



Care for the Obstetric Patient with Complex Cardiac Disease

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- Cardiovascular • Neuraxial analgesia

Key points

- Cardiovascular disease is a leading cause of maternal morbidity and mortality in the United States and the prevalence of cardiac disease in pregnancy is increasing.
- Pregnant patients with cardiovascular disease should be evaluated by a multi-disciplinary Pregnancy Heart Team, including an anesthesiologist, in the antepartum period.
- Risk stratification tools such as the ZAHARA, CARPREG II, and the modified World Health Organization Classification of Cardiovascular Disease in Pregnancy guide delivery locale and strategies.
- Anesthesiologists play a crucial role in caring for patients with cardiovascular disease by providing effective labor analgesia and surgical anesthesia, preventing adverse cardiac events, and leading rapid resuscitations.

INTRODUCTION

The maternal mortality rate in the United States in 2020 was 23.8/100,000, which is higher than any other industrialized nation [1]. Death from pregnancy or childbirth disproportionately affects Black and non-Hispanic American Indian or Alaska Native patients [1]. Cardiovascular diseases (CVDs) are the leading cause of maternal mortality in the United States. According to the Centers for Disease Control and Prevention, 28% of pregnancy-related deaths are attributed to various forms of cardiovascular conditions, with 12.5% due to cardiomyopathy alone [1].

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Experts believe that heart disease has become the leading cause of death in the obstetric population due to an increase in cardiovascular risk factors [2–6]. Over the past few decades, the number of pregnancies in women with congenital heart disease has increased globally and is expected to grow in the future [2,3]. Moreover, in comparison to the past, pregnant people are older and are more likely to have preexisting comorbidities such as diabetes mellitus, hypertension, obesity, and sleep apnea, among other cardiovascular risk factors [4–7].

Numerous organizations have recognized this issue as a crisis and have published national and international statements emphasizing the importance of diagnosing and managing CVDs during all stages of pregnancy and postpartum [5,8–10]. The anesthesiology team plays a critical role in optimizing a patient's hemodynamics and safely guiding a pregnant patient with CVD through delivery and the immediate postpartum period.

The largest available data set is the Registry of Pregnancy and Cardiac Disease cohort that includes 6000 pregnant patients with heart disease from over 60 countries [11]. These data indicate that most patients with CVDs do well when appropriate care is given including preconception counseling, risk stratification, multidisciplinary coordination, and planning. This review will focus on one essential aspect of the multidisciplinary care: the anesthetic management of women with known cardiac disease during delivery.

ANTEPARTUM

Consults/risk stratification

Women with CVD should be evaluated by a multidisciplinary Pregnancy Heart Team before delivery [5]. The American College of Obstetricians and Gynecologists (ACOG) recommends that the team, at a minimum, should consist of cardiologists, maternal–fetal medicine specialists, obstetric providers, and an anesthesiologist [5]. Depending on the underlying problem, other specialties may provide additional care and counseling (eg, neonatologists, geneticists, electrophysiologists, interventional cardiologists, cardiac surgeons, and heart failure specialists).

Individualized assessment by the Pregnancy Heart Team includes preconception counseling, risk stratification, education, and multidisciplinary coordination [12]. After a detailed history, physical examination, and appropriate testing, patients should be risk stratified to facilitate appropriate delivery location and planning. Several risk stratification tools have been published including the CARPEG II, ZAHARA, and the modified World Health Organization Classification of Cardiovascular Disease in Pregnancy (mWHO) (Fig. 1) to guide delivery strategies and support transfer to higher levels of care [13–15]. These tools should be used as a *starting point* to guide planning, but the team should individualize a plan for safe delivery and follow up, taking into account individual components of CVD, such as severity of valvular gradients, life-threatening events requiring hospitalization, or the need for early delivery [12,14,16].

