

Delivering Coordinated Cardio-Obstetric Care from Preconception through Postpartum



Anna C. O'Kelly, MD, MPhil^a, Nandita Scott, MD^b, Doreen DeFaria Yeh, MD^{b,*}

KEYWORDS

- Cardio-obstetrics • Coordinated care • Maternal mortality • Congenital heart disease
- Cardiovascular disease

KEY POINTS

- Cardiovascular disease is a leading cause of maternal mortality globally and in the United States.
- A cardio-obstetrics team is a multidisciplinary, collaborative team that cares for women from the preconception through postpartum periods and is composed of cardiologists with training in cardio-obstetrics and adult congenital heart disease, maternal and fetal medicine specialists, anesthesiologists, and allied health care professionals.
- There are limited guidelines to standardize how cardio-obstetrics care is provided, and more work needs to be done.
- Cardio-obstetrics education needs to be better integrated in general cardiology training programs.

INTRODUCTION

Cardiovascular disease (CV) is a leading cause of maternal mortality globally.^{1–4} It affects 1% to 4% of pregnancies in the United States^{1–4} and is the most common cause of pregnancy-related mortality.^{1–6} Although complications from congenital heart disease (CHD) account for some of this morbidity and mortality, acquired cardiovascular disease including cardiomyopathy and heart failure, ischemic heart disease, hypertensive disorders of pregnancy, arrhythmia, and stroke accounts for a much larger share.^{1,3,4} Cardiovascular complications during pregnancy are associated with future CV disease.^{7–10} Pregnancy is thus considered a vascular and hemodynamic

“stress test” that allows for early identification of women who may be at increased future CV risk.

CV disease during pregnancy is an increasing cause of maternal mortality in the United States.^{1–6} This growth is driven by many factors, including advances in the treatment of CHD, increasing comorbidities such as obesity and diabetes during pregnancy, advanced maternal age, and importantly inadequate access to health care.^{1,11–14} The risk of CV complications during pregnancy disproportionately affects racial minorities,^{2,5} and pregnancy-related mortality is 3 to 4 times higher in black than in white women.⁵

Developing a comprehensive cardio-obstetrics team is critical to optimizing preconception maternal health, manage CV complications as

^a Department of Medicine, Massachusetts General Hospital and Harvard Medical School, Yawkey 5700, 55 Fruit Street, Boston, MA 02114, USA; ^b Division of Cardiology, Cardiovascular Disease and Pregnancy Program, Massachusetts General Hospital and Harvard Medical School, Yawkey 5700, 55 Fruit Street, Boston, MA 02114, USA
* Corresponding author. Cardiology Division, Massachusetts General Hospital, Yawkey 5700, 55 Fruit Street, Boston, MA 02114.
E-mail address: ddefariayeh@mgh.harvard.edu

they arise during pregnancy, and ensure postpartum CV risk factors are addressed. The cardio-obstetrics team is a collaborative, multidisciplinary team composed of obstetricians-gynecologists and maternal and fetal medicine (MFM) specialists, cardiologists with subspecialty training and experience in cardio-obstetrics and adult congenital heart disease, anesthesiologists, primary care physicians, midlevel and allied health professionals, and may also include neonatologists and geneticists and is increasingly important in providing wraparound care for women at risk of CV complications peripartum.^{1,11} This collaborative approach to maternal health is supported by both the American Heart Association and the American College of Obstetricians and Gynecologists (ACOG).¹⁵

This paper outlines the importance of coordinated preconception through postpartum care. It highlights the potential role of such care in mitigating CV risk factors and addressing disparities in CV disease distribution. It also addresses the role of cardiology fellowship programs in educating trainees about the field of cardio-obstetrics and how coordinated efforts between obstetrics and cardiology departments can create collaborative and multifaceted cardio-obstetrics programs.

PRECONCEPTION

The preconception period is an important window to optimize maternal health before pregnancy.^{1,16–18} For women who plan their pregnancy and seek preconception care, preconception counseling can occur during an appointment with a primary care provider or obstetrician. For women with known congenital or acquired CV disease or who are at significant risk of CV complications during pregnancy, preconception counseling should be performed by the cardio-obstetrics team, especially a cardiologist with subspecialty expertise in CHD or cardio-obstetrics for careful evaluation and risk stratification.^{18–20} Because almost half of pregnancies may be unplanned and unintended, preconception counseling should take place as part of routine evaluation of women of childbearing age in the primary care setting or cardiology office.^{16,18} Unfortunately only half of reproductive age women receive counseling to address risks of future pregnancies and birth outcomes. The One Key Question initiative recommends providers caring for women of childbearing age ask “Would you like to become pregnant in the next year?” with the intention to identify women who may become pregnant and begin a conversation about their health and pregnancy risks.²¹ For

many women, their initial pregnancy visit—either preconception or shortly after conception—may be the first time they have recently engaged with the health care system, and it can be a vital opportunity for welcoming them in a nonjudgmental and supportive way so as to encourage ongoing care. Regardless of whether pregnancies are planned or not, preconception care is a vital opportunity to discuss modifiable maternal risk factors including weight loss, blood pressure and diabetes management, screening for and treatment of any chronic conditions, and assessment of vaccination status.^{3,16,18,20,22}

The preconception period is also an important opportunity to identify women who may be at higher risk of CV complications and refer them to appropriate subspecialty providers. Careful history-taking, specifically regarding any prior cardiac conditions or procedures and symptoms of exercise intolerance, is essential. A thorough physical examination should focus on assessing for cardiac abnormalities. Although soft systolic ejection murmurs are seen in greater than 90% of pregnant women,²³ any diastolic or loud murmurs (grade 3 or greater) are abnormal and should be further evaluated with echocardiography.^{20,24} When in doubt, referral to a cardiologist with expertise in cardio-obstetrics is prudent.

