Addressing maternal mortality: the pregnant cardiac patient

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THE PROBLEM: The high-risk birthing profile includes the cardiac pregnant patient at risk for maternal mortality because of (1) altered cardiac anatomy and/or physiology or (2) concurrent cardiovascular comorbidities. Intensive medical management and surveillance, coordination of multidisciplinary care, and referral to tertiary or quaternary levels of care can create health system challenges in caring for cardiac pregnant patients.

THE SOLUTION: We propose a triad of cardiovascular screening, patient education, and multidisciplinary team planning to address the top cause of maternal mortality in the United States.

Over the last 3 years, multiple reports have been published in the United States demonstrating the upward trends in maternal mortality.[1–3] This increase in maternal death rate is greatly driven by the cardiovascular disease–related deaths. Cardiovascular disease accounted for 15.5% of maternal deaths in the United States between years 2011 and 2013.

The United Nations Millennium Development Goal of a 75% reduction in maternal mortality has not been achieved. This may be explained by the increasing number of women with congenital heart disease (CHD) reaching reproductive age and a higher prevalence of chronic medical diseases that puts women at risk for cardiac complications because pregnancy is a physiological stress test.[1]

A number of experts in the field of obstetrics and gynecology recommend a call to action by the medical community to address the rise in maternal mortality.[4] To achieve this goal, it is imperative that models of care are created and sustained for a standardized approach to management of high-complexity pregnant patients. It mandates investment from institutions and stakeholders along with resources for outcomes research. We propose a triad solution for this problem that includes cardiovascular screening, patient education, and multidisciplinary team planning.

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Presentation

Cardiovascular screening

The Pregnancy Associated Mortality Review in the state of California identified contributing factors and quality improvement opportunity for cardiovascular disease in pregnancy.[5] The findings determined that early recognition of signs and symptoms of cardiovascular disease in pregnancy (ie, shortness of breath, fatigue, tachycardia, blood pressure change, low oxygen saturation, and improved management of hypertension) is imperative to eliminate preventable maternal deaths.

In response, the California Maternal Quality Care Collaborative in collaboration with the California Department of Public Health put forth a California Quality Improvement Toolkit. The toolkit was validated internally by application to the retrospective cohort of maternal deaths because of cardiac disease in the state of California, demonstrating that 88% of cases could have been identified prior to their death with the application of this screening tool. It would have identified these patients as high risk, requiring further evaluation and treatment.

The algorithm needs to be broadly validated and modified as a screening tool based on the maternal mortality reviews and at present is a potential guide for further investigation. It may be modified at the institutional level based on individual preferences. Currently the algorithm is undergoing validation at 2 institutions in the United States to determine its sensitivity, specificity, and predictive value. The algorithm is presented here (Figure 1) and is aimed for early identification of cardiac disease with a potential to prevent maternal death.

With respect to the algorithm, a chest X-ray, in a patient already having undergone an echocardiogram, may have limited diagnostic benefit; however, it is typically more readily available at all hours of the day or night and easily interpretable by many providers in a diversity of clinical settings.

A chest X-ray does have a place in the evaluation of primary pulmonary complaints, sometimes revealing the underlying etiology. Preferably the referral doctor should be from maternal-fetal medicine (MFM) and cardiology; however, in a large majority of birthing facilities, these services may not be available, and therefore, the primary care provider is included in the algorithm.

Additional study will further develop the proposed algorithm and may eventually be deployed as a valuable resource for the general obstetrician-gynecologist, primary care physician,

emergency department physician, and allied health professionals who are at the forefront of providing maternity care to women at all stages of pregnancy (ie, prenatal visits, postpartum encounters, and emergency room visits).

There is a national organizational effort to address a lack of resources and care after delivery. Dr Hayward Brown, President of the American College of Obstetrics and Gynecology, emphasized the Postpartum Task Force in his presidential address at the American College of Obstetrics and Gynecology annual meeting in Austin, TX, in 2018.

The new postpartum visit, the beginning of life-long health, intends to include at least 2 visits, embracing technology, video, telephone, and health promotion and increase the use of guidelines from our colleagues in medicine, cardiology, and family practice to recognize pregnancy risk factors. Included are cases of peripartum cardiomyopathy that often present during this period. A cardiovascular screening tool would easily fit into the postpartum visit, once validated for this purpose.

