



# Obstetric Anesthesia Considerations in Heart Failure

Joanna Cambria DNP, CRNA  
February 2026

# Sarah

25 y/o G2P1

Dx PPCM during 2<sup>nd</sup> pregnancy

1<sup>st</sup> misdx as PNA

PP decompensation to LVEF 5%

LVAD → TIA

Heart transplant

*“A lot of times, when you hear the words ‘heart failure,’ you think of the elderly.*

*As a healthy 25-year-old, never did I expect to hear those two words. And never did I ever expect to hear those two words while pregnant with my second.”*



<https://transplantliving.org/stories/i-only-had-a-2-chance/>  
<https://expectinghearts.com/sarahs-story>

# Objectives:

**Current Data on Maternal Mortality**

**Peripartum Hemodynamics Review**

**Maternal Cardiac Risk Scoring Systems  
& Heart Failure Identification Tools**

**Heart Failure from  
Preeclampsia & Peripartum Cardiomyopathy**

**Delivery Management Considerations in:**

- **Heart Failure**
- **Pulmonary Edema**

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# 2025 CDC Maternal Mortality Report

Aug 22, 2025



Among pregnancy-related deaths in 2021, MMRCs  
determined **87% to be preventable.** ( $^{654}/_{752}$ )

**Cardiac disease was 3<sup>rd</sup> leading cause** of Pregnancy-Related  
Death (PRD) (10.4%)<sup>1</sup>

# CDC 2025 Maternal Mortality Report

- **CV disease 3<sup>rd</sup> leading cause of PRD in 2021** (10.4%) after mental health, and infection (covid\*)
  - **Cardiomyopathy (4.6% total PRD)**
  - *other CV conditions 5.8%*
    - CAD, pulm HTN, acquired & congenital valvular heart dx, vascular aneurysm, HTN, Marfan dx, conduction defects, vascular malformations, and other CV dx;  
\*excluding cardiomyopathy & HTN disorders of pregnancy.
    - *HTN d/o of pregnancy* was 7<sup>th</sup> leading cause of PRD, accounting for 3.5%

# CDC 2025 Maternal Mortality Report

Timing of death	Percentage	Count
During pregnancy	19.5%	177
Day of delivery	9.1%	83
1–6 days postpartum	14.1%	128
7–42 days postpartum	29.2%	265
43–365 days postpartum	28.1%	255

Among pregnancy-related deaths in 2021:  
71.4% occurred postpartum, and **57.3% occurred 7–365 days postpartum (PP).**

