic blood loss anemia	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Depression	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Dementia	290, 294.10, 294.11, 294.20, 294.21, 330.8, 330.9, 331.0, 331.1, 331.2, 331.6, 331.7, 331.82, 331.83, 331.89, 331.9	F01, F02, F03, G30, G31
Hypertension	401.1, 401.9, 642.00, 642.01, 642.02, 642.03, 642.04, 401.0, 4372, 642.20, 642.21, 642.22, 642.23, 642.24, 402.00, 402.10, 402.90, 405.09, 405.19, 405.99, 402.01, 402.11, 402.91, 403.00, 403.10, 403.90, 405.01, 405.11, 405.91, 642.10, 642.11, 642.12, 642.13, 642.14, 403.01, 403.11, 403.91, 404.00, 404.10, 404.90, 404.01., 404.11, 404.91, 404.02., 404.12, 404.92, 404.03., 404.13, 404.93, 642.70,	I13.0, I13.2, I13.10, I13.11, I129, I15.0, I15.1, I120, I10, O10.011, O10.012, O10.013, O10.019, O10.02, O10.03, O10.911, O10.912, O10.913, O10.919, O10.92, O10.93, I160, I161, I169, I674, O10.111, O10.112, O10.113, O10.119, O10.12, O10.13, O10.211, O10.212, O10.213, O10.219, O10.22, O10.23, O10.311, O10.312, O10.313, O10.319, O10.32, O10.33, O10.411, O10.412, O10.413, O10.419, O10.42, O10.43, O11.1, O11.2, O11.3, O11.4, O11.5, O11.9, I110, I119, I15.2, I15.8, I15.9

	642.71, 642.72, 642.73, 642.74, 642.90, 642.91, 642.92, 642.93, 642.94	
Diabetes mellitus	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Dyslipidemia	272.0, 272.1, 272.2, 272.3, 272.4	E78.0, E78.00, E78.01, E78.1, E78.2, E78.3, E78.4, E78.5,E78.81, E78.89, E8889, E78.9
Obesity	From the Elixhauser comorbidities provided by the AHRQ comorbidity measures	
Smoking history	V15.82, 305.1	Z87.891, F17.200 to F17.229,F172.90, F172.93 , F172.98 , F172.99
Acute heart failure	428.21, 428.23, 428.31, 428.33, 428.41, 428.43	I50.21, I50.23, I50.31, I50.33, I50.41, I50.43
Cardiogenic shock	785.51	R57.0
Stroke	430, 431, 432, 433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11, 434.91, 997.02	I60, I61, I62, I63, I64
Acute kidney injury	584	N17
Bleeding	998.11, 998.12, 285.1	D62, G97.32, G97.52, I97.410, I97.411, I97.418, I97.42, I97.610, I97.611, I97.618, I97.620, T82.837, T82.838, T85.838

ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification; ICD-10-CM = International Classification of Diseases, Tenth Revision, Clinical Modification; TAVR = transcatheter aortic valve replacement; SAVR = surgical aortic valve replacement; PCI = percutaneous coronary intervention; CABG = coronary artery bypass grafting; AMI = acute myocardial infarction; STEMI = ST-segment elevation myocardial infarction; NSTEMI = non-ST-elevation myocardial infarction; AHRQ = Agency for Healthcare Research and Quality.

Table S2. Hospital-related characteristics of the included cohort.

	White (n=21,663,575) 46.4%	African American (n=6,302,089) 13.5%	Hispanic (n=8,914,065) 19.1%	Asian/Pacific Islander (n=2,251,824) 4.8%	P value
Hospital ownership					<.001
Government, nonfederal	11.05%	15.47%	17.93%	11.33%	
Private, not-profit	76.09%	69.15%	61.31%	75.91%	
Private, invest-own	12.86%	15.39%	20.76%	12.76%	
Hospital bed-size					<.001
Small	14.75%	10.74%	12.25%	10.78%	
Medium	28.07%	29.54%	27.78%	29.43%	
Large	57.18%	59.72%	59.96%	59.80%	
Hospital teaching status					<.001
Rural	13.49%	6.22%	4.57%	2.98%	
Urban nonteaching	36.60%	26.68%	38.52%	34.70%	
Urban teaching	49.91%	67.10%	56.91%	62.32%	
Hospital region					<.001
Northeast	19.15%	17.43%	13.19%	20.35%	
Midwest	22.48%	16.82%	6.66%	9.48%	
South	38.16%	57.06%	38.41%	21.40%	
West	20.22%	8.68%	41.74%	48.77%	
Patient disposition					<.001
Routine	97.51%	96.28%	98.33%	98.12%	
Transfer to Short-term Hospital	0.43%	0.49%	0.33%	0.27%	
Skilled Nursing Facility (SNF)	0.11%	0.21%	0.08%	0.06%	
Home Health Care (HHC)	1.70%	2.34%	1.02%	1.43%	
Against Medical Advice (AMA)	0.23%	0.66%	0.23%	0.11%	

Table S3. Sensitivity analysis of temporal trends of outcomes by race in females of known risk factors for cardiovascular disease.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
White											
Mortality	0.46%	0.45%	0.45%	0.38%	0.55%	0.40%	0.30%	0.18%	0.09%	0.11%	0.16%
AMI	1.28%	0.80%	1.40%	1.03%	0.99%	1.06%	0.90%	0.65%	0.95%	0.32%	0.53%
Stroke	1.46%	1.84%	2.00%	2.06%	1.67%	1.46%	1.49%	1.33%	0.71%	0.25%	0.37%
PE	0.41%	0.31%	0.33%	0.32%	0.59%	0.35%	0.34%	0.36%	0.36%	0.30%	0.28%
African American											
Mortality	1.32%	0.62%	1.82%	1.30%	0.55%	0.81%	0.89%	0.48%	0.54%	0.28%	0.38%
AMI	2.61%	1.48%	2.15%	1.30%	2.02%	1.31%	1.18%	1.26%	1.01%	0.80%	1.06%
Stroke	3.55%	2.25%	2.47%	2.89%	2.39%	2.01%	2.37%	2.51%	1.15%	0.38%	0.51%
PE	0.90%	0.74%	0.59%	0.86%	1.25%	0.60%	0.20%	0.39%	0.34%	0.59%	0.38%
Hispanic											
Mortality	1.05%	0.92%	0.25%	1.29%	0.42%	0.21%	0.18%	0.33%	0.11%	0.18%	0.08%
AMI	1.27%	0.49%	0.50%	1.55%	0.38%	1.87%	1.09%	0.49%	0.77%	0.27%	0.49%
Stroke	2.00%	2.33%	2.32%	3.52%	2.65%	3.53%	3.64%	2.60%	0.88%	0.14%	0.29%
PE	0.28%	0.24%	0.45%	0.21%	0.00%	0.00%	0.18%	0.00%	0.11%	0.18%	0.08%

The Accountable Health Communities Health-Related Social Needs Screening Tool

What's the Accountable Health Communities (AHC) Health-Related Social Needs (HRSN) Screening Tool?

We at the Centers for Medicare & Medicaid Services (CMS) Center for Medicare and Medicaid Innovation (CMMI) made the Accountable Health Communities (AHC) Health-Related Social Needs (HRSN) Screening Tool to use in the AHC Model.[1] We're testing to see if systematically finding and dealing with the health-related social needs of Medicare and Medicaid beneficiaries has any effect on their total health care costs and makes their health outcomes better.

Why is the AHC HRSN Screening Tool important?

Growing evidence shows that if we deal with unmet HRSNs like homelessness, hunger, and exposure to violence, we can help undo their harm to health. Just like with clinical assessment tools, providers can use the results from the HRSN Screening Tool to inform patients' treatment plans and make referrals to community services.