Patient education

Women with known cardiac disease, especially those with CHD, undoubtedly benefit from preconception counseling. Contraceptive care is essential for both preconception and interconception periods.[6,7] A detailed reproductive goals and plan is a must for women with chronic diseases including cardiac disease.

A study evaluating pre- and postreproductive life plan counseling to women of reproductive age with chronic diseases determined that both knowledge and attitudes toward their understanding of their own chronic disease has tremendous impact on a potential pregnancy.[8] The authors concluded that a reproductive life plan is a cost-effective tool when used in the primary setting and enables women with chronic conditions to make informed decisions about their reproductive future.

Patient education should include a review of the normal physiological changes and symptoms that occur in pregnancy, including its impact on the heart. Patients with cardiac disease need to be advised about warning signs that should prompt them to seek medical attention because benign symptoms of pregnancy may mimic worsening cardiac disease. Additionally, they need to be counseled that a cesarean delivery is not an absolute requirement for all patients with cardiac disease and that a normal spontaneous vaginal delivery and breast-feeding postpartum are optimal.

Multidisciplinary team planning

Institutions and departments must invest in collaborative models of care, which work across outpatient and inpatient domains

At Einstein/Montefiore of Bronx, NY, we created an MFM-cardiology outpatient joint program in February 2015 in response to the rising contribution of cardiovascular conditions to pregnancy-related morbidity and mortality.[1] The aim was to establish a multidisciplinary program to optimize the care of high-risk pregnant patients with known or suspected cardiac disease because there is a real potential for communication gaps when patients are seen separately in contrast with parallel visits by different specialists.

We accomplished this with co-departmental support that equipped the cardiology outpatient patient care rooms with obstetric-gynecology examination facilities, same-day echocardiogram, and simultaneous consultation with MFM and cardiology physicians present in the room. Select patients with known or suspected cardiac disease who are pregnant, planning a pregnancy, or who had a complicated postpartum course are referred for outpatient consultations by both obstetricians-gynecologists and primary care providers. We also receive referrals from other cardiologists seeking comanagement during the peripartum period.

While institutions in the United States embrace the same multidisciplinary approach, our program has unique features. Two subspecialists, one of MFM and the other of cardiology, interview and examine the patient together simultaneously. We then have a discussion to establish our final assessment and plan. Through this live clinical encounter, we have advanced understanding of the cardiac pregnant patient, mutual appreciation of each specialty's concerns and provide a platform for student, resident, and fellow education. Ultimately, patient care is expedited and their risk during delivery is individually assessed and stratified as low, moderate, or high based on their cardiac disease and comorbidities.