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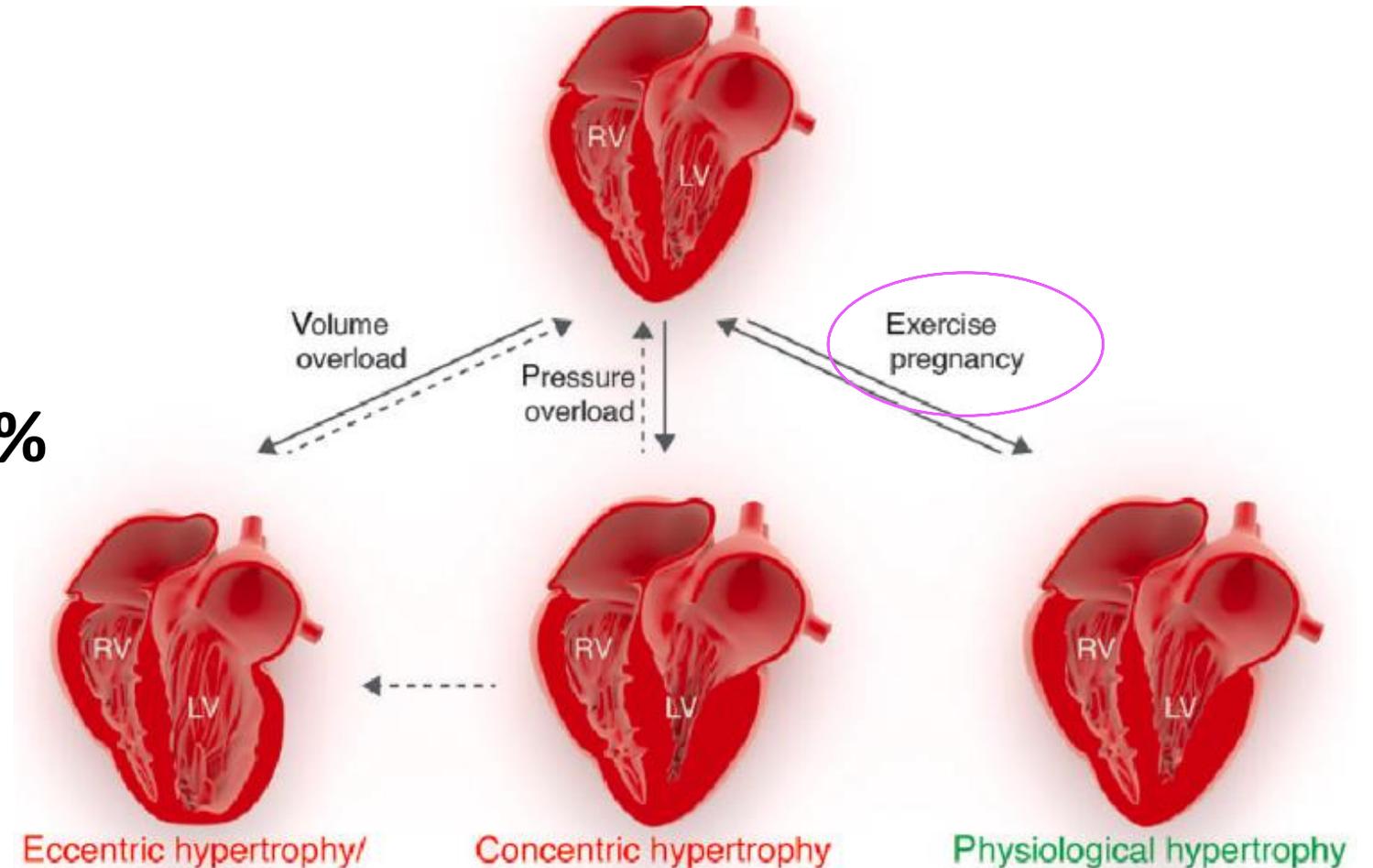
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# Peripartum Myocardial Remodeling

- LV wall thickness  $\uparrow$  28%
- LV mass  $\uparrow$  52%
- RV mass  $\uparrow$  40%



<https://www.semanticscholar.org/paper/Pregnancy-as-a-cardiac-stress-model.-Chung-Leinwand/cc0a22da784799b4682cc6bfa7937516a76272c>

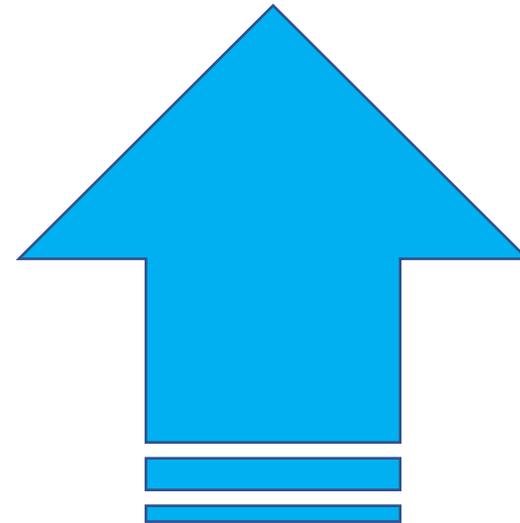
Peripartum  
fluid shifts..



can hit like a  
truck.

CO is highest **during labor and immediately after delivery**

- Increases 60 - 80% above pre-labor levels





Peripartum  
fluid shifts..

can hit like a  
truck.

