Cardiac Disease in Pregnancy

Learning in Action – Missouri PQC

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I have nothing to disclose and no conflicts of interest

Cardiac Disease in Pregnancy

- OUTLINE
  - Case presentation
  - Discussion of patient disease states
  - Current guidelines
    - Maternal monitoring
    - Fetal monitoring
  - Questions

Patient CM

- Pt is a 21 y/o G2P1001 @ 11 weeks who was brought to CV ICU s/p arrest x 2
  - OB: 1 FT vaginal delivery, now 11 weeks
  - GYN: none
  - PMH: none
  - PSH: knee arthroscopy
  - Meds: none
  - SOC: denies x 3

Patient CM

- Was at work and told co-worker she felt "funny" – had chest pain and felt lightheaded
- Her co-worker coincidentally worked as a nurse in cardiac unit and told her to call her doctor
- However, pt became unresponsive and several co-workers found her down in the break room. No CPR was performed
- Emergency services contacted and arrived within 5 min
- CPR performed with doses of epinephrine and 4 shocks administered – pt found to be in V-fib

Patient CM

- On arrival to ED: BP 118/78, HR 106, Temp 95 (placed on cooling protocol), RR 20, glc 135, SpO2 18%, CT with diffuse bilateral infiltrates, urine drug screen neg
- Immediately intubated in ED and sedated
- Appeared to be posturing so thought that possible seizure etiology, Ativan administered
- Due to episode of cardiac arrest from unknown etiology, decision was made to transfer to tertiary care center

Patient CM

Upon arrival at tertiary center, sustained hypoxic PEA

Regained pulse rapidly after 1 mg of epinephrine and chest compressions

Transferred to CV ICU

US: 11 week fetus with absent fetal heart tones

Diagnosis: recurrent V-tach with unknown etiology in 21 y/o with no history of CV disease, 11 weeks pregnant now with fetal demise

Plan:

- due to inability to oxygenate, decision made to place on VV ECMO
- Broad spectrum abx started
- Resp panel and cultures
- MFM consult for fetal demise
- Continue cooling
- Amiodarone drip
- Start Ionotropic support

Patient CM

- DDX:
  - Amniotic fluid embolism
  - Pulmonary embolism
  - Malignant arrhythmia
  - Myocardial infarction
  - Sepsis
  - Acute giant cell myocarditis

Patient CM

Bedside ECHO: abnormal wall motion with mild global hypokinesis, EF 30%, normal wall thickness, normal aorta, normal right size and function, no clot in PA trunk (done by CV intensivist)

Procedure: ECMO cannula placed, pt did sustain VT/VF arrest and required defibrillation

Repeat ECHO: LV worsening at 10%

Patient CM

- MFM consulted for emergent D&C
- Due to her unstable situation, felt D&C was not appropriate.
- Pt did pass tissue overnight and morning US revealed retained products
- Cytotec PV 400 mg x 3 placed
- 4 days later, US still revealed retained products so bedside D&C in CV ICU performed

Patient CM

- Over the next couple of days, continued ECMO support with vasopressors and ionotropes. Started on steroids for presumed myocarditis
- Repeat TEE on HD #4 with LV recovery to 45-50% with normal RV function
- On HD #7 ECMO discontinued and extubated on HD#8
- Cardiac MR performed on HD#11, EF 68% without any other notable structural abnormalities
- HD#14 underwent placement of ICD
- Suspected long QT syndrome
- Discharged home on amiodarone and nadolol, to follow up in heart failure clinic

Patient CM

Seen in MFM/Cardio-obstetrics clinic 6 months later and counseled about future pregnancies

- Mirena IUD placed

1 year later admitted for EP workup and underwent accessory pathway ablation. Diagnosed with WPW.

Came back to MFM 1.5 years after initial event desiring pregnancy; discussed need to follow up with cardiology for device interrogation and then will discuss removal of IUD

Showed up 6 months later pregnant at 8 weeks for establishment of care

Patient CM

- Plan:
  - Follow with Q trimester ECHO (enrolled in study for validation of non-invasive machine)
  - Visits Q2 weeks, Q trimester visit in HDPP clinic
  - Genetic counseling
  - TBD: timing, mode and location of delivery

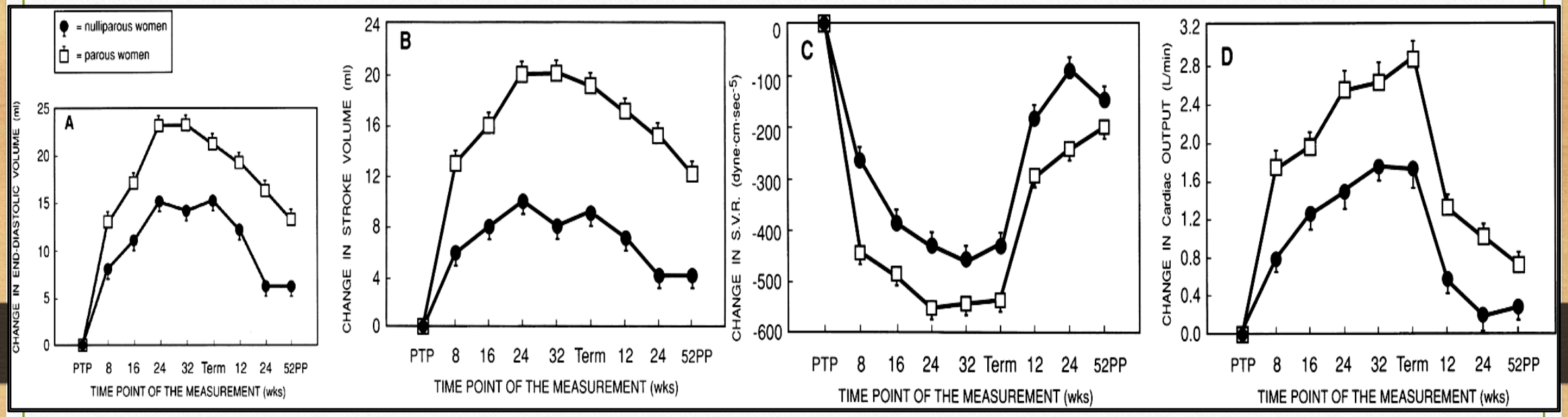
Patient
CM

At second trimester echo, got call from ECHO lab that patient has undiagnosed Ebstein's anomaly, normal LV function at 65%. No right ventricular dysfunction.

To make a long story short, she went on to deliver at 38w3d scheduled IOL on L&D with telemetry – delivered SVD and discharged home on PPD #3

Heart Disease in Pregnancy: Focus on Congenital Anomalies

Quick Physiology Review



Clapp AF III, Capeleas E: Am J Cardiol 80:1469–1473, 1997

- Cardiac output increases by 30-40% throughout gestation, and again by another 40% in labor
- This is all to increase uterine blood flow and therefore oxygenation to the fetus (at term, ~ 17% of total cardiac output)
- Blood volume and by default, venous distensibility also increases throughout gestation
- Maternal heart rate increases and decrease in SVR and PVR (nadir in the mid-second trimester)
- Decrease in colloid oncotic pressure of 20%

Anatomic alterations

- Ventricular wall muscle mass (1st trimester) and end-diastolic volume (2nd and 3rd trimester) increases
  - This increases cardiac compliance from softening of collagen without a reduction in EF
- Myocardial contractility increases
- Remodeling of the intimal lining
- Internal dimensions of all cardiac chambers are increased
- Slight regurgitation through the four valves is frequently observed
- Increase in cross-sectional area of the left ventricular outflow tract measured at aortic annulus

Review of Maternal Physiology

	Non-pregnant	Pregnant	Change
CO (L/min)	4.3 ± 0.9	**6.2 ± 1.0**	+ 43%
HR (bpm)	71 ± 10	**83 ±10**	+ 17%
SVR (dyne-sec cm^{-5})	1530 ± 520	**1210 ± 266**	- 21%
PVR (dyne-sec cm^{-5})	119 ± 47	**78 ± 22**	- 34%
CVP (mmHg)	3.7 ±2.6	**3.6 ± 2.5**	NS
COP (mmHg)	20.8 ± 1.0	**18 ± 1.5**	- 14%
PCWP (mmHg)	6.3 ± 2.1	**7.5 ± 1.8**	NS
COP-PCWP (mmHg)	14.5 ± 2.5	**10.5 ± 2.7**	- 28%

Review of Maternal Physiology

- **<u>Intrapartum dynamics</u>**
  - ***1st stage*** = 12-32% rise in cardiac output
    - Due to 22% increase in stroke volume
  - ***2nd stage*** = 50% rise in cardiac output
  - Laboring with epidural decreases this rise
  - Contractions result in a 300-500 mL increase in blood to circulation
  - Blood pressure increases by 35/25 mmHg

Review of Maternal Physiology

- **Postpartum dynamics**
- Immediate puerperium is associated with:
  - ***80%*** increase in cardiac output within 10-15 min after vaginal delivery
    - Caused by release of venacaval obstruction by the gravid uterus, autotransfusion of uteroplacental blood and rapid mobilization of extravascular fluid
  - 60% increase in stroke volume
  - Reflex bradycardia (15%)
- All of this results in increased venous return to the heart
- CO returns to pre-labor values 1 hr post delivery
- Changes can persist for up to 6 months postpartum