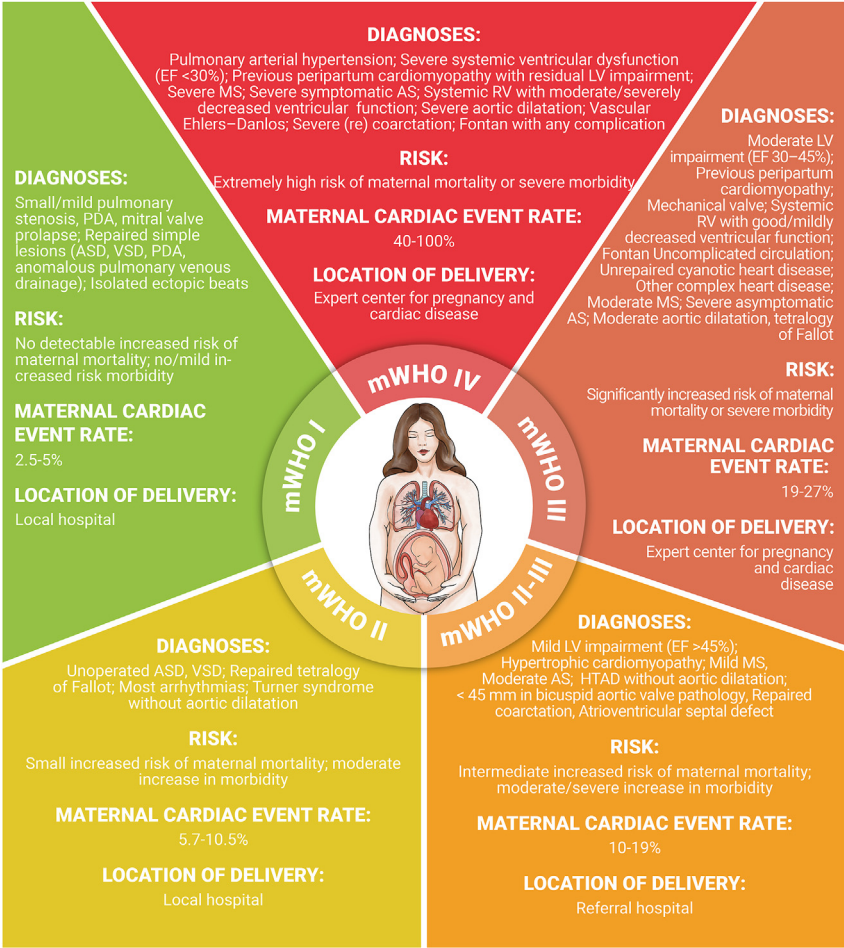


Fig. 1. Modified World Health Organization classifications of cardiovascular disease in pregnancy.[5,9]

Once risk stratified, delivery location should be decided with input from all members of the Pregnancy Heart Team. In 2019, ACOG updated the 2015 consensus on levels of maternal care in the United States. Hospitals are categorized level I to level IV and respectively defined as basic, specialty, subspecialty, and regional perinatal health care centers [17]. In general, women classified as mWHO risk class I may receive care at a maternal level I hospital (or higher) and this includes prepregnancy/pregnancy counseling, delivery and follow up (see Fig. 1) [5,9]. Higher risk patients such as class III and IV should be monitored in a maternal level IV care center where advanced therapies such as extracorporeal membrane oxygenation (ECMO), cardiac surgery, intensive care, and transplant services are available [5,9,12]. Higher levels of care should

have medical teams in the labor and delivery unit that can administer vasoactive and inotropic medications, inhaled or intravenous pulmonary vasodilators, and utilize telemetry and invasive monitoring during delivery.

An anesthesiologist should evaluate high-risk cardiac disease patients prior to their arrival for delivery. The essential components of this consultation are reviewed in Box 1. Anesthesiologists should consider involving a subspecialty trained cardiothoracic anesthesiologist in patients who are at a greater risk of decompensation, for example, patients with severe valvular lesions, severe or symptomatic heart failure, pulmonary hypertension with right heart failure

Box 1: Antepartum anesthesiology consultation for pregnant women with known cardiovascular disease

