Cardio-obstetrics:
What all cardiologists should know

Sarah Thordsen, MD FACC

Wisconsin ACC Meeting September 12th, 2021

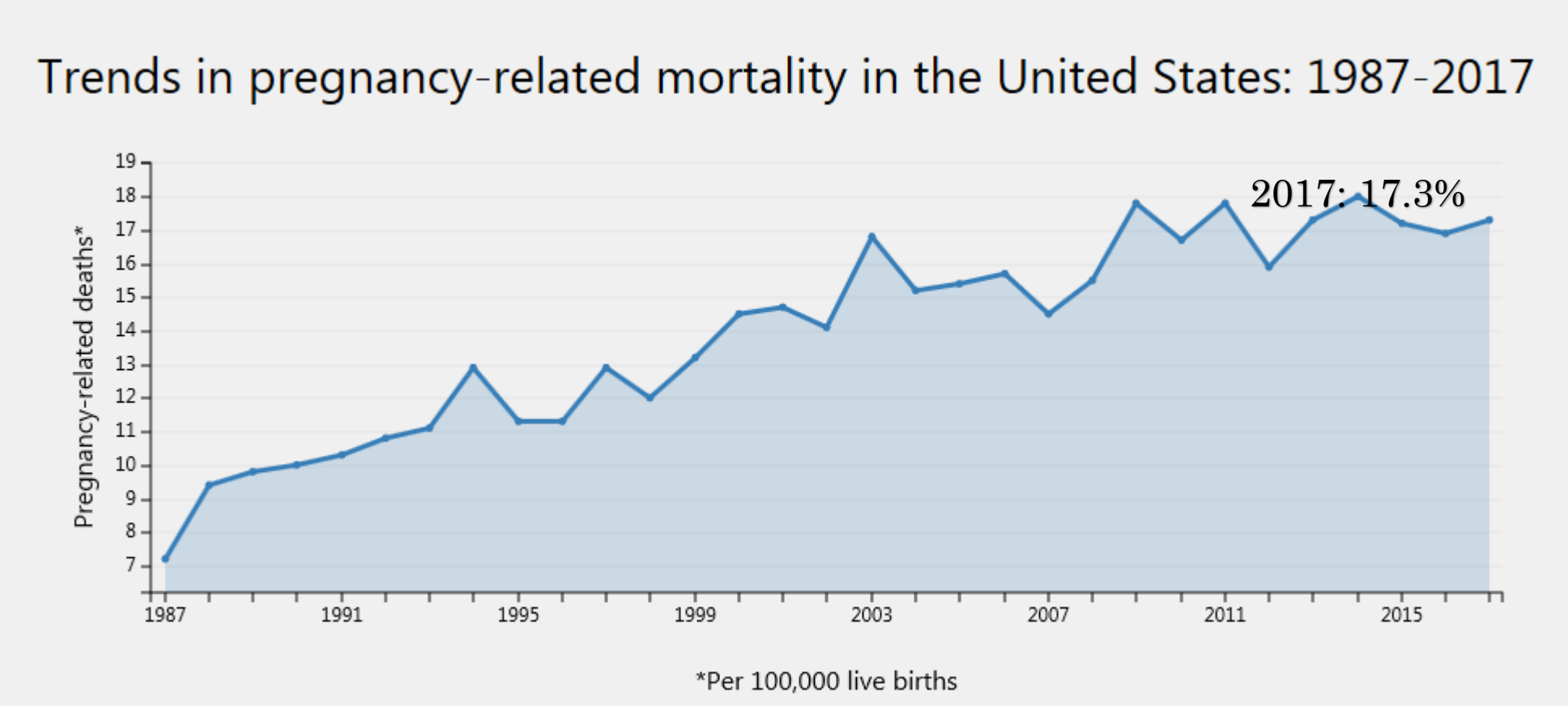
Disclosures

- Abiomed Research Grant – PPCM database.

Objectives

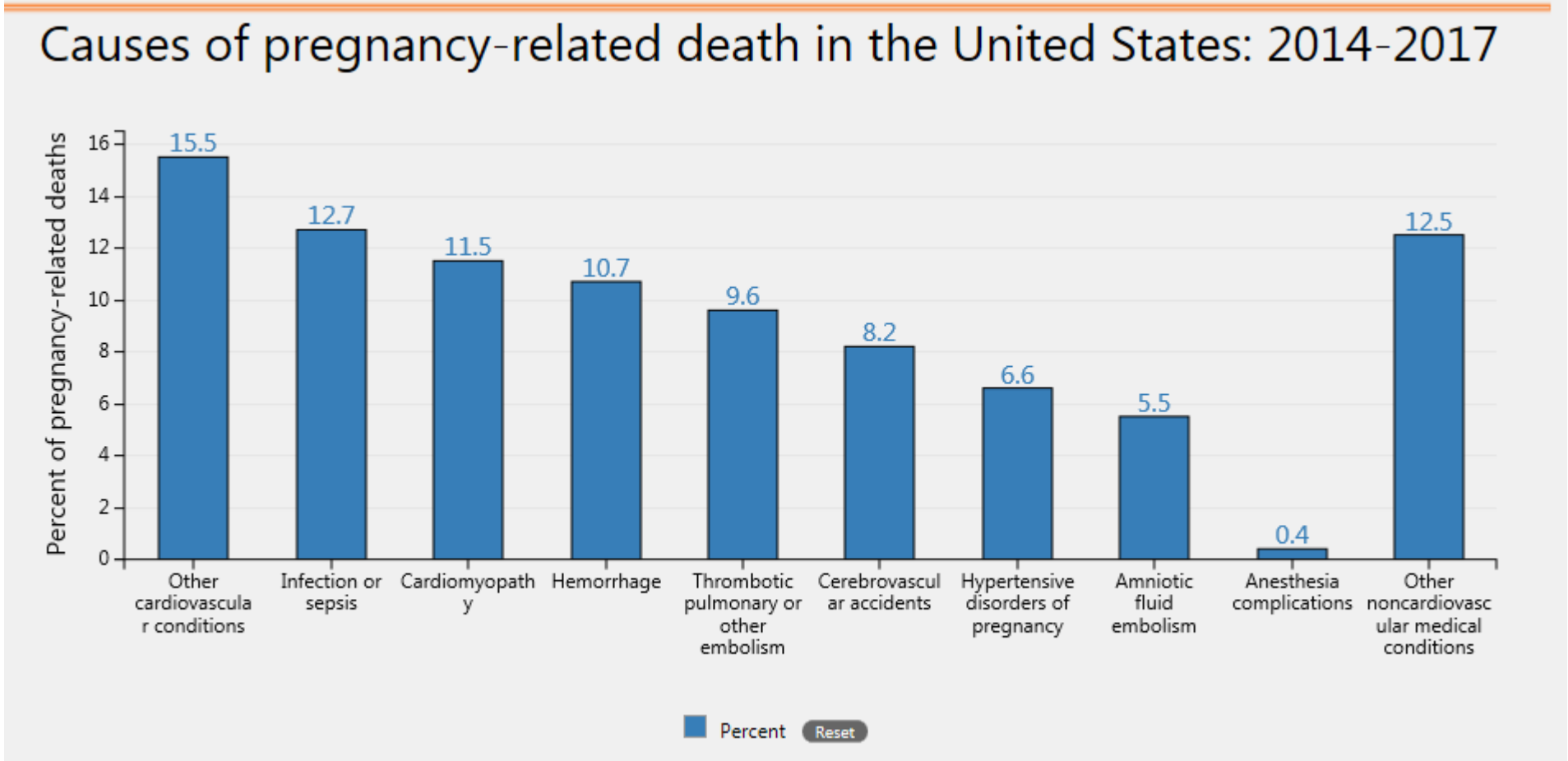
- 1. Discuss incidence / prevalence for maternal mortality
- 2. Discuss hemodynamic challenges of pregnancy
- 3. Discuss source of Cario-obstetric data
- 4. Discuss pre-conception counseling
- 5. Discuss Cardio-obstetric specific pathologies
- 6. Cardio-obstetrics team

Pregnancy Related Mortality per the CDC



CDC. Pregnancy Mortality Surveillance System. https://www.cdc.gov/reproductivehealth/maternal-mortality/pregnancy-mortality-surveillance-system.htm. Website updated Retrieved 9/5/2021

Pregnancy- Related Mortality in the US



CDC. Pregnancy Mortality Surveillance System. https://www.cdc.gov/reproductivehealth/maternal-mortality/pregnancy-mortality-surveillance-system.htm. Website updated Retrieved 9/5/2021

Causes of Pregnancy Associated Mortality in the US

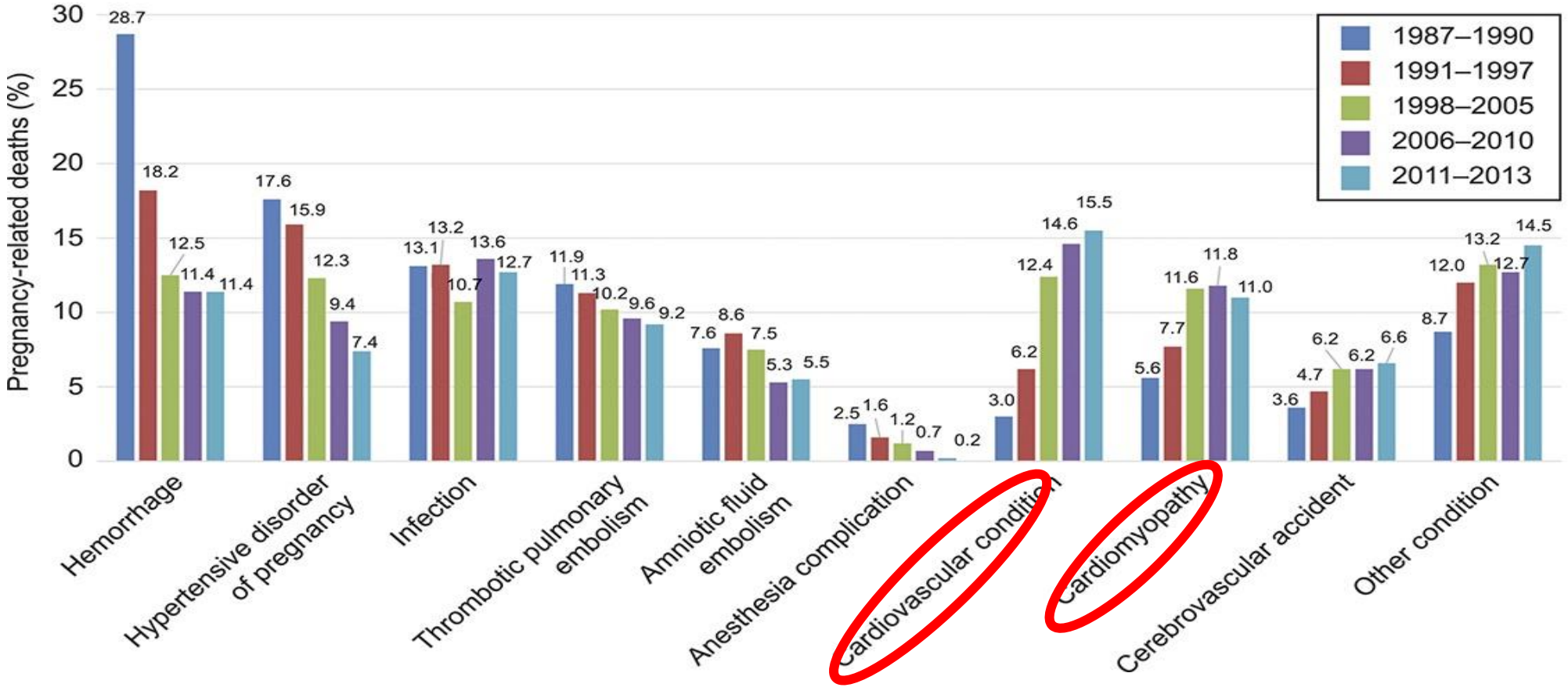
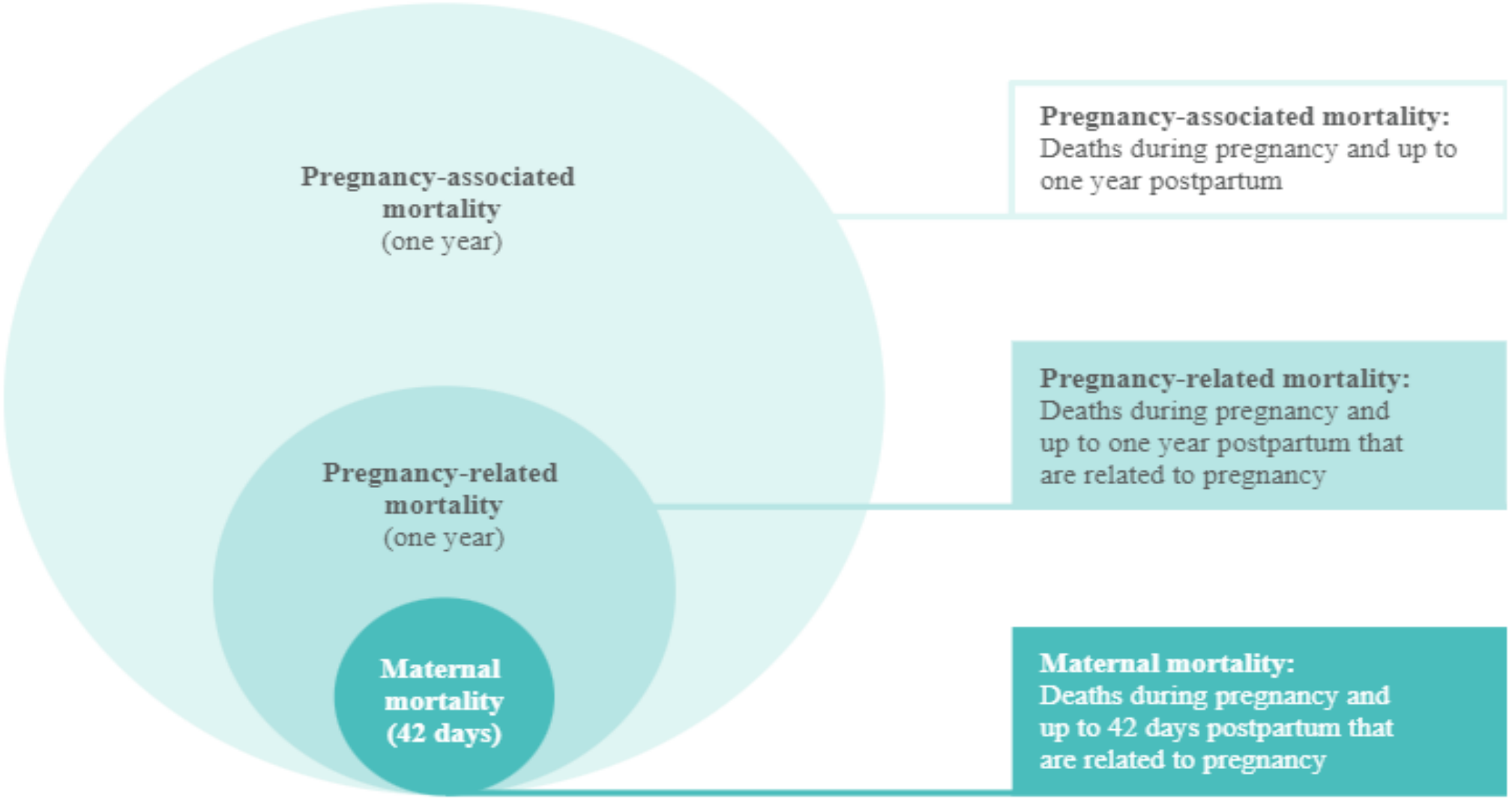


Figure 2. Creanga AA, Syverson C, Seed K, Callaghan WM. Pregnancy-Related Mortality in the United States, 2011-2013. Obstet Gynecol. 2017;130(2),366–373.