Table 2. How to Differentiate Common Signs and Symptoms of Normal Pregnancy Versus Those That Are Abnormal and Indicative of Underlying Cardiac Disease

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

Table 1. Cardiovascular Changes in a Normal Pregnancy*

	First Trimester	Second Trimester	Third Trimester	Stage 1 Labor	Stage 2 Labor	Early Postpartum	3–6 months Postpartum
Cardiac output	↑5–10%	↑↑35–45%		↑30%	↑↑50%	↑↑↑60–80% immediately, then rapidly decreases within the first hour	Return to prepregnancy values
Heart rate	↑3–5%	↑10–15%	↑15–20%	During uterine contractions: ↑40–50%		↓5–10% within 24 hours; continues to decrease throughout the first 6 weeks	Return to prepregnancy values
Blood pressure	↓10%	↓5%	↑5%	During uterine contractions: ↑SBP 15–25% ↑DBP 10–15%		↓SBP 5–10% within 48 hours; may increase again between days 3–6 due to fluid shifts	Return to prepregnancy values
Plasma volume	↑	↑↑40–50%		↑	↑↑	↑↑↑500 mL due to autotransfusion	Return to prepregnancy values

Congenital Heart Disease

Background

- More women with both corrected and uncorrected congenital defects surviving into adulthood (ACHD)
  - Adults now represent 2/3 of people with congenital disease
  - Affects 6.1 per 1000 adults, 60% are women
- Need for management strategies for these women during gestation

Outcomes

CARPREG: 20% neonatal

ROPAC: 0.6% neonatal mortality and 1.7% fetal mortality

ZAHARA: miscarriage (19.4%), preterm birth (12%) , SGA (14%) , and neonatal mortality (4%)

CAPREG: 16% cardiac complications

ROPAC: maternal mortality of 1% (gen pop 0.007%)

ZAHARA: no increase obstetric adverse outcomes but increase in cardiac adverse outcomes

Risk Stratification and Outcomes: CARPREG I

Table 1: Cardiac disease in pregnancy (CARPREG) risk score (from Siu et al, 2001).

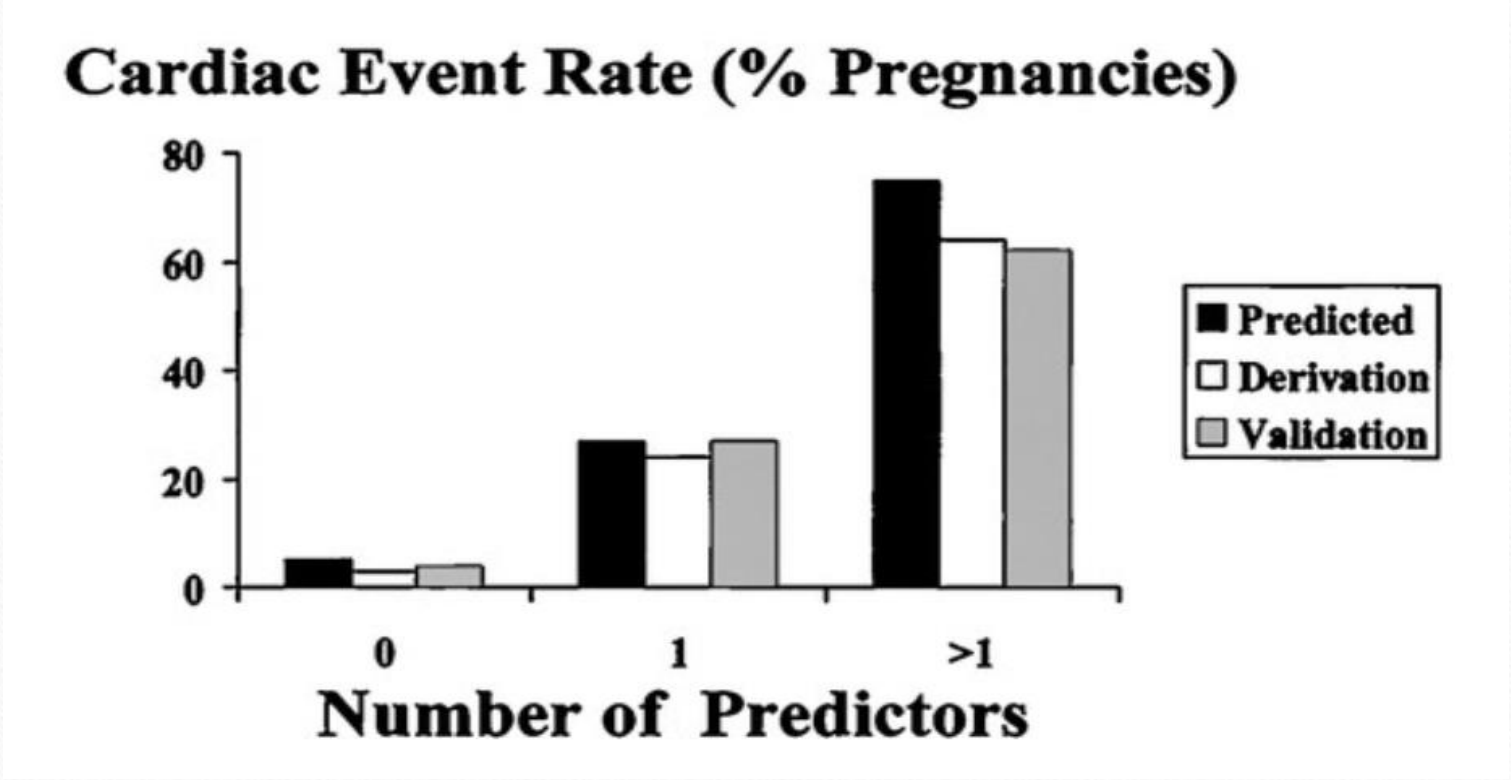
One point for each
History of prior cardiac event or arrhythmias
New York Heart Association functional class >II or cyanosis
Left heart obstruction (mitral valve area <2 cm^2, aortic valve area <1.5 cm^2, or left ventricular outflow tract gradient >30 mmHg)
Left ventricular ejection fraction <0.40

Risk Stratification and Outcomes: CARPREG I

No. of Predictors	Estimated Risk, %	Rate of Primary Cardiac Events			Rate of Primary or Secondary Cardiac Events, Revised Index	
		Derivation Group, Revised Index	Validation Group		Derivation Group	Validation Group
			Revised Index	Original Index		
0	5	7/249 (3%)	5/137 (4%)	5/136 (4%)	10/249 (4%)	6/137 (4%)
1	27	27/111 (24%)	17/64 (27%)	16/61 (26%)	35/111 (31%)	20/64 (31%)
>1	75	16/25 (64%)	8/13 (62%)	9/17 (53%)	17/25 (68%)	9/13 (69%)
C statistic (95% CI)		0.83 (0.77–0.89)	0.80 (0.72–0.88)	0.79 (0.71–0.87)	0.82 (0.76–0.88)	0.81 (0.74–0.88)

CI indicates confidence interval.

Risk Stratification and Outcomes: CARPREG I



Risk Stratification and Outcomes: CARPREG I

Principal Cardiac Lesions, Prenatal Characteristics, and Complications in Completed Pregnancies

	Pregnancies, n			Pregnancies With Events, n		
	Total	Cardiac History	Obstruction/Low EF	Primary Cardiac*	NYD/Procedures	Neonatal
Congenital acyanotic						
Shunts						
Unrepaired	76	SVT, 5; VT, 1; CVA, 1	2/3	5 (CHF, 3; SVT, 2; VT, 1)	2/0	7
Repaired	66	SVT, 2	1/1	CHF, 1; SVT, 1	…	10
Coarctation						
Unrepaired	8	…	1/0	…	…	2
Repaired	43	CHF, 3	10/0	CHF, 2	2/0	5
AS/BAV						
Unrepaired	57	CHF, 1; CVA, 1; brady, 1	31/0	CHF, 4; SVT, 1	4/2	15
Repaired	16	…	6/0	VT, 1	0/1	2
Pulmonary stenosis						
Unrepaired	35	…	…	…	…	3
Repaired	23	CVA, 1; brady, 1	…	…	1/0	7
Marfan syndrome	10	…	…	…	…	5
Tetralogy/DORV (repaired)	53	SVT, 3; VT, 3	…	…	2/0	11
D-transposition (Repaired)	25	CVA and SVT, 1; SVT, 3; brady, 2	0/12	6 (CHF, 3; SVT, 4; CVA, 1; death, 1)	1/0	3
L-transposition (Unrepaired)	6	SVT, 3; brady, 2	1/5	CHF, 2; SVT, 1; brady, 1	0/2	0
Ebstein anomaly						
Unrepaired	9	SVT, 3	…	2 (CHF, 1; SVT, 2)	…	2
Repaired	3	SVT, 2	…	SVT, 1	…	2
Univentricular connection (repaired)	5	CHF, 1	0/2	SVT, 2	2/0	4
Other†						
Unrepaired	3	…	…	CHF, 1	1/0	0
Repaired	3	…	…	…	…	1
Congenital cyanotic	4	…	…	…	…	2
Acquired valvular						
Unrepaired	64	CHF, 5; CVA, 2; SVT, 1; VT, 1; brady, 1	36/0	14 (CHF, 12; SVT, 3; VT, 1; CVA, 1)	7/4	15
Repaired	17	CHF and SVT, 1; CHF, 1; SVT, 3	10/0	6 (CHF, 4; SVT, 2; CVA, 1)	3/1	7
Cardiomyopathy						
Dilated	23	CHF, 4; CVA, 1; SVT, 3; VT, 1	0/13	12 (CHF, 7; SVT, 4; CVA, 1; death, 1)	1/0	7
Hypertrophic	9	…	4/0	VT, 1	0/1	3
Ischemic	11	…	0/2	CHF, 2	0/1	3
Pulmonary hypertension‡	3	…	…	Death, 1	…	1
Arrhythmias						
SVT	14	SVT, 14	…	SVT, 10	…	2
VT	7	VT, 7	…	VT, 2	…	2
Sick sinus syndrome	6	brady, 6	…	Brady, 1	0/1	1