1. Summarize cardiovascular, obstetric and anesthesia history, and risk factors
2. Cardiac history should pay special attention to
 - a. Prior surgeries
 - b. Prior ECGs, echocardiograms, Holter monitors, stress tests, heart catheterizations, etc.
 - c. Intra-cardiac shunting and cyanosis
 - d. Left heart obstructive lesions
 - e. Left and right heart function
 - f. Prior or current episodes of heart failure
 - g. Prior or current arrhythmias
3. Risk stratification using the mWHO criteria
4. In consultation with obstetric team, plan appropriate delivery location according to Maternal Levels of Care
 - a. Level 1: Basic care
 - b. Level 2: Specialty care
 - c. Level 3: Subspecialty care
 - d. Level 4: Regional perinatal health care centers
5. Partner with Pregnancy Heart Team for anticoagulation regimen to optimize ability to perform neuraxial analgesia and anesthesia
6. Clarify in the consultation note plan for pacemaker or defibrillator
 - a. Keep AICD "on" during labor
 - b. Plan to keep AICD active for cesarean delivery (surgery is below umbilicus)
7. Clarify which obstetric drugs could cause hemodynamic instability
8. Partner with the Pregnancy Heart Team to clarify post-delivery plans for monitoring

Abbreviations: AICD, automatic implantable cardioverter defibrillator; ECG, electrocardiogram, mWHO, the modified World Health Organization Classification of Cardiovascular Disease in Pregnancy.

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or cyanosis, or any patient who may need a combined delivery and cardiac procedure. In addition, cardiothoracic anesthesiologists can provide support with echocardiography, pulmonary pressure monitoring, pulmonary vasodilator titration and ECMO initiation.

Special consideration: termination of pregnancy in high-risk patients

Patients who are categorized as mWHO IV have a high risk of mortality, and there is a general consensus that pregnancy should be discouraged [10]. Termination of pregnancy may be offered to these patients if they are in their first or early second trimester [10]. Termination in these patients can be high-risk and should be performed in a Level IV regional perinatal health care center. In patients up to 9 weeks gestation, an antiprogesterin compound like mifepristone can be offered for chemically induced termination of pregnancy [10]. Even for medical abortions, mWHO IV patients should be admitted for monitoring.

For surgical management (eg, dilation and curettage or evacuation), the choice of anesthesia depends on the severity of the disease and the hemodynamic behavior of the lesion. Neuraxial anesthesia, general anesthesia, and deep sedation with and without paracervical block may all be options; however, deep sedation may be the least optimal choice, considering the elevation of carbon dioxide, respiratory acidosis, and secondary elevation of pulmonary artery pressures. For some, a single injection spinal anesthetic with a dermatomal block to T10 may be an option [18], although rapid identification and treatment of hypotension is necessary and intraarterial blood pressure should be considered with vasopressor/inotropic support.

General anesthesia should be considered, especially for mWHO IV patients with gestational age beyond first trimester or ossification of the fetus (thereby requiring greater cervical dilation for evacuation), increased likelihood of blood loss (eg, molar or scar pregnancy) [18], or if a patient is unable to lie flat secondary to heart failure [9]. These authors recommend that surgical terminations for mWHO IV patients occur in the cardiovascular operating room suite.

INTRAPARTUM

Vaginal delivery

Vaginal delivery is recommended for most patients with cardiac disease due to the higher risk of obstetric complications with cesarean delivery such as blood loss, infection, and venous thromboembolism [5,9,16,19]. Valsalva maneuver during vaginal delivery is believed a reasonable option for most patients with cardiovascular conditions [16]. There may be instances where assistance with the second stage of labor is recommended to avoid a forceful, prolonged, and repeated Valsalva. Because avoiding Valsalva may result in a greater risk for obstetric complications, there is a spectrum of practice. Maternal fetal medicine subspecialists may recommend assisted second stage in patients with significant ventricular dysfunction, Fontan circulation, aortic root aneurysm and severe pulmonary hypertension [20,21]. In cases where women have enlarged aortic aneurysms, a modified Valsalva maneuver with an open glottis has been

described to theoretically reduce shear stress from changes in preload during repeated closed-glottis Valsalva maneuvers [21].

Monitoring during vaginal delivery

The American Society of Anesthesiologists (ASA) guidelines recommend a parturient's vital signs and fetal heart rate be monitored and documented during neuraxial labor analgesia. Basic maternal monitoring includes heart rate, pulse oximetry, and non-invasive blood pressure measurements [21,22]. These minimum requirements may not be enough for patients with CVD to rapidly recognize cardiac, obstetric, or anesthetic emergencies. The most common cardiac complications in labor include pulmonary edema and arrhythmias. Continuous pulse oximetry with a visible waveform, 5 lead electrocardiographic monitoring, and intra-arterial blood pressure monitoring may need to be considered for patients at increased risk [5,9,14]. Audible alarms should be activated to alert for maternal arrhythmias and desaturations.