What do we mean by maternal mortality?



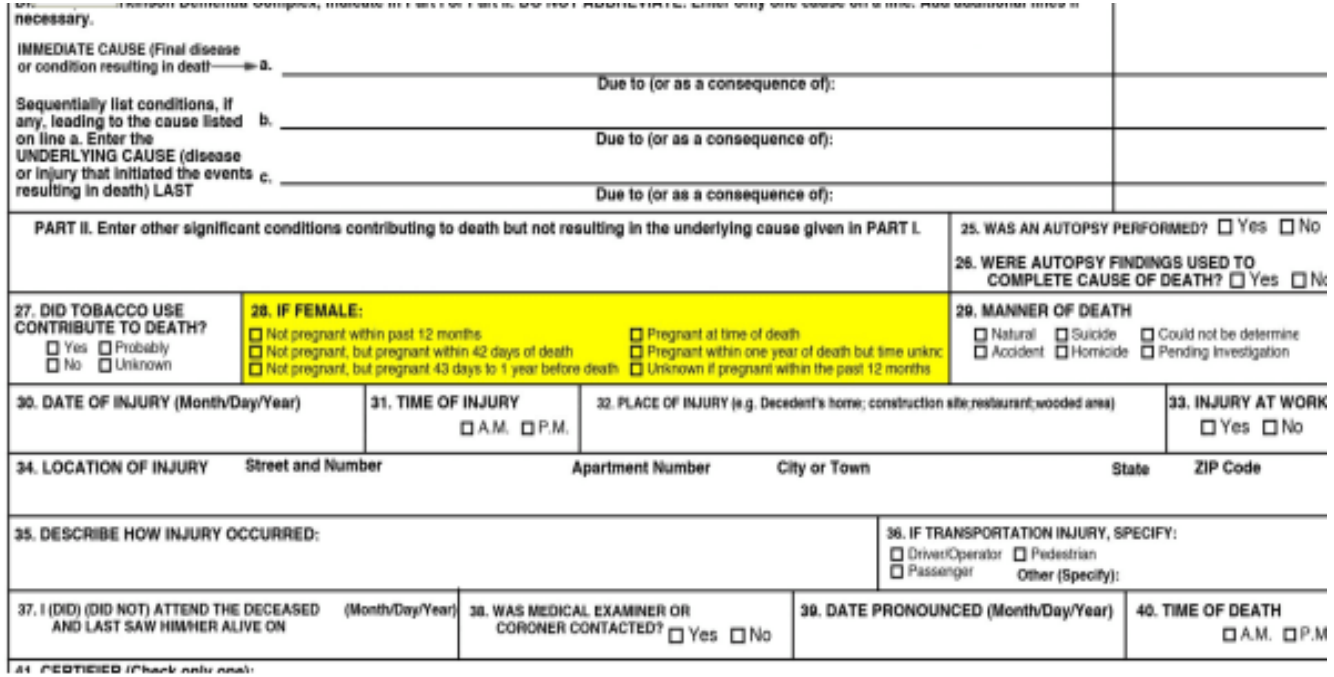
Source: Eugene Declercq and Laurie Zephyrin, *Maternal Mortality in the United States: A Primer* (Commonwealth Fund, Dec. 2020). https://doi.org/10.26099/ta1q-mw24

Froedtert & Medical College of Wisconsin

For Immediate Release: January 30, 2020

National Center for Health Statistics

First Data Released on Maternal Mortality in Over a Decade



necessary.

IMMEDIATE CAUSE (Final disease or condition resulting in death) a. _____ Due to (or as a consequence of):

Sequentially list conditions, if any, leading to the cause listed on line a. Enter the UNDERLYING CAUSE (disease or injury that initiated the events resulting in death) LAST b. _____ Due to (or as a consequence of):

c. _____ Due to (or as a consequence of):

PART II. Enter other significant conditions contributing to death but not resulting in the underlying cause given in PART I.

25. WAS AN AUTOPSY PERFORMED? ☐ Yes ☐ No

26. WERE AUTOPSY FINDINGS USED TO COMPLETE CAUSE OF DEATH? ☐ Yes ☐ No

27. DID TOBACCO USE CONTRIBUTE TO DEATH? ☐ Yes ☐ Probably ☐ No ☐ Unknown

28. IF FEMALE: ☐ Not pregnant within past 12 months ☐ Not pregnant, but pregnant within 42 days of death ☐ Not pregnant, but pregnant 43 days to 1 year before death ☐ Pregnant at time of death ☐ Pregnant within one year of death but time unknc ☐ Unknown if pregnant within the past 12 months

29. MANNER OF DEATH ☐ Natural ☐ Suicide ☐ Could not be determine ☐ Accident ☐ Homicide ☐ Pending Investigation

30. DATE OF INJURY (Month/Day/Year)

31. TIME OF INJURY ☐ A.M. ☐ P.M.

32. PLACE OF INJURY (e.g. Decedent's home; construction site;restaurant;wooded area)

33. INJURY AT WORK ☐ Yes ☐ No

34. LOCATION OF INJURY Street and Number Apartment Number City or Town State ZIP Code

35. DESCRIBE HOW INJURY OCCURRED:

36. IF TRANSPORTATION INJURY, SPECIFY: ☐ Driver/Operator ☐ Pedestrian ☐ Passenger Other (Specify):

37. I (DID) (DID NOT) ATTEND THE DECEASED AND LAST SAW HIM/HER ALIVE ON (Month/Day/Year)

38. WAS MEDICAL EXAMINER OR CORONER CONTACTED? ☐ Yes ☐ No

39. DATE PRONOUNCED (Month/Day/Year)

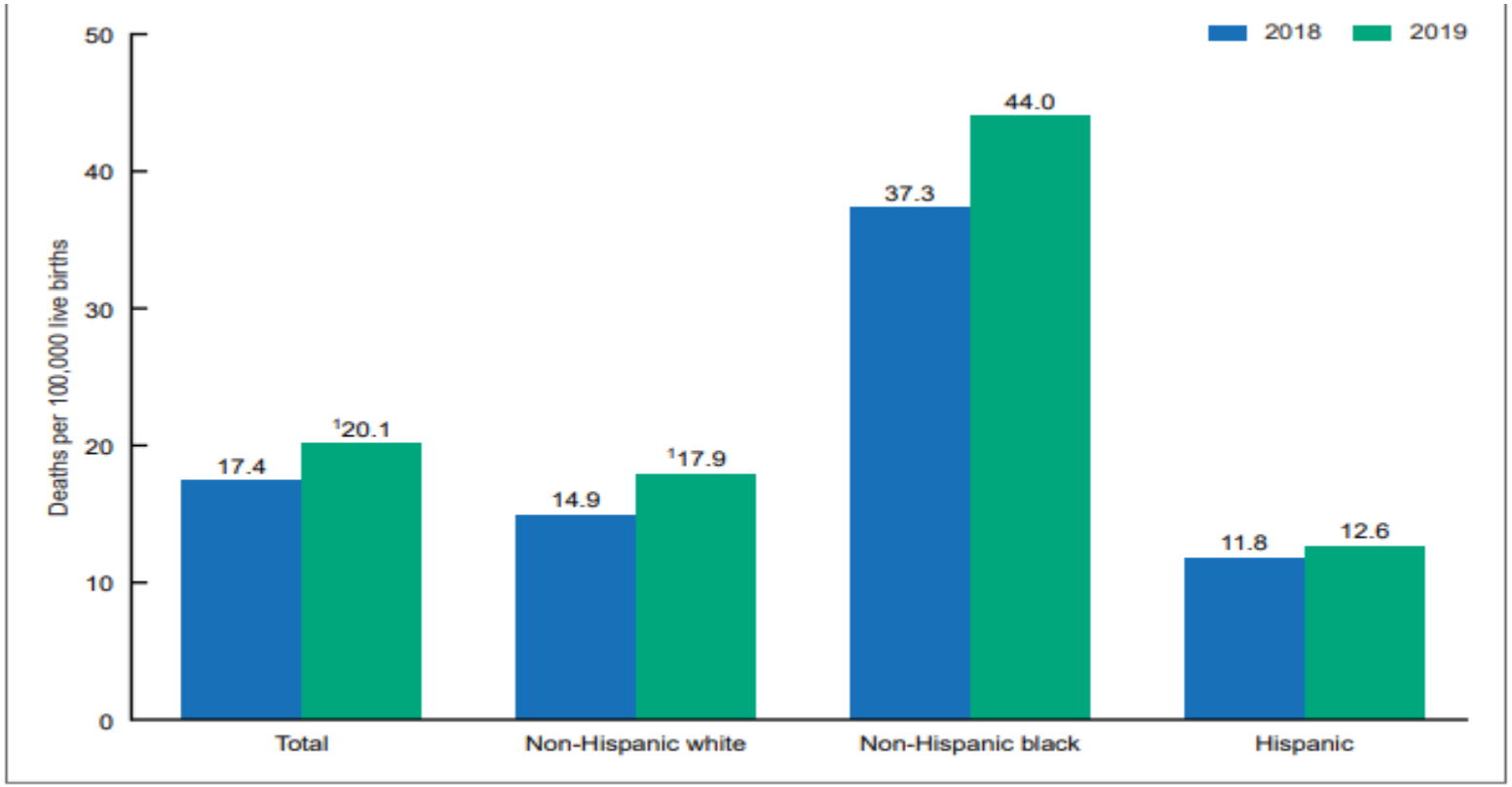
40. TIME OF DEATH ☐ A.M. ☐ P.M

41. CERTIFIER (Check only one):

National Center for Health Statistics

Froedtert & Medical College of Wisconsin

First Data Released on Maternal Mortality in Over a Decade



[1]Statistically significant increase in rate from 2018 to 2019 ($p < 0.05$).
NOTE: Race groups are single race.
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Figure 1. Hoyert DL. Maternal mortality rates in the United States, 2019. NCHS Health E-Stats. 2021. DOI: https://doi.org/10.15620/cdc:103855external icon.

First Data Released on Maternal Mortality in Over a Decade

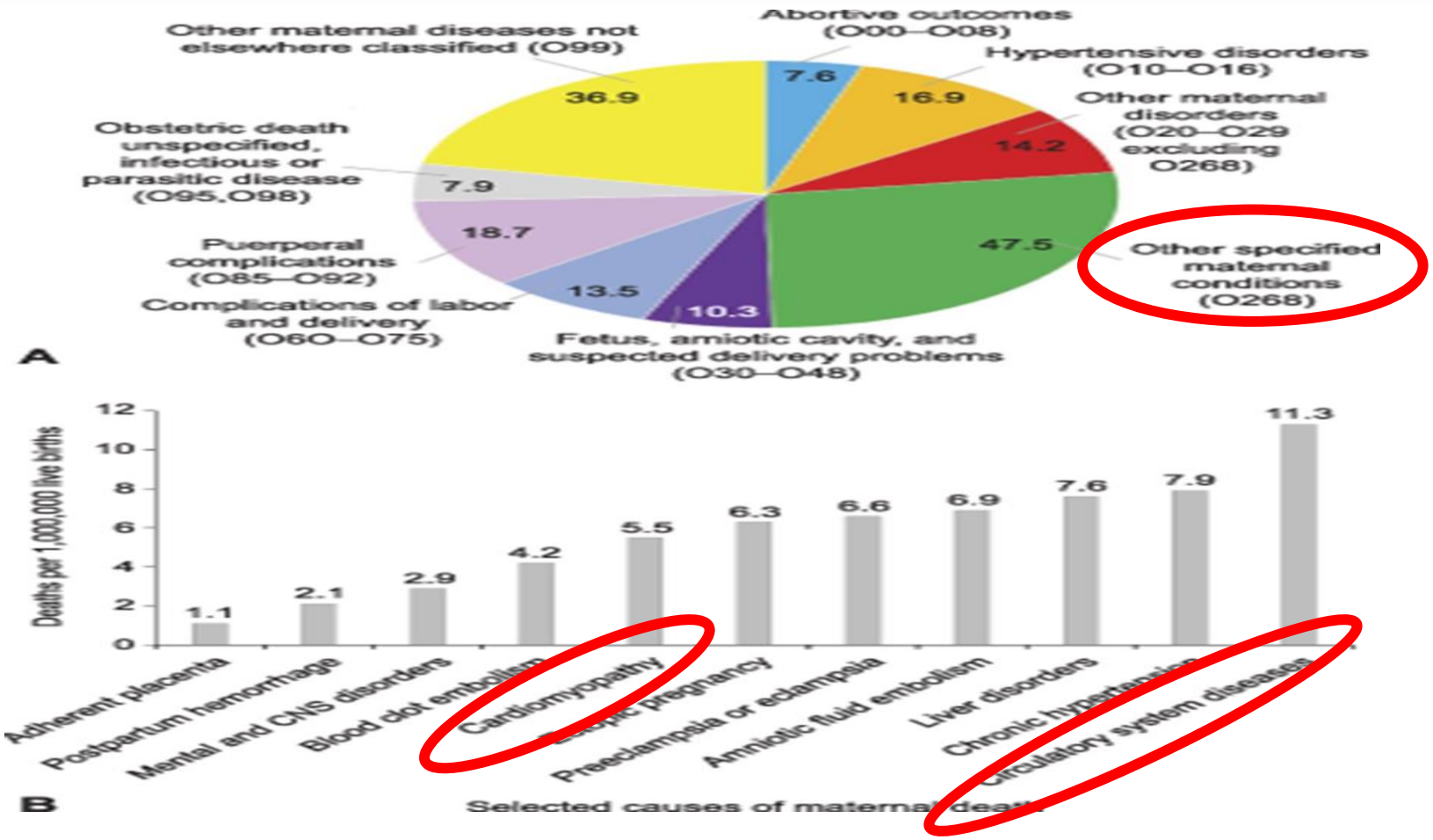
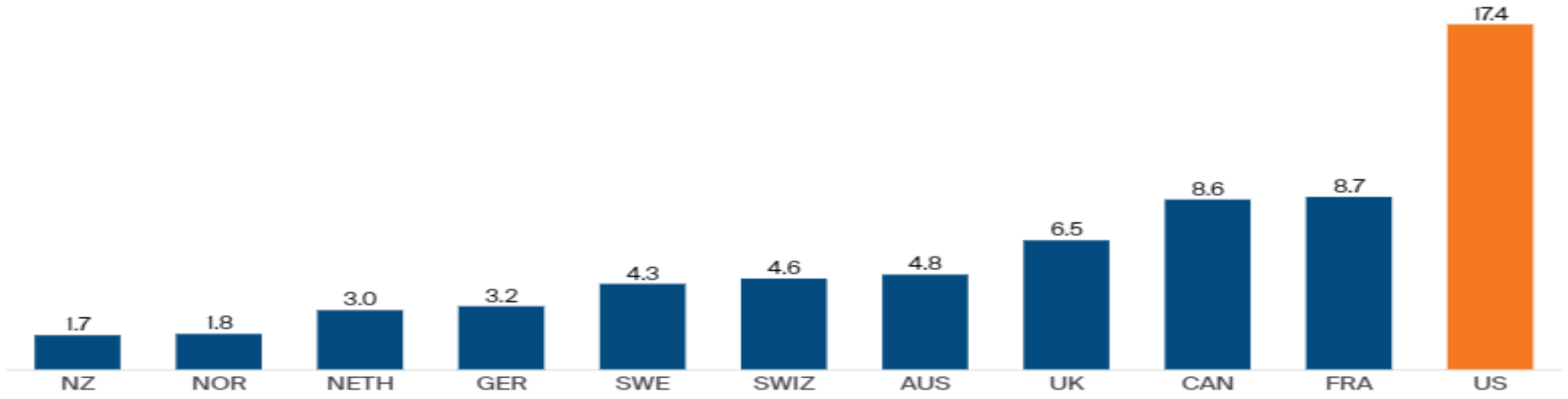


Figure 3. Joseph, K. S. MD, PhD; Boutin, Amélie PhD; Lisonkova, Sarka MD, PhD; Muraca, Giulia M. MPH, PhD; Razaz, Neda MPH, PhD; John, Sid MSc; Mehrabadi, Azar PhD; Sabr, Yasser MD, MHSc; Ananth, Cande V. PhD, MPH; Schisterman, Enrique PhD Maternal Mortality in the United States, Obstetrics & Gynecology: May 2021 - Volume 137 - Issue 5 - p 763-771

Exhibit 1

Maternal Mortality Ratios in Selected Countries, 2018 or Latest Year

Deaths per 100,000 live births



Download data

Notes: The maternal mortality ratio is defined by the World Health Organization as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes.