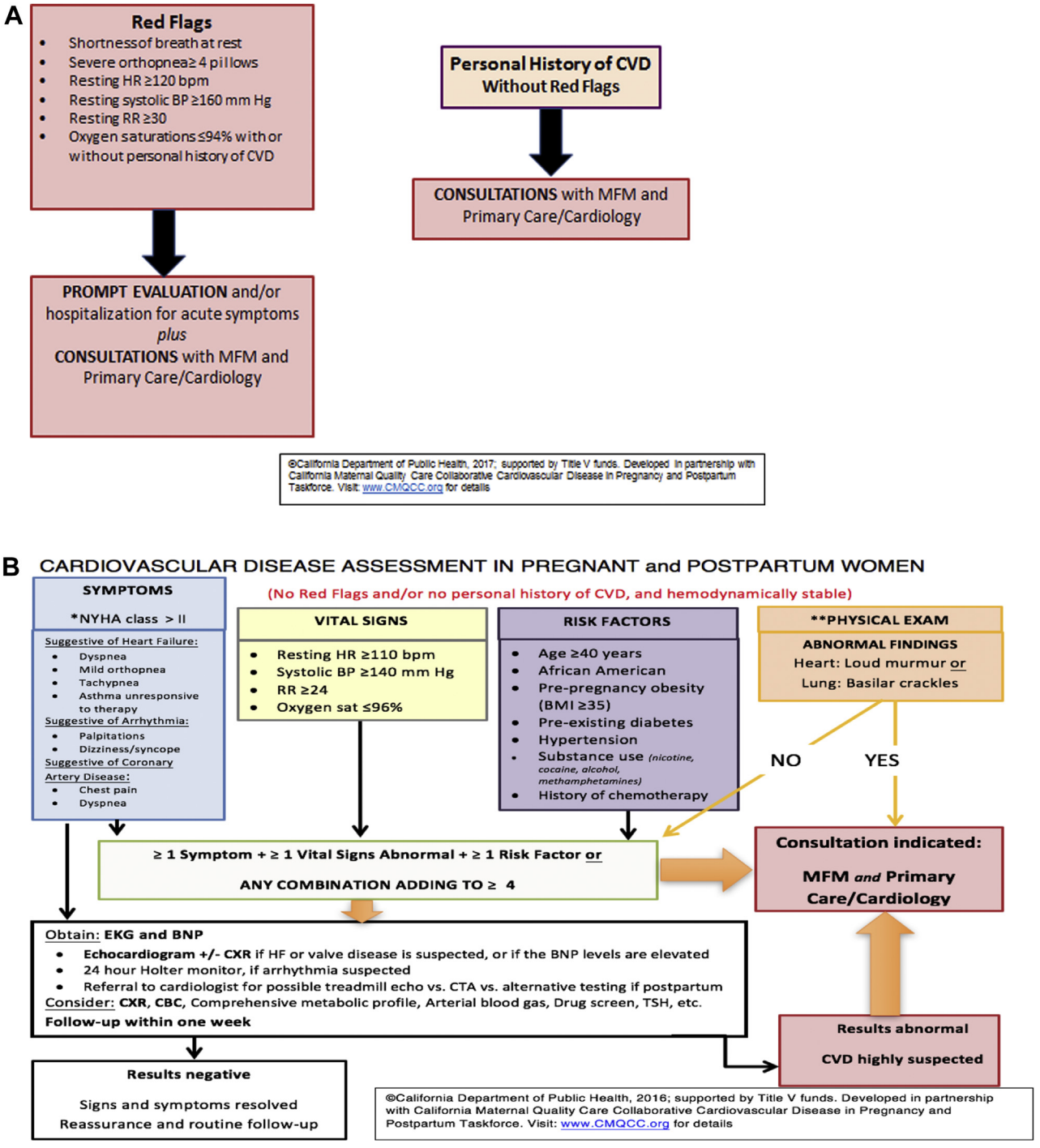
Notably, the majority of our high-risk patients are undiagnosed prior to pregnancy, and therefore, there is an urgent need for a timely multidisciplinary delivery planning. For some in our urban, minority population, the MFM-cardiology visit was the first foray into cardiology after a hiatus or ever, representing a pivotal opportunity to engage and retain women who need lifelong cardiac care.

We often identify the need for Social Work services and this is particularly well developed for women within the obstetrics and gynecology department. A summary of our new consults and their type of cardiac disease over the first 3 years is summarized in Table 1.

There is a wide scope of patients who come for consultation, some who require frequent visits, detailed multidisciplinary meetings in preparation for their delivery, and others who require only 1 consultation during their pregnancy. An example is a complex adult CHD pregnant woman vs a patient with chronic hypertension. The chronic hypertensive patient can be managed by an obstetrician-gynecologist while the adult CHD patient requires comanagement with adult congenital cardiology and anesthesia because of their complex physiology that is stressed during pregnancy.

A key element of our program is to improve the communication between outpatient and inpatient service lines of care through our monthly team meetings that occur in the cardiac intensive care unit of our hospital. The team consists of both inpatient physician and nursing stakeholders in MFM, cardiology, internal medicine, anesthesia, labor and delivery, and cardiac intensive care unit nurses.

FIGURE 1
Cardiovascular screening toolkit algorithm



Wolfe. The pregnant cardiac patient. Am J Obstet Gynecol 2019.