What does the AHC HRSN Screening Tool mean for me?

Screening for HRSNs isn't standard clinical practice yet. We're making the AHC HRSN Screening Tool a standard screening across all the communities in the AHC Model. We're sharing the AHC HRSN Screening Tool for awareness.

What's in the AHC HRSN Screening Tool?

In a National Academy of Medicine discussion paper,[2] we shared the 10-item HRSN Screening Tool. The Tool can help providers find out patients' needs in these 5 core domains that community services can help with:

- Housing instability
- Food insecurity
- Transportation problems
- Utility help needs

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[1] United States, U.S. Department of Health and Human Services, Centers for Medicare & Medicaid Services. (2017, September 05). Accountable Health Communities Model. https://innovation.cms.gov/initiatives/ahcm.

[2] Billioux, A., MD, DPhil, Verlander, K., MPH, Anthony, S., DrPH, & Alley, D., PhD. (2017). Standardized Screening for Health-Related Social Needs in Clinical Settings: The Accountable Health Communities Screening Tool. National Academy of Medicine Perspectives, 1-9. https://nam.edu/wp-content/uploads/2017/05/Standardized-Screening-for-Health-Related-Social-Needs-in-Clinical-Settings.pdf.

- Interpersonal safety

In the final version below, we made small revisions to the original 10 questions based on cognitive testing we did since we shared the first version. In the final version we also included questions in 8 supplemental domains that we haven't shared before:

- Financial strain
- Employment
- Family and community support
- Education
- Physical activity
- Substance use
- Mental health
- Disabilities

Who should use the AHC HRSN Screening Tool?

The questions in the AHC HRSN Screening Tool are meant to be used for individual respondents who answer the questions themselves. A parent or caregiver can answer for an individual, too, if that makes more sense. Clinicians and their staff can easily use this short tool as part of their busy clinical workflows with people of all different ages, backgrounds, and settings.

In the next 5 years, hundreds of participating clinical delivery sites across the 32 AHCs will screen over 7 million Medicare and Medicaid beneficiaries using the 10 core domain questions. The AHCs can also choose to add any of the supplemental domain questions into their standard screening processes.

Who made the AHC HRSN Screening Tool?

We made this tool with a panel of experts from around the country including:

- Tool developers
- Public health and clinical researchers
- Clinicians
- Population health and health systems executives
- Community-based organization leaders
- Federal partners

We got permission from the original authors of the questions to use, copy, modify, publish, and distribute the questions for the AHC Model and our use only. Based on feedback from the original question authors, CMS has created this table to specify the citation and notification process for each screening question in the AHC HRSN Screening Tool if the questions are used outside of CMS and the AHC Model.

AHC HRSN Screening Tool Core Questions

If someone chooses the underlined answers, they might have an unmet health-related social need.

Living Situation

1. **What is your living situation today?**[3]
   - ☐ I have a steady place to live
   - ☐ I have a place to live today, but **I am worried** about losing it in the future
   - ☐ I do not have a steady place to live (I am temporarily staying with others, in a hotel, in a shelter, living outside on the street, on a beach, in a car, abandoned building, bus or train station, or in a park)

2. **Think about the place you live. Do you have problems with any of the following?**[4]
   CHOOSE ALL THAT APPLY
   - ☐ Pests such as bugs, ants, or mice
   - ☐ Mold
   - ☐ Lead paint or pipes
   - ☐ Lack of heat
   - ☐ Oven or stove not working
   - ☐ Smoke detectors missing or not working
   - ☐ Water leaks
   - ☐ None of the above

Food

Some people have made the following statements about their food situation. Please answer whether the statements were OFTEN, SOMETIMES, or NEVER true for you and your household in the last 12 months. [5]

3. **Within the past 12 months, you worried that your food would run out before you got money to buy more.**
   - ☐ Often true
   - ☐ Sometimes true
   - ☐ Never true

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[3] National Association of Community Health Centers and partners, National Association of Community Health Centers, Association of Asian Pacific Community Health Organizations, Association OPC, Institute for Alternative Futures. (2017). PRAPARE. http://www.nachc.org/research-and-data/prapare/

[4] Nuruzzaman, N., Broadwin, M., Kourouma, K., & Olson, D. P. (2015). Making the Social Determinants of Health a Routine Part of Medical Care. Journal of Healthcare for the Poor and Underserved, 26(2), 321-327.

[5] Hager, E. R., Quigg, A. M., Black, M. M., Coleman, S. M., Heeren, T., Rose-Jacobs, R., Frank, D. A. (2010). Development and Validity of a 2-Item Screen to Identify Families at Risk for Food Insecurity. Pediatrics, 126(1), 26-32. doi:10.1542/peds.2009-3146

4. **Within the past 12 months, the food you bought just didn't last and you didn't have money to get more.**
   - ☐ Often true
   - ☐ Sometimes true
   - ☐ Never true

Transportation

5. **In the past 12 months, has lack of reliable transportation kept you from medical appointments, meetings, work or from getting things needed for daily living?**[6]
   - ☐ Yes
   - ☐ No

Utilities

6. **In the past 12 months has the electric, gas, oil, or water company threatened to shut off services in your home?**[7]
   - ☐ Yes
   - ☐ No
   - ☐ Already shut off

Safety

Because violence and abuse happens to a lot of people and affects their health we are asking the following questions. [8]

7. **How often does anyone, including family and friends, physically hurt you?**
   - ☐ Never (1)
   - ☐ Rarely (2)
   - ☐ Sometimes (3)
   - ☐ Fairly often (4)
   - ☐ Frequently (5)

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[6] National Association of Community Health Centers and Partners, National Association of Community Health Centers, Association of Asian Pacific Community Health Organizations, Association OPC, Institute for Alternative Futures. (2017). PRAPARE. http://www.nachc.org/research-and-data/prapare/

[7] Cook, J. T., Frank, D. A., Casey, P. H., Rose-Jacobs, R., Black, M. M., Chilton, M., . . . Cutts, D. B. (2008). A Brief Indicator of Household Energy Security: Associations with Food Security, Child Health, and Child Development in US Infants and Toddlers. Pediatrics, 122(4), 867-875. doi:10.1542/peds.2008-0286

[8] Sherin, K. M., Sinacore, J. M., Li, X. Q., Zitter, R. E., & Shakil, A. (1998). HITS: a Short Domestic Violence Screening Tool for Use in a Family Practice Setting. Family Medicine, 30(7), 508-512

8. How often does anyone, including family and friends, insult or talk down to you?

- ☐ Never (1)
- ☐ Rarely (2)
- ☐ Sometimes (3)
- ☐ Fairly often (4)
- ☐ Frequently (5)

9. How often does anyone, including family and friends, threaten you with harm?

- ☐ Never (1)
- ☐ Rarely (2)
- ☐ Sometimes (3)
- ☐ Fairly often (4)
- ☐ Frequently (5)

10. How often does anyone, including family and friends, scream or curse at you?

- ☐ Never (1)
- ☐ Rarely (2)
- ☐ Sometimes (3)
- ☐ Fairly often (4)
- ☐ Frequently (5)

A score of 11 or more when the numerical values for answers to questions 7-10 are added shows that the person might not be safe.