For women at elevated CV risk, collaborative care between the members of the cardio-obstetrics team is essential. Cardiologists with training and expertise in cardio-obstetrics should play a primary role in risk stratification.^{1,19,20,25,26} Numerous risk-stratification models exist and incorporate multiple factors including prior cardiac history and interventions, lesion-type if relevant, baseline functional status, and medication use.^{20,27,28} Of these, the modified World Health Organization (WHO) model is endorsed by expert consensus.^{20,29,30} Women with known cardiac lesions may require a baseline echocardiogram, electrocardiogram, and exercise stress test to assess functional status and appropriately risk stratify.^{1,18,20,31}

In addition to these factors, there are certain maternal congenital and cardiac diseases in which pregnancy is contraindicated due to prohibitive risk. These include pulmonary artery hypertension, severe systemic ventricular dysfunction including from prior peripartum cardiomyopathy, severe left-sided obstructive disease, Eisenmenger syndrome, severe aortic dilatation particularly with Marfan syndrome, and poorly tolerated complex CHD.^{19,20,32} For these especially high-risk lesions, early pregnancy termination is advised.^{19,20,31}

Preconception counseling should also include discussion about medication safety both in

pregnancy and post partum.^{11,19,20,31} This includes the cessation of known teratogenic medications and transition to safer alternatives, as well as the initiation of beneficial medication such as prenatal vitamins and daily aspirin for women at risk of preeclampsia.^{1,20,33}

For women with CHD, genetic testing and fetal risk of transmission should also be discussed.^{18,19,31} The risk of transmission varies widely and by lesion-type, from 3% to 50%,^{31,34} although it is considerably higher than the 0.3% to 1.2% risk of CHD in the general population.³⁴

In emphasizing the importance of wraparound care, preconception counseling should also include anticipatory guidance about ongoing care throughout pregnancy and some of the postpartum changes women may experience.³⁵ This can include counseling on adjustments to early motherhood and challenges with self-care, as well as the importance of medication compliance and ongoing follow-up to mitigate CV risk. In particular, counseling on the importance of exercise and the prevention of excessive weight gain during and following pregnancy should begin in the prenatal period. Despite the known associations of excessive weight gain with both pregnancy complications and future CV disease,^{36–40} only approximately 30% to 40% of women in the prenatal period receive counseling about weight management.^{41–43} Furthermore, moderate physical activity during pregnancy reduces the risk of hypertensive disorders including preeclampsia^{44–46} and gestational diabetes.^{47–50}

PREGNANCY AND PERIPARTUM

Just as coordinated care is important in risk-stratifying and optimizing health before pregnancy, so too is coordinated care throughout pregnancy. Coordinated visits with cardiologists, MFM specialists, and allied health professionals allows for close monitoring and treatment of any CV complications that occur. Although there are no clear guidelines for follow-up frequency during pregnancy,¹ expert opinion is that women should meet at least once per trimester with their cardiologist and MFM.^{31,51} A formalized delivery plan should be developed by the end of the second trimester or beginning of the third. Some models of cardio-obstetrics care include joint visits with both cardiologist and MFM specialist,⁵² whereas others include monthly integrated meetings between MFM specialists and cardiologists to ensure ongoing communication and updated care.⁵¹ At the authors' institution they hold monthly multidisciplinary cardio-obstetric meetings between MFM specialists, cardiologists with expertise in cardio-

obstetrics and CHD, anesthesiologists, and nurses to discuss all shared patients, detail plans for their upcoming deliveries, and provide documentation in the medical record for all providers to review when a woman presents in labor (Fig. 1).

There are no guidelines for the frequency of imaging monitoring throughout pregnancy either, and often it is lesion and patient specific. Expert consensus recommends serial echocardiography be performed approximately every trimester for women with valvular disease and cardiomyopathy and more frequently in severe disease or if symptoms develop.^{20,53–56} ACOG recommends ongoing surveillance every 4 to 6 weeks throughout pregnancy for women with congenital aortopathy including Marfan syndrome and bicuspid aortic valve.¹

Delivery Planning

For women at high risk of CV events during delivery, decisions regarding timing, location, and mode of delivery should be reached early in pregnancy and with input from the patient's multidisciplinary cardio-obstetrics team. This should ideally occur no later than the end of the second or early in the third trimester of pregnancy.^{57–59} Contingencies for possible obstetric and cardiac emergencies should be part of the preparation for labor and delivery.⁵⁹

The patient's specific CV disease, whether congenital or acquired, her functional status, and risk of cardiac event should be primary factors in guiding discussions about delivery.^{3,18,31} High-risk patients should be delivered at a tertiary care center.^{19,20,31} Women who are especially high risk, such as those with pulmonary hypertension, may need to be hospitalized late in their second or early in their third trimester and closely monitored until delivery.⁶⁰ In general, planned vaginal delivery is preferred over cesarean delivery,^{20,57,61,62} and cesarean delivery is generally only indicated by obstetric need.^{20,57,60} In the absence of contraindications or spontaneous onset of labor, women with CV disease may be induced between 39 and 40 weeks gestation, although specific guidance should be directed by the cardio-obstetrics team.¹ Any medication changes indicated before delivery, including changes in anticoagulation, should also be discussed early in the pregnancy course.¹ Continuous pulse oximetry throughout delivery is generally advised, and invasive hemodynamic monitoring is very rarely indicated.^{20,60} Continuous telemetry during delivery is generally not warranted given that most arrhythmias peripartum are both benign and rare,^{63,64} though are more