Data: OECD Health Data 2020, showing data for 2018 except 2017 for Switzerland and the UK; 2016 for New Zealand; 2012 for France.

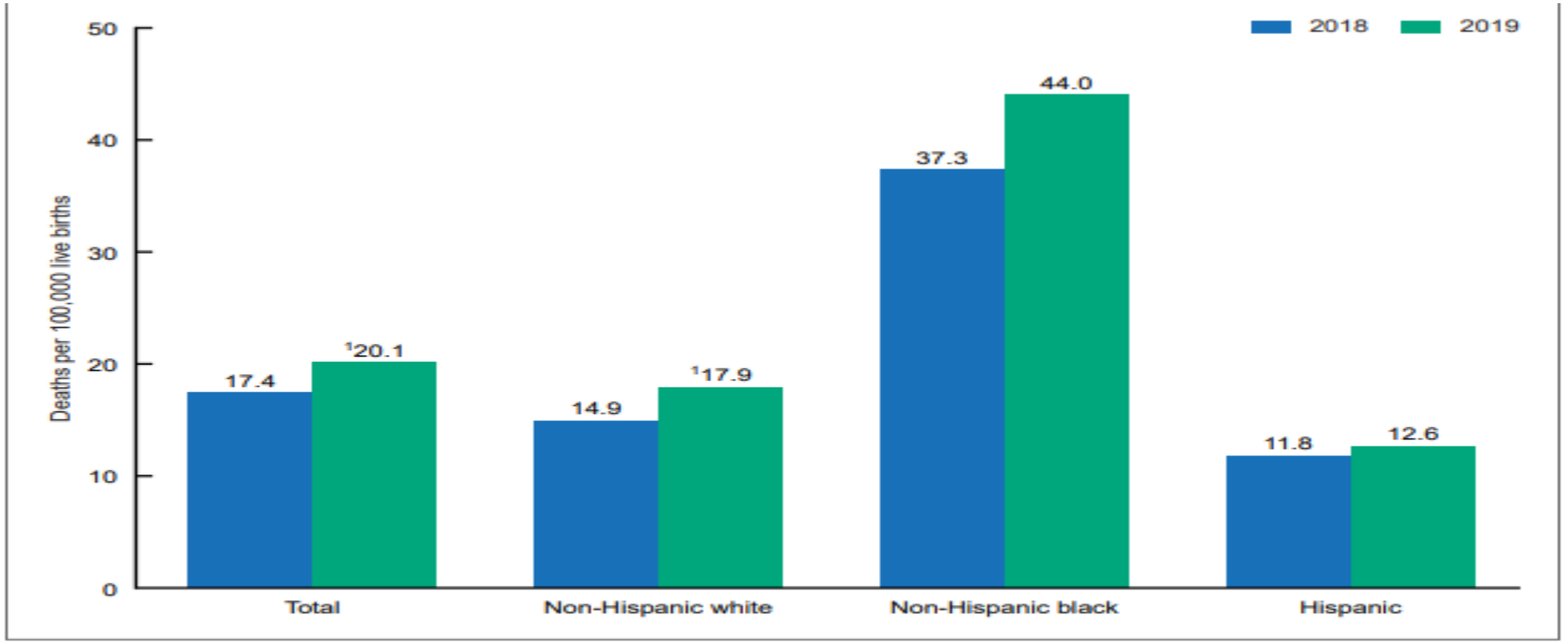
Source: Roosa Tikkanen et al., *Maternal Mortality and Maternity Care in the United States Compared to 10 Other Developed Countries* (Commonwealth Fund, Nov. 2020). https://doi.org/10.26099/411v-9255

Sexual and Reproductive Health and Research. Maternal mortality: Levels and trends 2000 to 2017. Edited by WHO, UNICEF, UNFPA, UN and WORLD BANK, Pg 104, **ISBN:** 9789241516488

National Center for Health Statistics

Froedtert & Medical College of Wisconsin

First Data Released on Maternal Mortality in Over a Decade



†Statistically significant increase in rate from 2018 to 2019 ($p < 0.05$).
NOTE: Race groups are single race.
SOURCE: National Center for Health Statistics, National Vital Statistics System, Mortality.

Figure 1. Hoyert DL. Maternal mortality rates in the United States, 2019. NCHS Health E-Stats. 2021. DOI: https://doi.org/10.15620/cdc:103855external icon.

Cardiovascular maternal mortality significant problem in the US

-Much of the previous reported temporal increase in US maternal mortality is thought to be related to differences in data collection

-US maternal mortality is worse than other developed countries

-Etiology of maternal mortality is not as specifically defined under the new reporting system

- There is significant racial disparity in US maternal mortality rates. These differences persist despite the change in reporting system

Froedtert & Medical College of Wisconsin

The 40 week stress test…

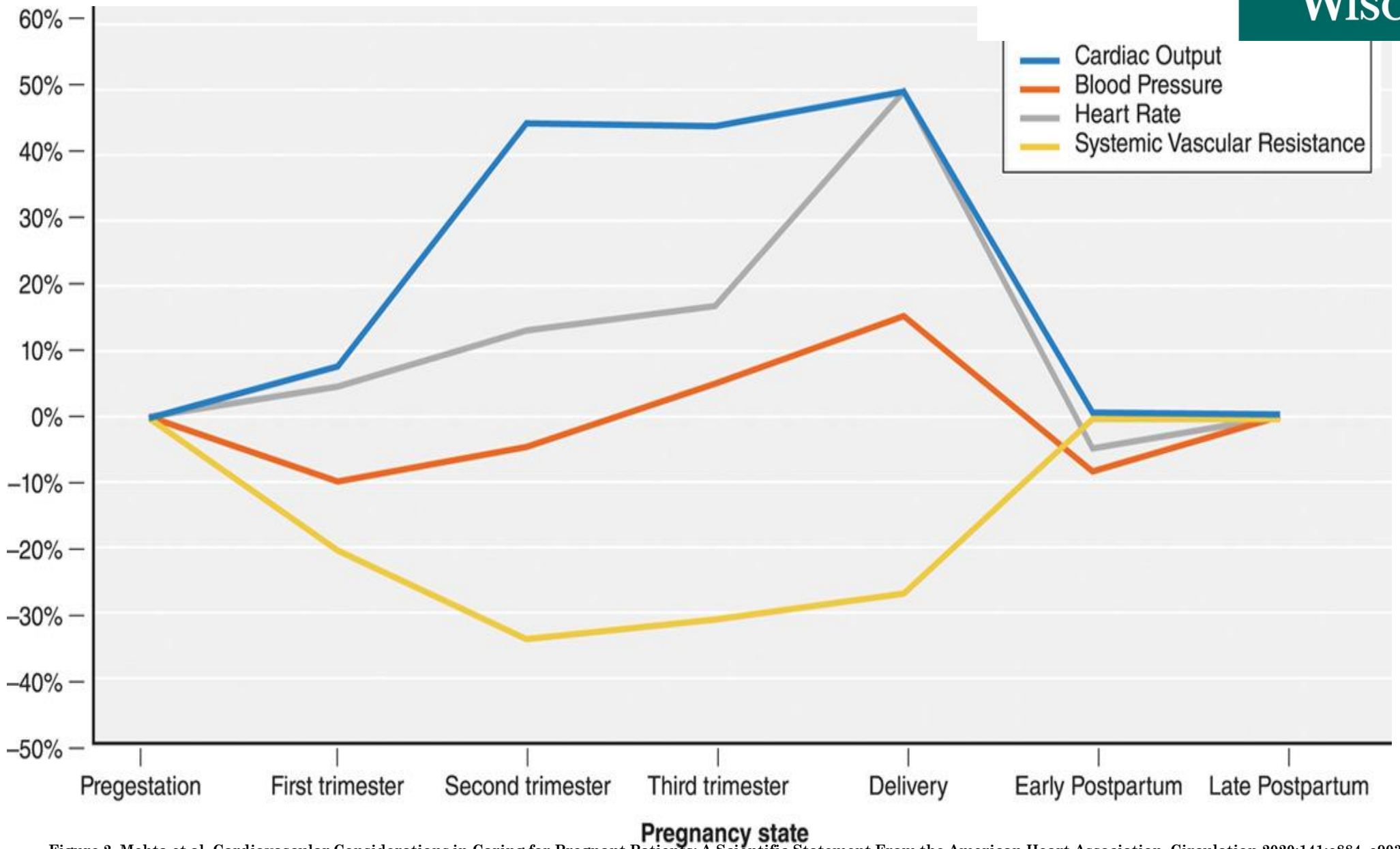


Figure 2. Mehta et al. Cardiovascular Considerations in Caring for Pregnant Patients: A Scientific Statement From the American Heart Association. Circulation.2020;141:e884–e903
ACOG Practice Bulletin No. 212: pregnancy and heart disease. *Obstet Gynecol*. 2019;133:e320–e356.

	1st Trimester	2nd Trimester	3rd Trimester	During Labor	Early Postpartum *(<3 Months)*	Late Postpartum *(3-6 Months)*
Cardiac Output	↑	↑	↑	↑	↔	↔
Blood Pressure	↓	↓	↑	↑	↓	↔
Heart Rate	↑	↑	↑	↑	↓	↔
Systemic Vascular Resistance	↓	↓	↓	↓	↑	↔

Supplementary Table 1. . Mehta et al. Cardiovascular Considerations in Caring for Pregnant Patients: A Scientific Statement From the American Heart Association. Circulation.2020;141:e884–e903

Froedtert & Medical College of Wisconsin

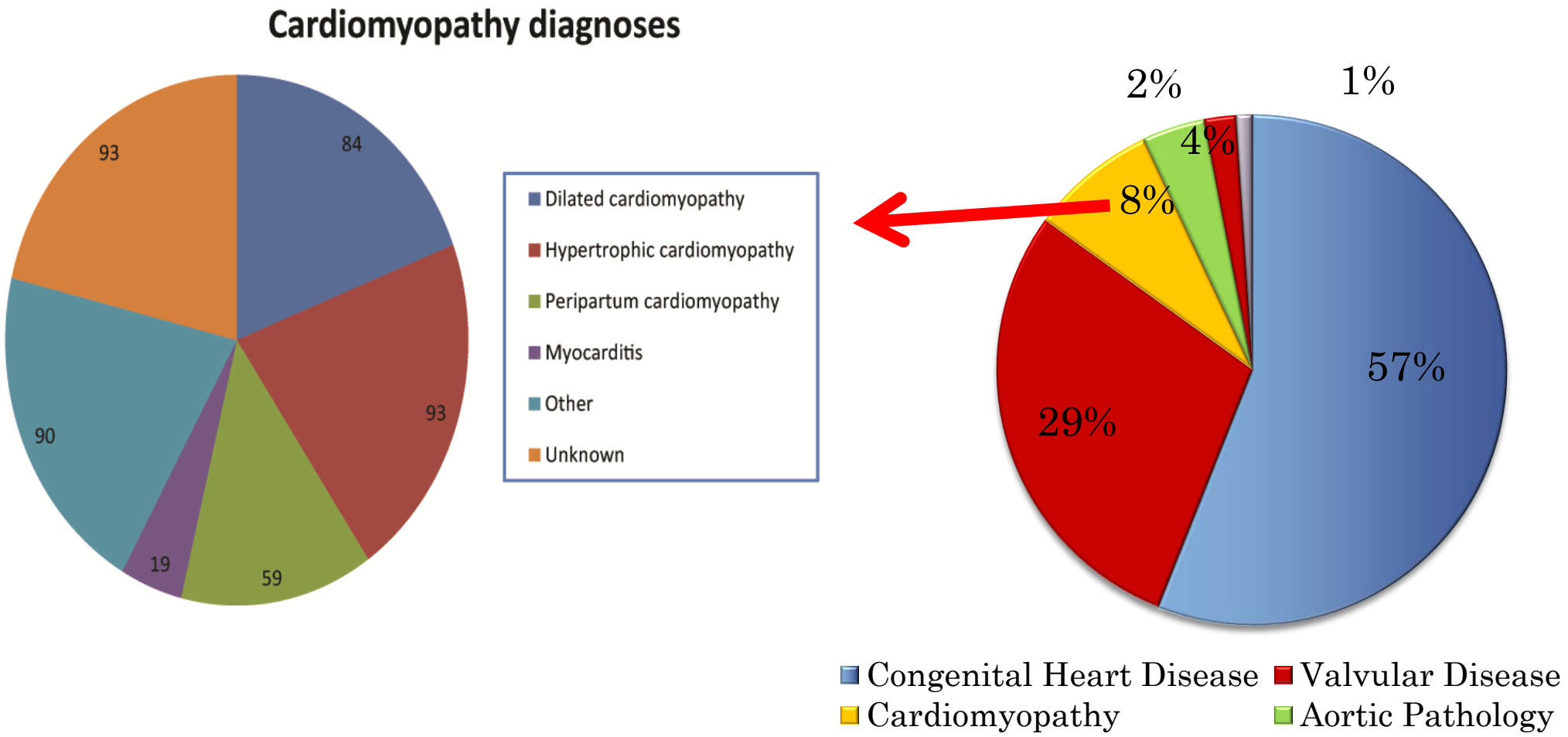
Where do we get our data on pregnant women with cardiac conditions?

European Society of Cardiology (ESC) Registry on Pregnancy and Cardiac disease (ROPAC)

- ROPAC started in 2007 – patient level data on total of 5739 pregnancies
  - 60% of pts were from developed countries (primarily Europe but some in US)
- Major Findings: Maternal Cardiovascular disease complicates 1-4% of pregnancies
- CV disease responsible for 15% of maternal perinatal mortality (WHO 2019)

Roos-Hesselink, et al. Pregnancy outcomes in Cardiovascular Disease: evolving trends over 10 years in the ESC Registry of Pregnancy and Cardiac Disease. EHJ. Pg 3348-3855. March 2019.

ROPAC: CV Disease in Pregnancy



Roos-Hesselink, et al. Pregnancy outcomes in Cardiovascular Disease: evolving trends over 10 years in the ESC Registry of Pregnancy and Cardiac Disease. EHJ. Pg 3348-3855. March 2019.

Outcomes

- Maternal mortality and/or heart failure occurred in 629 pregnancies
  - Maternal death in 34 women (0.6%)
    - 15 pts with HF (including PAH)
    - 4 pts with mechanical valve thrombosis mechanical valve thrombosis
    - 2 pts with endocarditis
    - 2 pts with primary cardiac arrest
- Heart failure complicated 611 pregnancies (11%)
- In women with a mechanical valve, 22 (7%) pregnancies were complicated by valve thrombosis, which was lethal in four (18%).
- Aortic dissection occurred in four pts (1.8%)*, at a mean of 34 weeks gestation.