AHC HRSN Screening Tool Supplemental Questions

Financial Strain

11. How hard is it for you to pay for the very basics like food, housing, medical care, and heating? Would you say it is:[9],

- ☐ Very hard
- ☐ Somewhat hard
- ☐ Not hard at all

Employment

12. Do you want help finding or keeping work or a job?[10]

- ☐ Yes, help finding work
- ☐ Yes, help keeping work
- ☐ I do not need or want help

Family and Community Support

13. If for any reason you need help with day-to-day activities such as bathing, preparing meals, shopping, managing finances, etc., do you get the help you need?[11]

- ☐ I don't need any help
- ☐ I get all the help I need
- ☐ I could use a little more help
- ☐ I need a lot more help

14. How often do you feel lonely or isolated from those around you?[12]

- ☐ Never
- ☐ Rarely
- ☐ Sometimes
- ☐ Often
- ☐ Always

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9 Hall, M. H., Matthews, K. A., Kravitz, H. M., Gold, E. B., Buysse, D. J., Bromberger, J. T., . . . Sowers, M. (2009). Race and Financial Strain are Independent Correlates of Sleep in Midlife Women: The SWAN Sleep Study. Sleep, 32(1), 73-82. doi:10.5665/sleep/32.1.73

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11 Kaiser Permanente. (2012, June). Medicare Total Health Assessment Questionnaire. Retrieved from https://mydoctor.kaiserpermanente.org/ncal/Images/Medicare%20Total%20Health%20Assessment%20Questionnaire_tcm75-487922.pdf

12 Anderson, G. Oscar and Colette E. Thayer. Loneliness and Social Connections: A National Survey of Adults 45 and Older. Washington, DC: AARP Research, September 2018. https://doi.org/10.26419/res.00246.001

Education

15. Do you speak a language other than English at home?[13]

- ☐ Yes
- ☐ No

16. Do you want help with school or training? For example, starting or completing job training or getting a high school diploma, GED or equivalent.[14]

- ☐ Yes
- ☐ No

Physical Activity

17. In the last 30 days, other than the activities you did for work, on average, how many days per week did you engage in moderate exercise (like walking fast, running, jogging, dancing, swimming, biking, or other similar activities)?[15]

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7

18. On average, how many minutes did you usually spend exercising at this level on one of those days?[16]

- ☐ 0
- ☐ 10
- ☐ 20
- ☐ 30
- ☐ 40
- ☐ 50
- ☐ 60

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[13] United States, US Census Bureau. (2017). American Community Survey. Retrieved from https://www.census.gov/programs-surveys/acs/

[14] Identifying and Recommending Screening Questions for the Accountable Health Communities Model (2016, July) Technical Expert Panel discussion conducted at the U.S. Department of Health and Human Services, Centers for Medicare & Medicaid Services, Baltimore, MD.

[15] Coleman, K. J., Ngor, E., Reynolds, K., Quinn, V. P., Koebnick, C., Young, D. R., . . . Sallis, R. E. (2012). Initial Validation of an Exercise "Vital Sign" in Electronic Medical Records. Medicine and Science in Sport and Exercise, 44(11), 2071-2076. doi:10.1249/MSS.0b013e3182630ec1

[16] Ibid

☐ 90
☐ 120
☐ 150 or greater

Follow these 2 steps to decide if the person has a physical activity need:

1. Calculate ["number of days" selected] x ["number of minutes" selected] = [number of minutes of exercise per week]
2. Apply the right age threshold:
   - Under 6 years old: You can't find the physical activity need for people under 6.
   - Age 6 to 17: Less than an average of 60 minutes a day shows an HRSN.
   - Age 18 or older: Less than 150 minutes a week shows an HRSN.

Substance Use

The next questions relate to your experience with alcohol, cigarettes, and other drugs. Some of the substances are prescribed by a doctor (like pain medications), but only count those if you have taken them for reasons or in doses other than prescribed. One question is about illicit or illegal drug use, but we only ask in order to identify community services that may be available to help you. [17]

19. How many times in the past 12 months have you had 5 or more drinks in a day (males) or 4 or more drinks in a day (females)? One drink is 12 ounces of beer, 5 ounces of wine, or 1.5 ounces of 80-proof spirits.

☐ Never
☐ Once or Twice
☐ Monthly
☐ Weekly
☐ Daily or Almost Daily

20. How many times in the past 12 months have you used tobacco products (like cigarettes, cigars, snuff, chew, electronic cigarettes)?

☐ Never
☐ Once or Twice
☐ Monthly
☐ Weekly
☐ Daily or Almost Daily

[17] United States, U.S. Department of Health and Human Services, National Institutes of Health. (n.d.). Helping Patients Who Drink Too Much: A Clinician's Guide (2005 ed., pp. 1-34).

21. How many times in the past year have you used prescription drugs for non-medical reasons?

- ☐ Never
- ☐ Once or Twice
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or Almost Daily

22. How many times in the past year have you used illegal drugs?

- ☐ Never
- ☐ Once or Twice
- ☐ Monthly
- ☐ Weekly
- ☐ Daily or Almost Daily

Mental Health

23. Over the past 2 weeks, how often have you been bothered by any of the following problems?[18]

a. Little interest or pleasure in doing things?

- ☐ Not at all (0)
- ☐ Several days (1)
- ☐ More than half the days (2)
- ☐ Nearly every day (3)

b. Feeling down, depressed, or hopeless?

- ☐ Not at all (0)
- ☐ Several days (1)
- ☐ More than half the days (2)
- ☐ Nearly every day (3)

If you get 3 or more when you add the answers to questions 23a and 23b the person may have a mental health need.

[18] Kroenke, K., Spitzer, R. L., & Williams, J. B. (2003). The Patient Health Questionnaire-2: validity of a two-item depression screener. Medical Care, 41(11), 1284-1292.

24. Stress means a situation in which a person feels tense, restless, nervous, or anxious, or is unable to sleep at night because his or her mind is troubled all the time. Do you feel this kind of stress these days?[19]

- ☐ Not at all
- ☐ A little bit
- ☐ Somewhat
- ☐ Quite a bit
- ☐ Very much

Disabilities

25. Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?[20] (5 years old or older)

- ☐ Yes
- ☐ No

26. Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?[21] (15 years old or older)

- ☐ Yes
- ☐ No

[19] Elo, A.L., Leppänen, A., & Jahkola, A. (2003). Validity of a Single-Item Measure of Stress Symptoms. Scandinavian Journal of Work, 29(6), 444-451.
[20] United States, U.S. Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation (n.d.). (2011). Implementation Guidance on Data Collection Standards for Race, Ethnicity, Sex, Primary Language, and Disability Status. Retrieved from https://aspe.hhs.gov/basic-report/hhs-implementation-guidance-data-collection-standards-race-ethnicity-sex-primary-language-and-disability-status
[21] Ibid.

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Article

The Cycle to Respectful Care: A Qualitative Approach to the Creation of an Actionable Framework to Address Maternal Outcome Disparities

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Abstract: Despite persistent disparities in maternity care outcomes, there are limited resources to guide clinical practice and clinician behavior to dismantle biased practices and beliefs, structural and institutional racism, and the policies that perpetuate racism. Focus groups and interviews were held in communities in the United States identified as having higher density of Black births. Focus group and interview themes and codes illuminated Black birthing individual's experience with labor and delivery in the hospital setting. Using an iterative process to refine and incorporate qualitative themes, we created a framework in close collaboration with birth equity stakeholders. This is an actionable, cyclical framework for training on anti-racist maternity care. The Cycle to Respectful Care acknowledges the development and perpetuation of biased healthcare delivery, while providing a solution for dismantling healthcare providers' socialization that results in biased and discriminatory care. The Cycle to Respectful Care is an actionable tool to liberate patients, by way of their healthcare providers, from biased practices and beliefs, structural and institutional racism, and the policies that perpetuate racism.