Invasive blood pressure monitoring can be considered even before the placement of neuraxial analgesia to maintain maternal blood pressure. It can be especially useful in cardiac, anesthetic, or obstetric emergencies. Consideration should be given to arterial line placement in severe left-sided outflow tract obstructions, mitral stenosis, cardiomyopathy with reduced ejection fraction, right heart dysfunction, pulmonary hypertension, or any form of CVD with concurrent preeclampsia [9].

Intravenous access must be ensured in cardiac patients although central venous access is typically reserved for the sickest patient who may need vasoactive medications or if pulmonary artery catheter pressures are needed to monitor the response of pulmonary vasodilator therapy. Transthoracic echocardiography, or if under general anesthesia transesophageal echocardiography, is useful tool for assessing heart function and can be employed if there are signs of hemodynamic instability [9].

Labor analgesia

During labor, cardiac output increases likely secondary to increased circulating plasma catecholamines, mainly norepinephrine and epinephrine, and an increase in preload during uterine contraction from autotransfusion [22]. Epidural labor analgesia is thought to reduce circulating plasma catecholamines, thereby reducing the risk of cardiovascular events, especially arrhythmias [9,23].

Consideration should be given to anticoagulation regimens in patients with cardiac disease. Communication with the different team members is key to appropriately hold peripartum anticoagulation to facilitate neuraxial procedures and reduce the risk of postpartum hemorrhage (PPH). Guidelines from The American Society of Regional Anesthesia and Society for Obstetric Anesthesia and Perinatology are readily available and help guide decision making regarding holding anticoagulation before and after neuraxial procedures [24,25].

A fluid bolus before neuraxial techniques can worsen pulmonary edema in patients with heart failure. Small fluid boluses (eg.: 200 mL) might be helpful

alongside direct vasoactive medications such as phenylephrine to control blood pressure during and after a neuraxial block. If contractility is needed to increase heart rate and systemic vascular resistance (SVR), ephedrine can be a good agent to use in small doses (eg, 5–10 mg IV). Another example is a norepinephrine infusion at 0.02 to 0.08 mcg/kg/min (or 1–6 mcg/min) to achieve inotropic support and increase SVR. This can be safely administered through a peripheral IV [26]. Other examples of medications that could be required during labor and delivery in cardiac patients include dobutamine, dopamine, and milrinone [9].

Different epidural techniques may be used to initiate labor analgesia, including a combined spinal epidural (CSE), a dural puncture epidural (DPE), or an epidural catheter. Regardless of the technique, the most important aspect is to provide safe and effective analgesia that provides pain relief and can be used for emergent cesarean delivery [9]. A DPE or CSE technique can help confirm catheter placement and facilitate sacral nerve root coverage [27]. Some reviews suggest using a loss of resistance technique with saline (not air) in patients with intracardiac shunting to decrease the chance of a paradoxical air embolism due to inadvertent intravascular puncture [28,29].

Test dose strategies to ensure proper placement of the catheter in the epidural space require special consideration in patients with CVD. A combined test dose with an epinephrine-containing local anesthetic solution (eg, 1.5% lidocaine with 1:200,000 epinephrine) is commonly used to test for intrathecal and intravascular catheter placement. However, an intravascular catheter may cause harm in patients with arrhythmias, stenotic heart lesions, or aortic pathology [9]. Alternative test dose options include a divided test dose (45–60 mg lidocaine to test for potential intrathecal placement followed by 100 mg lidocaine to test for intravascular placement), fentanyl (administer 50–100 mcg of fentanyl and monitor for intrathecal and systemic opioid effects) [30,31], or gradual titration of a dilute solution of local anesthetic in 5 mL aliquots (eg, bupivacaine 0.0625%–0.125% with 1–2 mcg/mL of fentanyl and assess for any signs or symptoms of intrathecal or intravascular placement) [32].