Values are No. of pregnancies. AS/BAV indicates congenital aortic stenosis or bicuspid aortic valve; brady, bradycardia; CHF, pulmonary edema; CVA, stroke or transient ischemic attack; DORV, double-outlet right ventricle; Low EF, systemic ventricular ejection fraction <0.40; Obstruction, left heart obstruction; NYD, deterioration in functional class; procedure, urgent invasive cardiac procedure; SVT, supraventricular tachycardia or atrial flutter/fibrillation; and VT, ventricular tachycardia.

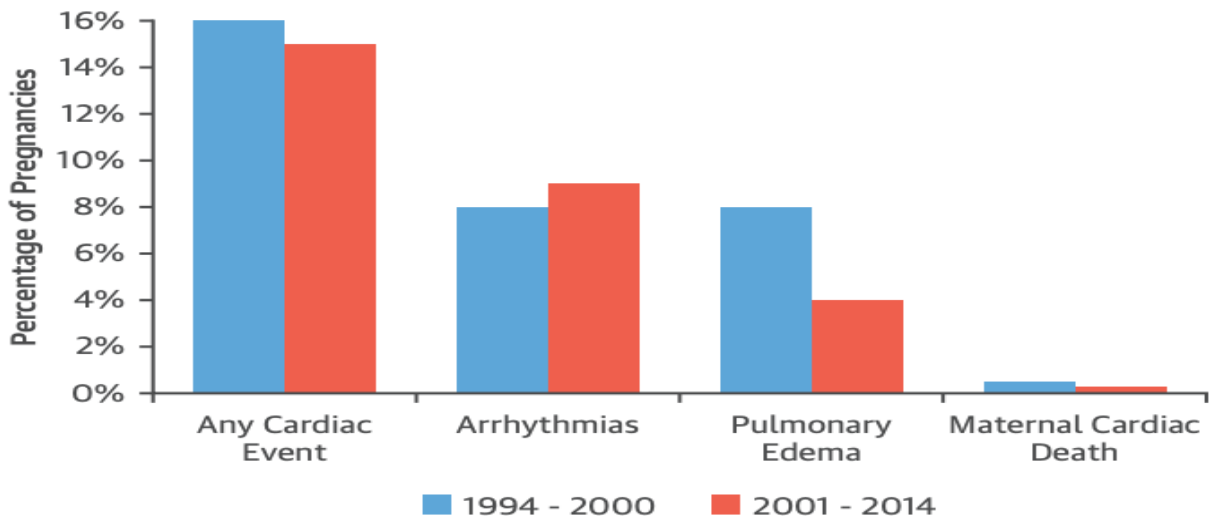
*Not mutually exclusive.

†Endocardial fibroelastosis (n=1), dextrocardia with situs inversus (n=2), repaired anomalous origin of left coronary artery from pulmonary artery (n=2), repaired truncus arteriosus (n=1).

‡From primary cause (including 1 patient after heart-lung transplant) or from systemic lupus.

Risk Stratification and Outcomes: CARPREG II

FIGURE 3 **Changes in the Incidence of Adverse Cardiac Events Over Time**



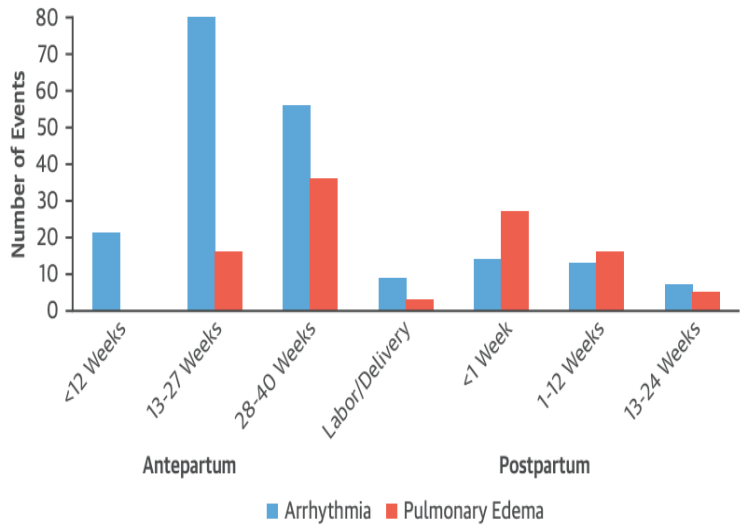
Blue bars represent the incidence of cardiac complications during pregnancy in the years 1994 to 2000, and the **orange bars** represent the incidence in the years 2001 to 2014.

Risk Stratification and Outcomes: CARPREG II

- 73% of all pregnancies with cardiac disease had at least one cardiac event (223/307)

  Most common lesions:
  - arrhythmias (9.3%)
  - heart failure (6.2%)

FIGURE 1 Timing of Complications in Women Who Develop Arrhythmias or Congestive HF During Pregnancy



The x-axis shows the timing of presentation in women who develop arrhythmias **(blue bars)** or pulmonary edema **(orange bars).** The y-axis shows the total number of adverse events. HF = heart failure.

Risk Stratification and Outcomes: CARPREG II

- 73% of all pregnancies with cardiac disease had at least one cardiac event (223/307)

  Most common lesions:
  - arrhythmias (9.3%)
  - heart failure (6.2%)

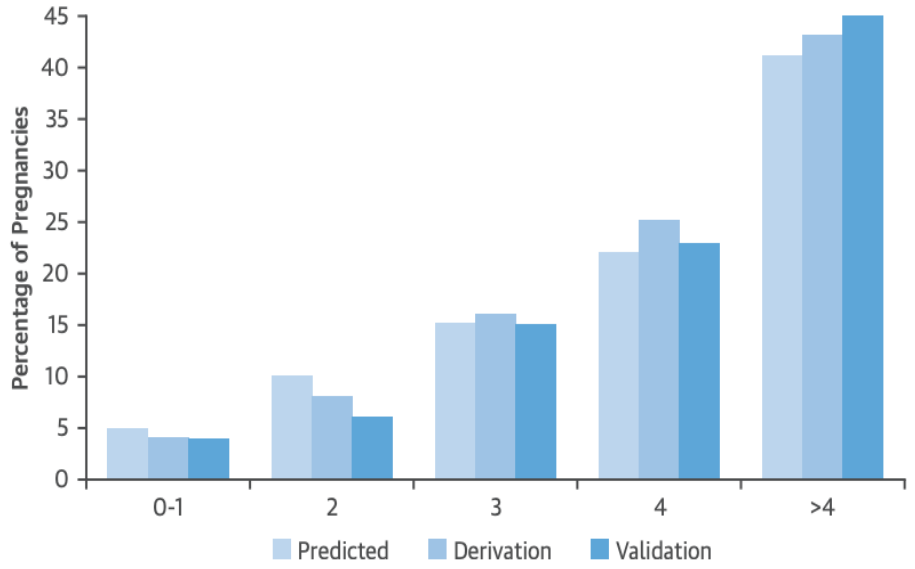
TABLE 2 Incidence of Adverse Cardiac Event Rates During Pregnancy (N = 1,938)

Any maternal cardiac events	307 (15.8)
Maternal cardiac death	6 (0.3)
Maternal cardiac arrest	8 (0.4)
Arrhythmias	181 (9.3)
Any left- or right-sided HF	120 (6.2)
Left-sided HF	106 (5.5)
Right-sided HF	19 (1.0)
Stroke	13 (0.7)
Myocardial infarction	8 (0.4)
Dissection	7 (0.4)
Cardiac thromboembolism	6 (0.3)

Values are n (%). Events are not mutually exclusive.
HF = heart failure.