Additional members are included on an ad hoc basis, but Social Work is often consulted. This model is aligned with the August 2018 European Society of Cardiology (ESC) guidelines that describes a multidisciplinary pregnancy heart team.[9]

At team meetings, we review a checklist for each patient (Figure 2), which provides a standardized template for discussion to systematically review the patient's cardiac history, comorbidities, cardiac studies, fetal issues, and obstetric history, such as prior cesarean delivery. An individualized delivery plan

TABLE
The MFM-cardiology joint program, 2015–2017

Cardiac disease	Frequency, 2015 (n = 61)	Frequency, 2016 (n = 75)	Frequency, 2017 (n = 101)	Examples
Benign	42% (26)	4% (3)	30% (30)	Syncope, palpitations, murmur, shortness of breath
ACHD (congenital)	24% (15)	30% (23)	25% (25)	TOF, Marfan, VSD, Ebstein, subaortic, AV canal defect
Cardiomyopathy	6% (4)	9% (7)	10% (10)	Prior PPCM, new diagnosis
Arrhythmia	6% (4)	29% (22)	19% (19)	Brugada, WPW, prolonged QT, heart block
Non congenital valve	8% (5)	3% (2)	9% (9)	Rheumatic, septic infection
Vascular	11% (7)	24% (18)	8% (8)	CHTN, preeclampsia, PP eclampsia, prior PE, carotid disease

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CHTN, chronic hypertension; *PE*, pulmonary embolism; *PP*, postpartum; *PPCM*, peripartum cardiomyopathy; *TOF*, tetraology of Fallot; *VSD*, ventricular septal defect; *WPW*, Wolff Parkinson White Syndrome.

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is formulated with the target gestational age at delivery, mode of delivery, and consideration of special situations such as strategies for management of preeclampsia, postpartum hemorrhage, medications/fluids, arterial and/or central venous line placement, and telemetry.

While cardiac pregnant patients will often benefit from regional anesthesia and a normal spontaneous vaginal delivery, this approach is sometimes not an option. For example, a patient with multiple prior cesarean deliveries will have a repeat cesarean delivery and a patient with severe thrombocytopenia may require general anesthesia. The checklist is intended to include all obstetric and monitoring options to prompt discussion of nuances in patient care.

One aspect of discussion is hemodynamic assessment. Central venous pressure monitoring may be used in those patients with right heart dysfunction; however, there are other modalities for cardiac monitoring, and we are often able to avoid pulmonary artery catheters or central lines. The reason for this is 3-fold: (1) active labor can create large oscillations on the tracings, making them less interpretable; (2) placement can expose the patient to risk; and (3) volume resuscitation or aggressive diuresis can often be performed through large bore peripheral intravenous access. However, we include a discussion of invasive monitoring as an option to cover all aspects of care in the checklist, particularly in discussion of contingency plans.

Delivery plans are made available to all stakeholders in our system through the electronic medical record to allow coordination of delivery and postpartum course. We follow up all patients in the postpartum period in the outpatient MFM-cardiology program until they are transitioned back to their usual physician or retain them in long-term cardiology care once out of the highest risk window. We provide family planning counseling and referral if a contraceptive choice has not been made.

We strongly recommend that tertiary facilities with resources to care for the high-risk pregnancy develop multidisciplinary teams consisting of at least a MFM subspecialist a cardiologist and anesthesiologist, in agreement with the ESC guidelines, working in partnership to evaluate and mitigate the patient's risk of mortality and morbidity in pregnancy. Cardiologists are familiar with the heart team approach to expedite care for cardiothoracic surgical patients through joint office visits, and we modeled our program on this concept.