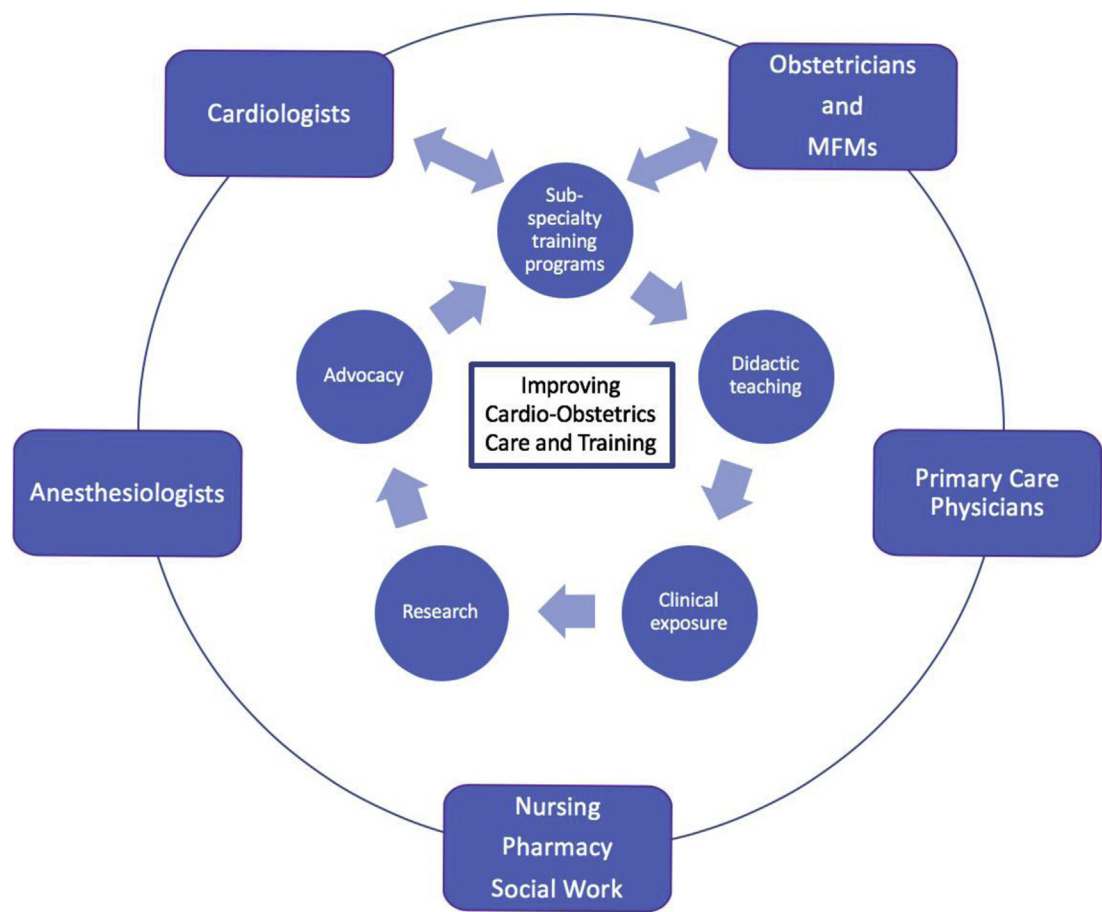


Fig. 1. Improving cardio-obstetrics care and training.

common in women with known arrhythmia before pregnancy.^{65,66} In women with known arrhythmia or at risk of malignant arrhythmia including ventricular tachycardia, continuous telemetry during delivery may be considered and may require modifications to nursing staffing.^{67–69}

With appropriate planning and specialist input, most women with CV disease have uncomplicated deliveries. It is estimated that only 1% to 3% of pregnancies in the United States require critical care management at the time of delivery.⁵⁸ Hemorrhage and hypertension are the most common reasons for intensive care unit admission peripartum, and 20% to 30% of patients have a non-obstetrical indication for admission.⁵⁸ When possible, it is best to decide on the need for intensive care before delivery.⁵⁸

If pregnant women present hemodynamically unstable or in cardiogenic shock, urgent decision-making regarding management and delivery are essential.^{20,70–72} This should be driven by the cardio-obstetrics team, with additional input from an advanced heart failure team,

interventional cardiology or cardiac surgery, intensivists, and neonatologists when needed.^{20,70,72} Women may require urgent vasopressor support and rapid evaluation for advanced mechanical circulatory support,^{20,70,71} and emergent delivery may be required regardless of gestational age.^{20,69–71,73} If hospitals do not have on-call advanced heart failure or cardiac interventional/surgical resources, collaboration with tertiary centers is critical to ensure rapid transfer of care is facilitated in these time-sensitive situations.

POSTPARTUM

The postpartum period, which is generally considered to extend up to 1 year after delivery, allows not only for monitoring of postpartum complications but also for interventions to reduce future obstetric and CV risk.⁷⁴ For this reason, the postpartum period is often considered the “fourth trimester.”³⁵ Importantly, women with known cardiac disease and CV complications of pregnancy require lifelong cardiac care.

The immediate postpartum period should be focused on ensuring hemodynamic safety before discharge from the hospital. With the significant hemodynamic shifts of delivery, women are at risk of heart failure and pulmonary edema, arrhythmia, stroke, acute coronary syndrome, aortic dissection, and death.^{1,18,27,60,75–78} This is especially true for women with congenital or acquired CV disease.^{4,11} Contraception for those desiring it should be discussed before discharge from the hospital.^{1,11,35,79}

Although close postpartum monitoring after discharge is important, there are no guidelines to standardize the follow-up schedule. ACOG generally recommends initial follow-up with their obstetrician within approximately 3 weeks after delivery and a comprehensive postpartum visit within the first 12 weeks.³⁵ The WHO recommends follow-up at 3 days, 1 to 2 weeks, and 6 weeks post partum.^{35,80}

Women with congenital or acquired CV disease should be followed more closely. ACOG recommends follow-up with a cardiologist or primary care provider within 7 to 14 days of delivery.¹ For women with hypertensive disorders of pregnancy, ACOG recommends a blood pressure check within 7 to 10 days after delivery and within 72 hours after delivery if severe hypertension.^{35,81} Although in-person visits are ideal, new mothers may face challenges in coordinating numerous appointments both for themselves and their infants. At the authors' institution, they coordinate postpartum visits with pediatric visits when able. To reduce visit burden, these initial visits may be performed virtually in some circumstances or with visiting nurses. Follow-up visits are tracked and promptly rescheduled if missed or canceled, to support continued cardiac care. A subsequent 3-month follow-up visit to assess CV risk modification is advised.¹