Keywords: birth equity; framework; maternal health; maternal morbidity; racial equity; respectful care

1. Introduction

Black birthing people and babies are consistently the most impacted by adverse health outcomes in the United States, and growing literature suggests that experiences of racism and disrespect during healthcare encounters impacts health [1]. Decades of medical and public health research have failed to explain or reduce race-associated differences in maternal outcomes—such as mortality, morbidity, and patient experiences—in the United States. Women of color (i.e., Black, Latina, and Asian women) are more likely to experience a comorbid illness [2] and maternal death [3] and report being unfairly treated within healthcare settings based on their race or ethnicity [4,5]. In addition to increasing trends in maternal mortality overall, perhaps more distressing is the persistent, large, and increasing mortality gaps between Non-Hispanic (NH) Black and all other birthing persons in the United States [3,6]. Healthcare provider factors- delayed response to clinical warning signs, followed by ineffective care- were the most common type of contributor to

maternal deaths [5]. An actionable framework that centers Black birthing people, those most impacted by disrespectful treatment and care, is needed to resolve persistent maternal outcome disparities.

2. Shifts in Policy and Practice

In wealthy countries like the United States, there is a grassroot and political call to action for a radical shift in practice to reduce inequities in birth outcomes using respectful maternity care as a model for change [7]. The concept of Respectful Care, "care provided to all women in a manner that maintains their dignity, privacy and confidentiality, ensures freedom from harm and mistreatment, and enables informed choice and continuous support during labor and childbirth" [8] is globally accepted. The World Health Organization has called for further research on defining and measuring disrespect in public and private facilities, [5] yet there is not consensus of the ways to improve respectful care.

3. Taking Action to Address Maternal Outcome Disparities

This study was developed in response to the growing demand for frameworks to achieve birth equity and promote respectful maternity care in clinical settings that is informed by patients. Current data relies on system needs and does not adequately address the needs of birthing people. In order to address the needs of birthing people, it is necessary to illuminate birthing experiences to inform the ways in which systems might be improved to address disparities in maternal outcomes. The purpose of this study is to create an actionable framework for the practice of respectful maternity care based on the experiences of Black birthing people. This was achieved by eliciting feedback from Black birthing individuals across the United States and incorporating the findings to inform a framework to achieve respectful care. To achieve birth equity and a standard of respectful care, it is time to challenge the frameworks used and the values upheld to determine data collection and quality improvement activities. These measures currently detect symptoms of dysfunction, not the cause [9]. Focusing on easily measurable markers of quality diverts resources from harder-to-measure aspects of care, resulting in unchanged or even worse quality overall [9]. Recent studies support efforts to quantify and codify respectful care as well as address the need for radical change in medical practice [10].

4. Methods

In order to ensure the research process centers the experiences of Black birthing people, the research team identified three frameworks to guide the approach for participant recruitment, facilitation, development of the facilitator guide, analysis of the findings, and framework development. Cultural humility [11], Reproductive Justice [12], and Research Justice [13] are the guiding research frameworks of this study. Cultural Humility incorporates a lifelong commitment to self-evaluation and self-critique to address power imbalances in the patient-physician interactions in order to develop a mutually beneficial and non-hierarchical clinical and advocacy partnership with communities on behalf of the individuals and populations [11]. Reproductive Justice is the human right to maintain personal bodily autonomy in an individuals' decision to have or not have children and to parent children in a safe and sustainable community [12]. Research Justice centers community voices and leadership to be active participants in the process for change and policy reform at local, regional, national, and global levels in order to facilitate lasting social change [13]. Together these frameworks: (a) address the hierarchical structure of medicine, that has historically set aside the needs of the patient, in order to center the needs and experiences of the patient; (b) center the experiences of Black birthing people and the communities they live in; and (c) promote actionable solutions.

5. Data Collection

This study was approved by the Institute of Women and Ethnic Studies (IWES) IRB.

Development of the facilitator guide was informed by an extensive review of literature; feedback from Birthing Justice and Birth Equity activists and researchers, health services researchers, the Institute for Women and Ethnic Studies, and health care providers (e.g., midwives, OB/Gyn physicians, doulas, lactation consultants, nurses, etc.); and Dr. Karen Scott's Sacred Birth research [14]. All focus groups were co-facilitated by leaders of CBOs serving local communities of Black families.

All participants were given the option of a one-on-one interview to ensure their comfort in sharing their birthing experiences Before the focus group or interview, participants completed a questionnaire that included demographic information, information about utilization of healthcare services, and access to healthcare services. Guiding questions were developed based on a review of the literature and the expertise of study investigators from various disciplines (birth equity research, reproductive justice, health services research, OB/Gyns, and sociology) and tested in a pilot focus group. Modifications were made in the interview guide to decrease the number of questions.

To illuminate the birthing experiences of Black birthing individuals in hospital labor and delivery units, we conducted qualitative focus group discussions and an interview to identify the components of respectful maternity care. All focus groups were moderated and led by two leaders of community-based organizations serving Black birthing communities trained by the research team on facilitation of focus groups and the study research methods. A member of the research team (CLG) was available to the moderators for support and co-facilitation during the focus groups. Focus groups and interviews lasted 2-h.

Childcare was provided and participants were compensated $150 for their time and other study related expenses (e.g., transportation, childcare) related to participation.

6. Data Analysis

Digital recordings were transcribed verbatim and reviewed for accuracy in transcription. A team of five (5) scholars with backgrounds and expertise in maternal mental health, Black birthing justice, health services research, and birth equity independently reviewed the transcripts. The team identified overarching themes that were then further refined using codes. Codes were applied to each of the transcripts in a line-by-line coding process. Coders paid specific attention to the role of racism and discrimination in the treatment and care of participants. Themes and codes were developed and identified in relationship to participants' experiences as Black birthing people. The expansiveness, range of ethnic and cultural groups, of the African diaspora has influenced family lineage in many different countries, and researchers did not want to discount the experience of any birthing person who may inform this inquiry on respectful maternity care.

Data were independently reviewed by three coders. Coders discussed the themes and codes and came to a consensus on recurrent themes, conceptual descriptions, and illustrative examples of respectful care and compiled a codebook for assessing the remaining transcripts. To be included as a salient aspect of respectful care, a theme has to appear in two or more focus groups. Community based organization (CBO) leaders and partners that provide services for black birthing individuals and communities reviewed the preliminary codes and the remaining transcripts were then reviewed.

CBO leaders collaborated with the research team for the initial identification of themes and codes and remained engaged during data analysis. CBO leaders were asked to critically evaluate the codes and draft models in our community validation process. As themes and codes were refined, the research team checked-in with the CBO leaders to ensure the themes and codes were representative of the experiences of their communities and that key themes and concepts were not overlooked. After completion of coding of all the transcripts, the CBOs reviewed the final codes and unique definitions for each of the codes. Five of six CBO leaders refined themes based on the codes and their experiences, refined our definitions, and suggested de novo codes.

7. Creating the Framework

Once the themes and codes were established, CBO leaders were asked to provide feedback by walking through several exercises with the research team. The qualitative findings that were identified by the research team, CBO leaders, and stakeholders as critical to respectful care that were then examined in the context of existing frameworks in public health and health psychology. In the style of a listening session, CBO leaders were asked to apply the codes and themes to existing frameworks/models to contextualize the relationships of the codes and themes into the components of a framework to promote respectful maternity care.

8. Participant Recruitment

Data were collected in select communities of the United States identified as having higher density of Black births—Atlanta, GA; Baltimore, MD; Chicago, IL; Dallas, TX; Houston, TX; and Tulsa, OK during the Spring and Summer of 2019. Participants were recruited by community-based organizations located in these cities that provide resources and support for Black Birthing individuals in these communities.

The researchers and CBO partners recruited Black birthing people, over 18 years old, who had a birthing experience in a local hospital facility within the last two years. Blackness and identifying as Black includes a wide range of ethnic diversity, including African immigrants, Indigenous groups, Afro-Latinx, mixed race, etc. It was important that participants self-identified as Black and Blackness is a personal identity. In the participant demographic questionnaire, they were all asked to identify their race and gender identity. As all participants identified as Black and as women, they will be referred to as Black mothers for the duration of the report.

