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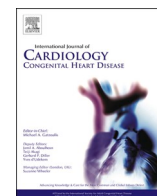
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Development of delivery plans for pregnant women with complex heart disease[☆]

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ABSTRACT

The population of pregnant patients with complex cardiac disorders is increasing. The overarching goal of guidelines and best practices revolve around optimal patient outcome and experience. This is achieved through collaborative practice models focused on the goal of the management of these high-risk patients. A coordinated multidisciplinary delivery plan is a centerfold of this iterative collaborative team approach to safe pregnancy care of the pregnant person and her neonate. Here, we provide an overview of how the delivery plan is developed and integrated into the clinical management of pregnant women with complex cardiac disease.

1. Introduction

Cardiovascular diseases are the leading cause of maternal mortality in the Western world [1], with congenital heart disease (CHD) being the more frequent cardiovascular disorder managed in pregnancy [1–3]. As a result, pregnancy management has become increasingly specialized. Today, the clinical management of pregnancy in pregnant women with complex heart disease requires input from a diverse number of health care practitioners in developing a personalized plan of care [4]. Over the past twenty years, a multidisciplinary approach to pregnancy management that brings together all the relevant disciplines to discuss optimal care has been recommended in pregnancy guidelines [5,6]. Similarly, the American College of Obstetricians and Gynecologists (ACOG), and the Alliance for innovation on Maternal Health (AIM) have collaborated to create “bundles of best practices” for clinicians and facilities who are consistently involved in the management of high-risk pregnancy women in order to improve safety in maternity care [7,8]. Among their recommendation is the implementation of obstetrical multidisciplinary staff meetings to assess and review the obstetrical patient’s risk factors according to established pregnancy guidelines and to institute collaborative practice models to deal with unplanned events and emergencies 24/7. In addition, workflow protocols such as delivery plans should be developed in order for staff to respond quickly to sudden changes in patient status and that these protocols and guidelines are followed throughout the hospitalization and postpartum follow-up period.

Today, many institutions have formally established multidisciplinary care models as a benchmark for accreditation and funding [9].

The following provides an overview of how delivery plans can bring together the collaborative effort of the cardio-obstetric team to deliver a safe plan of care to each patient.

For the patient with complex heart disease (HD), existing guidelines have long emphasized the importance of a collaborative cardio-obstetric team multidisciplinary approach to ensure maternal and fetal safety; one that includes not only risk assessment but an individualized management plan that includes a written delivery plan [5,10].

In recent years, this approach has gained favor as a direct result of the increased referral of high-risk patients to tertiary and quaternary centers that are supported by providers with knowledge and expertise in the management of these high-risk patient populations [5–10,14]. While initially described to manage only high-risk patients, increased experience has recognized the need for multidisciplinary approach for clinically stable patients with moderate to complex HD as well. As often experienced, the level of obstetrical and cardiac care for the patient, who was clinically stable prior to or at onset of pregnancy, may progressively or quickly change during the course of the pregnancy requiring urgent changes in the management plan.

With this in mind, the multidisciplinary team approach should be available for all patients with moderate heart disease regardless of the patient’s clinical presentation during the antepartum period, but the degree of multidisciplinary member involvement in regular care is

[☆] This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation”.