Risk Stratification and Outcomes: CARPREG II

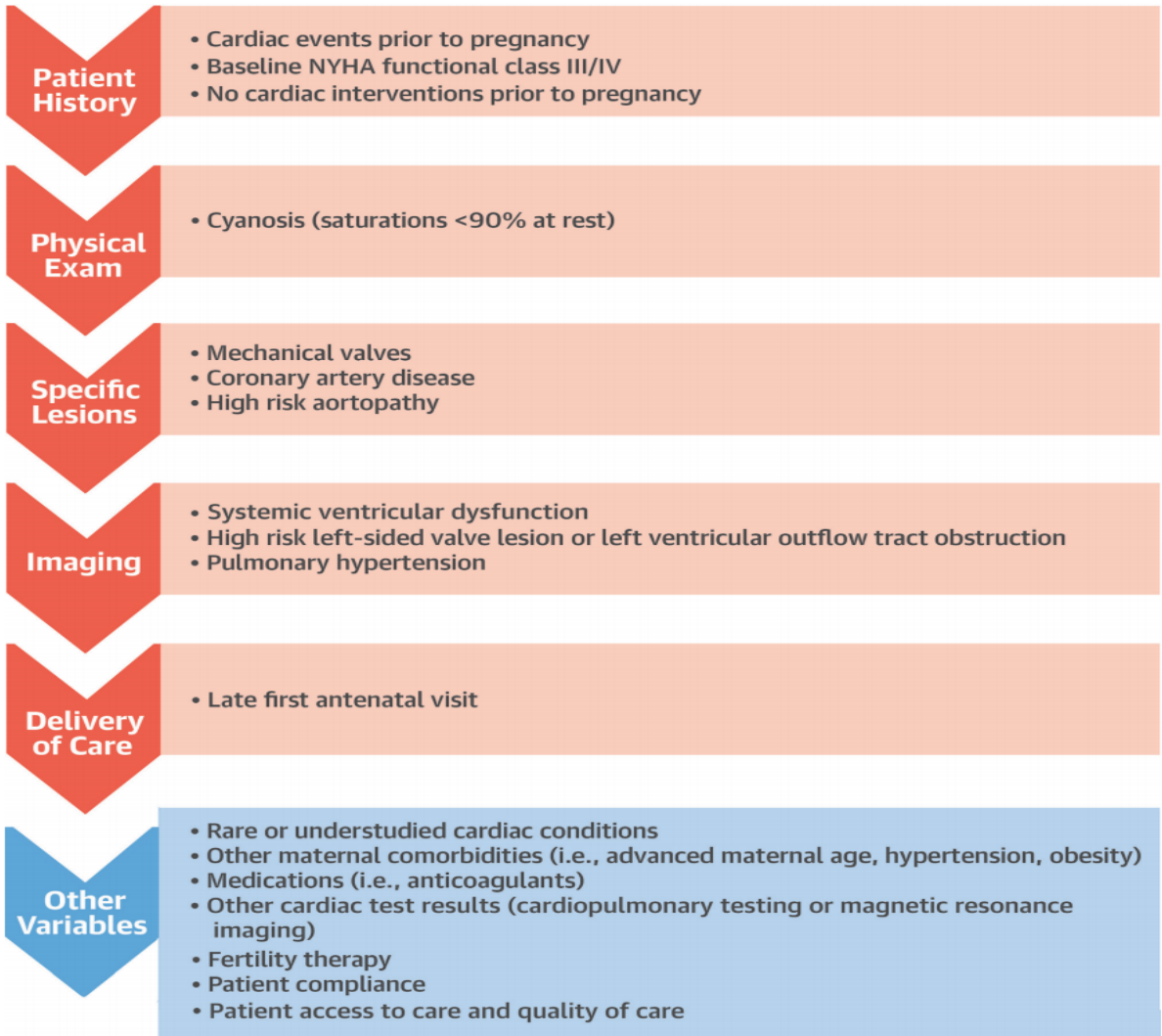
FIGURE 4 CARPREG II Risk Prediction Index: Incidence of Adverse Cardiac Events Stratified According to CARPREG II Risk Scores



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

The CARPREG (Cardiac Disease in Pregnancy Study) II risk score is based on 10 predictors, shown in the **box.** Each predictor is assigned a weighted point score. The sum of points represents the risk score. Risk scores are categorized into the 5 groups (x-axis). The predicted **(light blue)** and the observed frequency of primary cardiac events in the derivation **(medium blue)** and validation **(dark blue)** groups are shown on the y axis. NYHA = New York Heart Association.

CENTRAL ILLUSTRATION **Predictors of Adverse Events in Pregnant Women With Heart Disease**

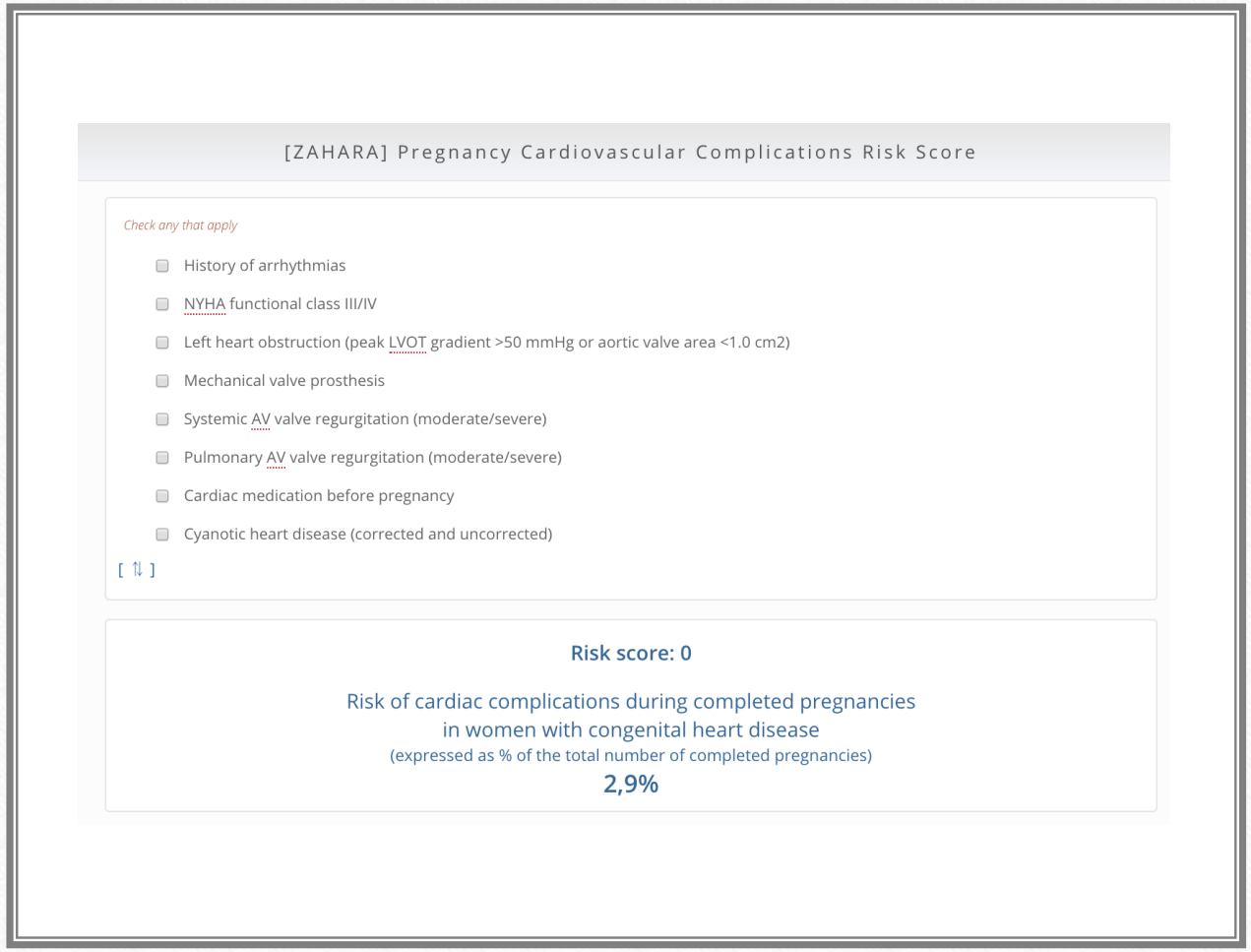


Silversides, C.K. et al. J Am Coll Cardiol. 2018;71(21):2419-30.

Determining cardiac risk in pregnant women with heart disease requires integration of risk score estimates, individual factors, and clinical judgment. The **red arrows** show the variables in the CARPREG II risk score used to predict adverse cardiac events in pregnant women with heart disease. In addition to the variables in the CARPREG II risk score, there may be other factors that impact outcomes for the individual patient. The **blue arrow** shows some of the other variables to consider when estimating pregnancy risks.