Cardiovascular risk factor modification in the postpartum period is especially important given the increase risk for future CV disease,^{1,35,82,83} and any modifiable CV risk factors should be aggressively managed.^{1,35,82,83} Both chronic hypertension and excessive weight gain during and following pregnancy mediate future CV disease.^{39,40} Furthermore, women should be counseled that obstetric history is increasingly recognized as an integral part of their CV history^{10,19,20,84} and that expert guidelines now include CV complications during pregnancy as disease-modifying factors that influence CV disease prevention strategies.^{10,84} Collaboration between cardiologists and primary care physicians is essential.

Despite these recommendations, the postpartum period remains a high-risk period for

women, and more than half of pregnancy-related deaths occur during this period.^{1,3,35,85} Although the event rate of CV complications is fairly low (6%–12%),^{86,87} their potential repercussions are devastating.^{18,27,60,75–77} This is also a high-risk period for women to fall through the cracks of a fragmented health care system.⁷⁶ During the postpartum period, women are often transitioning from inpatient to outpatient care and out of the obstetrics space and into the primary care setting.^{35,88} Furthermore, for numerous personal, logistical and systems-level reasons, women are frequently unable to seek care as recommended. Despite advised follow-up within the first 3 weeks, many women do not have first contact with their provider until 4 to 6 weeks post partum and are frequently without accessible guidance or support in the intervening weeks.³⁵ In addition, 40% of US women do not attend any postpartum follow-up appointments.³⁵ This is especially true of minority and socioeconomically disadvantaged women, which may contribute to disparities in CV risk factor management and disease burden.³⁵ Inconsistent health care insurance is one of the primary barriers to adequate continuity of care,^{89,90} and many women in the United States lose their insurance after 42 days following delivery.¹ This is especially problematic for the disproportionate number of racial minorities who have CV complications during pregnancy and insecure health insurance.^{3,5,91,92} Increasingly, virtual visits prove to be a helpful means of addressing challenges with facilitating both prenatal and postpartum care.^{93–95} It is critical that women with known CV disease and CV complications of pregnancy are counseled early and often regarding the importance of lifelong cardiac care.

It is unclear how to best overcome these obstacles and provide appropriately focused, continuous postpartum care for women with CV disease.^{96–98} Although specialty clinics can play an important role in the postpartum period,^{96,97} relying on such clinics may be unrealistic for all women.⁹⁸ The postpartum period thus presents an especially important time for coordinated care between primary care physicians, cardiologists, and allied health professionals in ensuring that women's CV risk factors are appropriately addressed.

CARDIO-OBSTETRICS TEAM: WHAT HAS BEEN ACHIEVED AND WHAT REMAINS TO BE ACHIEVED

Delivering coordinated comprehensive multidisciplinary cardio-obstetric care from preconception through postpartum is critical in optimizing

immediate and long-term maternal health. Despite the growing recognition of the relationship between peripartum CV complications and future CV risk, many physicians—including cardiologists—are insufficiently aware of this relationship and fail to include obstetric history in their assessment of CV risk or screen for future pregnancy.^{12,99,100} Dedicated cardio-obstetrics teams can help to raise awareness about these issues and guide care in the dynamic period following pregnancy.

Creating a dedicated cardio-obstetrics team has many challenges. It requires longitudinal commitment from multiple specialists, and allied health care professionals, as well as commitment from institutional leadership. Often these teams develop organically, and there is no standard of care to guide how these teams should form, who should be included, when they should meet, and how they should best complement each other’s roles. Many academic cardiology divisions,

however, now have focused heart centers for women (HCW) and/or adult CHD programs and these potentially offer a physical home for collaboration.¹²

As the cardio-obstetrics team plays an increasingly central role in caring for women with CV disease from preconception to postpartum and beyond, cardiologists need to be better trained in cardio-obstetrics. Most HCW have faculty who can support research in women’s CV disease and cardio-obstetrics, but formal training and educational guidelines for CV trainees do not yet exist.^{99,101,102} At the Massachusetts General Hospital a multipart didactic series has been implemented for general cardiology fellows that is offered throughout the academic year, in addition to required Women’s Heart Health and adult CHD clinical rotations including peripartum management. In 2013 the authors’ cardio-obstetrics program began a full-day Cardiovascular Disease and Pregnancy educational course for a

Box 1

Key questions that remain

Preconception

How early should preconception counseling begin?

How should those without health insurance best receive preconception counseling?

What is the best preconception risk stratification test?

How do we improve rates of preconception counseling and risk stratification, particularly among cardiologists?

Pregnancy and peripartum

How often should a cardio-obstetrics team meet as a group, with patients? How can “visit burnout” best be prevented? When are virtual visits safe and appropriate?

How frequently should echocardiography be performed throughout pregnancy?

Postpartum

How to best predict who will require postpartum monitoring in the intensive care unit (ICU)?

How can we facilitate keeping women in CV care long term?

How should postpartum CV care best be provided for women with limited or no health insurance?

What is the relative role of primary care physicians versus subspecialists in providing ongoing postpartum follow-up?

Cardio-Obstetrics teams: what we have achieved and what remains to be achieved

How should cardio-obstetrics teams best collaborate? Is shared physical space important?

How can we expand education content for trainees? How should exposure to and focused clinical training in cardio-obstetrics best be integrated in general cardiology fellowship programs?

What role can cardiologists play in advocating for health policies to promote CV follow-up after pregnancy?

How can cardiology and obstetrics professional societies best create joint cardio-obstetrics guidelines?