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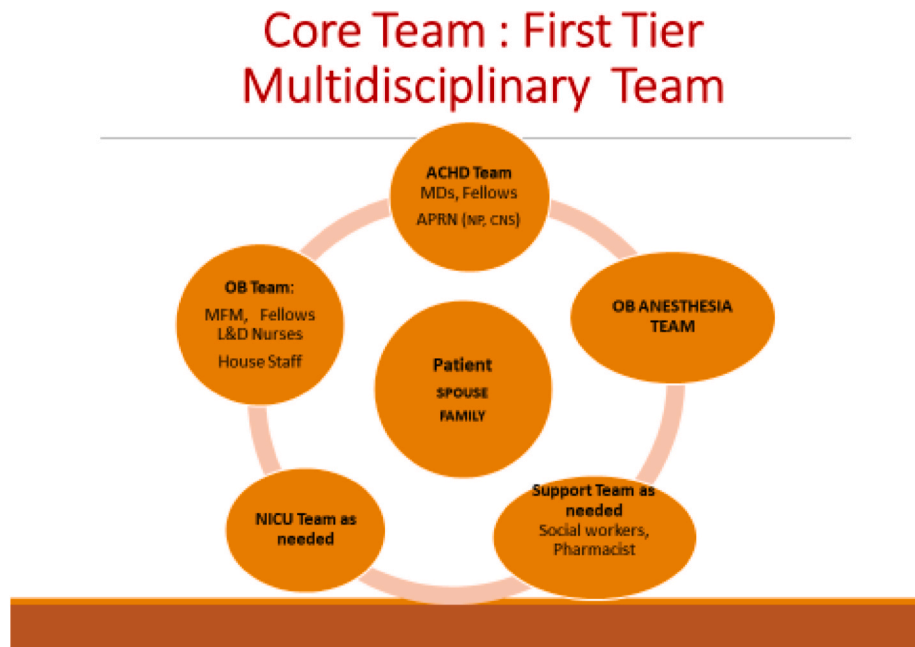
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iterative in nature, and reflects a two-tier approach. The first tier team which becomes the *Core Team* always includes the patient’s primary cardiologist(s), the obstetrician (generally a maternal fetal medicine (MFM) physician), and OB anesthesiologist[13], all with expertise in the management of high-risk pregnancies in women with heart disease

(Fig. 1a). Additionally, the labor and delivery teams should include nurse managers as well as a nurse or clinical specialist who assumes responsibility for coordinating and overseeing the development and distribution of the delivery plan to team members [12]. Additional expertise may be required depending on pregnancy course. These would

A CORE TEAM – FIRST TIER



B CORE TEAM – SECOND TIER

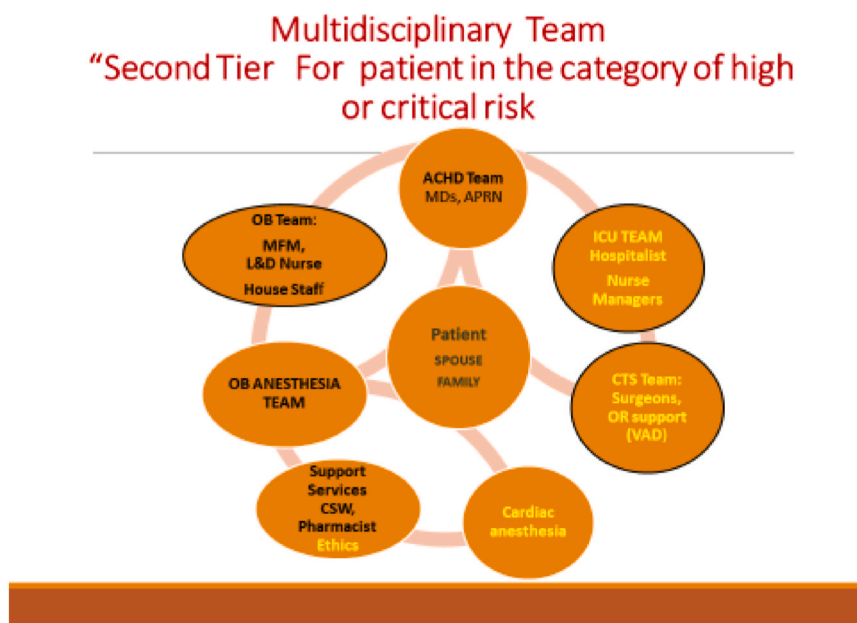


Fig. 1. Multidisciplinary teams.

Table 3
Modified WHO classification of maternal cardiovascular risk^a.