Labor analgesia can be maintained with a continuous epidural infusion or programmed intermittent epidural boluses using a standard local anesthetic infusion combined with opioid (eg, bupivacaine 0.0625%–0.125% with fentanyl 1–2 mcg/mL) [9,16]. During an assisted vaginal delivery, such as with vacuum or forceps, the labor epidural may require increased sacral coverage to decrease pain. Further, the epidural can be converted to a surgical block for cesarean delivery. Either assisted vaginal or cesarean delivery can be facilitated with 5 to 20 mL of epidural lidocaine 2% or chloroprocaine 3% with continued hemodynamic monitoring throughout the procedure and immediately postpartum [9].

Labor analgesia considerations (summary)

- The most common cardiac complications in labor include pulmonary edema and arrhythmias. Appropriate monitoring should be employed for patients at increased risk.

- Anticoagulation is important for patients with CVD; appropriate holding times should be discussed with the Pregnancy Heart Team to facilitate neuraxial analgesia for labor.
- In patients with heart disease, prevent, identify, and rapidly respond to pulmonary edema. Routine fluid boluses should be withheld or cautiously administered before a neuraxial technique.
- Test dose strategies should be carefully selected. Epinephrine containing solutions should be considered carefully in patients with heart disease who could decompensate from the inotropy (eg, HOCM) or arrhythmogenesis (eg, prior history of tachyarrhythmia).
- Vasoactive and inotropic medications to support blood pressure during labor should consider the patient's specific cardiovascular status. Norepinephrine is safe to give peripherally.
- Early placement of an epidural catheter allows time for trouble shooting and replacement if needed.

Cesarean delivery

Cesarean deliveries are typically reserved for obstetric indications [5]. Exceptions include patients who are actively decompensating before delivery or anticipated to acutely deteriorate at the time of delivery. Examples include decompensated severe or critical obstructive lesions, decompensated pulmonary hypertension, or any patient needing tracheal intubation for acute heart failure [9,16]. Cesarean delivery is also considered for cardiovascular indications in patients with significant aortopathy [16]. The repeated fluctuations of cardiac output associated with labor and vaginal delivery may result in an increase in the aortic wall's shear stress and an increased risk of dissection [16]. Another indication for cesarean delivery includes a patient recently anticoagulated with warfarin, as warfarin crosses the placenta while reversal agents do not, increasing the anticoagulated fetus's risk for cerebral hemorrhage during vaginal birth [10].

Cesarean anesthesia

Depending on the lesion and risk stratification, patients with high-risk lesions (such as mWHO III or IV) may benefit from a gradual onset of the neuraxial sympathectomy. This can be achieved by an epidural technique, a CSE technique with intrathecal opioids and epidural local anesthetic, or a sequential CSE in which intrathecal opioids and low-dose bupivacaine (2.5–5 mg) are administered, followed by a slow epidural 2% lidocaine titration to T4–T6 level [33,34]. Other options that have been described include intrathecal catheters [35], and continuous epidural anesthesia with double catheters to ensure slow onset of anesthesia [36]. At the time of block placement, initiation of a prophylactic vasopressor infusion to maintain blood pressure and SVR should occur with either phenylephrine (eg, starting titration at $0.5\text{--}0.75\text{ }\mu\text{g kg}^{-1}\cdot\text{min}^{-1}$) or norepinephrine (eg, starting titration at $0.05\text{--}0.075\text{ }\mu\text{g kg}^{-1}\cdot\text{min}^{-1}$). We typically use the sequential CSE technique in patients with cardiac disease for planned cesarean delivery. Patients deemed low risk for cardiovascular complications (eg, mWHO I-II) can often tolerate a traditional spinal dose with 10 to 15 mg of hyperbaric bupivacaine and a prophylactic vasopressor infusion [16].