Roos-Hesselink, et al. Pregnancy outcomes in Cardiovascular Disease: evolving trends over 10 years in the ESC Registry of Pregnancy and Cardiac Disease. EHJ. Pg 3348-3855. March 2019.

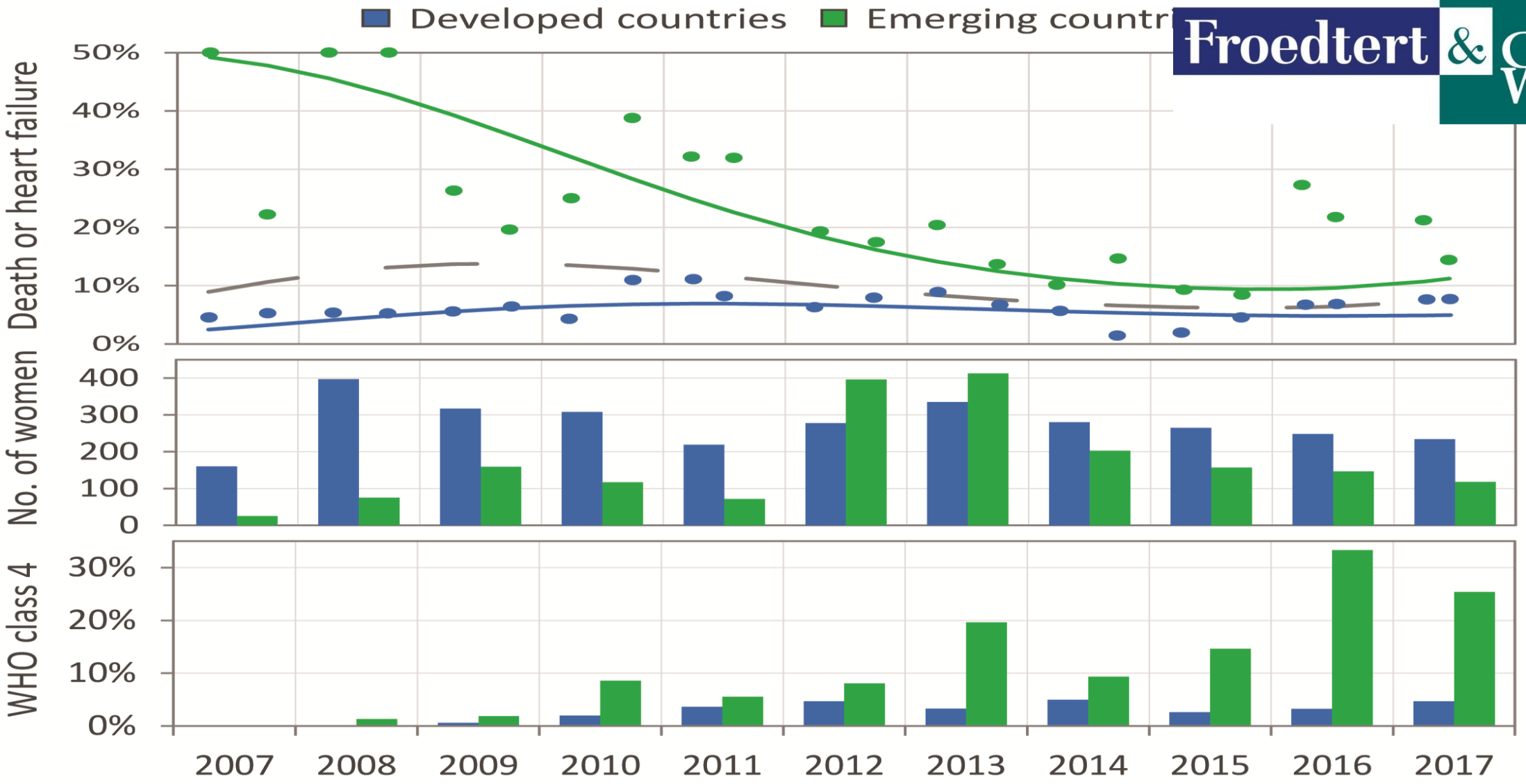
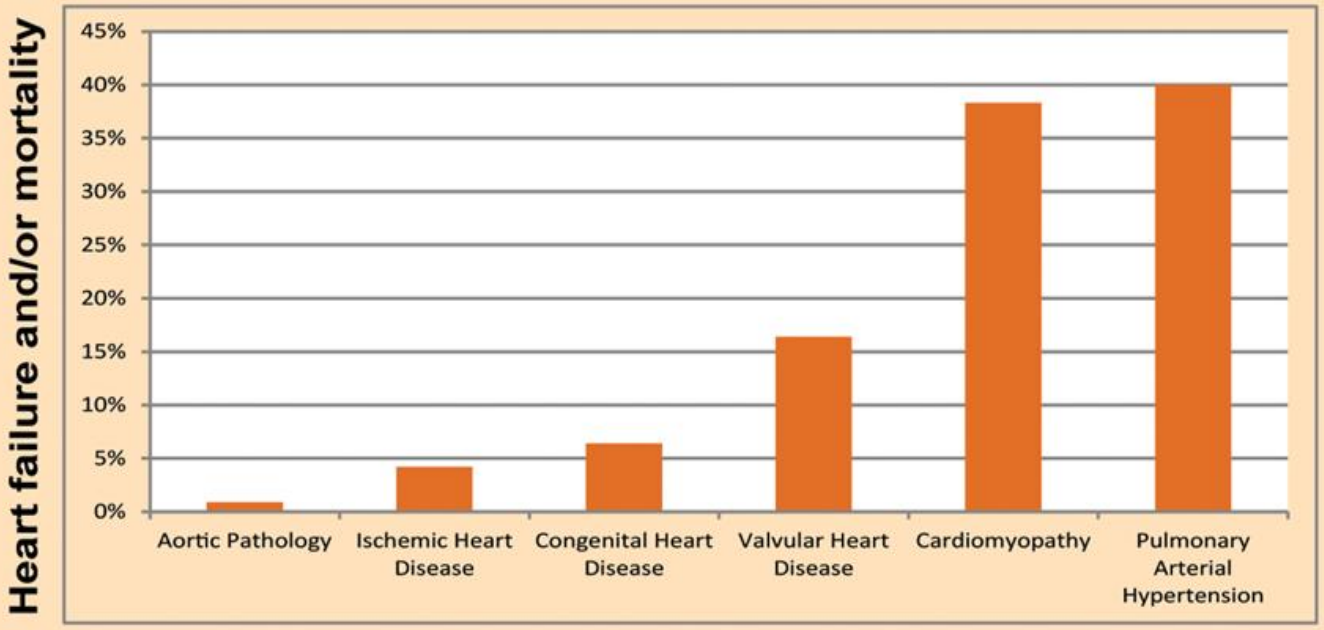
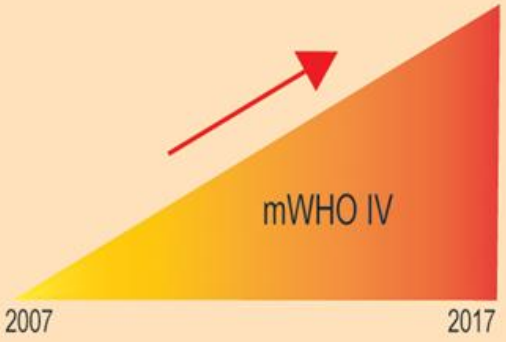


Figure S5. Trends over time in mortality/heart failure subdivided for emerging and developed countries
The trends over time in the primary endpoint, as well as the number of included pregnancies and the percentage inclusion of mWHO class IV per category in the corresponding year. The data points represent the number of death and/or heart failure per year.

Roos-Hesselink, et al. Pregnancy outcomes in Cardiovascular Disease: evolving trends over 10 years in the ESC Registry of Pregnancy and Cardiac Disease. EHJ. Pg 3348-3855. March 2019.

Registry Of Pregnancy And Cardiac disease





An increasing number of women in mWHO IV became pregnant

Pre-pregnancy risk factors
Clinical signs of heart failure
NYHA class > II
Systemic ventricular ejection fraction < 40%
mWHO class IV
Anticoagulation use

Predictors of heart failure and/or mortality

The incidence of heart failure and/or mortality decreased

Roos-Hesselink, et al. Pregnancy outcomes in Cardiovascular Disease: evolving trends over 10 years in the ESC Registry of Pregnancy and Cardiac Disease. EHJ. Pg 3348-3855. March 2019.

Obstetric and fetal outcomes

- A total of 992 pregnancies (17%) were complicated by obstetric events during pregnancy.
  - Emergency caesarean section was performed in 537 pregnancies (9%), 84 (16%) were for cardiac reasons.

- In 1186 pregnancies (21%), one or more fetal complications occurred.
  - Prematurity was particularly prevalent, complicating about 16% of pregnancies.

Roos-Hesselink, et al. Pregnancy outcomes in Cardiovascular Disease: evolving trends over 10 years in the ESC Registry of Pregnancy and Cardiac Disease. EHJ. Pg 3348-3855. March 2019.

Pre-conception risk counseling

- Only the WHO score is prospectively validated
- Pre-conception counseling should be part all routine CV visits with child-bearing aged women
- Important to counsel on potential teratogenicity of commonly used medication

Table 1: CARPREG II Risk Predictors

Predictor	Points
Prior cardiac events or arrhythmias	3
Baseline NYHA 3–4 or cyanosis	3
Mechanical valve	3
Systemic ventricular dysfunction LVEF<55 %	2
High-risk valve disease or left ventricular outflow tract obstruction (aortic valve area <1.5 cm^2, subaortic gradient >30, or moderate to severe mitral regurgitation, mitral stenosis < 2.0 cm^2)	2
Pulmonary hypertension, RVSP >49 mmHg	2
High-risk aortopathy	2
Coronary artery disease	2
No prior cardiac intervention	1
Late pregnancy assessment	1

Primary cardiac event risk: score = 1, 5 % risk, score = 2, 10 % risk, score = 3, 15 % risk, score = 4, 22 % risk and 41 % risk if score greater than 4. NYHA = New York Heart Association Functional Classification; LVEF = left ventricular ejection fraction; RVSP = right ventricular systolic pressure. Source: Silversides et al., 2018, with permissior

Silversides et al. Pregnancy Outcomes in Women with Heart Disease. JACC. 2018:2419 – 2430.

Zahara Risk Score

Predictors	Points		Total Points	Risk
Prior arrhythmias	**1.5**		**0**	**2.9%**
NYHA class ≥II	**0.75**		**0.5-1.5**	**7.5%**
Left heart obstruction (PG >50 mmHg or AVA <1 cm^2)	**2.5**		**1.51-2.50**	**17.5%**
Cardiac medication before pregnancy	**1.5**		**2.51-3.50**	**43.1%**
Systemic AV valve regurgitation	**0.75**		**>3.51**	**70%**
Pulmonary AV valve regurgitation	**0.75**			

Drenthen W, Boersma E, Balci A, et al. Predictors of pregnancy complications in women with congenital heart disease. *Eur Heart J*. 2010;31(17):2124–2132

WHO Pregnancy Risk Classification (Risk of pregnancy by medical condition)	Cardiovascular Conditions by Class

WHO Risk Class I
No detectable increased risk of maternal mortality and no or mild increase in morbidity.
	• 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

WHO Risk Class II (If otherwise well and uncomplicated) *Small increased risk of maternal mortality or moderate increase in morbidity.*	• Unoperated atrial or ventricular septal defect • Repaired tetralogy of Fallot • Most arrhythmias
WHO Risk Class II or III (Depending on individual) *Risk as indicated in Class II (above) or Class III (below).*	• Mild left ventricular impairment • Hypertrophic cardiomyopathy • Native or tissue valvular heart disease not considered WHO I or IV • Marfan syndrome without aortic dilatation • Aorta <45 mm in aortic disease associated with bicuspid aortic valve • Repaired Coarctation
WHO Risk Class III *Significantly increased risk of maternal mortality or severe morbidity. Expert counseling required. If pregnancy is decided upon, intensive specialist cardiac and obstetric monitoring needed throughout pregnancy, childbirth and the puerperium.*	• Mechanical valve • Systemic right ventricle • Fontan circulation • Cyanotic heart disease (unrepaired) • Other complex congenital heart disease • Aortic dilatation 40-45 mm in Marfan Syndrome • Aortic dilatation 45-50 mm in aortic disease associated with bicuspid aortic valve
WHO Risk Class IV (Pregnancy contraindicated) *Extremely high risk of maternal mortality or severe morbidity; pregnancy contraindicated. If pregnancy occurs termination should be discussed. If pregnancy continues, care as for class III.*	• Pulmonary arterial hypertension of any cause • Severe systemic ventricular dysfunction (LVEF <30%, NYHA III-IV)* • Previous peripartum cardiomyopathy with any residual impairment of left ventricular function • Severe symptomatic mitral or aortic stenosis • Marfan syndrome with aorta dilated >45 mm • Aortic dilation >50 mm in aortic disease associated with bicuspid aortic valve • Native severe Coarctation

Regitz-Zagrosek V, Blomstrom Lundqvist C, Borghi C, et al. ESC Guidelines on the management of cardiovascular diseases during pregnancy: The task force on the management of cardiovascular diseases during pregnancy of the European Society of Cardiology (ESC). European Heart Journal. 2011;32(24):3147-3197

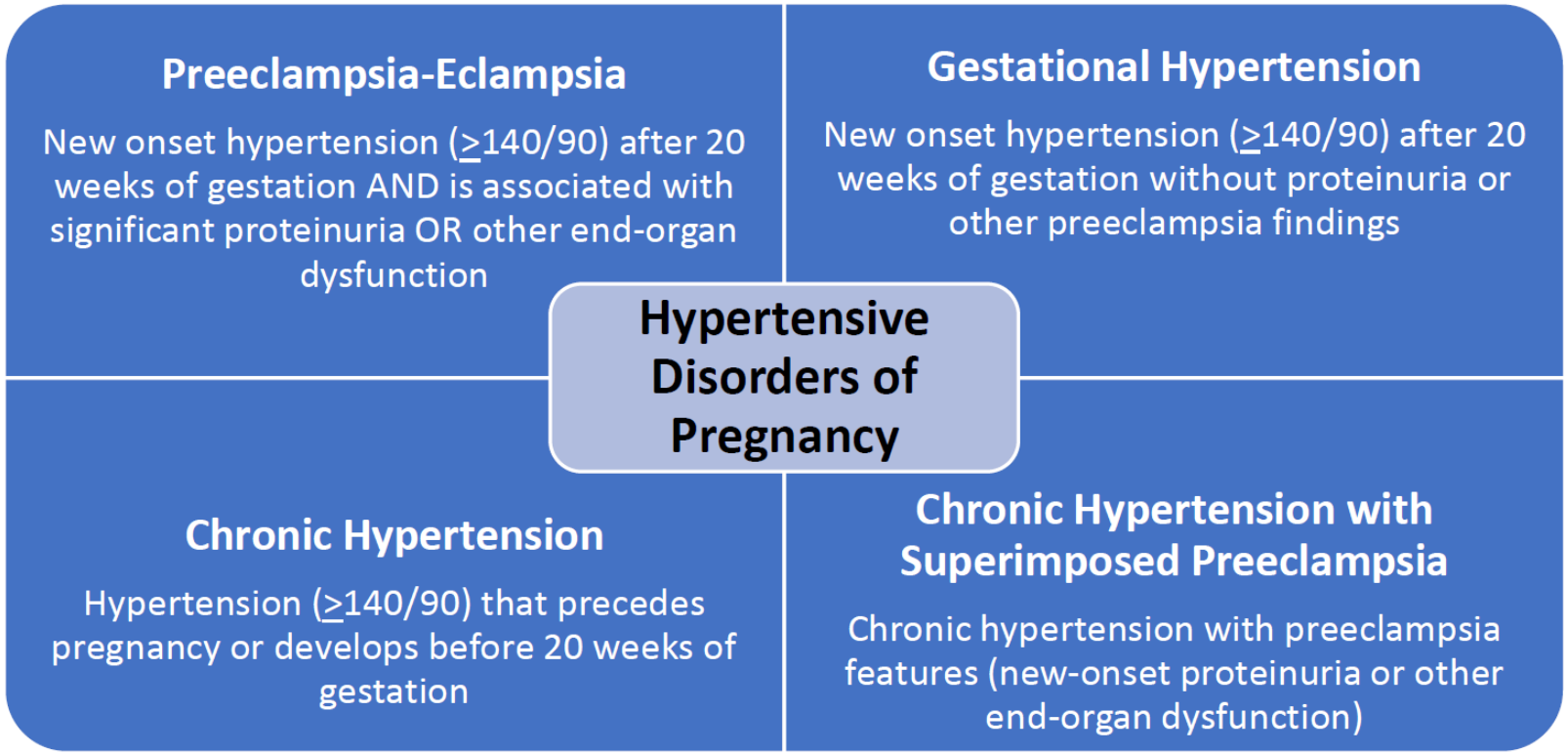
Pre-conception counseling case:

- Pt is a nulliparous 33 year old female who presents to discuss her cardiac risk during a pregnancy. She has a past cardiac history of known bicuspid aortic valve. Her last transthoracic echocardiogram, which was completed about 6 months prior to conception, showed that her AVA by continuity is 1.4 cm2, she has moderate aortic regurgitation. There were no other significant findings. A cardiac MRI done within the past 6 months, shows that her ascending aorta is 3.6 cm in maximum linear diameter (BSA 1.9). She is NYHA Class 1 and on no cardiac medications.
- CARPREG II- risk score =3, 15% risk of pregnancy complication (LV obstruction and no prior CV intervention)
- ZAHARA – risk score 0.75 (systemic valve regurgitation) = 7.5% risk of pregnancy complication
- WHO = II/III (non-severe native valve disease, aorta < 45 mm in bicuspid valve)= moderately increased risk, recommend specialist care.