How do cardiologists and obstetricians address the marked disparities that exist in maternal outcomes?

multidisciplinary audience including cardiology, obstetrics, and anesthesiology and included both trainees and practicing physicians and allied health providers. The University of Pennsylvania CV disease fellowship program has developed a focused woMen's Cardiovascular Health curriculum to facilitate formal training in identifying sex differences in the diagnosis and treatment of CV disease.¹⁰³ Standard educational requirements across all CV fellowship training programs is needed. By integrating more cardio-obstetrics experiences into general cardiology fellowship programs and offering dedicated subspecialty programs and training in the field, the next generation of general cardiologists can be better equipped with the knowledge to improve maternal mortality and address disparities in maternal and CV health.

There are additional systems-level changes that would further bolster these efforts. Government policies to support paid parental leave would potentially help women attend their postpartum medical appointments, and extending prenatal and postpartum health insurance would lessen the financial cost to do so.³⁵ Furthermore, additional data about CV disease during pregnancy would help develop guidelines and standards of care. One such solution is the Heart Outcomes in Pregnancy: Expectations for Mom and Baby Registry, which is a multicenter, multidisciplinary collaborative initiative to gather data about pregnant mothers with CV disease in the United States.⁹¹ Such a coordinated initiative will catalyze the development of best practices and guidelines. Guidelines should be jointly developed and endorsed by expert groups in both obstetrics and cardiology.^{15,99} Current guidelines are developed by either obstetric¹ or CV societies.^{19,20,31} Joint efforts would both strengthen recommendations for caring for women during this critical time and further galvanize collaboration⁹⁹ (**Box 1**).

SUMMARY

Coordinated preconception through postpartum cardio-obstetrics care is necessary to optimize both maternal and fetal health. Maternal mortality in the United States is increasing, largely driven by increasing CV disease burden during pregnancy, and needs to be addressed emergently. Both for women with congenital and acquired heart disease, CV complications during pregnancy are associated with increased future risk of CV disease. Comprehensive cardio-obstetrics care is a powerful way of ensuring that women's CV risks before and during pregnancy are appropriately identified and treated and that they remain

engaged in CV care long term to prevent future CV complications.

CLINICS CARE POINTS

- Preconception counseling is critical for all women with pre-existing structural or congenital heart disease, hypertension and ischemic heart disease.
- Patients with known or previously repaired congenital heart disease should be referred to adult congenital heart disease specialists for preconception and peripartum evaluation and management.
- Case review and multidisciplinary discussion of all pregnant women at high risk of cardiovascular complication should be conducted regularly.

DISCLOSURE

None.

REFERENCES

1. Hollier L. ACOG practice bulletin No. 212: pregnancy and heart disease. *Obstet Gynecol* 2019; 133(5):e320–56.
2. Pregnancy mortality surveillance system | Maternal and infant health | CDC. 2020. Available at: <https://www.cdc.gov/reproductivehealth/maternal-mortality/pregnancy-mortality-surveillance-system.htm>. Accessed July 18, 2020.
3. Hameed AB, Lawton ES, McCain CL, et al. Pregnancy-related cardiovascular deaths in California: beyond peripartum cardiomyopathy. *Am J Obstet Gynecol* 2015;213(3):379.e1–10.
4. Briller J, Koch AR, Geller SE. Maternal cardiovascular mortality in Illinois, 2002–2011. *Obstet Gynecol* 2017;129(5):819–26.
5. Creanga AA, Syverson C, Seed K, et al. Pregnancy-related mortality in the United States, 2011–2013. *Obstet Gynecol* 2017;130(2):366–73.
6. MacDorman MF, Declercq E, Cabral H, et al. Is the United States maternal mortality rate increasing? Disentangling trends from measurement issues short title: U.S. Maternal mortality trends. *Obstet Gynecol* 2016;128(3):447–55.
7. Grandi SM, Filion KB, Yoon S, et al. Cardiovascular disease-related morbidity and mortality in women with a history of pregnancy complications: systematic review and meta-analysis. *Circulation* 2019; 139(8):1069–79.
8. Wu P, Gulati M, Kwok CS, et al. Preterm delivery and future risk of maternal cardiovascular disease: a systematic review and meta-analysis. *J Am Heart Assoc* 2018;7(2). <https://doi.org/10.1161/JAHA.117.007809>.