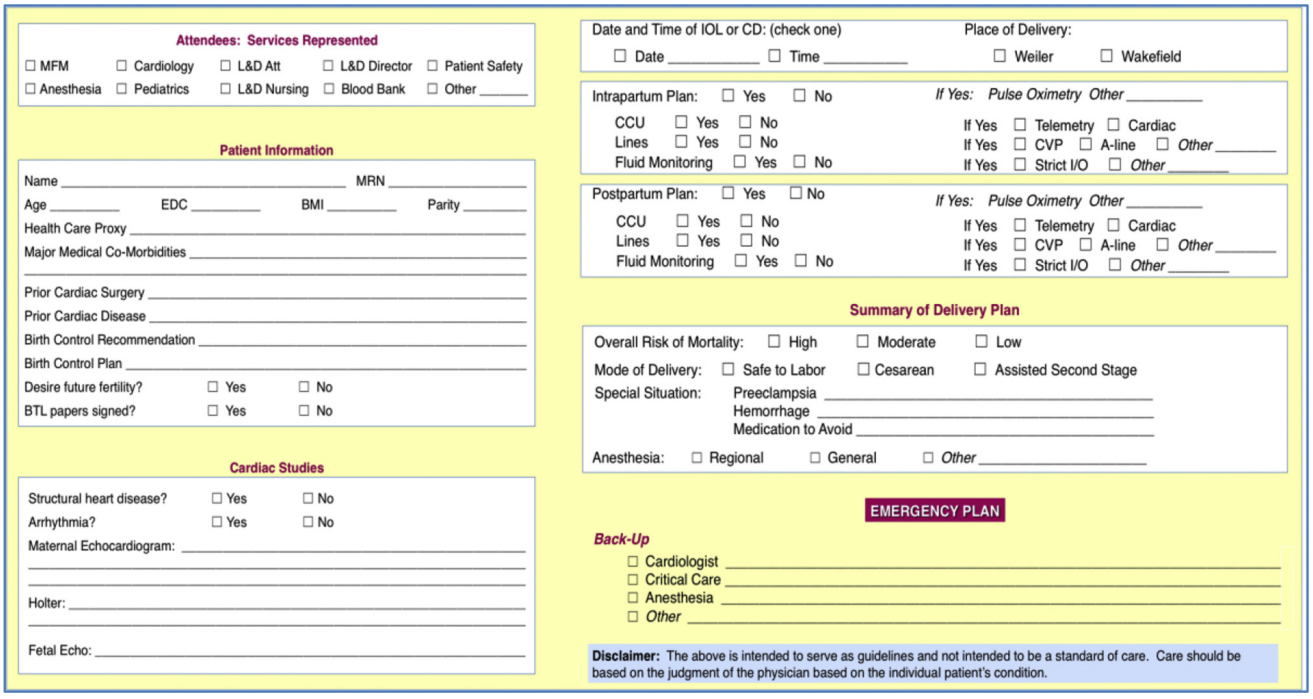
The heart team model has usually been reserved for the evaluation of high-risk patients by both cardiology and cardiothoracic surgery, often at the same visit, an approach supported by prior American College of Cardiology/American Heart Association and ESC guidelines[10] for surgical pregnant patients, in which the team consists of cardiology, MFM, obstetrics-gynecology, anesthesiology, cardiothoracic surgery, and other subspecialists, as needed. We use a similar heart team approach for even our nonsurgical high-risk pregnant women and advocate for its more widespread adoption.

Obstetricians should be astute to abnormal physical examination, laboratory, or imaging findings that might point to high-risk cardiac disease in their patients

Normal cardiovascular changes in pregnancy include an increased cardiac output, volume overload, and reduced systemic vascular resistance that commences in the second and peaks in the third trimester.[11] These changes are geared to provide optimal development of the fetus and protect the mother by virtue of additional blood volume.

The consequences of these significant changes are physical examination findings, laboratory changes, and image findings that often mimic cardiac

FIGURE 2
MFM-cardiology joint program: an interdisciplinary team planning form



Attendees: Services Represented

☐ MFM ☐ Cardiology ☐ L&D Att ☐ L&D Director ☐ Patient Safety
☐ Anesthesia ☐ Pediatrics ☐ L&D Nursing ☐ Blood Bank ☐ Other _____

Patient Information

Name _____ MRN _____
Age _____ EDC _____ BMI _____ Parity _____
Health Care Proxy _____
Major Medical Co-Morbidities _____
Prior Cardiac Surgery _____
Prior Cardiac Disease _____
Birth Control Recommendation _____
Birth Control Plan _____
Desire future fertility? ☐ Yes ☐ No
BTL papers signed? ☐ Yes ☐ No

Cardiac Studies

Structural heart disease? ☐ Yes ☐ No
Arrhythmia? ☐ Yes ☐ No
Maternal Echocardiogram: _____
Holter: _____
Fetal Echo: _____

Date and Time of IOL or CD: (check one) Place of Delivery:
☐ Date _____ ☐ Time _____ ☐ Weiler ☐ Wakefield