	Risk description	Maternal risk factors
WHO I	No detectable increase in maternal mortality and no/mild increase in morbidity risk Maternal cardiac event rate 5.7–10.5%	Uncomplicated small/mild pulmonary stenosis, PDA, mitral valve prolapse Successfully repaired simple lesions (ASD, VSD, PDA, anomalous pulmonary venous drainage) Atrial or ventricular ectopic beats, isolated
WHO II	Small increase in maternal mortality and moderate increase in morbidity risk Maternal cardiac event rate 2.5–5%	(If otherwise well and uncomplicated) Unoperated ASD, VSD Repaired TOF Most arrhythmias Mild LV impairment
WHO II-III	Moderate increase in maternal mortality morbidity risk Maternal cardiac event rate 10–19%	Hypertrophic cardiomyopathy Native or tissue valvular disease (not considered risk category I or IV) Marfan syndrome without aortic dilation Aortic dilation <45 mm in bicuspid aortic valve aortopathy Repaired coarctation
WHO III	Significantly increased maternal mortality or severe morbidity risk. Expert counseling required. In the event of pregnancy, intensive specialist cardiac and obstetric monitoring needed throughout pregnancy, childbirth and the puerperium Maternal cardiac event rate 9–27%	Mechanical valve Systemic RV Fontan circulation Cyanotic heart disease (unrepaired) Other complex CHD Aortic dilation 40–45 mm in Marfan syndrome Aortic dilation 45–50 mm in bicuspid aortic valve aortopathy Pulmonary arterial hypertension (of any cause)
WHO IV	Extremely high maternal mortality or severe morbidity risk. Pregnancy is contraindicated. In the event of pregnancy, termination should be discussed. If pregnancy continues, care should follow class III recommendations Maternal cardiac event rate 40–100%	Severe systemic ventricular dysfunction (LV ejection fraction <30%, NYHA class III-IV) Previous peripartum cardiomyopathy with any residual impairment of LV function Severe mitral stenosis, severe symptomatic aortic stenosis Aortic dilation >45 mm in Marfan syndrome Aortic dilation >50 mm in bicuspid aortic valve aortopathy Native severe coarctation

AS: aortic stenosis; ASD: atrial septal defect; LV: left ventricle; NYHA: New York Heart Association; PDA: patent ductus arteriosus; RV: right ventricle; TOF: tetralogy of Fallot; VSD, ventricular septal defects; WHO: World Health Organizations.

^a Modified from Thorne et al. Heart 2006; Jastrow N, Int J Cardiol 2010: From Canobbio et al. Circulation 2017. 2018 ESC guidelines for the management of cardiovascular diseases during pregnancy add.

with cardiac management such as arrhythmia identification and treatment, nor with managing complex patients going into heart failure or decompensating as result of pulmonary hypertension, therefore the delivery plan serves as a guide not only on how to proceed with delivery but also understand and look for potential complications associated with the disorder that require monitoring as well as who to call should symptoms develop.

A delivery plan, consists of three parts beginning with the patient's clinical history, which briefly lists cardiac history (i.e. underlying disorder or congenital heart defect), surgical history, or percutaneous therapies, any complications or residual effects that may or may not have required treatment such as baffle leak, oxygen desaturation or residual septal defect. Co-morbidities should also be listed.

The development of any pre-pregnancy clinical problems such as

arrhythmias, thromboembolic events, and how treated should also be included, as some like arrhythmias, are known to reappear under the stress of labor [19–21].

The patient's pregnancy history including number of pregnancies and outcomes should be listed including mode of delivery(ies), preterm deliveries, hypertensive diseases of pregnancies, etc. Cardiac complications related to pregnancy, such as arrhythmias, symptoms of ventricular dysfunction during antepartum period, during labor and delivery or the postpartum, should also be included.

Other items to list include medications, prescribed and over the counter, allergies, any non-medical issues such as proximity to hospital, birth preferences for delivery such as "unmedicated childbirth".

The Core Team assigned to the patient should be listed with their contact information as should any consultants such as electrophysiologist or pulmonologist assigned to the case.

3.1. Intrapartum management

Beginning with risk category score, the delivery plan also should outline the potential complications that may occur along with the associated signs and symptoms for staff to assess and report. A brief summary of antepartum events such as complaints of palpitations, shortness of breath as pregnancy progresses may be indicators of problems that may appear during labor, delivery or in post-delivery period. A summary of last echo highlighting key findings such as decreased ejection fraction, narrowed valve or outflow gradients may be a quick reference to compare with admission or post-partum echocardiogram. Similarly, a summary of electrocardiogram findings including history of non-sustained ventricular rhythms, episodes of SVT or atrial fibrillation during pregnancy should be noted. The presence of a pacemaker with rates and/or implantable cardiac defibrillators (ICD) should be noted in the event the patient will require caesarian section.