9. Framework Development

The themes and codes were applied to develop a framework for achieving respectful maternity care with the feedback and input from stakeholders (e.g., clinicians, nurses, birth workers, professional organizations, and health service researchers) and leadership from community-based organizations. After the identification of codes and themes, the research team and CBO leaders underwent an iterative process to develop a framework that were actionable steps for providers to practice respectful maternity care that included the themes from the focus groups. See Figure 1: Methods Process for an overview of this methodological approach.

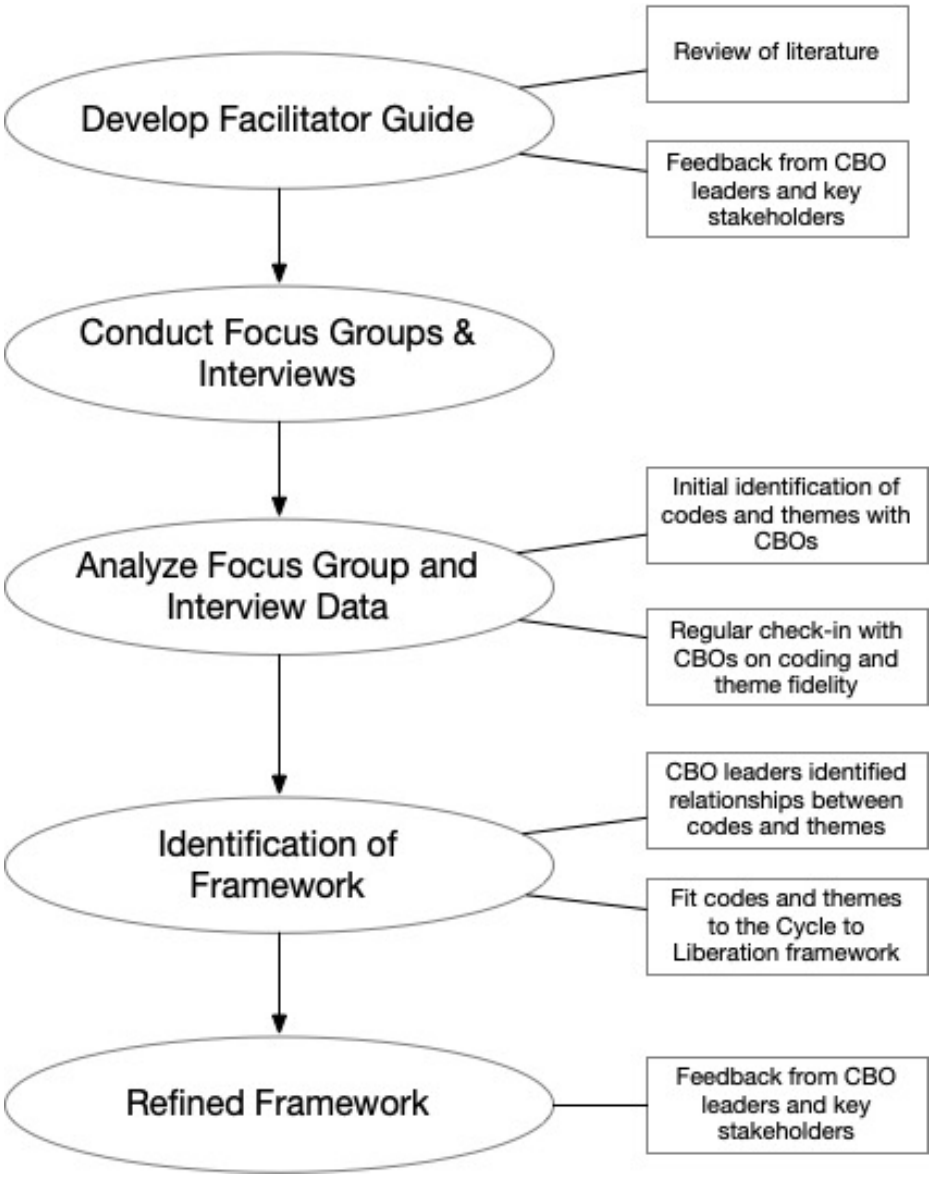

Figure 1. Methods Process. CBO: Community based organization.

10. Results

Several focus groups with 3–11 participants per focus group and one (1) one-on-one interview (N = 50) were held with Black mothers. Participants represented numerous communities across the United States and a range of socioeconomic backgrounds. See Table 1: Participant Demographics and Characteristics.

The research team explored and presented numerous existing models and frameworks including the Bronfenbrenner Ecological Model [15], the Feminist Ecological Model [16], and Maslow's Hierarchy of Needs [17] to stakeholders and CBO leaders in order to provide context for how the themes and codes might fit into existing frameworks and models.

CBO leaders unanimously rejected the idea of a hierarchical framework to achieve respectful care, noting that the absence of respect does not prevent a birth from happening, such that there is no one value or event that leads to a respectful birth experience. CBO leaders identified a need for a model of respectful care that was cyclical and relational, rather than hierarchical. The CBO leaders asserted that a linear process is irrelevant in communicating how providers achieve respectful care and that respectful care is dependent on antiracism and eliminating individual racist beliefs. They unanimously accepted the

Table 1. Participant Demographic and Characteristics.

Variable	*n* (%)
Location	
Atlanta	11 (22%)
Baltimore	7 (14%)
Chicago	9 (18%)
Dallas	6 (12%)
Houston	9 (18%)
Tulsa	8 (16%)
Insurance	

depiction of the cyclical model that promotes ongoing growth toward respectful care practices by confronting racism.

Table 1. Participant Demographics and Characteristics.

Variable	*n* (%)
Location	
Atlanta	11 (22%)
Baltimore	7 (14%)
Chicago	9 (18%)
Dallas	6 (12%)
Houston	9 (18%)
Tulsa	8 (16%)
Insurance	
Public	25 (50%)
Private	16 (32%)
Both (Public and Private)	7 (14%)
Decline to state/Unsure	2 (4%)
Annual Household Income	
<$25,000	16 (32%)
$25,000–$49,999	18 (36%)
$50,000–$74,999	7 (14%)
$75,000–$99,999	4 (8%)
$100,000+	5 (10%)
Education	
Some High School	3 (6%)
High School Graduate/GED	6 (12%)
Trade School	1 (2%)
Some College	17 (34%)
Bachelor's Degree or Higher	23 (46%)

A CBO leader introduced the research team to Bobby Harro's Cycles of Liberation [18] and Socialization [19]. Examining all the existing frameworks and models, all research partners arrived at a consensus that a cyclical model best illustrates the continuous and ongoing work of achieving respectful care. The Cycle of Liberation was adapted to include focus group themes to arrive at the Cycle to Respectful Care.

Themes and codes identified from the focus groups were incorporated into the Cycle to Liberation. (See Figure 2: Cycle to. Respectful Care) To fit the Cycle to Liberation with the focus groups and interview findings, the research team used an iterative process engaging CBO leadership, Birthing Justice and Birth Equity activists and researchers, health services researchers, birth equity researchers, leaders at professional organizations, and health care providers (e.g., midwives, OB/Gyn physicians, doulas, lactation consultants, nurses, etc.) to integrate the themes and codes into, what is now, the Cycle to Respectful Care. In addition to the feedback from key stakeholders, the research team identified existing quality improvement initiatives and models of care to incorporate into the framework to provide actionable solutions. The iterative process led to the Cycle to Respectful Care.