## Immediately on Delivery:

- **Increased preload:**
  - 1) Gravid uterus offloaded from great vessels
  - 2) **Auto-Transfusion** from uterine involution
    - On delivery: ~ **500-750cc**
      - **Can be HUGE stress on failing heart**
    - Also occurs during labor, but smaller volume
      - ~ 300-500cc with each cxn
- CO ~ doubled above non-pregnant levels.
- CO, HR, SV remain significantly elevated for first few days PP to accommodate IV fluid shifts.<sup>3</sup>
- Hemodynamics take ~ 2 wks to return to normal in patients with *normal cardiac function* as extravascular fluid shifts back into intravascular space.<sup>2</sup>

2. Sanghavi & Rutherford, *Circulation*, 2014

3. Meng ML, Arendt KW, *Anesthesiology*, 2021

The sudden ↑ in preload and C.O. on delivery can overwhelm a failing ventricle

## Jessica

30 y/o G2P1 HTN at 32w → PO Anti-HTN, IOL 37wk → Breech c/s.

Coded in PACU.

10 min CPR , Impella, then ECMO for 2 wks.

Dx: paraganglioma: rare adrenal tumor likely contributed to HF.

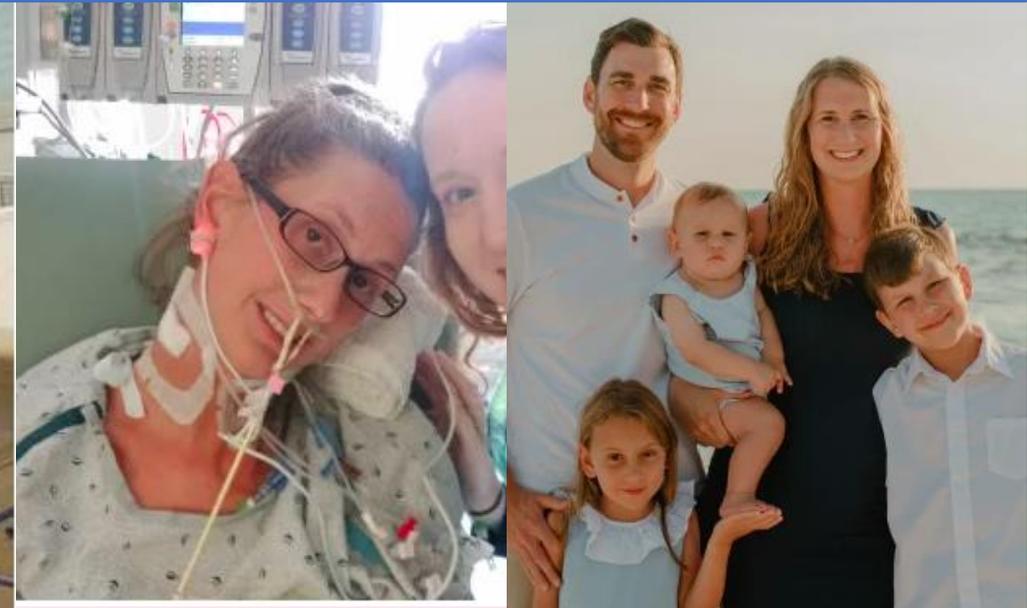
*“This pregnancy was different. I was more tired, I got winded easily, and I had terrible headaches when I would lay down at night.”*



<https://www.stroke.org/en/news/2020/11/19/mother-brought-back-to-life-the-day-she-gave-birth>

<https://www.today.com/health/womens-health/peripartum-cardiomyopathy-mom-30-shares-symptoms-rcna50204>

<https://thebirthtraumamama.com/jessicas-story-surviving-peripartum-cardiomyopathy/>



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Current  
Maternal  
Cardiac Risk  
Scoring Systems