In patients with heart failure who have difficulty tolerating the supine position, general anesthesia is a reasonable option because these patients may further decompensate after delivery due to autotransfusion and aortocaval decompression from uterine involution [16]. During general anesthesia for cesarean delivery in CVD, induction should focus on maintaining hemodynamic stability. Pre-induction intra-arterial blood pressure monitoring and prioritizing hemodynamic stability (over aspiration risk, and newborn sedation) should be considered with a potential slow titration of induction agents such as propofol (1–2 mg/kg) or etomidate (0.1–0.3 mg/kg). Premedication should be considered including medications that are often avoided in obstetrics (eg, lidocaine, fentanyl) or remifentanyl (infusion 0.2–0.5 mcg/kg/min for 5–10 minutes or boluses 2–4 mcg/kg) which could theoretically cause less newborn sedation due to its rapid metabolism [37–39]. Vasopressors should be in-line and oxytocin should be infused via an infusion pump immediately after delivery without bolus dosing.

Monitoring during cesarean delivery

Monitoring during cesarean delivery includes standard ASA monitors and a low threshold for intraarterial blood pressure monitoring [40]. Beat-to-beat blood pressure measurements assist with titration of vasopressors like phenylephrine, norepinephrine, and ephedrine during neuraxial or general anesthesia. In cases of right ventricular failure or acute decompensation that requires vasopressors and pulmonary vasculature dilators, central venous catheter and pulmonary artery pressure monitoring should be considered [9]. Point-of-care transthoracic echocardiography can be used to assess volume status, ventricular function, regional wall motion abnormalities, pericardial effusion, valvular function, and changes in the proximal aorta [41,42]. In the case of general anesthesia, transesophageal echocardiography can be also considered.

EMERGENCIES

Identification and response

According to the National Partnership for Maternal Safety, there are several early warning signs and symptoms to rapidly identify women with undiagnosed cardiac disease, or those with known cardiac disease who may be decompensating: shortness of breath, orthopnea, lung crackles or wheezing, resting heart rate lesser than 120 beats/min, resting respiratory rate greater than 30, oxygen saturation less than 95% on room air without a history of CVD (Table 1) [5,12,43]. These signs can be suggestive of heart failure, arrhythmias, or coronary artery disease and should lead to a high clinical suspicion of impending decompensation that would need prompt intervention.

Cardiac ultrasound

A focused cardiac ultrasound can be performed at the bedside to assist in treatment of cardiac-related complications. This tool is easily accessible, safe, and may help reduce the time to diagnosis and treatment [41,42]. Ultrasound can help assess volume status to guide fluid administration, left and right ventricular global function and regional wall abnormalities, pericardial effusions,

Table 1
Maternal early warning signs and symptoms

Vital signs and physical exam signs	Symptoms
Heart rate > 120 or < 50 beats/min	Chest pain at rest or with minimal exertion
Systolic blood pressure > 160 mm Hg or < 90 mm Hg	Shortness of breath at rest, orthopnea, paroxysmal nocturnal dyspnea
Diastolic blood pressure > 100 mm Hg	Extreme fatigue
Respiratory rate > 30 breaths/min	Agitation, confusion, unresponsiveness
Oxygen saturation < 95% on room air without a history of cardiovascular disease	Patient with preeclampsia with headache or shortness of breath
Oliguria < 35 mL/h	Unprovoked or exertional syncope
Wheezing, crackles	
Loud systolic murmur or S4, jugular venous pressure visible 2 cm above clavicle at 45°	
Marked peripheral edema	

valvular regurgitation or stenosis, and changes in the proximal aorta. Uterine displacement of the heart upwards and laterally helps to obtain a parasternal and apical views more easily. The subcostal views may be more challenging to achieve in pregnancy [16].

Cardiac ultrasound can also be useful in cases of maternal arrest as it can help narrow the differential diagnosis in undifferentiated shock or cardiac arrest. In hemorrhage, the heart will be hyperdynamic and the inferior vena cava collapsible. In cardiogenic shock, the ventricular function will be decreased, and B lines can be present as a sign of alveolar fluid accumulation. In obstructive shock, the right ventricle will be dilated, and the inferior vena cava will be non-collapsible. In sepsis, the heart may be hyperdynamic or display decreased function [9].