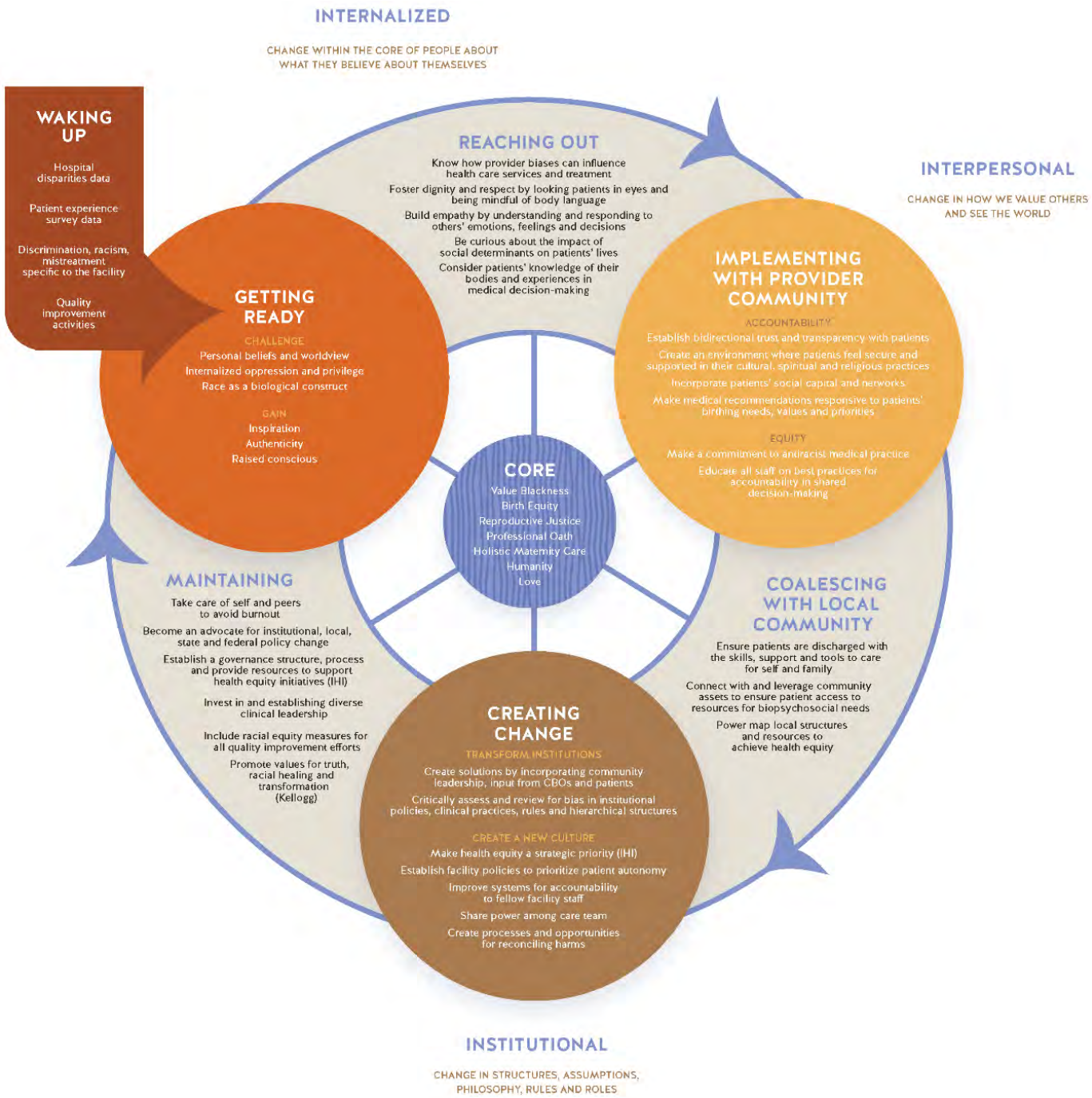

Figure 2. Cycle to Respectful Care.

11. The Core of the Cycle to Respectful Care

The core connects to each section of the cycle. Therefore, as a person progresses around the cycle the core values remain. Some of the values are present when a person first enters the cycle, those values are then fostered, expanded upon, and matured as they proceed through the various phases. The core values of the Cycle of Respectful Care include valuing patients' Black Intersectionality [1,5], Birth Equity, Reproductive Justice [12,20], the Professional Pledge/Oath [5] healthcare professionals commit to at the start of their career, Holistic Maternity Care, Humanity [21–23], and Love of self and others. (See Table 2: Definitions and Descriptions of the Core.) Values are strengthened through each phase, as they exist and operate on both the individual and collective levels. Harm can come from anywhere, but for the purpose of illustrating the ways in which the cycle could be put into practice Table 3: Examples of Individuals Moving through the Cycle illustrate the process by which a physician, nurse, and patient might move through the cycle. S

put into practice Table 3: Examples of Individuals Moving through the Cycle illustrates the process by which a physician, nurse, and patient might move through the cycle. See Table 4: Moving through the Cycle to Respectful Care for the rationale and evidence for each phase.

Table 2. Definitions and Descriptions of the Core.

Core Value	Description
Black Intersectionality *	Valuing the Black experience rather than the physical dark skin. Maternal experiences from Black identifying mothers are rich with data about bias and racism negatively affecting their births. It is imperative that making strides in quality improvement efforts to value the culture and experiences of being Black. Any quality improvement in maternal experiences are hypothesized to impact Black women most directly; therefore, any solutions developed must explicitly center Black women [1].
Birth Equity *	The assurance of the conditions of optimal births and wellbeing for all people with a willingness of systems to address racial and social inequities in a sustained effort.
Reproductive Justice	Capacious envisioning of reproductive possibilities that requires the use of intersectionality, the perspective that allows us to comprehend how race, class, ethnicity, and sexuality together construct gendered implications of motherhood and citizenship, sex and reproduction [12,20].
Professional Pledge/Oath	The commitment and promise of each profession. This is included in the core to remind hospital staff of the reasons why they practice and the foundational values of their profession. This could include the Hippocratic Oath, Imhotep Oath, Nightingale Pledge, etc. [5].
Holistic Maternity Care	Black Mamas Matter Alliance's (BMMA's) holistic maternity care concept is anchored in: addressing gaps in care and ensures continuity of care, is confidential, safe and trauma-informed, is culturally informed and includes traditional practices, respects spirituality and spiritual health, and lastly is provided by culturally competent and culturally congruent providers [21,22].
Humanity	Characterized by the United Nations treaty for Human Rights. From the perspective of mothers, being treated with humanity is being seen and regarded equally on the same level as another person you are interacting with, kindness, courtesy and politeness [23].
Love of self and others *	Respectful care is the practice of love. It is developing a sense of self as a care provider so that they can love others who are different than themself.

* Definitions based on the focus group findings.

Table 3. Examples of Individuals Moving through the Cycle.

Cycle Stage	Physician	Nurse	Black Patient
Waking-Up	A physician does not believe themselves to be personally are racist, but the data from their medical director shows disparities in HCAHPS (Hospital Consumer Assessment of Healthcare Providers and Systems) [24] and C-section rates for Black patients.	A nurse views countless news stories on police brutality and the Black Lives Matter Movement, and thus, she begins to reflect upon her role in contributing to racism.	A patient realizes she gets different types of questions from her doctor than the White mothers in her mom group. Questions such as whether she plans to terminate or continue the pregnancy and questions about her relationship with the baby's father.
Getting Ready	A physician is required to take implicit bias training but is uncertain on how the training will impact their medical practice.	A certified nurse midwife (CNM), continues to raise her consciousness and educate herself on privilege and the construction of racism in the U.S.	A patient begins to educate herself on her birthing options and the hospital policies.