Risk Stratification Models: ZAHARA

- 1802 women with 1300 pregnancies
- All with CHD
- Maternal cardiac outcomes, neonatal outcomes and obstetric outcomes



http://www.pmidcalc.org/?sid=20584777&newtest=Y

Table 3. Modified World Health Organization Pregnancy Risk Classification for Women With Preexisting Cardiovascular Disease

Modified WHO Pregnancy Risk Classification (Risk of Pregnancy by medical condition) Suggested follow-up*	Specific Cardiac Lesions	Pregnancy Care
mWHO Risk Class I No detectable increased risk of maternal mortality and no or mi increase in morbidity (2–5% risk of maternal cardiac event rate) Follow-up: Cardiology evaluation once or twice during pregnancy	• Uncomplicated, small, or mild ○ Pulmonary stenosis ○ Patient ductus arteriosus ○ Mitral valve prolapse • Successfully repaired simple lesions (atrial or ventricular septal defect, patent ductus arteriosus, anomalous pulmonary venous drainage) • Atrial or ventricular ectopic beats, isolated	• Prepregnancy/pregnancy counseling • Care at local hospital • Delivery at local hospital*
mWHO Risk Class II Small increased risk of maternal mortality or moderate increase in morbidity (6–10% maternal cardiac event rate) Follow-up: Cardiology, every trimester	• Repaired Tetralogy of Fallot or aortic coarctation • Most arrhythmias (supraventricular arrhythmias) • Turner syndrome without congenital cardiac disease	• Prepregnancy/pregnancy counseling • Pregnancy Heart Team* consultation/ counseling • Care at local hospital • Delivery at local hospital*
mWHO Risk Classes II and III Intermediate increased risk of maternal mortality or moderate to severe increase in morbidity (11–19% maternal cardiac event rate) Follow-up: Cardiology, every trimester	• Mild left ventricular impairment (EF >45%) • Hypertrophic cardiomyopathy • Native or bioprosthetic valve disease not considered mWHO Risk Class I or IV (mild mitral stenosis, moderate aortic stenosis) • Marfan or other HTAD syndrome without aortic dilation • Aorta <45 mm in bicuspid aortic valve pathology • Repaired coarctation without residua (non-Turner) • Atrioventricular septal defect	• Prepregnancy/pregnancy counseling • Pregnancy heart team* consultation/ counseling • Care at an appropriate level hospital (critical members of the Pregnancy Heart Team* available depending on cardiac disease) • Delivery at an appropriate level hospital*†
Pre-mWHO Risk Class III Significantly increased risk of maternal mortality or severe morbidity (20–27% maternal cardiac event rate) Follow-up: Cardiology, every 1–2 months	• Moderate left ventricular impairment (EF 30–45%) • Previous peripartum cardiomyopathy without any residual left ventricular impairment • Mechanical valve • Systemic right ventricle with good or mildly decreased ventricular function • Uncomplicated Fontan circulation, • Unrepaired cyanotic heart disease • Other complex heart disease • Moderate mitral stenosis • Severe asymptomatic aortic stenosis • Moderate aortic dilation (40–45 mm in Marfan syndrome or other HTAD; 45–50 mm in bicuspid aortic valve; Turner syndrome ASI 20–25 mm/m²; Tetralogy of Fallot <50 mm) • Ventricular tachycardia	• Prepregnancy/pregnancy counseling • Pregnancy Heart Team* consultation/ counseling • Care at an appropriate level hospital† • Delivery at an appropriate level hospital*†

Table 3. Modified World Health Organization Pregnancy Risk Classification for Women With Preexisting Cardiovascular Disease (*continued*)

Modified WHO Pregnancy Risk Classification (Risk of Pregnancy by medical condition) Suggested follow-up*	Specific Cardiac Lesions	Pregnancy Care Delivery Location
mWHO Risk Class IV Pregnancy contraindicated Discuss induced abortion Extremely high risk of maternal mortality or severe morbidity (>27% maternal cardiac event rate) Follow-up: Cardiology follow-up every month (minimum)	• Pulmonary arterial hypertension • Severe systemic ventricular dysfunction (EF <30%, NYHA III-IV) • Previous peripartum cardiomyopathy with any residual left ventricular dysfunction • Severe mitral stenosis • Severe symptomatic aortic stenosis • Systemic right ventricle with moderate to severely decreased ventricular function • Severe aortic dilation (>45 mm in Marfan syndrome or other HTAD; >50 mm in bicuspid aortic valve; Turner syndrome ASI >25 mm/m²; Tetralogy of Fallot >50 mm) • Vascular Ehlers-Danlos • Severe (re)coarctation • Fontan circulation with any complication	• Pregnancy Heart Team* consultation/ counseling • Care at an appropriate level hospital‡ (critical members of the Pregnancy Heart Team available depending on cardiac disease) • Delivery at an appropriate level hospital*‡

FIGURE 1 Comorbidity Classification of Women With CHDs Admitted for Delivery, by CHD Severity