Froedtert & Medical College of Wisconsin

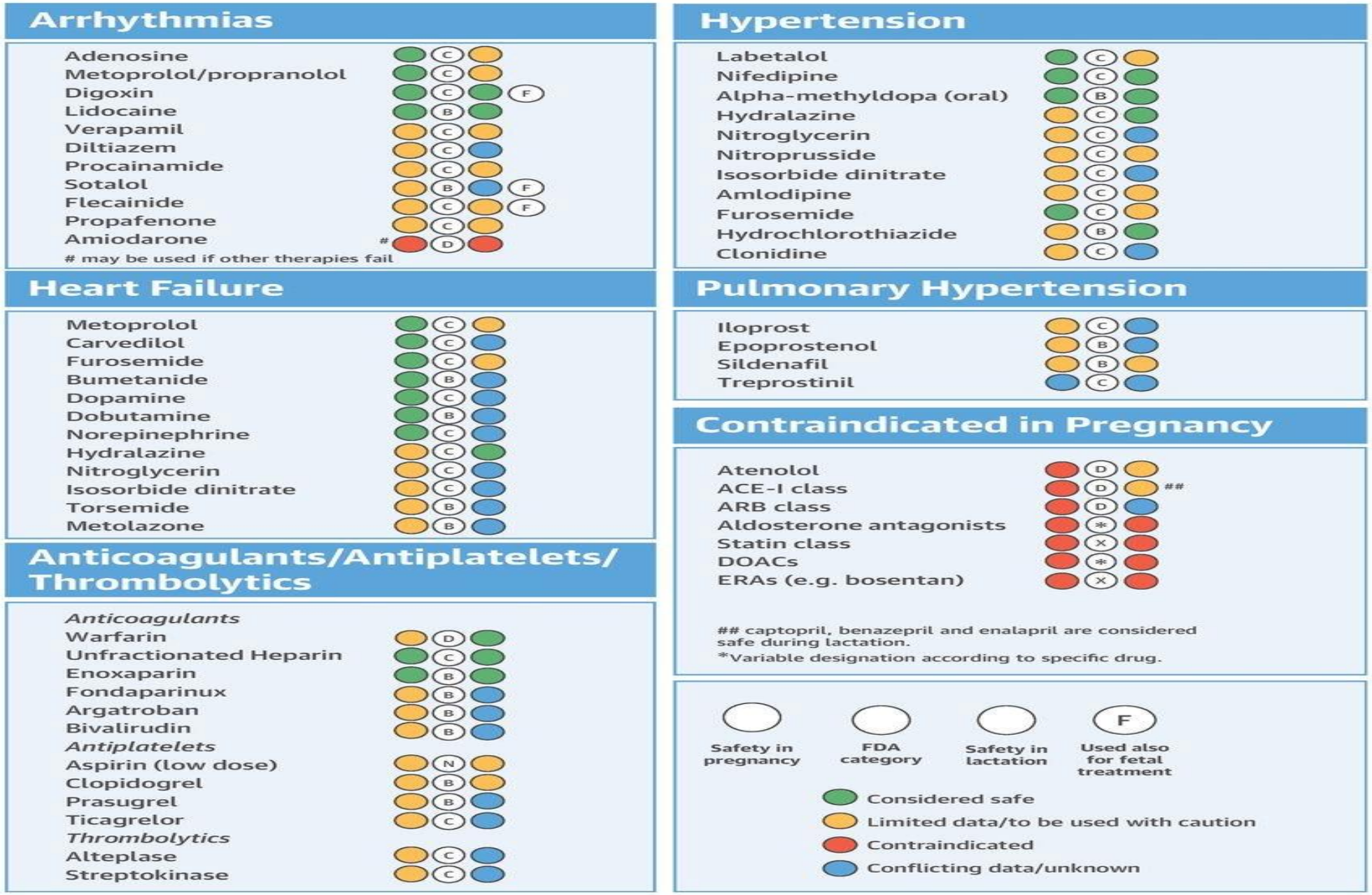
Common Cardiovascular Conditions in Pregnancy

Hypertensive Disorders of Pregnancy



Supplementary Figure 1. Mehta et al. Cardiovascular Considerations in Caring for Pregnant Patients: A Scientific Statement From the American Heart Association. Circulation.2020;141:e884–e903

CENTRAL ILLUSTRATION: Cardiovascular Medications in Pregnancy



Halpern, D.G. et al. J Am Coll Cardiol. 2019;73(4):457–76.

Arrhythmias in Pregnancy

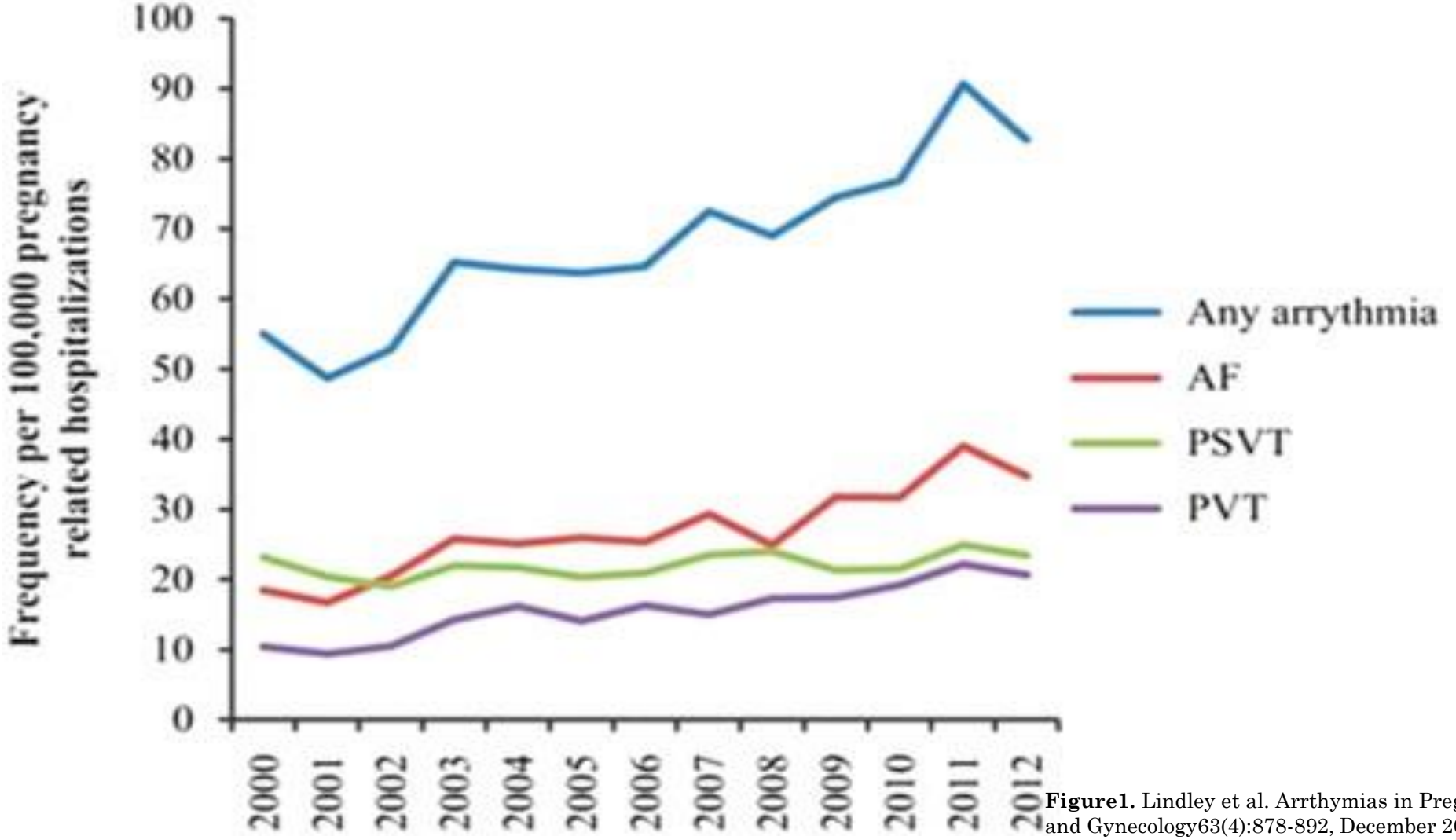


Figure1. Lindley et al. Arrthymias in Pregnancy. Clinical Obstetrics and Gynecology63(4):878-892, December 2020

Arrhythmias in Pregnancy Management

- PACs/PVCs – beta-blockade for severe symptoms
- SVTs
  - Most common: 24 per 100,000 pregnancy related hospital admissions
  - 20% pre-existing that will have an exacerbation
  - Adenosine is OK for pregnant patients
- Afib/Aflutter
  - Less common than AVNRT
  - Hx of PAF→ more than 50% will have exacerbation
  - Anticoagulation: CHADSVASC ?

Lindley et al. Arrthymias in Pregnancy. Clinical Obstetrics and Gynecology63(4):878-892, December 2020

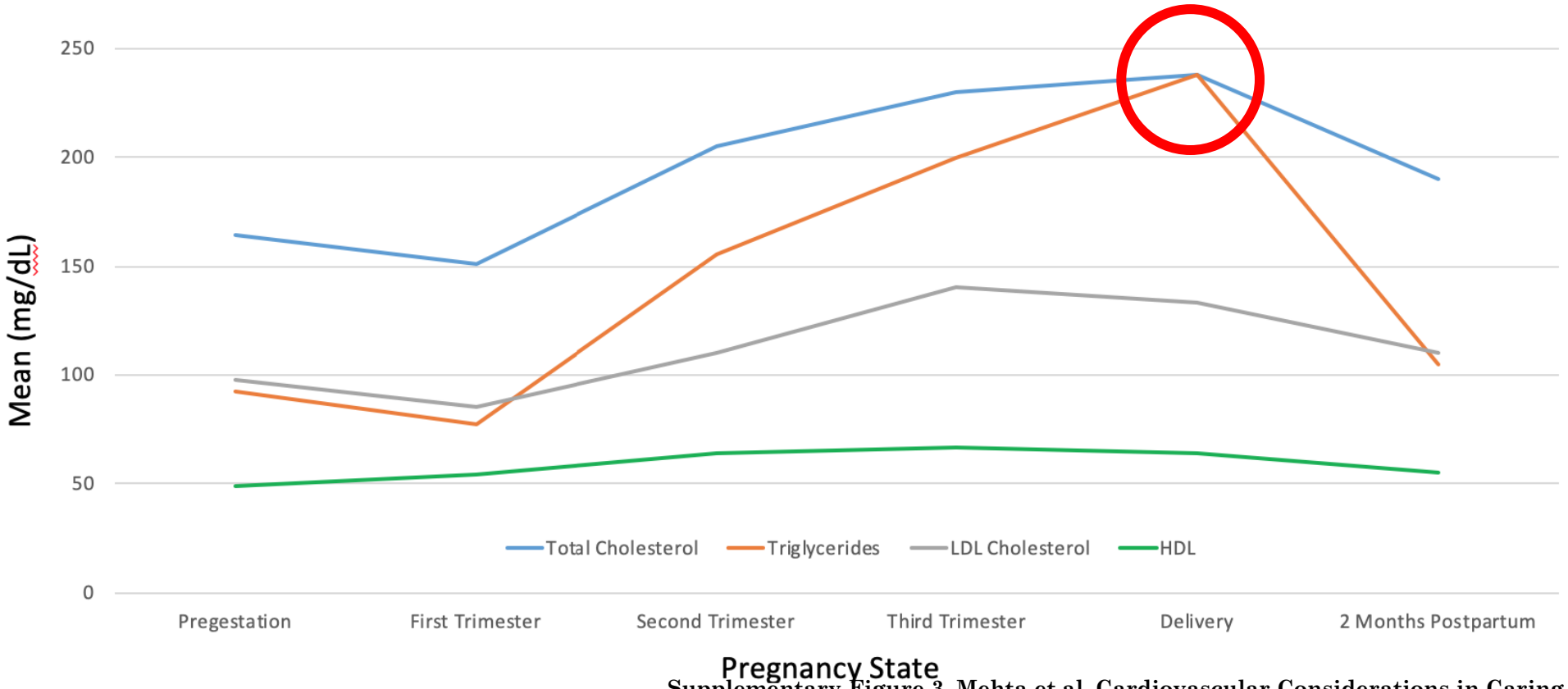
Supplemental Table 6: Recommendations for antiarrhythmic treatmen

based on the underlying arrhythmia.[21, 22]

	First line	Second line or if needed	Third line or if needed
AVNRT	Vagal maneuvers	IV adenosine	Beta-blocker
AVRT	Beta-blocker	IV Procainamide	
Atrial flutter	Beta-blocker	Catheter ablation	
Atrial fibrillation	Beta-blocker		
CPVT	Beta-blocker		
Long QT	Beta-blocker		
Long term management VT	Beta-blocker	ICD	
Stable monomorphic VT	Sotalol	IV Procainamide	Catheter ablation
Unstable monomorphic VT	DCCV	Amiodarone	DCCV ± amiodarone
Ventricular fibrillation	DCCV	ICD	

Supplementary Table 6. Mehta et al. Cardiovascular Considerations in Caring for Pregnant Patients: A Scientific Statement From the American Heart Association. Circulation.2020;141:e884–e903