Table 3. *Cont.*

Cycle Stage	Physician	Nurse	Black Patient
Reaching Out	A physician recognizes the ways in which their biases influence patient care and seeks to identify ways in which their practice might be more holistic by asking patients about their experiences at home, at work, and with family.	A nurse midwife could start with practicing new approaches with her patient interactions, such as looking patients in the eyes when she's speaking with them, showing patients they have her full attention with the positioning of her body, and making a conscious effort to listen to patients while checking her own biases.	A patient communicates her birthing needs and priorities with her care team.
Implementing with the Provider Community	A physician is, perhaps, now aware of the patient's support system and considers the patient's knowledge of their body in medical decision-making.	A nurse midwife becomes her department's champion for educating the staff on best practices for accountability and decision-making.	A patient asserts her knowledge of her body and experiences to create a birthing plan where she would feel most safe and supported.
Coalescing with the Local Community	A physician ensures patients are discharged with all that they need to care for themselves and their family by connecting with and leveraging community assets.	A nurse midwife leads a power mapping exercise, starting with her network of local CMNs, to identify structure and processes for health equity.	When a patient shares her birth plan, the nurse provides resources to complement the birth plan and to meet the patient's biopsychosocial needs.
Creating Change	A physician might suggest at quality improvement meetings with all hospital staff to create a system of accountability and leveled hierarchies among all hospital staff.	A nurse midwife builds relationships with local Women, Infants, and Children (WIC) offices and CBOs and creates a transparent process for patients to report harms, mistreatment or complaints.	A patient is educated on ways to report harms and complaints, and they are invited to participate in a department-wide maternal mortality review committee as a patient liaison.
Maintaining	A physician advocates for institutional policy and on-going workshops/medical education to minimize risk of burnout.	A nurse midwife engages with her statewide professional organization to establish policies for investment and promotion of diverse hiring practices.	A patient is introduced to services at health systems and hospitals that have shown a commitment to racial equity, made possible by the strength of community-hospital partnerships

Table 4. Moving through the Cycle to Respectful Care.

Cycle Phase	Definition	Actions
Waking Up	In the Cycle to Respectful Care, this waking up might include a critical incident of racism, discrimination, or mistreatment in the healthcare facility. Providers are made aware of the incident through patient reports, disparities data, or mandates to address disparate outcomes through implicit bias training or a quality improvement initiative. The American College of Obstetrics and Gynecologists (ACOG) ACOG AIM Patient Safety Bundles [25] and quality improvement initiatives are resources for hospitals and health systems that may illuminate racist and discriminatory care in order to prompt this Waking-Up phase.	Due to the urgency of growing maternal inequities in the United States, hospitals, healthcare systems, and policy makers have taken action to mandate implicit bias training thereby initiating the Waking-Up process rather than waiting for maternal care staff to Wake-Up on their own. The Cycle to Respectful Care begins when an individual observes or experiences the world differently than s/he has in the past.

Table 4. *Cont.*

Cycle Phase	Definition	Actions
Getting Ready	Getting Ready is the point at which individuals move from exclusively internal work to application in how they interact with and speak to others. This can be achieved through reviewing evidence-based research, attending anti-racist workshops, training on various topics, and building connections with others. This phase can include challenging beliefs in our worldview, medical education, and consciousness raising.	In preparation of the practice of valuing Black mothers more intensely, healthcare providers become conscious and make note of thoughts, language, and actions to see if they are consistent with newly established beliefs or they can be dismantled [18]. This intrapersonal section requires us to develop a repertoire of skills and tools that will serve us throughout the rest of the Cycle. These skills are built with others in Reaching Out.
Reaching Out	Reaching Out describes the ways in which an individual solidifies a new understanding of Respectful Care. Providers, who are educated about their biases, can identify the behaviors they exhibit that influence care and treatment for patients they are biased towards. Communication and information sharing become more important to the provider, to show themselves more trustworthy [5]. Overall, curiosity about the impact of social determinants on patients' lives can help providers build empathy and understand others. Small shifts in behavior communicate a level of respect to Black mothers, that impacts their experience. This Reaching Out phase moves us from the internal work to the truly interpersonal within the provider community.	In this phase, a person begins to incorporate their new ideals and knowledge into their everyday interactions, observing the response of others in their life to their new perspective. It is imperative to practice the new skills with others, test expressing new views, vocalize uncertainty instead of staying silent, and examine ideals through reflection and introspection, and seek out a greater range of differences than before. This Reaching Out phase provides strategies to practice the ways in which new worldviews will be met by patients.
Implementing with Provider Community	The Provider Community phase of the Cycle to Liberation contains two components: conversing with those who possess similar social identities and those who are different to build coalitions [18]. The interpersonal phase of the respectful care process is marked by a change in the value of others. This phase is characterized by the creation of an ongoing dialogue where views are exchanged, people are listened to and valued, and the process of seeing others' points of view as making sense and having integrity, even if they are very different from our own, begins. An integral part of this dialogue is exploring differences, clarifying them, erasing assumptions, and replacing them with firsthand contact and good listening. Building a solid provider community for respectful care means that small groups within institutions come to a common understanding of respectful care for Black mothers. These individuals will begin to conduct themselves differently in ways that impact their colleagues.	Addressing the provider community consists of two steps: (1) dialoguing with people who are like us for support and (2) dialoguing with people who are different from us for gaining understanding about oppression. Patients' culture, religion, fears, and hopes for their birth experience, must be discussed. It is useful to collectively create guidelines on normalizing best practices that are not standardized, like visitation policies or emerging anti-racism tools [26]. The Black mothers in the study suggested that provider accountability is shown either to the health system itself or to the patient. It is socialized in the provider community to build trust with the patient, such that the patient adheres to clinical guidance. It is not socialized in the provider community to be responsive to the knowledge, words, birthing needs, and priorities of the patient as an autonomous decisionmaker in the birthing experience [27]. The Institute for Healthcare Improvement (IHI) Framework [28] and AIM Patient Safety Bundle Reduction of Peripartum Racial/Ethnic Disparities are resources for organizational self-evaluation for accountability and equity of care to guide health systems and hospitals through this phase.

Table 4. *Cont.*

Cycle Phase	Definition	Actions
Coalescing with Local Community	The Coalescing phase is where the actions of the organized coalitions and groups begin to disrupt oppressive systems and create change [18]. It is vital during this phase to realize the collective work of the cohesive group is greater than individual actions. Once obstacles have been ameliorated, one can address factors that maintain racial inequities by joining forces with the broader community beyond that of the hospital facility or healthcare system [27].	Working in a true collaborative manner means that providers are culpable in ensuring patients are well when they are outside of the direct care and oversight of the care facility. Providers, who have coalesced with their patients' communities are able to ensure patients leave with access to resources to meet biopsychosocial needs. This may require large systems to power map structures and processes for health equity in their locations. This phase is intended to disrupt the status quo and for members of coalitions to take a stand with their beliefs. Consistent with existing quality improvement efforts, this phase also aligns with the IHI Framework sections four and five [28], National Quality Forum's domains of health equity [27] and the ACOG AIM Patient AIM Patient Safety Bundle Reduction of Peripartum Racial/Ethnic Disparities [29]. The actions in this phase of the Cycle lead to collective work to create change in structures, assumptions, philosophy, rules, and roles
Creating Change	The Creating Change phase of the cycle includes redesigning health services to create new culture and norms that reflect the public's collective identity [30], resulting in new assumptions, new structures, new roles, and new rules consistent with birth equity. Establishing health equity as a strategic priority and challenging structures, greatly enhances efforts to critically transform systems. Another way to create a culture of respectful care is to improve methods of accountability so that providers can have critical conversations amongst themselves, this involves taking leadership risks and becoming a beacon of change. Critical transformation takes place when organizations make conscious collective decisions for all policies for a collaborative structure rather than hierarchical. The new assumptions, rules, roles and structures must be cultivated.	*Creating Change* for respectful care means transforming institutions and creating a new culture [31]. Centering the voices and experiences of the group most impacted by the inequity is of greatest importance. Institutional change also depends on an assessment of institutional policies, clinical practices, and structures undergirding the system. Mentorship from identified birth equity champions within the facility or dismantling structures of power in and around quality improvement projects are legitimate activities to create change [5,32]. Tools for assessments include the Institute for Healthcare Improvement tools, National Quality Forum's health equity domains [27], AIM tools and the strategy of applying the Brooks Equity Typology assessment [33] described in the R4P framework [34].
Maintaining	Maintaining is a phase where all the previous changes become routines in the life of the person, and that people in this phase of the system support each other, to hold one another accountable for maintenance of the change [18]. Moving towards a respectful and anti-racist practice necessitates that institutions challenge structural racism and other intersecting oppressive systems (e.g., ableism, classism, ethnocentrism, homophobia, sexism, transphobia- and shift power in resources, leadership, and policies) [10]. In order to succeed, change needs to be strengthened, monitored, and integrated into the ritual of daily life. Just like anything new, it needs to be nurtured, learned again "debugged," and modified as needed. Maintaining includes a paradigm shift in medical training and competencies for respectful and anti-racist care models [10]. There must be an ongoing commitment and investment of resources from leadership and systems to maintain Respectful Maternity Care initiatives.	Providers are under extreme pressure and responsibility. Taking care of themselves and others on the care team helps them to avoid burnout and desensitization from repeated issues. Individual providers can help maintain systems change by advocating for institutional, local, state, and federal policies that impact social determinants [30], structural racism [35,36] and healthcare overall. They may be trained to advocate or exercise their inherent knowledge of the administrative or legislative process. Advocacy within the healthcare facility would be helping establish a governance structure and process for health equity, including hiring a diverse staff. Quality improvement efforts of any kind must address racial equity and bias to impact care. The Institute for Healthcare Improvement Achieving Health Equity: A Guide for Health Care Organizations provides guidance on this process [28].