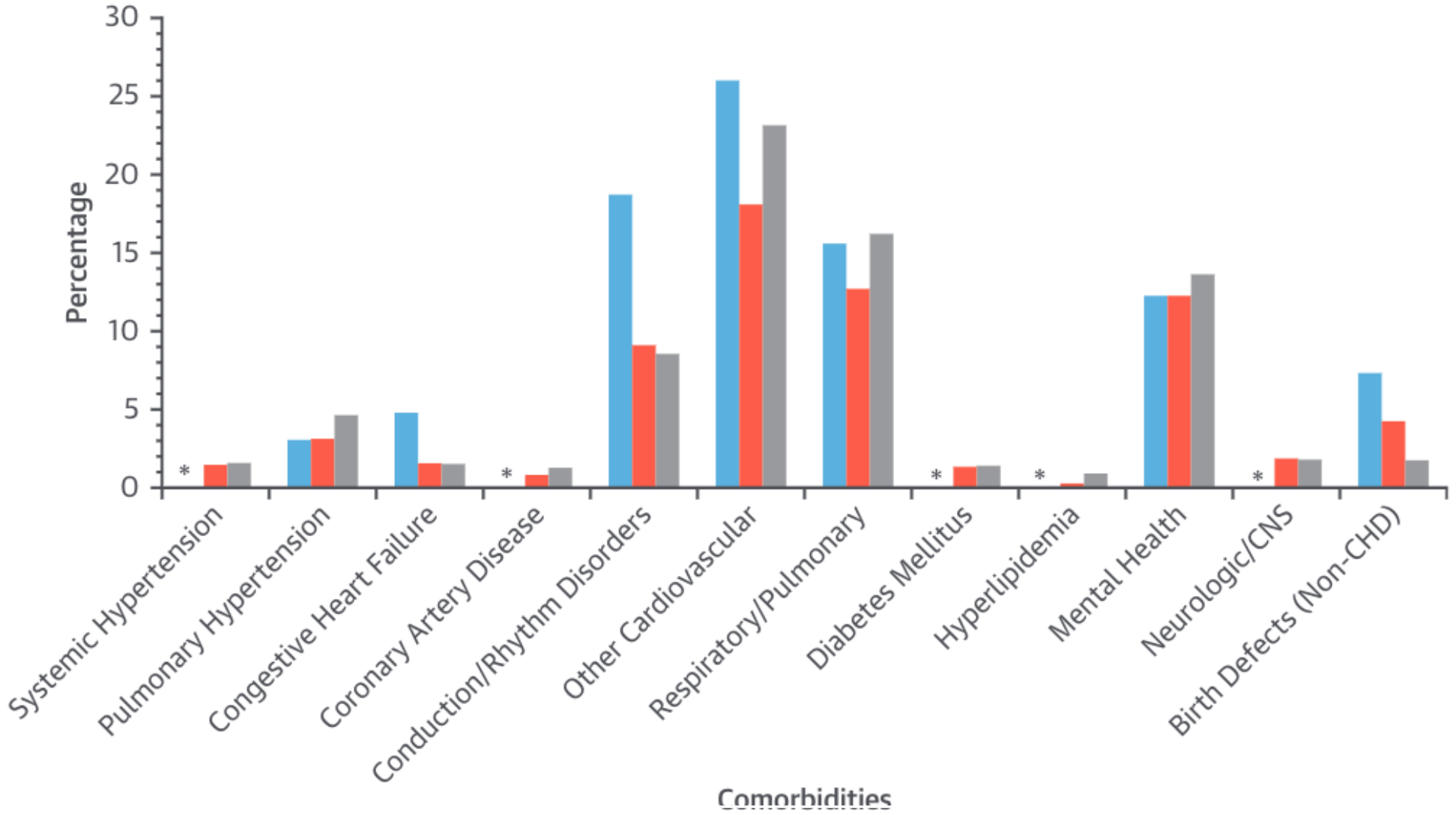


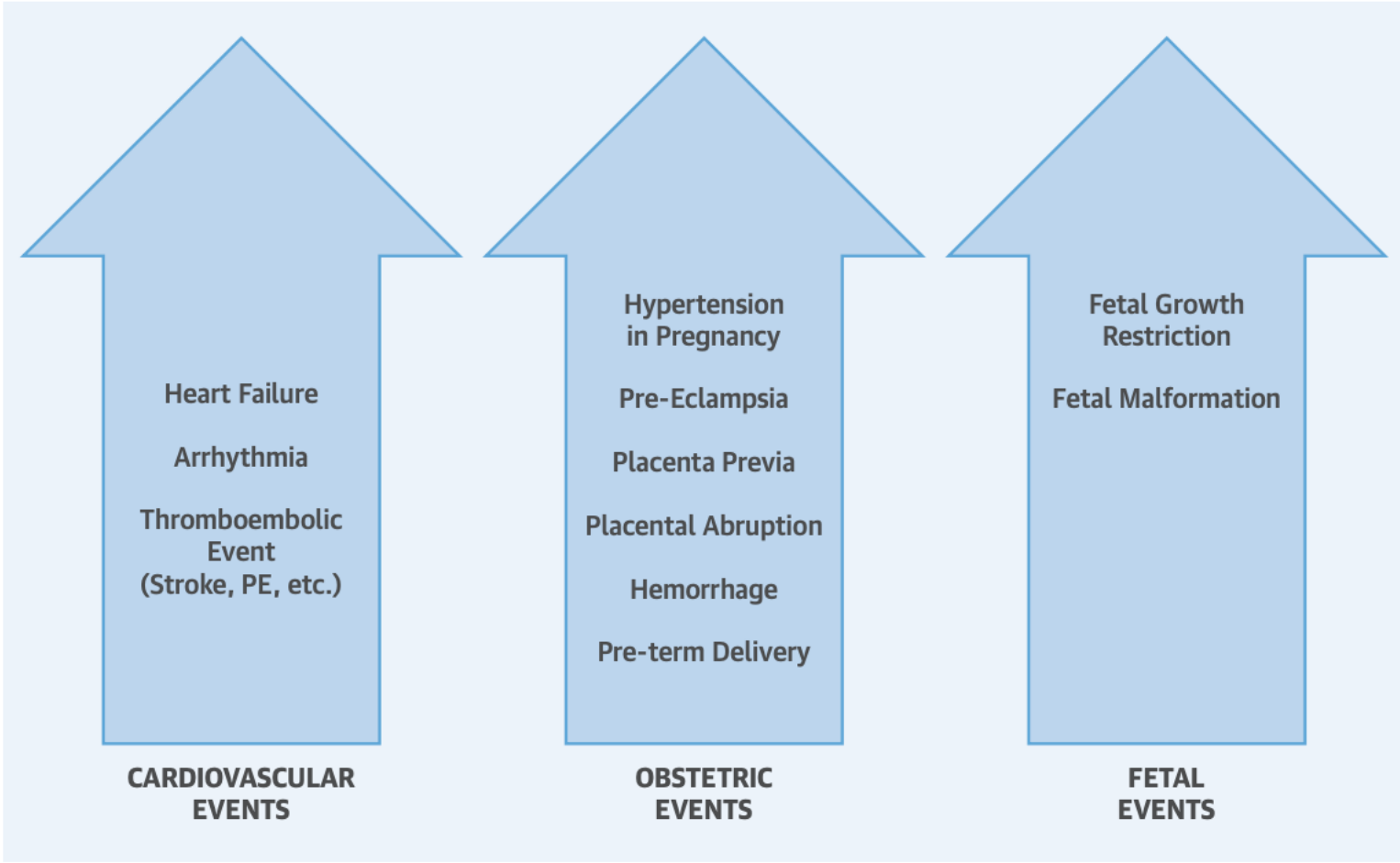
TABLE 4 Adverse Cardiovascular, Obstetric, and Fetal Events Experienced by Women With and Without CHDs Admitted for Delivery

	CHD (n = 17,729)	No CHD (n = 22,863,961)	Adjusted OR* (95% CI)
Cardiovascular events			
Heart failure	268 (1.51)	10,935 (0.05)	27.6 (20.5–37.3)
Arrhythmia	1,694 (9.55)	163,964 (0.72)	12.4 (11.0–14.0)
Myocardial infarction	<11†	491 (0.002)	NC
Thromboembolic event (stroke, PE, and so on)	676 (3.81)	339,468 (1.48)	2.4 (2.0–2.9)
Obstetric events			
Hypertension in pregnancy	1,460 (8.24)	1,265,414 (5.53)	1.4 (1.3–1.6)
Pre-eclampsia	1,274 (7.19)	982,021 (4.30)	1.5 (1.3–1.7)
Placenta previa	460 (2.59)	361,572 (1.58)	1.5 (1.2–1.8)
Placental abruption	276 (1.56)	241,860 (1.06)	1.5 (1.1–1.9)
Hemorrhage	893 (5.04)	727,288 (3.18)	1.6 (1.3–1.8)
Pre-term delivery	2,133 (12.03)	1,604,696 (7.02)	1.6 (1.4–1.8)
Prolonged pregnancy	1,351 (7.62)	2,706,483 (11.84)	0.6 (0.5–0.7)
Fetal events			
Fetal distress	1,770 (9.98)	2,350,617 (10.28)	0.8 (0.7–0.9)
Fetal growth restriction	862 (4.86)	529,466 (2.32)	1.9 (1.6–2.3)
Fetal malformation	3,282 (18.51)	3,413,566 (14.93)	1.2 (1.1–1.3)
Fetal death or stillbirth	131 (0.74)	153,958 (0.67)	1.4 (1.0–2.0)
Delivery procedure			
Cesarean section	7,546 (42.56)	7,561,396 (33.07)	1.6 (1.5–1.7)
Operative vaginal delivery	544 (3.07)	228,507 (1.00)	3.9 (3.2–4.8)
Artificial rupture of the membranes	4,201 (23.70)	5,410,787 (23.67)	1.0 (0.9–1.0)
Induction	4,596 (25.92)	4,822,314 (21.09)	1.3 (1.2–1.4)

Values are n (%) unless otherwise indicated. National estimates of prevalence (n [%]) of specific demographic characteristics were made using HCUP-provided sample weights. Sample weights were used in all multivariate analyses to get estimates of measures of association generalizable to the U.S. population. *Covariates considered for adjustment included age, race/ethnicity, method of delivery (cesarean or vaginal), primary insurance, and hospital teaching status. †Because the number of patients with CHDs who experienced myocardial infarction was <11, the value is not reported, due to HCUP guidelines for the NIS. Adjusted ORs were not calculated for these complications.

NC = not calculated; PE = pulmonary embolism; other abbreviations as in Tables 1 and 3.

CENTRAL ILLUSTRATION **Increased Risk for Adverse Cardiovascular, Obstetric, and Fetal Events in Women With Congenital Heart Defects**



Schlichting, L.E. et al. J Am Coll Cardiol. 2019;73(17):2181–91.

This figure shows the cardiovascular, obstetric, and fetal adverse events more common in women with CHDs. CHD = congenital heart defect; PE = pulmonary embolism.