Intrapartum Plan: ☐ Yes ☐ No *If Yes: Pulse Oximetry Other* _____
CCU ☐ Yes ☐ No If Yes ☐ Telemetry ☐ Cardiac
Lines ☐ Yes ☐ No If Yes ☐ CVP ☐ A-line ☐ *Other* _____
Fluid Monitoring ☐ Yes ☐ No If Yes ☐ Strict I/O ☐ *Other* _____

Postpartum Plan: ☐ Yes ☐ No *If Yes: Pulse Oximetry Other* _____
CCU ☐ Yes ☐ No If Yes ☐ Telemetry ☐ Cardiac
Lines ☐ Yes ☐ No If Yes ☐ CVP ☐ A-line ☐ *Other* _____
Fluid Monitoring ☐ Yes ☐ No If Yes ☐ Strict I/O ☐ *Other* _____

Summary of Delivery Plan

Overall Risk of Mortality: ☐ High ☐ Moderate ☐ Low
Mode of Delivery: ☐ Safe to Labor ☐ Cesarean ☐ Assisted Second Stage
Special Situation: Preeclampsia _____
Hemorrhage _____
Medication to Avoid _____
Anesthesia: ☐ Regional ☐ General ☐ *Other* _____

EMERGENCY PLAN

Back-Up
☐ Cardiologist _____
☐ Critical Care _____
☐ Anesthesia _____
☐ *Other* _____

Disclaimer: The above is intended to serve as guidelines and not intended to be a standard of care. Care should be based on the judgment of the physician based on the individual patient's condition.

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pathology. It is common to hear a systolic ejection murmur or exaggerated splitting in a pregnant patient. However, we encourage the obstetricians-gynecologists to listen to their patients' heart every trimester and refer to cardiology for further evaluation of suspicious findings. Examples of suspicious findings include diastolic murmurs and systolic murmurs louder than 2/4.

There is evidence that normal pregnancy imposes structural and physiological changes seen on the echocardiogram.[12] This may account for a rise in serum brain natriuretic peptide, a natriuretic peptide secreted by cardiomyocytes in response to stretching caused by increased ventricular blood volume. Increased brain natriuretic peptide levels are often detected in heart failure; however, the interpretation in pregnancy is muddled by the fact that there is a physiological increase in left ventricular blood volume.[13–16]

The appearance of cardiomegaly on chest X-ray or an echocardiogram with an exaggerated transvalvular gradient can be due to the hemodynamic changes in pregnancy; however, further inquiry may be necessary to interpret the importance of these findings. We have discovered high-risk disease in our practice based on perceptive assessments of subtle changes in examination and studies found by our obstetrician-gynecologist colleagues. In the first 3 years of our program, while approximately one third of patients had benign findings, two thirds had high-risk cardiac disease (Table).

Symptoms may require a detailed evaluation to distinguish benign from pathological and further review with a cardiologist may be warranted. A careful history should include prior medical, cardiac, surgical and obstetric history, medication review, family history, country of origin to assess risk of rheumatic disease, cardiac examination, review of electrocardiogram and echocardiographic imaging, or arrhythmic event monitoring. A general cardiology evaluation may then lead to subspecialty referral to heart failure, interventional cardiology, electrophysiology, or adult congenital heart disease, for example.

Cardiac risk assessment for maternal mortality should begin before conception, particularly for adult congenital heart disease patients

Cardiologists must be aware of physiological changes in pregnancy and the highest-risk lesions, namely Marfan syndrome and other connective tissue disorders (ie, Loews Dietz, Ehlers-Danlos), with aortopathy and other high-risk aortopathies, pulmonary hypertension regardless of etiology, mechanical valves, peripartum cardiomyopathy with residual left ventricular dysfunction, and acute coronary syndromes during pregnancy.[10]

There are 4 predictive models, CARPREG I and II, ZAHARA, and World Health Organization (WHO), used to quantify patients' risk. CARPREG I includes these antepartum predictors, prior cardiac event or arrhythmia, prior

New York Heart Association poor functional classes III or IV, cyanosis, systemic ventricular systolic dysfunction <40%, and left heart obstruction, while CARPREG II, a new risk index, encompasses 10 predictors.[17,18]