The body of the delivery plan which includes the anticipated plan of care for the patient, begins with the expected date of confinement (EDC) and projected date for delivery or induction of labor (IOL). Next, providing staff with the risk scoring and antepartum summary allows nursing and the obstetrical team time to determine if this patient will require a higher level of care such as ICU, or may be admitted directly to labor and delivery (L&D). Using a standardize checklist template (Table 4), details regarding planned mode of delivery, vaginal vs cesarean birth, whether labor should be controlled (e.g. shortened second stage), anesthesia considerations, specific diagnostic tests to be obtained upon admission such as BNP, echocardiogram or EKG can be easily filled out and edited as needed.

Details regarding monitoring need to be clearly delineated as to when to initiate, and should provide parameter guidelines. Planning and outlining what may be required for the patient will allow time for arranging the necessary staffing and/or disposition of the patient to an ICU where advanced hemodynamic monitoring such as arterial or pulmonary artery catheters maybe used. Unless the patient is listed as high-risk, monitoring is generally limited to cardiac and oxygen saturation. The planning and use of cardiac monitoring may also require unit and staffing adjustments, however, as the discipline of cardio-obstetrics has evolved, introduction of tele monitoring systems now permits patients to remain in the labor and delivery area. Finally, because of the potential risk for thromboembolic events, infective endocarditis, use of bubble filters, compression stockings during lengthy induction of labor and use of prophylaxis antibiotic should be included, as clinicay indicated.

3.2. Post-partum and discharge

Owing to the dramatic hemodynamic shift that occur immediately after delivery [20], postpartum surveillance is important, thus the DP must again clearly delineate where the patient may recover, what, if any monitoring procedures will be required and for how long, and what diagnostic testing, should be obtain. Recognizing the importance and

Table 4

Sample preliminary delivery plan checklist.

1) Patient risk category: **WHO 1** (The risk of maternal morbidity and mortality is not detectably higher than that in the general population) **WHO 2**; conditions carry a small increased risk of maternal mortality or morbidity.) 6.8% (*Heart 2014*) **WHO 3** conditions carry a significant increased risk of maternal morbidity or mortality)-(24.5% *Heart 2014*) **WHO 4** (Conditions carry an extremely high risk of maternal mortality or severe morbidity; pregnancy is contraindicated. If pregnancy occurs, termination should be discussed.) (*100% Heart 2014*)**2) Patient is at risk for**

- Atrial arrhythmias
- Ventricular arrhythmias
- Heart failure/volume overload
- Other:

3) Admission: Notify heart team of patient admission; please call ACHD between 7 am and 9 pm, unless patient is unstable No additional monitoring required beyond normal L&D monitoring Continuous telemetry upon admission. Continue telemetry until 24 hours postpartum or per Core Team's recommendations

If significant arrhythmias (non-sustained or sustained ventricular tachycardia, sustained tachycardia in the absence of triggers such as pain, anxiety), L&D/postpartum nurse to notify Ob physician. Please assess the patient : obtain VS and inquire about symptoms, obtain an EKG, check electrolytes (BMP, Mg) and replete for K>4.0, Mg >2.0.

 Continuous pulse oximetry during active labor and delivery Cardiac or ICU nurse recommended due to risk for maternal cardiac event Invasive hemodynamic monitoring:

- CVP line
- Arterial line

 Obtain an EKG on admission and place on the chart for ACHD team review. (No need to page ACHD for EKG review.) BNP, CMP, Magnesium, CBC on admission PT/INR on admission Additional labs on admission:**4) OB anesthesia**

- No contraindications to epidural placement if desired by the patient
- Epidural is recommended from cardiac perspective

5) Inpatient peripartum management

- Compression socks
- Sequential compression devices
- Bubble/particle filters
- Strict I/Os

6) Infective endocarditis prophylaxis

- None indicated
- Ampicillin 2g IV OR Cefazolin or ceftriaxone 1g IV, 30-60 minutes prior to anticipated delivery
- PCN allergy, use alternative: clindamycin 600 mg IV, 30-60 minutes prior to anticipated delivery

7) Delivery management

- Vaginal delivery
- No cardiac indication for Cesarean delivery, but this is acceptable if indicated for obstetric reasons.
- May push during second stage of labor
- Minimize pushing during second stage of labor
- Cesarean delivery planned for obstetric reasons
- Cesarean delivery recommended for cardiac reasons

8) Recovery/postpartum

- Routine postpartum recovery and nursing care
- Transfer to CCU for monitoring postpartum
- Echocardiogram postpartum, prior to discharge. Please order "Congenital transthoracic echo" and specify in comments "ACHD attending to read"
- BNP postpartum

9) Discharge planning. ACHD team will provide recommendations for f/u

- testing and visit prior to discharge
- Contraception management

the desire to breastfeed should be considered as the reinstatement of cardiac medications that may be contraindicated for lactation, and may require adjustment.