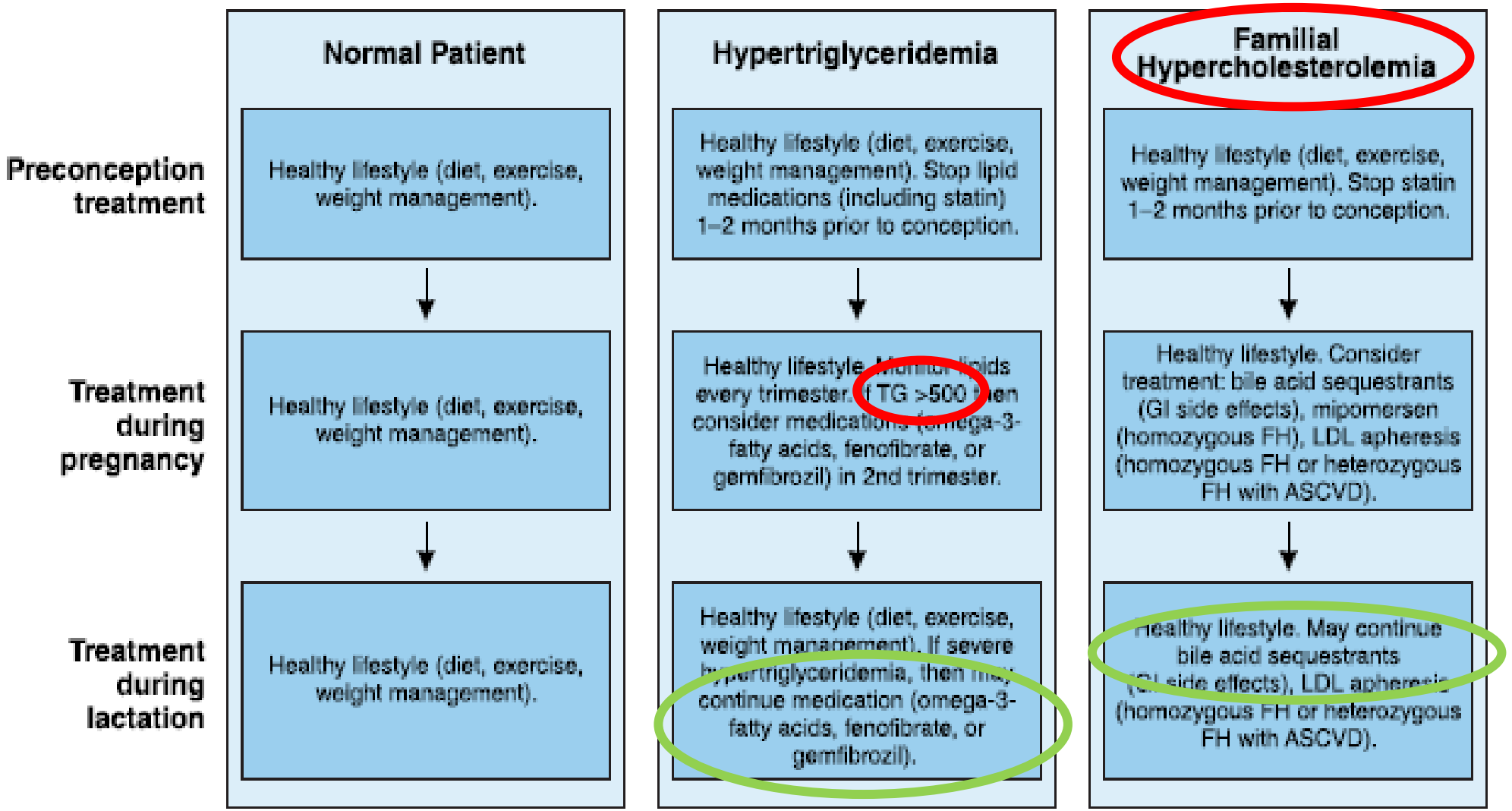
Lipids and Pregnancy



Supplementary Figure 3. Mehta et al. Cardiovascular Considerations in Caring for Pregnant Patients: A Scientific Statement From the American Heart Association. Circulation.2020;141:e884–e903

Froedtert & Medical College of Wisconsin

Supplemental Figure 4: Management of lipid disorders during pregnancy.[4, 5]



Supplementary Figure 4. Mehta et al. Cardiovascular Considerations in Caring for Pregnant Patients: A Scientific Statement From the American Heart Association. Circulation.2020;141:e884–e903

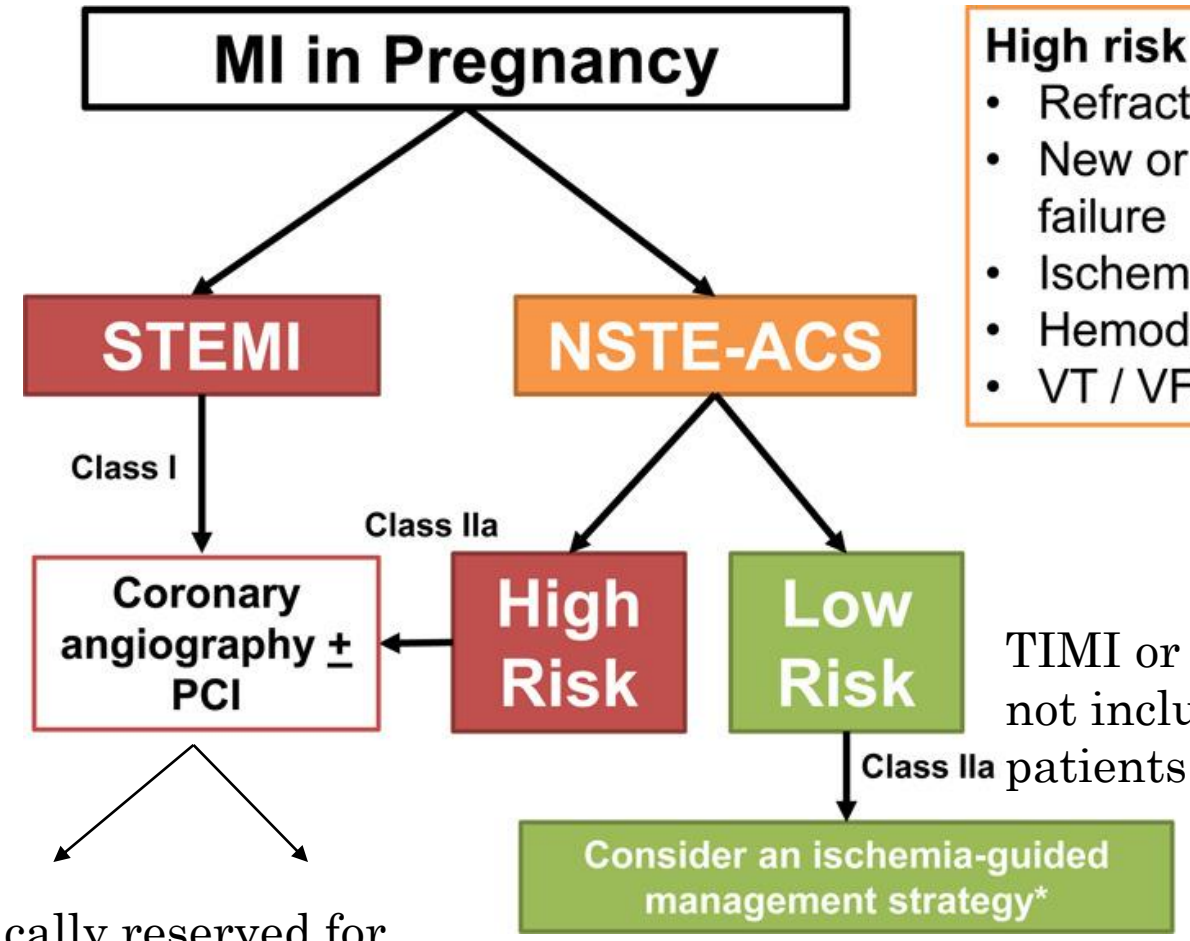
Pregnancy Associated Myocardial Infarction (PAMI)

- (PAMI) accounts for over 20% of maternal cardiac deaths → 2.8 to 8.1 per 100 000 deliveries
  - 4-fold higher than age matched women

- Case fatality rate is 5%
  - Higher than MI fatality for non pregnant age matched women

- Presentation:
  - 75% STEMI
  - 38% CV shock
  - 12% V arrhythmias

Tweet et al. Pregnancy – Associated Myocardial Infarction: Prevalence, Causes and Interventional Management. Circulation: Cardiovascular Interventions. 2020;13:e008687



High risk NSTE-ACS:

- Refractory angina
- New or worsening heart failure
- Ischemic mitral regurgitation
- Hemodynamic instability
- VT / VF

TIMI or Grace Score – did not include pregnant patients

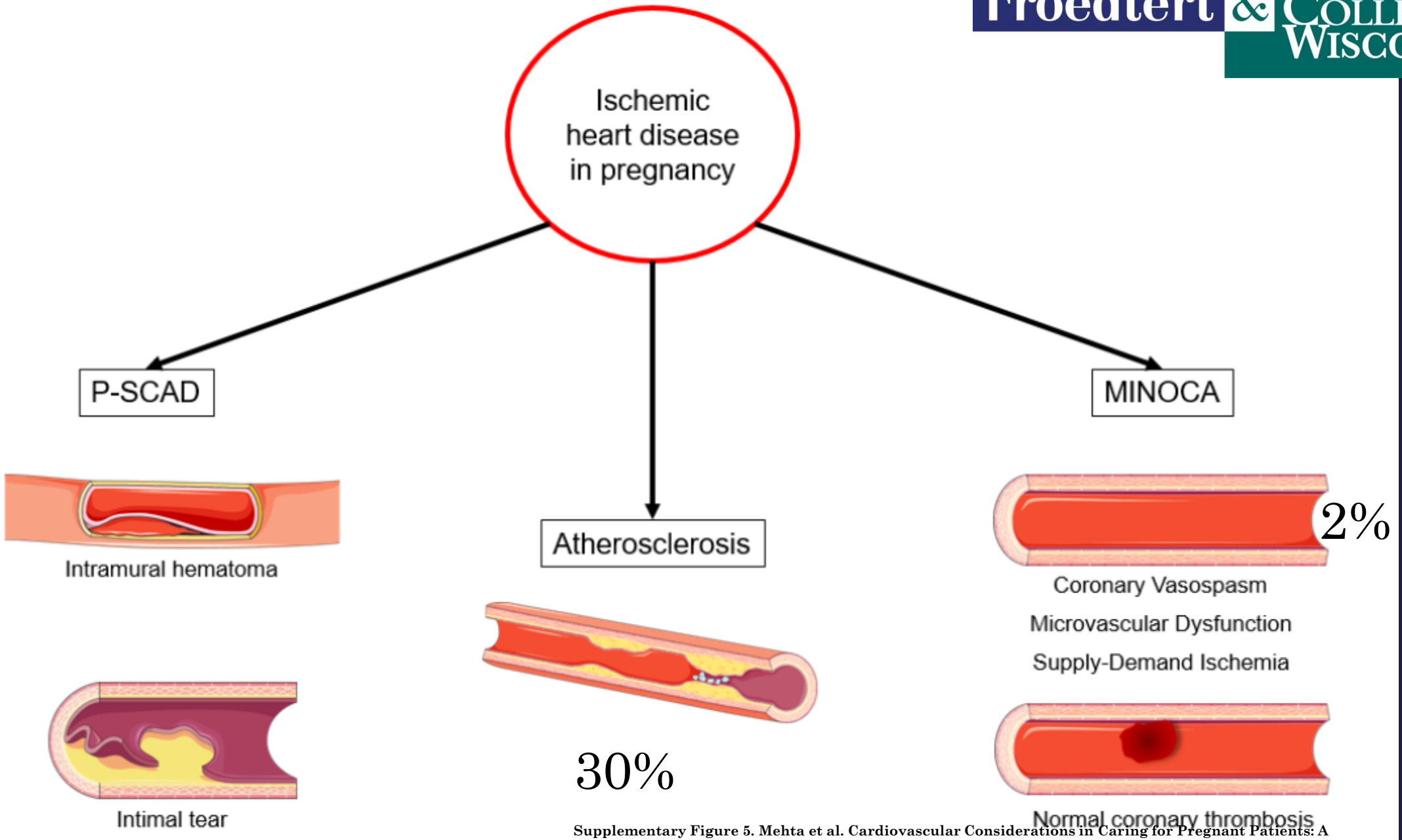
Stenting typically reserved for atherosclerotic lesions or very high risk SCAD. In general, DES are preferred in the first 2 trimesters, whereas bare-metal coronary stent or DES may be reasonable in the third trimester

Figure 6. Tweet et al. Pregnancy – Associated Myocardial Infarction: Prevalence, Causes and Interventional Management. Circulation: Cardiovascular Interventions. 2020;13:e008687

	Normal Changes in Cardiac Exam and Testing during Pregnancy and Delivery	Abnormal Cardiac Exam and Pregnancy and Delivery
Symptoms	• Dyspnea is reported in up to 76% by 3rd trimester • Reduction in exercise tolerance, palpitations, and light-headedness are commonly reported	• Chest pain, pressure, or discomfort • Dyspnea out of proportion to pregnancy, especially if occurs or worsens suddenly • Associated pain radiating to arms, shoulder, or jaw, diaphoresis, nausea, or vomiting
Physical exam	• Normal or mild jugular venous distension • Soft, mid-systolic flow murmur • Widely split S1, loud S3 • Cervical venous hum	• Prominent jugular venous distension • Holosystolic murmur at apex • Diastolic murmur • Fixed split S2, S4 • Pulmonary rales
Electrocardiogram	• Q waves in leads III and aVF • T wave inversions in leads III, V1 – V3 • Transient ST depressions with cesarean delivery	• ST elevations • ST depressions that are persistent or occur in the setting of chest pain • T wave inversions, especially if deep and/or present in leads other than V1 – V3
Cardiac Biomarkers	• Levels generally peak at 24 hours after delivery • CK and CKMB can double after delivery and may exceed ULN • High sensitivity TnT can be elevated after uncomplicated deliveries in a minority of women • Preeclampsia and gestational HTN can be associated with increases in TnI and TnT	• Elevated biomarkers in the setting of new symptoms, especially if not occurring immediately after delivery, if elevation is more than mild, or if the levels increase on serial measurements

4%

Figure 2. Tweet et al. Pregnancy – Associated Myocardial Infarction: Prevalence, Causes and Interventional Management. Circulation: Cardiovascular Interventions. 2020;13:e008687



Supplementary Figure 5. Mehta et al. Cardiovascular Considerations in Caring for Pregnant Patients: A Scientific Statement From the American Heart Association. Circulation.2020;141:e884–e903

Tweet et al. Pregnancy – Associated Myocardial Infarction: Prevalence, Causes and Interventional Management. Circulation: Cardiovascular Interventions. 2020;13:e008687

Differential Diagnosis of PAMI

- Aortic dissection
  - Connective tissue disease: Marfan, LD, EDS IV, Turner Syndrome, BAV
- Pulmonary Embolism
- Takotsubo Cardiomyopathy – About 2% of a recent cohort
- PPCM
- Myocarditis
- Pre-eclampsia

Tweet et al. Pregnancy – Associated Myocardial Infarction: Prevalence, Causes and Interventional Management. Circulation: Cardiovascular Interventions. 2020;13:e008687