9. Gulati MM. Improving the cardiovascular health of women in the Nation: moving beyond the bikini boundaries. *Circulation* 2017;135(6):495–8.
10. Arnett Donna K, Blumenthal Roger S, Albert Michelle A, et al. 2019 ACC/AHA guideline on the primary prevention of cardiovascular disease: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on clinical practice guidelines. *Circulation* 2019;140(11):e563–95.
11. Mehta Laxmi S, Warnes Carole A, Bradley Elisa, et al. Cardiovascular considerations in caring for pregnant patients: a scientific statement from the American Heart Association. *Circulation* 2020; 141(23):e884–903.
12. Lundberg Gina P, Mehta Laxmi S, Sanghani Rupa M, et al. Heart centers for women. *Circulation* 2018;138(11):1155–65.
13. Elkayam U, Goland S, Pieper PG, et al. High-risk cardiac disease in pregnancy: part I. *J Am Coll Cardiol* 2016;68(4):396–410.
14. Shapero KS, Desai NR, Elder RW, et al. Cardio-obstetrics: recognizing and managing cardiovascular complications of pregnancy. *Cleve Clin J Med* 2020;87(1):43–52.
15. Brown HL, Warner JJ, Gianos E, et al. Promoting risk identification and reduction of cardiovascular disease in women through collaboration with obstetricians and gynecologists: a presidential advisory from the American Heart Association and the American College of Obstetricians and Gynecologists. *Circulation* 2018;137(24). <https://doi.org/10.1161/CIR.0000000000000582>.
16. Farahi N, Zolotor A. Recommendations for preconception counseling and care. *Am Fam Physician* 2013;88(8):499–506.
17. Harville EW, Viikari JSA, Raitakari OT. Preconception cardiovascular risk factors and pregnancy outcome. *Epidemiology* 2011;22(5):724–30.
18. Clapp MA, Bernstein SN. Preconception counseling for women with cardiac disease. *Curr Treat Options Cardiovasc Med* 2017;19(9):67.
19. Stout KK, Daniels CJ, Aboulhosn JA, et al. 2018 AHA/ACC guideline for the management of adults with congenital heart disease: executive summary. *J Am Coll Cardiol* 2019;73(12):1494–563.
20. Regitz - Zagrosek V, Roos - Hesselink JW, Bauersachs J, et al. 2018 ESC Guidelines for the management of cardiovascular diseases during pregnancy. *Eur Heart J* 2018;39(34):3165–241.
21. Allen D, Hunter MS, Wood S, et al. One Key Question®: first things first in reproductive health. *Matern Child Health J* 2017;21(3):387–92.
22. Harrison CL, Brown WJ, Hayman M, et al. The role of physical activity in preconception, pregnancy and postpartum health. *Semin Reprod Med* 2016; 34(2):e28–37.
23. Cutforth R, MacDonald CB. Heart sounds and murmurs in pregnancy. *Am Heart J* 1966;71(6):741–7.
24. Stout KK, Otto CM. Pregnancy in women with valvular heart disease. *Heart* 2007;93(5):552–8.
25. Nanna M, Stergiopoulos K. Pregnancy complicated by valvular heart disease: an update. *J Am Heart Assoc* 2014;3(3). <https://doi.org/10.1161/JAHA.113.000712>.
26. Nishimura RA, Otto CM, Bonow RO, et al. 2014 AHA/ACC guideline for the management of patients with valvular heart disease: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines. *J Am Coll Cardiol* 2014; 63(22):2438–88.
27. Siu SC, Sermer M, Colman JM, et al. Prospective multicenter study of pregnancy outcomes in women with heart disease. *Circulation* 2001; 104(5):515–21.
28. Drenthen W, Boersma E, Balci A, et al. Predictors of pregnancy complications in women with congenital heart disease. *Eur Heart J* 2010;31(17):2124–32.
29. Balci A, Sollié-Szarynska KM, van der Bijl AGL, et al. Prospective validation and assessment of cardiovascular and offspring risk models for pregnant women with congenital heart disease. *Heart* 2014;100(17):1373–81.
30. van Hagen IM, Boersma E, Johnson MR, et al. Global cardiac risk assessment in the Registry of Pregnancy and Cardiac disease: results of a registry from the European Society of Cardiology. *Eur J Heart Fail* 2016;18(5):523–33.
31. Canobbio MM, Warnes CA, Aboulhosn J, et al. Management of pregnancy in patients with complex congenital heart disease: a scientific statement for healthcare professionals from the American Heart Association. *Circulation* 2017; 135(8). <https://doi.org/10.1161/CIR.0000000000000458>.
32. Hemnes AR, Kiely DG, Cockrill BA, et al. Statement on pregnancy in pulmonary hypertension from the pulmonary vascular research institute. *Pulm Circ* 2015;5(3):435–65.
33. American College of Obstetricians and Gynecologists Committee Opinion. Low dose aspirin use during pregnancy. 2018;132(1):9.
34. Donofrio MT, Moon-Grady AJ, Hornberger LK, et al. Diagnosis and treatment of fetal cardiac disease: a scientific statement from the American Heart Association. *Circulation* 2014;129(21):2183–242.
35. American College of Obstetricians and Gynecologists Committee Opinion. Optimizing postpartum care. 2018;131(5):11.
36. Whitaker KM, Wilcox S, Liu J, et al. Patient and provider perceptions of weight gain, physical activity, and nutrition counseling during pregnancy: a qualitative study. *Womens Health Issues* 2016;26(1):116–22.