A plan for contraceptive management following delivery should also be documented in the DP in the event a post placental long-acting reversible contraceptive or implant will be placed before discharge. Pregnancy planning is imperative to optimal maternal and neonatal outcomes in this high-risk population.

To ensure compliance with follow-up care, discharge planning should be included with arranged dates for obstetrical and cardiac follow-up and a contraceptive plan that would have been discussed prior to admission.

4. When to initiate delivery plan

The timing of when to initiate the delivery plan is determined by the complexity of the cardiac disorder, and risk score assigned to the patient as well as the proposed date delivery date.

While ACOG recommends IOL for women with cardiac disease between 39 and 40 weeks of gestation [22,23], this recommendation is extrapolated from non-cardiac pregnancies. The potential risk of premature labor known to occur in certain subsets of patients with such as in pregnancies with Fontan physiology, best practice urges us to have an initial draft of the delivery plan distributed to the Core teams between 32 and 34 weeks' gestation. The document is dynamic and updates can

then be made up to the time of admission, but this guarantees us that should patient present with preterm labor, or becomes decompensated a delivery plan is readily available for the unit staff. Additionally, it provides an opportunity for team members time to review the plan, raise questions, seek clarification of potential problems.

For the patient at high-risk (WHO IV), an initial draft should be initiated once fetal viability has been determined. In these cases, all members of the multidisciplinary teams should meet and the delivery plan should be initiated then and updated regularly until admission.

4.1. Location of delivery plan

As the technology advances, forms such as delivery plans may be integrated into the electronic medical record (EMR) in a format that makes it a live document that can be edited and update online. For institutions without this technology, a paper document can be distributed to Core Teams with a copy accessible to labor and delivery staff at all times.

For patients who lives geographically distant from the tertiary center, the DP can also provide guidance and communication with local cardio-obstetrical teams should the patient present in labor and unable to be transferred.

5. Clinical application of delivery plans

Despite the continuous recommendations to develop delivery plans, the format and experience of clinical application has not been described. Our own experience for implementing the delivery plan began with the establishment of our first high risk obstetrical program for congenital heart disease in 2004. Initially designed only for high risk patient (WHO III, IV), over the years, as our pregnancy population grew, the realization that a patient who began pregnancy at a WHO level II, could and would display symptoms that would need careful surveillance and additional management during labor, delivery and in the post-partum period. Since our program has now broadened to a full cardio-obstetric service, it is now standard practice that a preliminary delivery plan checklist is included in the cardiology consult note for each new patient who presents for initial pregnancy evaluation and care (Table 4). Then over the course of the pregnancy it will be updated as needed. Beginning around week 32, as admission for delivery approaches, a more thorough plan, as previously outlined, is developed and distributed for reviewed by the Core Team members. At this point, a copy is placed on the labor and delivery unit, in the event that the patient would present to labor and delivery prematurely, and is updated as needed until the patient arrives for admission. All Core Team members get a final copy at the time of admission. A representative sample of a written DP for a CHD patient post Fontan is found as supplemental table. Currently, we are developing an on-line method to electronically upload the patient's individualized plan onto our EPIC system using drop down menu for ease of application and distribution.

6. Summary

In the last two decades, it has become clear that the population of pregnancy patients with cardiac disorders will continue to increase despite the complexity of the patient's diagnosis. As a result, the need, not only for experienced cardio-obstetric teams, but also for clear and continuous communication about the care of the patient among the Core team members is essential for the safe delivery of the mother and her infant. Delivery plans provides that communication, and as technology expands the ease of developing and sharing the plan of care for delivery will continue to expand.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijchd.2022.100375>.

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