Fetal distress and emergency cesarean delivery

A plan for emergency cesarean delivery must be delineated with the obstetric team before delivery. All laboring women, including those with CVD, are at risk for placental abruption, umbilical cord prolapse, uterine rupture, or persistent uteroplacental insufficiency that can necessitate emergent cesarean delivery resulting in the need for rapid conversion of preexisting neuraxial labor analgesia to surgical anesthesia. The maternal state and fetal status will dictate how rapidly the epidural medications can be titrated to effect. The anesthesiologist must keep in mind that a rapid conversion to general anesthesia may be required for any laboring patients with CVD and have an emergent general anesthesia induction plan formulated [9]. During labor, the team should be a step ahead of such possible obstetric emergencies with redundant intravenous access as well as additional monitors such as an intra-arterial line and 5 lead ECG in patients categorized as mWHO III or IV.

Medications used in obstetrics have a particular pharmacologic profile that can adversely affect a patient with CVD. For example, terbutaline is used as a uterine relaxing agent due to its beta 2 agonistic effects to improve uteroplacental perfusion. It is administered in the setting of fetal bradycardia caused by uterine tachysystole. It causes vasodilation and tachycardia that could result in hemodynamic collapse in specific patients such as those with hypertrophic cardiomyopathy, severe aortic stenosis, or history of tachyarrhythmias. Nitroglycerin acts as a uterine relaxant and is administered either IV or sublingually. This agent can also cause a rapid decrease in SVR. The entire team should be aware that such drugs, need to be used especially carefully, or in some cases even avoided, in specific cardiac patients [9].

Postpartum hemorrhage

PPH is twice as common in patients with CVD [44,45]. Early recognition of PPH and rapid treatment is important in every postpartum woman, especially in those with CVD disease. Oxytocin is the most effective uterotonic agent. In patients with CVD, oxytocin should be titrated via an infusion pump. Bolus dosing should be avoided because of a potential rapid decrease in SVR that could lead to cardiovascular collapse [46]. For cesarean delivery, the estimated effective dose of oxytocin infusion to obtain satisfactory tone in 90% of parturients in non-laboring patients was 16.2 IU/h and in laboring patients was 44.2 U/h [47–49]. Higher doses are associated with greater side effects. As hypotension occurs from oxytocin, counteraction with a vasoconstrictor is suggested.

Conversely, methylergonovine can increase SVR and pulmonary vascular resistance due to alpha-adrenergic agonism. This increase in blood pressure can result in hypertensive crisis, stroke, or coronary vasospasm that could result in myocardial ischemia and death [47,50,51]. This agent should be avoided in patient with hypertension, preeclampsia, ischemic heart disease, vascular dissection (eg, history of spontaneous coronary artery dissection), intracardiac shunts, and aortic pathology [47,50–52].

Carboprost is a prostaglandin F2-alpha that increases pulmonary artery pressure by 125% and pulmonary vascular resistance by more than 100% [53]. It can also precipitate bronchospasm, hypoxemia, increased intrapulmonary shunt fraction, and death [54–56]. Consideration should be given to avoiding this medication in patients with Fontan circulation, intracardiac shunt, pulmonary hypertension, and preexisting asthma.

Finally, misoprostol is a drug that is well tolerated in this patient population as it has no cardiopulmonary effects, unfortunately it is the least effective uterotonic agent [9]. It is reasonable for this drug to be administered prophylactically in patients with CVD as an adjunct to oxytocin to prevent PPH.

Arrhythmias

Patients with a history of tachyarrhythmias are at increased risk of experiencing arrhythmia during the peripartum period. This can lead to maternal hemodynamic instability and fetal compromise [57,58]. These patients should be

monitored with 5 lead electrocardiography during labor with central telemetric monitoring if available [9]. The most common arrhythmias found in pregnancy and delivery are atrial fibrillation and paroxysmal supraventricular tachycardia [58]. Other entities like heart block, ventricular fibrillation, and ventricular tachycardia are rare. If the patient presents with a pacemaker or an implantable cardioverter-defibrillator, these should be left “on” during labor. If an emergency cesarean delivery is needed, it is reasonable to proceed without disabling the defibrillation function according to the most recent guidelines as the incision for a cesarean is below the umbilicus [9,59]. Note that in the setting of elective cesarean delivery an anesthesiologist may choose to have this device interrogated and the defibrillation function turned off and replaced with external pads to reduce the risk of accidental shock. However, in a recent systematic review, no appropriate or inappropriate ICD shocks during delivery were reported in the literature [60].