37. Hernandez DC. Gestational weight gain as a predictor of longitudinal body mass index transitions among socioeconomically disadvantaged women. *J Womens Health* 2012;21(10):1082–90.
38. Holland DJ, Kumbhani DJ, Ahmed SH, et al. Effects of treatment on exercise tolerance, cardiac function, and mortality in heart failure with preserved ejection fraction: a meta-analysis. *J Am Coll Cardiol* 2011;57(16):1676–86.
39. Honigberg MC, Zekavat SM, Aragam K, et al. Long-term cardiovascular risk in women with hypertension during pregnancy. *J Am Coll Cardiol* 2019;74(22):2743–54.
40. Timpka S, Stuart JJ, Tanz LJ, et al. Lifestyle in progression from hypertensive disorders of pregnancy to chronic hypertension in Nurses' Health Study II: observational cohort study. *BMJ* 2017;358.
41. Stotland N, Tsoh JY, Gerbert B. Prenatal weight gain: who is counseled? *J Womens Health* 2011;21(6):695–701.
42. McDonald SD, Pullenayegum E, Taylor VH, et al. Despite 2009 guidelines, few women report being counseled correctly about weight gain during pregnancy. *Am J Obstet Gynecol* 2011;205(4):333.e1–6.
43. McDonald SD, Park CK, Pullenayegum E, et al. Knowledge translation tool to improve pregnant women's awareness of gestational weight gain goals and risks of gaining outside recommendations: a non-randomized intervention study. *BMC Pregnancy Childbirth* 2015;15(1):105.
44. Sorensen TK, Williams MA, Lee I-M, et al. Recreational physical activity during pregnancy and risk of preeclampsia. *Hypertension* 2003;41(6):1273–80.
45. Barakat R, Pelaez M, Cordero Y, et al. Exercise during pregnancy protects against hypertension and macrosomia: randomized clinical trial. *Am J Obstet Gynecol* 2016;214(5):649.e1–8.
46. Farpour-Lambert NJ, Eells LJ, Martinez de Tejada B, et al. Obesity and weight gain in pregnancy and postpartum: an evidence review of lifestyle interventions to inform maternal and child health policies. *Front Endocrinol* 2018;9. <https://doi.org/10.3389/fendo.2018.00546>.
47. Tobias DK, Zhang C, Dam RM van, et al. Physical activity before and during pregnancy and risk of gestational diabetes mellitus: a meta-analysis. *Diabetes Care* 2011;34(1):223–9.
48. American College of Obstetricians and Gynecologists Committee Opinion. Physical activity and exercise during pregnancy and the postpartum period. 2020;135(4):11.
49. Aune D, Sen A, Henriksen T, et al. Physical activity and the risk of gestational diabetes mellitus: a systematic review and dose–response meta-analysis of epidemiological studies. *Eur J Epidemiol* 2016;31(10):967–97.
50. Wang Z, Wang Z, Wang L, et al. Hypertensive disorders during pregnancy and risk of type 2 diabetes in later life: a systematic review and meta-analysis. *Endocrine* 2017;55(3):809–21.
51. Verma AK, Williams D, Nelson DM, et al. A cardio-obstetric approach to management of the complex pregnant cardiac patient. *J Am Coll Cardiol Case Rep* 2020;2(1):86–90.
52. Grodzinsky A, Florio K, Spertus JA, et al. Importance of the cardio-obstetrics team. *Curr Treat Options Cardiovasc Med* 2019;21(12):84.
53. O'Kelly AC, Sharma G, Vaught AJ, Zakaria S. The use of echocardiography and advanced cardiac ultrasonography during pregnancy. *Curr Treat Options Cardiovasc Med* 2019;21(11):71.
54. Castleman S, Ganapathy YH, Taki P, et al. Echocardiographic structure and function in hypertensive disorders of pregnancy: a systematic review. *Circ Cardiovasc Imaging* 2016;9(9):e004888.
55. Elkayam U. Risk of subsequent pregnancy in women with a history of peripartum cardiomyopathy. *J Am Coll Cardiol* 2014;64(15):1629–36.
56. Elkayam U, Bitar F. Valvular heart disease and pregnancy: Part I: Native valves. *J Am Coll Cardiol* 2005;46(2):223–30.
57. Goldszmidt E, Macarthur A, Silversides C, et al. Anesthetic management of a consecutive cohort of women with heart disease for labor and delivery. *Int J Obstet Anesth* 2010;19(3):266–72.
58. Practice bulletin No. 170: critical care in pregnancy. *Obstet Gynecol* 2016;128(4):e147–54.
59. Arendt KW, Lindley KJ. Obstetric anesthesia management of the patient with cardiac disease. *Int J Obstet Anesth* 2019;37:73–85.
60. Uebing A, Steer PJ, Yentis SM, et al. Pregnancy and congenital heart disease. *BMJ* 2006;332(7538):401–6.
61. Liu S, Liston RM, Joseph KS, et al. Maternal mortality and severe morbidity associated with low-risk planned cesarean delivery versus planned vaginal delivery at term. *CMAJ* 2007;176(4):455–60.
62. Lau E, DeFaria Yeh D. Management of high risk cardiac conditions in pregnancy: anticoagulation, severe stenotic valvular disease and cardiomyopathy. *Trends Cardiovasc Med* 2019;29(3):155–61.
63. Li J-M, Nguyen C, Joglar JA, et al. Frequency and outcome of arrhythmias complicating admission during pregnancy: experience from a high-volume and ethnically-diverse obstetric service. *Clin Cardiol* 2008;31(11):538–41.
64. Vaidya VR, Arora S, Patel N, et al. Burden of arrhythmia in pregnancy. *Circulation* 2017;135(6):619–21.
65. Silversides CK, Harris L, Haberer K, et al. Recurrence rates of arrhythmias during pregnancy in