**mWHO**

**CARPREG II**

**ZAHARA**

**mWHO**

# Modified World Health Organization Classification of Maternal Cardiovascular Risk

**Table 2: Modified World Health Organization (WHO) Classification of Maternal Cardiovascular Risk: Application**

WHO Pregnancy Risk Classification (Risk of pregnancy by medical condition)	Cardiovascular Conditions by WHO Risk Class
<p><b>WHO Risk Class I</b> <i>No detectable increased risk of maternal mortality and no or mild increase in morbidity.</i></p>	<ul style="list-style-type: none"> <li>• Uncomplicated, small or mild               <ul style="list-style-type: none"> <li>○ Pulmonary stenosis</li> <li>○ Patent ductus arteriosus</li> <li>○ Mitral valve prolapse</li> </ul> </li> <li>• Successfully repaired simple lesions (atrial or ventricular septal defect, patent ductus arteriosus, anomalous pulmonary venous drainage).</li> <li>• Atrial or ventricular ectopic beats, isolated</li> </ul>
<p><b>WHO Risk Class II</b> (If otherwise well and uncomplicated) <i>Small increased risk of maternal mortality or moderate increase in morbidity.</i></p>	<ul style="list-style-type: none"> <li>• Unoperated atrial or ventricular septal defect</li> <li>• Repaired tetralogy of Fallot</li> <li>• Most arrhythmias</li> </ul>
<p><b>WHO Risk Class II or III</b> (Depending on individual) <i>Risk as indicated in Class II (above) or Class III (below).</i></p>	<ul style="list-style-type: none"> <li>○ Mild left ventricular impairment</li> <li>○ Hypertrophic cardiomyopathy</li> <li>• Native or tissue valvular heart disease not considered WHO I or IV</li> <li>• Marfan syndrome without aortic dilatation</li> <li>• Aorta &lt;45 mm in aortic disease associated with bicuspid aortic valve</li> <li>• Repaired Coarctation</li> </ul>
<p><b>WHO Risk Class III</b> <i>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.</i></p>	<ul style="list-style-type: none"> <li>• Mechanical valve</li> <li>• Systemic right ventricle</li> <li>• Fontan circulation</li> <li>• Cyanotic heart disease (unrepaired)</li> <li>• Other complex congenital heart disease</li> <li>• Aortic dilatation 40-45 mm in Marfan Syndrome</li> <li>• Aortic dilatation 45-50 mm in aortic disease associated with bicuspid aortic valve</li> </ul>
<p><b>WHO Risk Class IV</b> (Pregnancy contraindicated) <i>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.</i></p>	<ul style="list-style-type: none"> <li>○ Pulmonary arterial hypertension of any cause</li> <li>• Severe systemic ventricular dysfunction (LVEF &lt;30%, NYHA III-IV)*</li> <li>○ Previous peripartum cardiomyopathy with any residual impairment of left ventricular function</li> <li>• Severe symptomatic mitral or aortic stenosis</li> <li>• Marfan syndrome with aorta dilated &gt;45 mm</li> <li>• Aortic dilation &gt;50 mm in aortic disease associated with bicuspid aortic valve</li> <li>• Native severe Coarctation</li> </ul>

# Cardiac Event Rate Based on mWHO classification

<b>I: 2.5%-5%</b>	No detectable increased risk of maternal mortality No or mild increased risk in morbidity
<b>II: 5.7-10.5%</b>	Small increased risk of maternal mortality Moderate increase in morbidity
<b>II-III: 10%-19%</b>	Intermediate increased risk of maternal mortality Moderate to severe increase in morbidity
<b>III: 19%-27%</b>	Significantly increased risk of maternal mortality Significant increase in severe morbidity
<b>IV: 40%-100%</b>	Extremely high risk of maternal mortality Extremely high risk of severe morbidity