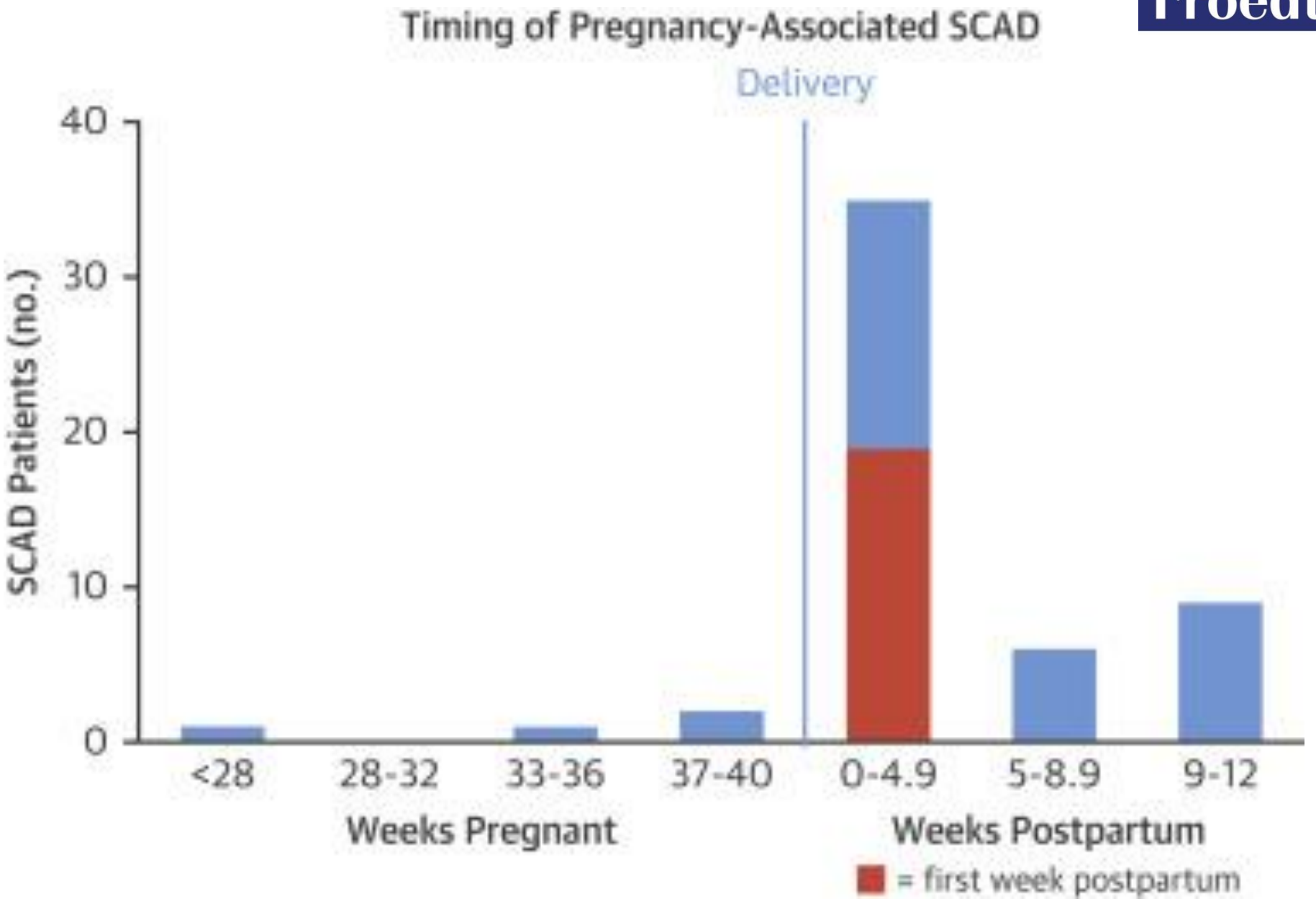


Figure 1. Tweet et al. Spontaneous coronary artery dissection associated with pregnancy. JACC. 2017; 70 (4): 426-435

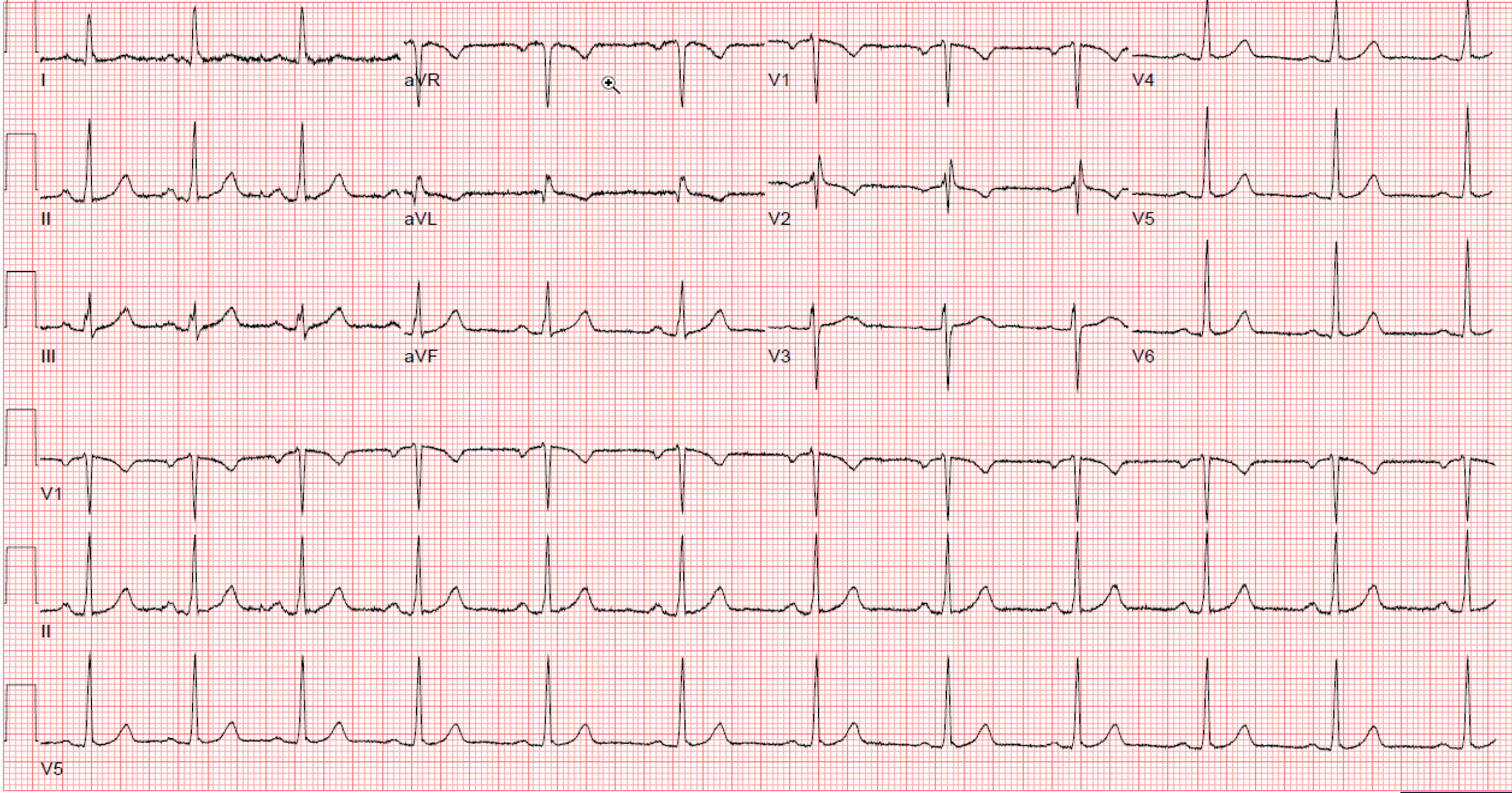
SCAD Case

- 33 yo G1P0 at 35 weeks gestation presenting with chest pain. PMH includes previous two prior SCAD events with PCI to LAD, RCA treated conservatively. PMH includes FMD and history of tobacco abuse.

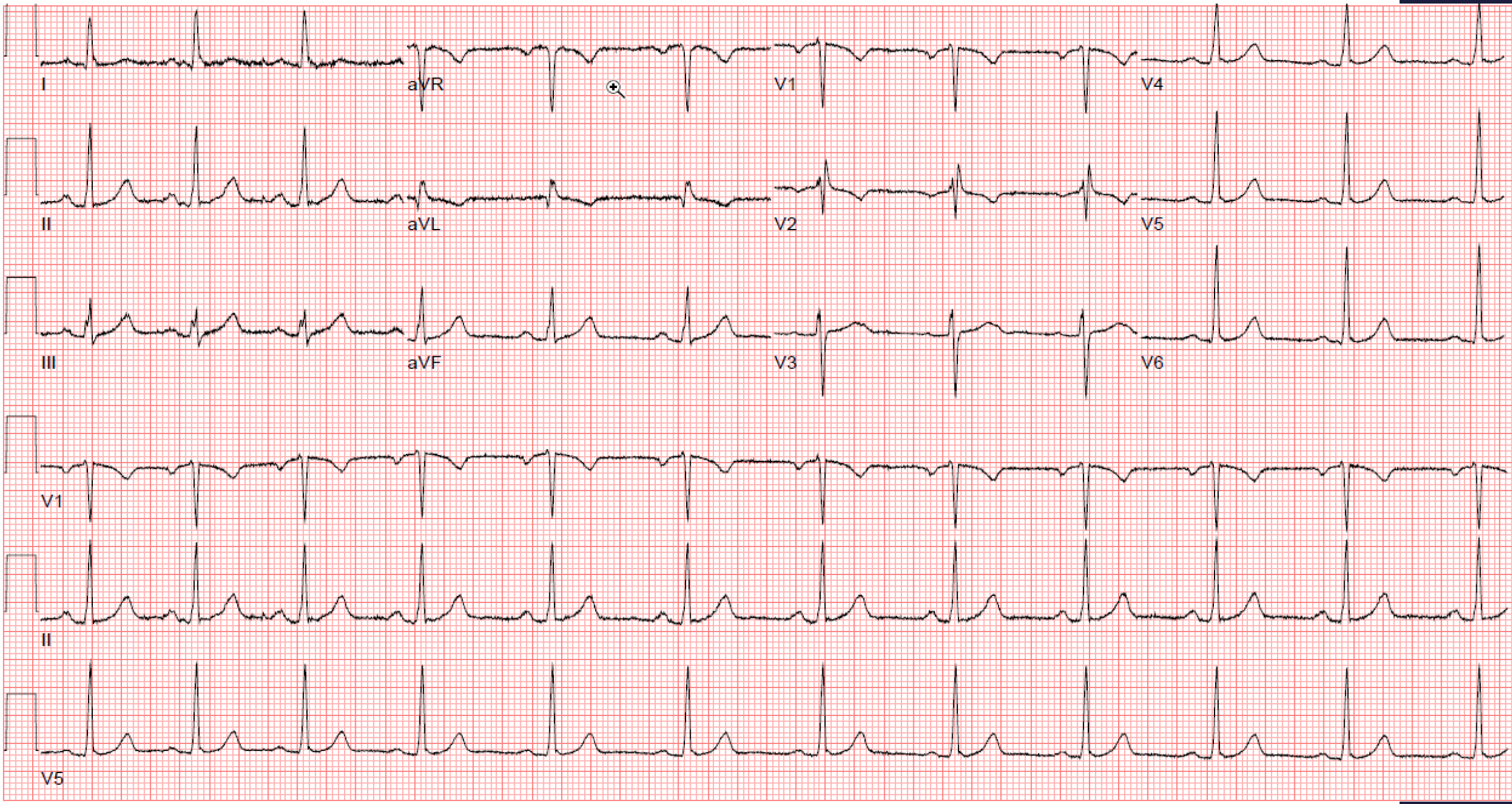
- Chest pain started while bending over, persistent to ER presentation. Some associated nausea.

- PTA medications: ASA 81 mg, Plavix 75 mg, Metoprolol tartrate 25 mg BID.

- Most recent echocardiogram: 2020- normal LVEF no significant regional dysfunction.