- women with previous tachyarrhythmia and impact on fetal and neonatal outcomes. *Am J Cardiol* 2006;97(8):1206–12.
66. Laksman Z, Harris L, Silversides CK. Cardiac arrhythmias during pregnancy: a clinical approach. *Fetal Matern Med Rev* 2011;22(2):123–43.
 67. Roston TM, van der Werf C, Cheung CC, et al. Caring for the pregnant woman with an inherited arrhythmia syndrome. *Heart Rhythm* 2020;17(2):341–8.
 68. Henry D, Gonzalez JM, Harris IS, et al. Maternal arrhythmia and perinatal outcomes. *J Perinatol* 2016;36(10):823–7.
 69. Pieper PG. The pregnant woman with heart disease: management of pregnancy and delivery. *Neth Heart J* 2012;20(1):33–7.
 70. Bauersachs J, König T, van der Meer P, et al. Pathophysiology, diagnosis and management of peripartum cardiomyopathy: a position statement from the Heart Failure Association of the European Society of Cardiology Study Group on peripartum cardiomyopathy. *Eur J Heart Fail* 2019;21(7):827–43.
 71. Mebazaa A, Yilmaz MB, Levy P, et al. Recommendations on pre-hospital & early hospital management of acute heart failure: a consensus paper from the Heart Failure Association of the European Society of Cardiology, the European Society of Emergency Medicine and the Society of Academic Emergency Medicine. *Eur J Heart Fail* 2015;17(6):544–58.
 72. Stergiopoulos K, Lima FV. Peripartum cardiomyopathy-diagnosis, management, and long term implications. *Trends Cardiovasc Med* 2019;29(3):164–73.
 73. Grewal J, Silversides CK, Colman JM. Pregnancy in women with heart disease: risk assessment and management of heart failure. *Heart Fail Clin* 2014;10(1):117–29.
 74. ICD-10: International Statistical Classification of diseases and related health problems. World Health Organization; 2011.
 75. Hayward RM, Foster E, Tseng ZH. Maternal and fetal outcomes of admission for delivery in women with congenital heart disease. *JAMA Cardiol* 2017;2(6):664–71.
 76. Karamlou T, Diggs BS, McCrindle BW, et al. A growing problem: maternal death and peripartum complications are higher in women with grown-up congenital heart disease. *Ann Thorac Surg* 2011;92(6):2193–9.
 77. Thompson JL, Kuklina EV, Bateman BT, et al. Medical and obstetric outcomes among pregnant women with congenital heart disease. *Obstet Gynecol* 2015;126(2):346–54.
 78. Connolly HM. Managing congenital heart disease in the obstetric patient. *Semin Perinatol* 2018;42(1):39–48.
 79. Committee opinion No. 654: reproductive life planning to reduce unintended pregnancy. *Obstet Gynecol* 2016;127(2):e66.
 80. WHO | WHO recommendations on health promotion interventions for maternal and newborn health 2015. WHO. Available at: http://www.who.int/maternal_child_adolescent/documents/health-promotion-interventions/en/. Accessed July 21, 2020.
 81. American College of Obstetricians and Gynecologists; Task Force on Hypertension in Pregnancy. Hypertension in pregnancy. Report of the American College of Obstetricians and Gynecologists' Task Force on Hypertension in Pregnancy. *Obstet Gynecol* 2013;122(5):1122–31.
 82. Mosca LM, Barrett-Connor E, Kass Wenger N. Sex/gender differences in cardiovascular disease prevention: what a difference a decade makes. [Miscellaneous Article]. *Circulation* 2011;124(19):2145–54.
 83. Rich-Edwards JW, Fraser A, Lawlor DA, et al. Pregnancy characteristics and women's future cardiovascular health: an underused opportunity to improve women's health? *Epidemiol Rev* 2014;36(1):57–70.
 84. Grundy SM, Stone NJ, Bailey AL, et al. 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APHA/ASPC/NLA/PCNA guideline on the management of blood cholesterol. *J Am Coll Cardiol* 2019;73(24):e285–350.
 85. Kassebaum NJ, Bertozzi-Villa A, Coggeshall MS, et al. Global, regional, and national levels and causes of maternal mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014;384(9947):980–1004.
 86. Kampman MAM, Balci A, Groen H, et al. Cardiac function and cardiac events 1-year postpartum in women with congenital heart disease. *Am Heart J* 2015;169(2):298–304.
 87. Balint OH, Siu SC, Mason J, et al. Cardiac outcomes after pregnancy in women with congenital heart disease. *Heart* 2010;96(20):1656–61.
 88. Wise PH. Transforming preconceptional, prenatal, and interconceptional care into A comprehensive commitment to women's health. *Womens Health Issues* 2008;18(6):S13–8.
 89. Gifford K, Walls J, Ranji U. Apr 27 IGP, 2017. Medicaid coverage of pregnancy and perinatal benefits: results from a state survey - introduction. The Henry J. Kaiser Family Foundation; 2017. Available at: <https://www.kff.org/report-section/medicaid-coverage-of-pregnancy-and-perinatal-benefits-introduction/>. Accessed May 5, 2020.
 90. Prenatal and postpartum care (PPC). NCQA. Available at: <https://www.ncqa.org/hedis/>

- measures/prenatal-and-postpartum-care-ppc/. Accessed May 5, 2020.
91. Grodzinsky A, Florio K, Spertus J, et al. Maternal mortality in the United States and the HOPE registry. *Curr Treat Options Cardiovasc Med* 2019;21(9):42.
 92. Moaddab A, Dildy GA, Brown HL, et al. Health care disparity and pregnancy-related mortality in the United States, 2005–2014. *Obstet Gynecol* 2018;131(4):707–12.
 93. Aziz A, Zork N, Aubey JJ, et al. Telehealth for high-risk pregnancies in the setting of the COVID-19 pandemic. *Am J Perinatol* 2020;37(8):800–8.
 94. Harrison BJ, Hilton TN, Riviere RN, et al. Advanced maternal age: ethical and medical considerations for assisted reproductive technology. *Int J Womens Health* 2017. <https://doi.org/10.2147/IJWH.S139578>.
 95. Zork NM, Aubey J, Yates H. Conversion and optimization of telehealth in obstetric care during the COVID-19 pandemic. *Semin Perinatol* 2020;151300. <https://doi.org/10.1016/j.semperi.2020.151300>.
 96. Smith GN, Pudwell J, Roddy M. The maternal health clinic: a new window of opportunity for early heart disease risk screening and intervention for women with pregnancy complications. *J Obstet Gynaecol Can* 2013;35(9):831–9.
 97. Smith GN, Louis JM, Saade GR. Pregnancy and the postpartum period as an opportunity for cardiovascular risk identification and management. *Obstet Gynecol* 2019;134(4):851–62.
 98. Park K, Wu P, Gulati M. Obstetrics and gynecological history: a missed opportunity for cardiovascular risk assessment. *J Am Coll Cardiol Case Rep* 2020;2(1):161–3.
 99. Sharma G, Zakaria S, Michos ED, et al. Improving cardiovascular workforce competencies in cardio-obstetrics: current challenges and future directions. *J Am Heart Assoc* 2020;9(12):e015569.
 100. Roberts JM, Catov JM. Pregnancy is a screening test for later life cardiovascular disease: now what? Research recommendations. *Womens Health Issues* 2012;22(2):e123–8.
 101. Davis MB, Walsh MN. Cardio-obstetrics. *Circ Cardiovasc Qual Outcomes* 2019;12(2):e005417.
 102. Halperin JL, Williams ES, Fuster V, et al. ACC 2015 core cardiovascular training statement (COCATS 4) (revision of COCATS 3). *J Am Coll Cardiol* 2015;65(17):1721–3.
 103. Reza N, Adusumalli S, Saybolt MD, et al. Implementing a women's cardiovascular health training program in a cardiovascular disease fellowship: the MUCHACHA curriculum. *JACC Case Rep* 2020;2(1):164–7.