Antenatal Management

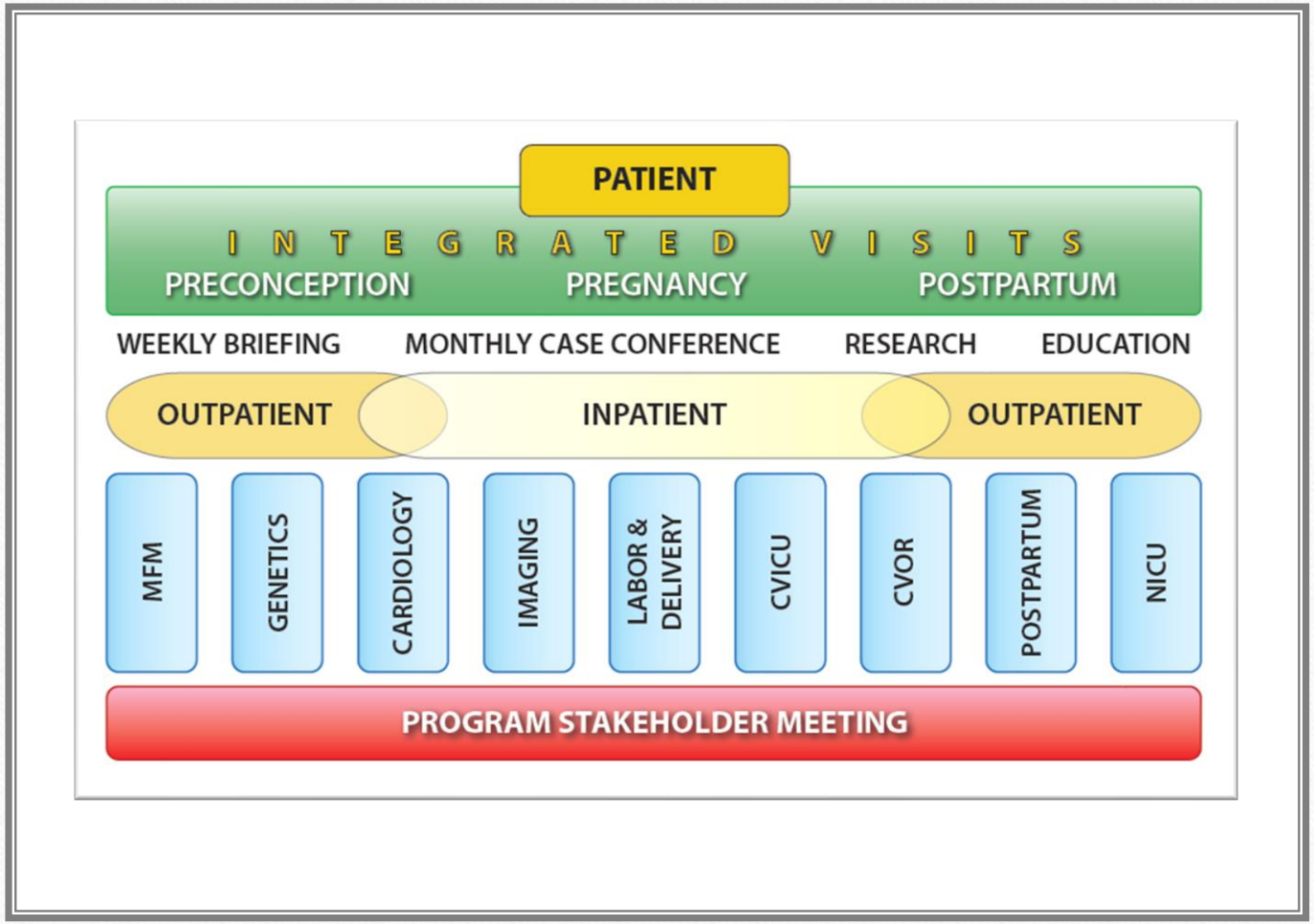


FIGURE 2

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* _____

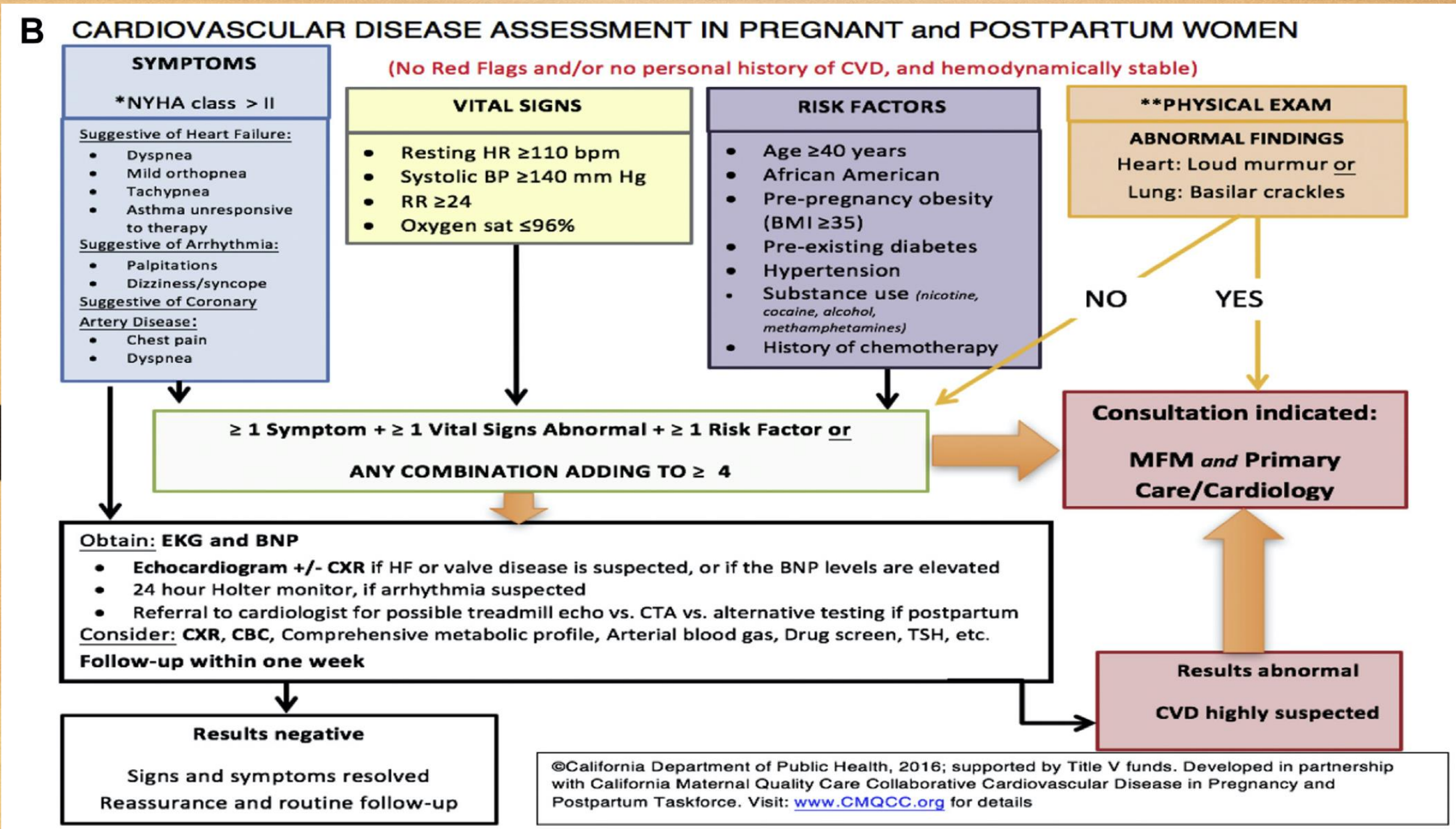
EMERGENCY PLAN

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.

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



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

Intrapartum Management

TABLE 4
Obstetric and cardiovascular outcomes according to planned mode of delivery

Outcomes	Total (n = 276)	Planned vaginal birth (n = 210)	Planned cesarean delivery (n = 66)	*P* value[a]
Composite cardiac outcome[b]	11 (4.0)	9 (4.3)	2 (3.0)	1.00
Sustained arrhythmia	1 (0.36)	1 (0.48)	0 (0)	1.00
Heart failure	9 (3.3)	7 (3.3)	2 (3.0)	1.00
Composite obstetric outcome[c]	33 (12.0)	21 (10.0)	11 (18.2)	.08
Postpartum hemorrhage	11 (4.0)	4 (1.9)	7 (10.6)	< .01
Blood transfusion	10 (3.6)	4 (1.9)	6 (9.1)	.01
Estimated blood loss ≥1500 mL	8 (2.9)	3 (1.4)	5 (7.6)	.02
Hysterectomy	2 (0.72)	1 (0.48)	1 (1.5)	.42
Peripartum infection	24 (8.8)	19 (9.1)	5 (7.6)	.81
Chorioamnionitis	11 (4.0)	11 (5.2)	0 (0)	.07
Endometritis	7 (2.5)	4 (1.9)	3 (4.6)	.36
Wound cellulitis	4 (1.5)	3 (1.4)	1 (1.5)	1.00
Wound reopening	2 (0.72)	1 (0.48)	1 (1.5)	.42
Venous thromboembolism	3 (1.1)	0 (0)	3 (4.6)	.01
Severe maternal morbidity	17 (6.2)	9 (4.3)	8 (12.1)	.04
Maternal ICU admission	3 (1.1)	1 (0.48)	2 (3.0)	.14
NICU admission[d]	5 (2.4)	4 (2.3)	1 (2.4)	1.00
Composite neonatal outcome[d]	0 (0)	0 (0)	0 (0)	1.00

ICU, neonatal intensive care unit; *NICU*, neonatal intensive care unit.

[a] *P* value was calculated by a χ^2 test or Fisher exact for categorical variables; [b] None of the cases of cerebral vascular accidents (n = 1), cardiac arrest (n = 1), endocarditis, percutaneous intervention (n = 5), aortic dissection (n = 1), or cardiac surgery (n = 6) were attributable to delivery. There were no maternal deaths; [c] Composite obstetric outcome consisting of postpartum hemorrhage, peripartum infection, and venous thromboembolism; [d] NICU admission and composite neonatal outcome was limited to 37 week, singleton, nonanomalous fetuses. Composite neonatal outcome includes 5 minute Apgar <4, skeletal fracture, nerve palsy, subgaleal hemorrhage, intubation within the first 24 hours for at least 2 days, hypoxic ischemic encephalopathy, and neonatal death.

Easter et al. Vaginal delivery for cardiovascular disease. Am J Obstet Gynecol 2020.

Intrapartum Management

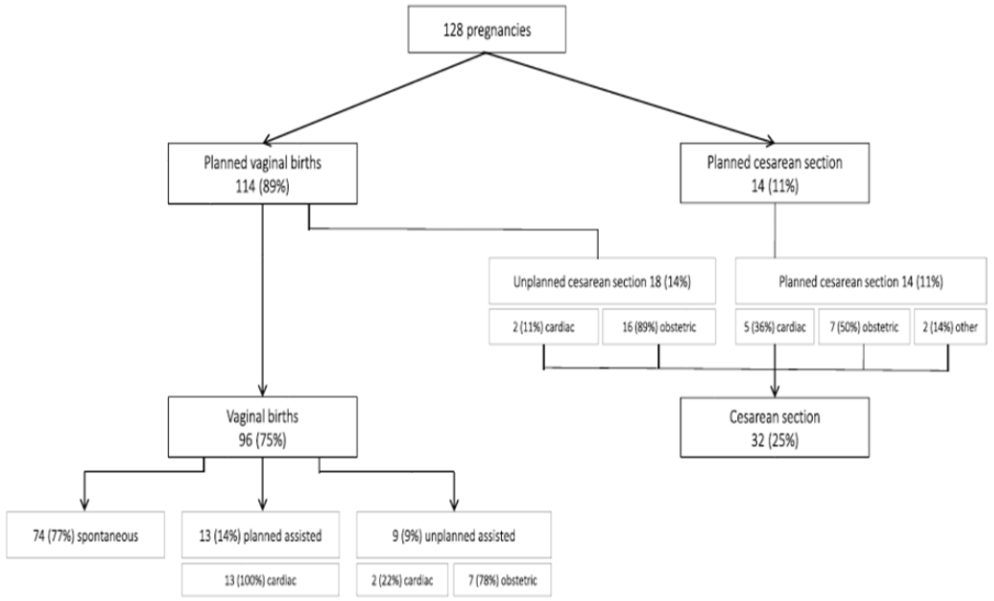


Fig. 1. Planned and performed modes of birth.