ZAHARA is exclusive to adult congenital heart disease, modeling risk for 8 conditions.[19] The WHO guidelines were modified and included in the ESC guidelines in 2012.[20] The modified WHO model was validated when applied to a large international cohort of 2742 pregnant patients with cardiac disease from a total of 39 countries.[21]

The Registry of Pregnancy and Cardiac Disease, a registry from the ESC, is an ongoing worldwide registry collection of data on pregnant women with cardiac disease commenced in 2008 and has subsequently published their outcomes on several cardiac lesions including pulmonary hypertension, cardiomyopathy, and arrhythmias.[22–24]

We recommend using these risk estimates for guidance when appropriate, but ultimately risk assessment is based on interdisciplinary clinical judgment because some women with understudied phenotypes might not be captured by a 1-time score. Similarly, previously healthy women may present with new-onset peripartum cardiomyopathy after delivery, disease not predicted by the available scoring systems.

Cardiologists may be counseling high-risk women to avoid pregnancy, particularly when they are on teratogenic medications such as statins, angiotensin-converting enzyme inhibitors, and warfarin, but implementing a contraception plan is likely beyond the scope of their usual practice. This is where comanagement can be impactful. Family-planning services should be accessible to high-risk women because they will likely use more than 1 contraceptive method over the course of their reproductive life and require serial evaluation.

There may be misconceptions that physicians and patients have about contraceptive choices for high-risk women, and the obstetrics-gynecology community can help dispel myths leading to underutilization. The female cardiac patient has many contraceptive options including oral contraceptives, long-acting reversible contraceptives, emergency contraception, and permanent sterilization.

The Centers for Disease Control and Prevention publish a document that evaluates the safety for all contraceptive options per each chronic condition, including cardiac disease.[25] The Medical Eligibility Criteria is numerated 1–4, 1 corresponding to no restriction and 4 an unacceptable health risk. The female cardiac patient scores 1 or 2 for all contraceptive choices. Cardiologists may be unaware of this scoring tool.

We recommend all cardiac patients of reproductive age be referred to family planning before, during, and/or after pregnancy for detailed options counseling, which is educative and supportive of women's family planning. This is particularly relevant for adolescent CHD patients. This kind of approach might inspire a high-risk woman to contemplate pregnancy at a safer time when postoperative for a corrective cardiac procedure or surgery, for example.

Additionally, women may be interested in reproductive technologies such as surrogacy or preimplantation genetic diagnosis with subsequent embryo selection to avoid inheritance of congenital disease. Engaging subspecialists with family planning or reproductive endocrinology expertise early in the contemplative phase may alert the high-risk woman to alternatives that she might not have considered. Indeed, an encouraging area of growth in our program has been in the number of preconception consults for women diagnosed with high-risk cardiac disease, growing from 4.8% in the first to 11.3% in the third year, but clearly there is room for earlier referral because 24% of consultations in the first year were for pregnant women with CHD.

This group in particular should be routinely engaged in preconception counseling, an opportunity for providers caring for these patients through their transition from adolescence to adulthood. Additionally, as MFM subspecialists encounter potentially high-risk patients, they should consider referring to their cardiology colleagues for evaluation and management. Over time, these dialogues facilitate mutual understanding and promote cross-collaboration for advancement of patient care.

Conclusion

In conclusion, the alarming trend of rising cardiovascular-related maternal mortality should serve as an impetus for MFM, obstetricians-gynecologists, and cardiologists to join hands and take up the call to action in a coordinated effort. Cardiovascular screening, patient education, and multidisciplinary team planning is an essential triad to eliminate preventable maternal death. A joint MFM-cardiology program may be the solution. ■

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ABSTRACT

Addressing maternal mortality: the pregnant cardiac patient

Cardiac disease in pregnancy is the number one indirect cause of maternal mortality in the United States. We propose a triad solution that includes universal screening for cardiovascular disease in pregnancy and postpartum women, patient education, and institution of a multidisciplinary cardiac team. Additionally, we emphasize essential elements to maximize care for the pregnant cardiac patient based on our experience at our institution in Bronx, NY.

Key words: cardiac disease, high-risk pregnancy, maternal death