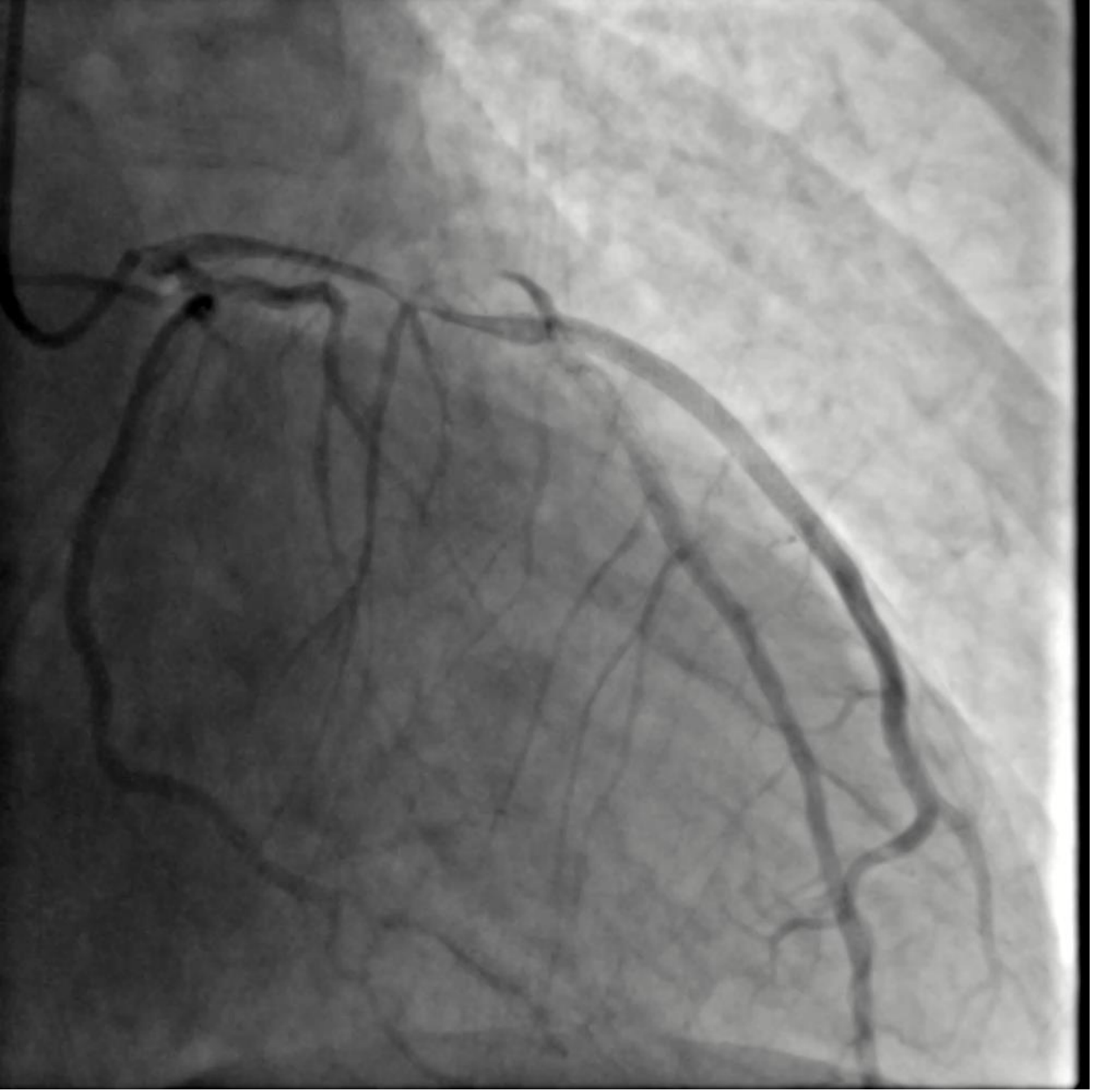


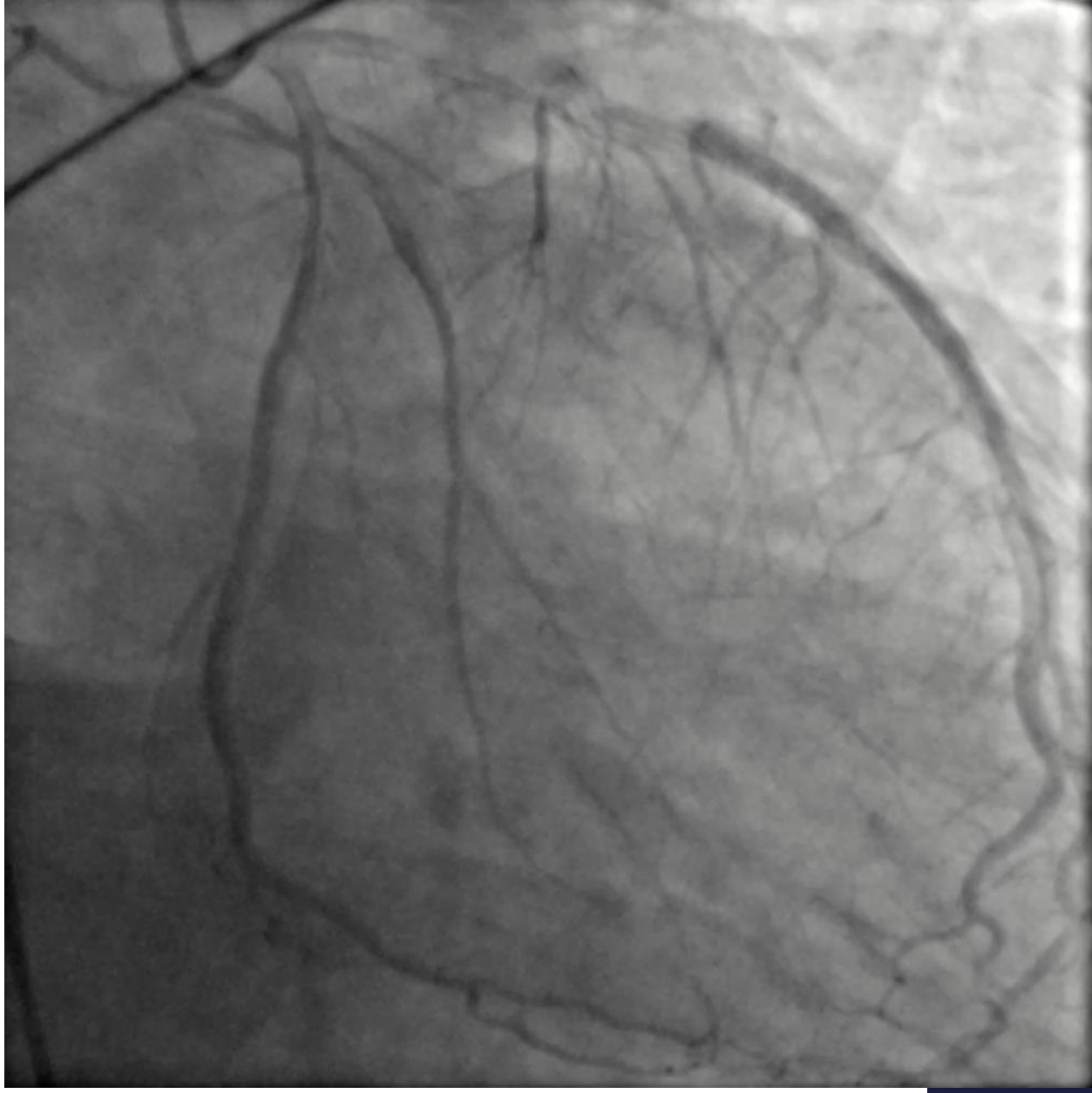
EKG – ER intake


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
II
V5

What are the next steps?

Delivery now or later? Mode of delivery?





Standard of care for the non-pregnant patient with MI should be standard of care for the pregnant patient

Medication	Use during pregnancy?	Pregnancy Notes	Use during lactation?
Aldosterone antagonists	No.	Crosses the placenta, feminization of the male fetus.	Yes
ACE inhibitors/ARBs	No.	Contraindicated in pregnancy due to intrauterine growth restriction, decreased fetal renal function, lung hypoplasia, skeletal malformations, and oligohydramnios (Class X).	Enalapril or captopril are preferred, would NOT use ARBs.
Aspirin	Yes.	The 325 mg daily may be utilized until 32 weeks gestation due to concern for premature closure of the fetal ductus arteriosus. However, the 81mg formulation may be used at any time during gestation and does not require discontinuation prior to delivery. Higher doses (>180 mg) are associated with increased bleeding, birth defects, premature closure of patent ductus arteriosus, intrauterine growth restriction, birth defects, and fetal mortality.	Yes (81mg/day).
Beta-blockers	Yes.	Beta blockers such as metoprolol, labetalol, carvedilol are variably associated with fetal growth restriction (Class C). Nonselective beta-blockers can increase uterine activity. Atenolol crosses the placental and can cause fetal bradycardia, hypoglycemia, intrauterine growth restriction, birth defects, apnea (Class D).	Yes.
Bivalrudin	If needed.	Limited data and may cause maternal and fetal adverse effects.	Unknown.
Calcium Channel Blockers (CCB)	If needed.	All but diltiazem cross the placenta, but diltiazem is associated with adverse fetal effects in animal studies. Associated with pre-maturity, intrauterine growth restriction, fetal bradycardia. Useful for hypertension, ischemic symptoms (amlodipine) and atrial fibrillation when there are contraindications to beta-blockers but important to avoid hypotension.	Nifedipine considered safe, otherwise unknown as CCB transfer to milk.
Clopidogrel	Yes.	Clopidogrel (Class B) may be used during pregnancy but must be discontinued 5-7 days prior to delivery if neuraxial anesthesia is planned. Case reports and post marking surveillance demonstrates increased bleeding risk at delivery without other noted risks.	Unknown.
Fibrinolytics	If needed.	Limited data. Unknown if it crosses the placenta with isolated case reports of use.	Unknown.
Glycoprotein IIb/IIIa inhibitors	If needed.	Limited information in pregnancy with isolated case reports of use.	Unknown.
Heparin/low-molecular weight heparin	Yes.	Does not cross the placenta. Well studied without significant risks, Class C for unfractionated heparin, Class B for enoxaparin.	Yes.
Isosorbide dinitrate	Yes.	Limited information in pregnancy with isolated case reports of safety (Class B).	Unknown.
Nitroglycerin	Yes.	Risk of hypotension and uterine and placental hypoperfusion (Class C).	Yes.
Direct-acting oral anticoagulants	No.	Crosses the placenta with potential for placental and fetal bleeding.	Unknown.
Statins	No.	Risk of congenital anomalies (Class X).	Unknown.
Warfarin	Yes.	Risk of embryopathy is reduced at doses ≤5 mg/day. If requiring higher doses, use heparin for first 12 weeks.	Yes.

Figure 7. Tweet et al. Pregnancy – Associated Myocardial Infarction: Prevalence, Causes and Interventional Management. Circulation: Cardiovascular Interventions. 2020;13:e008687

Timing of Delivery (PAMI)

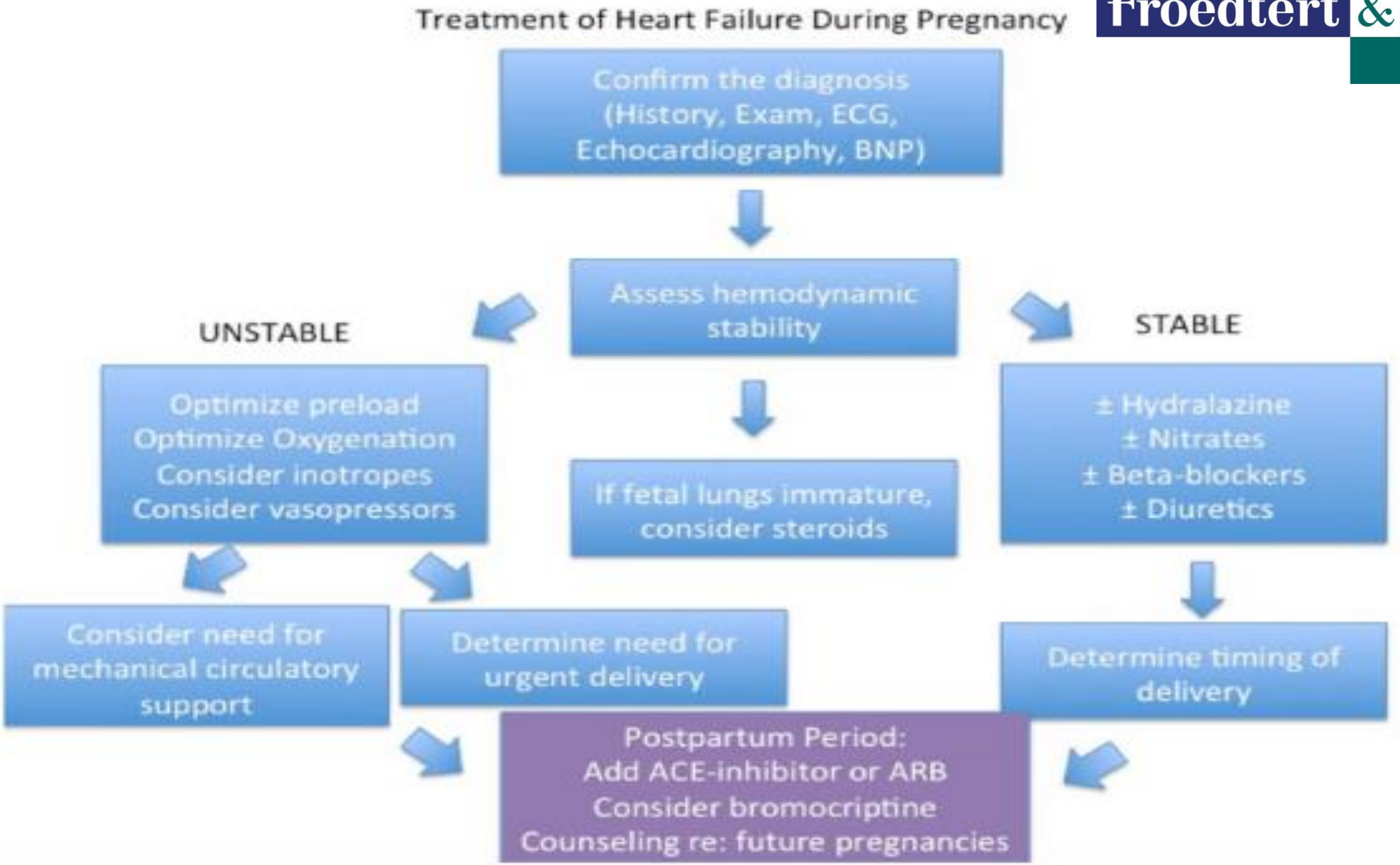
- DAPT cessation of the P2Y12 inhibitor (eg, clopidogrel) at about 7 days before neuraxial anesthesia
- ? Use of bridging with IV P12Y12
- ?Elective cesarean section under general anesthesia despite DAPT (SIGNIFIACNT hemorrhage risk)
- If possible, postponing delivery for at least 2 weeks after PAMI
- Advise to avoid the use of Methylergonovine (spasm), Terbutaline (tachycardia), Tranexamic Acid (Thrombosis)

Tweet et al. Pregnancy – Associated Myocardial Infarction: Prevalence, Causes and Interventional Management. Circulation: Cardiovascular Interventions. 2020;13:e008687

Cardiac Arrest in the Pregnant Patient

- Patients should be supine on a firm backboard
- No medication substitutions or dose modifications are required.
- Recommendations specific to pregnancy include continuous manual left uterine displacement to offload aortocaval compression during cardiopulmonary resuscitation, intravenous access in a vein above the diaphragm to ensure that therapy is not obstructed by the gravid uterus.
- If return of spontaneous circulation is not achieved after 4 minutes of resuscitation. Proceed with cesarean delivery

Tweet et al. Pregnancy – Associated Myocardial Infarction: Prevalence, Causes and Interventional Management. Circulation: Cardiovascular Interventions. 2020;13:e008687



Supplementary Figure 7. Mehta et al. Cardiovascular Considerations in Caring for Pregnant Patients: A Scientific Statement From the American Heart Association. Circulation.2020:141:e884–e903

Cardio-Obstetric Care team

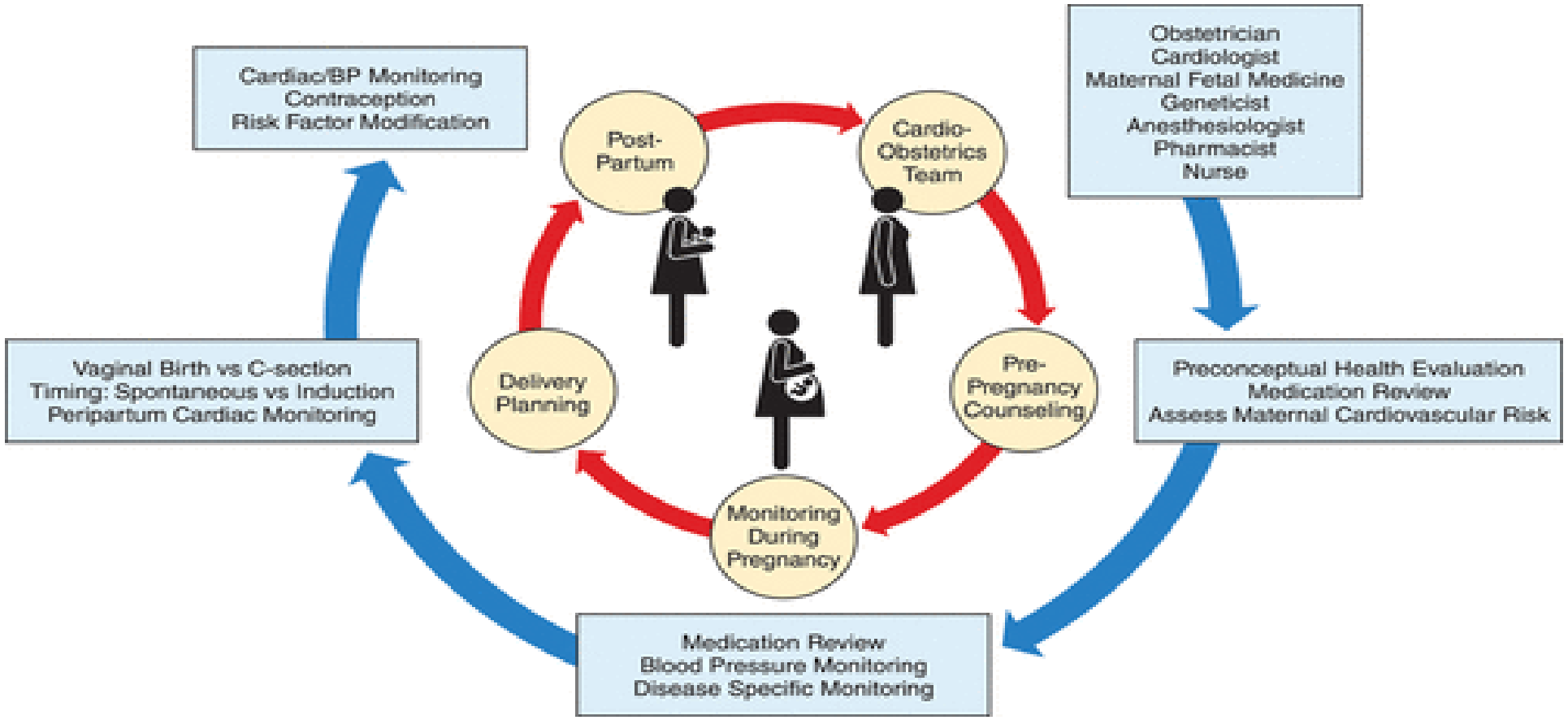


Figure 1 . Mehta et al. Cardiovascular Considerations in Caring for Pregnant Patients: A Scientific Statement From the American Heart Association. Circulation.2020;141:e884–e903