Table 3
Pregnancy outcomes for the total study population and stratified per modified World Health Organization classification.

	Total (n = 128)	mWHO class I (n = 29)	mWHO class II (n = 64)	mWHO class III (n = 27)	mWHO class IV (n = 8)
Maternal cardiac outcomes					
Heart failure	5 (3.9 %)	–	2 (3.1 %)	2 (7.4 %)	1 (13 %)
During pregnancy	2 (1.6 %)	–	–	1 (3.7 %)	1 (13 %)
During labor	1 (0.8 %)	–	–	1 (3.7 %)	–
Postpartum	2 (1.6 %)	–	2 (3.1 %)	–	–
Arrhythmia	4 (3.1 %)	–	2 (3.1 %)	1 (3.7 %)	1 (13 %)
During pregnancy	3 (2.3 %)	–	2 (3.1 %)	1 (3.7 %)	–
Postpartum	1 (0.8 %)	–	–	–	1 (13 %)
Myocardial infarction	–	–	–	–	–
Thromboembolic events	2 (1.6 %)	–	2 (3.1 %)	–	–
Stroke	1 (0.8 %)	–	1 (1.6 %)	–	–
Deep vein thrombosis	1 (0.8 %)	–	1 (1.6 %)	–	–
Pulmonary embolism	–	–	–	–	–
Cardiac intervention	1 (0.8 %)	–	–	–	1 (13 %)
Maternal death	–	–	–	–	–
Maternal obstetric outcomes					
Pregnancy-induced hypertension	5 (3.9 %)	3 (10 %)	1 (1.6 %)	1 (3.7 %)	–
Pre-eclampsia	3 (2.3 %)	–	1 (1.6 %)	1 (3.7 %)	1 (13 %)
HELLP syndrome	1 (0.8 %)	–	1 (1.6 %)	–	–
Gestational diabetes	3 (2.3 %)	1 (3.4 %)	–	1 (3.7 %)	1 (13 %)
Postpartum hemorrhage	9 (7.0 %)	2 (6.9 %)	4 (6.3 %)	2 (7.4 %)	1 (13 %)
Fetal and neonatal outcomes					
Apgar <7 at 1 min	10 (7.9 %)	–	4 (6.3 %)	5 (19 %)	1 (13 %)
Apgar <7 at 5 min	5 (3.9 %)	–	3 (4.7 %)	1 (3.7 %)	1 (13 %)
Prematurity	12 (9.4 %)	2 (6.9 %)	2 (3.1 %)	6 (22 %)	2 (25 %)
Small for gestational age	14 (11 %)	1 (3.4 %)	8 (13 %)	3 (11 %)	2 (25 %)
NICU admission	12 (9.4 %)	1 (3.4 %)	6 (9.4 %)	3 (11 %)	2 (25 %)
Congenital heart disease	15 (11.7 %)	1 (3.4 %)	11 (17 %)	2 (7.4 %)	1 (13 %)
Other congenital / syndromic disease	2 (1.6 %)	2 (6.9 %)	–	–	–
Perinatal or neonatal mortality	–	–	–	–	–

HELLP, hemolysis elevated liver enzymes low platelets; mWHO, modified World Health Organization; NICU, neonatal intensive care unit.

Intrapartum Management

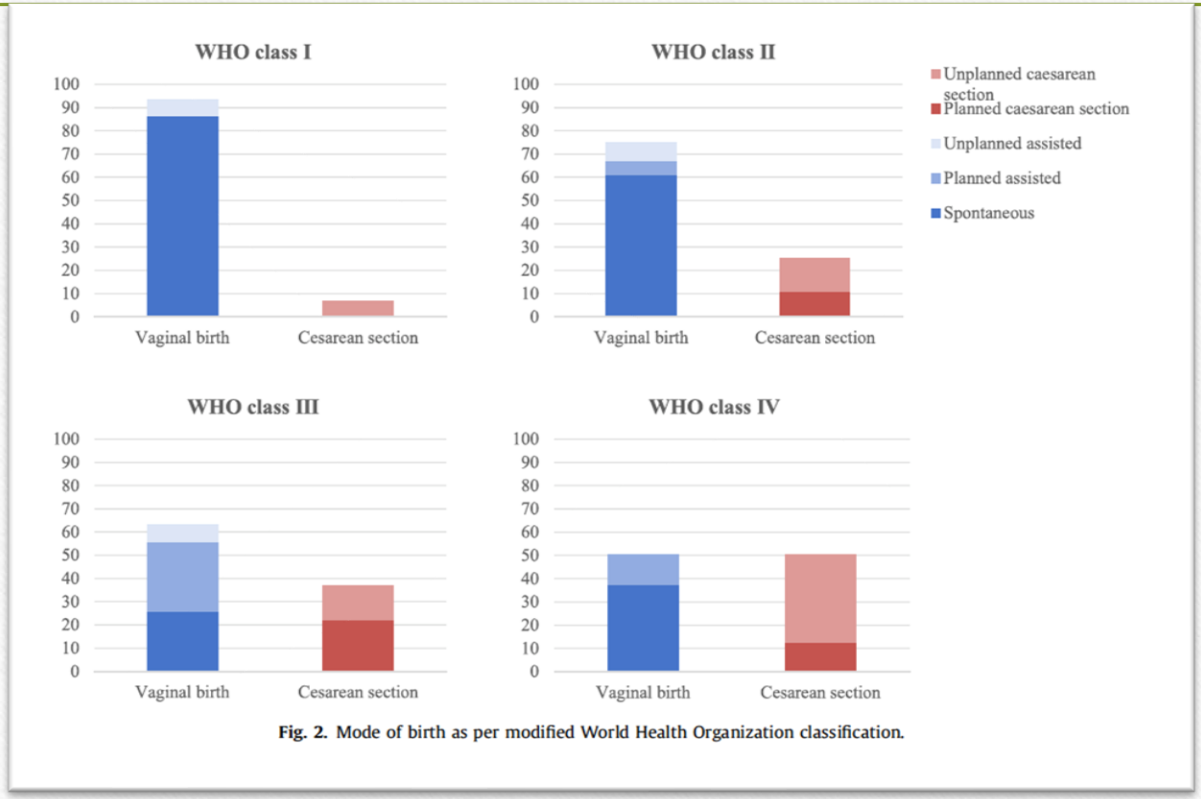


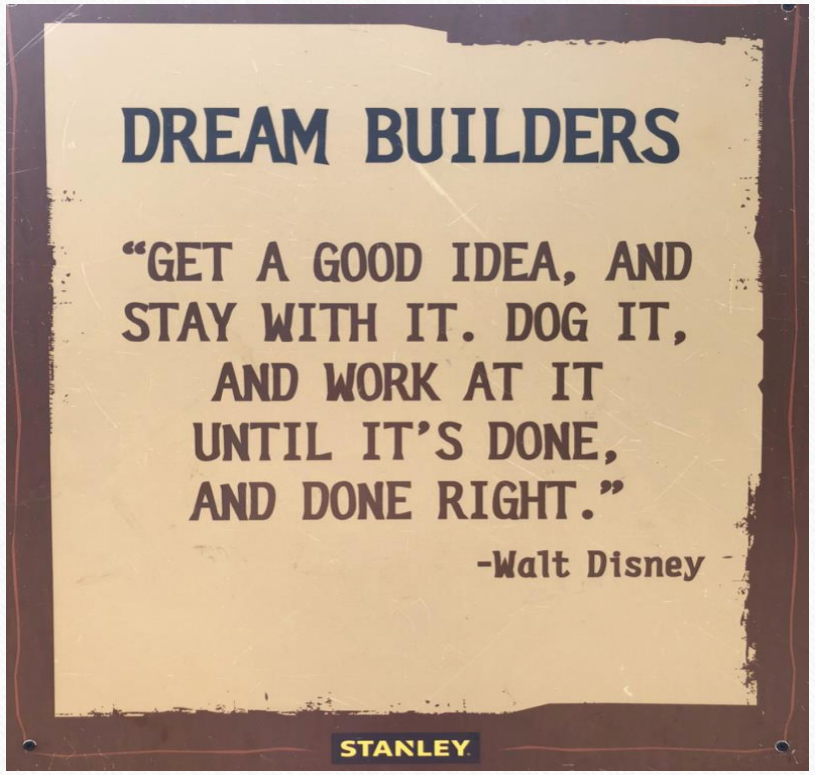
Fig. 2. Mode of birth as per modified World Health Organization classification.

Postpartum Management

- Remember autotransfusion
  - Consideration of prolonged stay in ICU or on cardiac monitoring in those women at higher risk
- Plan to be seen sooner in office after discharge
- Start the discussion of contraception postpartum!
  - Most women have intercourse before 6 week appt
  - Racial disparity in discussions about contraception

Summary

- Assemble a multidisciplinary team
- Establish plan early
  - Where, when and how
- Utilize risk stratification models for counseling
- Vaginal delivery if possible
- LARC is key!


DREAM BUILDERS
"GET A GOOD IDEA, AND STAY WITH IT. DOG IT, AND WORK AT IT UNTIL IT'S DONE, AND DONE RIGHT."
-Walt Disney
STANLEY

Resources

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