Management of arrhythmias in pregnancy is the same as for the non-pregnant patient [61]. Chemical and electric cardioversion can be performed in pregnancy [62]. Adenosine can be used for paroxysmal supraventricular tachycardia. Beta blockers and calcium channel blockers can be used for rate control in atrial fibrillation [10,61]. If the patient becomes unstable, immediate cardioversion should occur [61]. If the patient is not in cardiac arrest, then during an arrhythmia episode the fetus should be monitored. Fetal distress can also be an indication for cardioversion. According to the American Heart Association (AHA), application of defibrillation and cardioversion shocks to the maternal chest would be expected to pass minimal energy to the fetus and is considered safe in all stages of pregnancy [61]. Defibrillation would be unlikely to cause electric arcing to fetal monitors, and the presence of fetal monitors should not deter providers from the use of rapid electricity administration when indicated [61].

Cardiovascular surgery

In the case of dissection of a major vessel or other cardiovascular emergency requiring emergent surgery, the presence of a pregnancy should not delay life-saving cardiac surgery. A cesarean delivery may be performed concurrent with the vascular or cardiac surgery in a term pregnancy or for signs of fetal distress in a viable fetus [9]. The risk of prematurity must be weighed with the benefits of delivery on a case-by-case basis. If the decision is made to maintain the pregnancy through a surgery requiring cardiopulmonary bypass, optimizing uteroplacental perfusion with high flow normothermic perfusion is recommended.

Maternal cardiac arrest

In the United States, maternal arrest occurs in about 1 of every 9000 (13.4 per 100,000) hospitalizations for delivery from 2017 to 2018 with the most common etiologies being hemorrhage, heart failure, amniotic fluid embolism, and sepsis [63,64]. According to the AHA and the Society for Obstetric Anesthesiology and Perinatology, cardiopulmonary resuscitation should occur at the site

of the cardiac arrest; chest compressions should be performed at a rate of 100 per minute; with the patient positioned supine with a second provider performing manual left uterine displacement to remove aortocaval compression [61,65,66]. Defibrillation should occur and Advanced Cardiac Life Support medications are dosed as indicated in nonpregnancy patients [61,65,66]. A resuscitative hysterotomy (also called a perimortem cesarean delivery) at the site of arrest is prioritized if return of spontaneous circulation does not occur within 4 minutes [67]. The goal for delivery is 5 minutes after arrest which will release aortocaval compression resulting in improved maternal hemodynamics, reduced maternal oxygen demand, and improved survival of the mother and fetus [65,66]. Maternal cardiac arrest code teams should include a typical hospital code team along with obstetric and neonatal teams. If available, resources to perform transesophageal or transthoracic echocardiography, as well as an ECMO team should be mobilized early in the code [68].

SUMMARY

The anesthesiologist is an essential member of the Pregnancy Heart Team as they are immediately available in labor and delivery, and they have extensive training in caring for patients in acute settings with cardiac disease. Anesthesiologists should embrace the role of the peri-delivery physician leader and provide excellent labor analgesia and surgical anesthesia, prevent adverse cardiac events, rapidly recognize cardiovascular instability, and lead rapid and precise resuscitation in patients with CVD.

CLINICS CARE POINTS

- To ensure safe management of pregnancy in patients with cardiovascular disease, pre-delivery evaluation by a multidisciplinary Pregnancy Heart Team should occur.
- Risk stratification tools evaluate the etiology and severity of cardiovascular disease to determine the appropriate hospital type and location for delivery and anesthetic management.
- Intrapartum hemodynamic monitoring may need to be intensified for patients at increased risk.
- Anticoagulation is important for patients with CVD. Appropriate holding times should be discussed with the Pregnancy Heart Team to facilitate neuraxial blockade for labor analgesia or surgical anesthesia.
- Vasoactive and inotropic medications to support blood pressure during labor should consider the patient's specific cardiovascular status.
- Early placement of an epidural catheter allows time for trouble shooting and replacement if needed and reduces circulating plasma catecholamines.
- The anesthesiologist must be prepared for both obstetric and cardiac emergencies.

DISCLOSURE

The authors have nothing to disclose.

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