12. Discussion

Historically, research in underserved communities has not included community partners, instead it has made these communities serve as laboratories, and the community members as experimental subjects [37]. This study engaged birthing communities, stakeholders, and organizations, which allowed for unique insight about specific needs and health impacts observed by Black mothers. Participants' social and cultural experiences informed our study methods, research questions, research findings, and the iterations in the development of the Cycle for Respectful Care. Active and informed participation of birthing people in all aspects of the design and implementation of institutional change was critical for constructive accountability [1,38].

Qualitative findings illuminated the hospital birthing experiences of Black birthing people to inform an actionable framework for healthcare providers and birth workers to address persistent and widening disparities in maternal health outcomes. Engagement with stakeholders at all steps of the research process ensured fidelity to centering the experiences of Black birthing people. An iterative process to identifying a framework that appropriately contextualizes the themes and codes of the qualitative findings resulted in the Cycle to Respectful Care—an actionable framework to address biased and disrespectful care. A high level of trust was established and investment in the process was mutual.

Accordingly, the Cycle to Respectful Care framework combines theory, analysis, and experiences of Black mothers across the United States It describes a recurrent process that is reminiscent of successful social change efforts, which led to some extent of liberation from the negative impact of oppressive systems for everyone involved. The Cycle to Respectful Care supports intentional patient engagement, promotes advocacy, and is an actionable tool to address birth equity in maternity care. The Cycle to Respectful Care framework was created for health systems and providers as an actionable guide toward respectful care for Black mothers, and eventually all birthing people.

The Cycle to Respectful Care is a tool for health care providers to understand how their Black patients experience disrespect, and how patients could be liberated from biased practices and beliefs, structural and institutional racism, and the policies that perpetuate racism. The primary provider audience for this framework is physicians, nurse midwives, and nurses because participants' hospital and clinic experiences are highly influenced by these individuals. Any care provider can operate in a disrespectful practice that may or may not be rooted in racism. Though this framework is written for the direct use of medical professionals, it can be used by any health care professional who serves Black birthing people in their reproductive life course.

The Cycle to Respectful Care flows through the levels of racism [39], internalized racism, personally mediated racism, and institutionalized racism [40]. Harro [18] claims that a person can start anywhere on the Cycle of Liberation, but that it is usually inevitable that intrapersonal, interpersonal, and systemic change will transpire while using this framework, which causes one to "wake up". After entering, one may repeat the process many times as there is no end to pursuing equity.

The Cycle to Respectful Care theoretical framework is based on the birth experiences of Black mothers in order to inform the ways in which to achieve respectful care. This framework complements existing provider educational tools, promotes anti-racist and birth equity practices, and bridges community assets to hospital care by centering the cultural, biopsychosocial, and holistic needs of Black mothers in order to reduce disparities in clinical and patient reported experience measure outcomes for all birthing people.

Limitations of this study were that one of the six CBO leaders was not able to participate in the development of the framework and validation of the qualitative analysis. Other limitations were that the communities selected for recruitment were based on a convenience sample of the areas where the research team had established relationships. This resulted in a lack of geographic spread that excluded middle America and rural communities.

As hospitals and health systems look for solutions to promoting equity and resolving disparities, this framework is a guide for hospital staff and administrators who seek to

achieve equity in their practice. The development of the Cycle to Respectful Care framework will ensure that hospital staff have tools to introduce and continuously work toward respectful care practices. As tools to address the patient led development and validation of measures for respect and discrimination in maternity care progress, a clinical standard for community engages quality improvement will emerge. From the perspective of professional responsibility and anti-racism, it should be expected that healthcare providers prioritize frameworks created for, by and with Black birthing people.

13. Conclusions

The Cycle to Respectful Care theoretical framework underscores the process to achieving respectful care for Black mothers and all birthing people. This framework is the inception of Respectful Maternity Care provider education tools, community awareness messaging, and a patient reported experience measure. The framework is expected to have applications in healthcare quality improvement initiatives for improving experiences and outcomes for birthing people (Supplementrary Material see PREM FACILITATOR GUIDE).

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/ijerph18094933/s1.

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The SHARE Approach:

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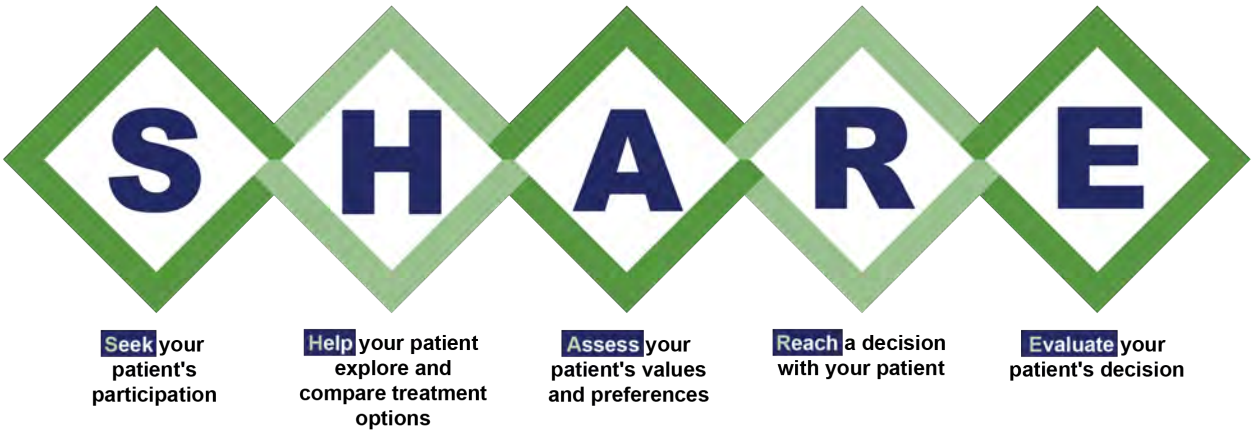

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NOTES