# ZAHARA & CARPREG II

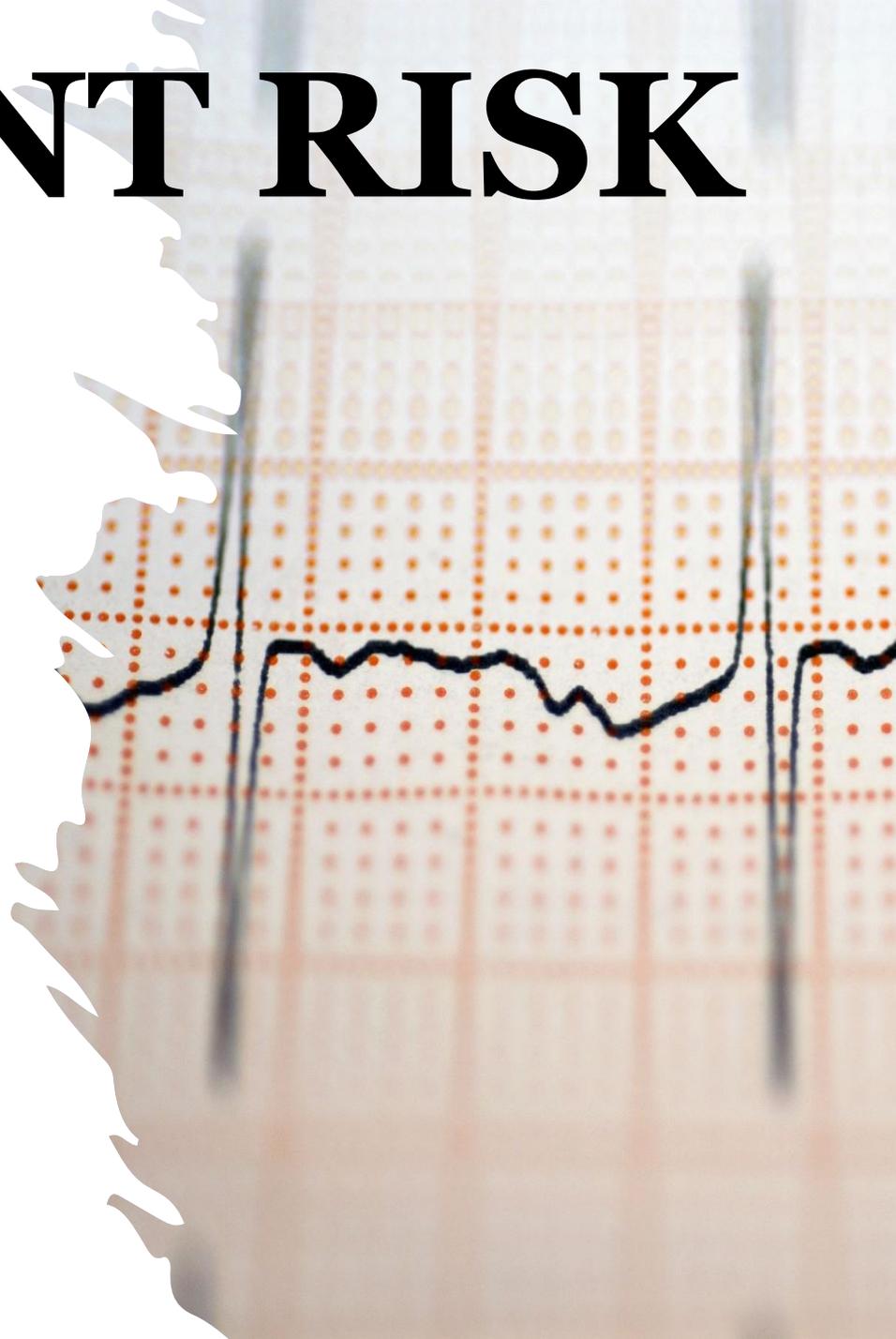
**Table 1: Clinical Factors Identified as Risks in the Current Scoring Tools**

Current Scoring Tools	Points per Factor	Maternal Risk
<b>CARPREG</b>		
<ul style="list-style-type: none"> <li>• Prior cardiac event (including arrhythmia)</li> <li>• NYHA III/IV or cyanosis</li> <li>• Systemic ventricular dysfunction (EF &lt;40)</li> <li>• Left heart obstruction</li> </ul>	1 for each factor	0 points – 5% 1 point – 27% >1 point – 75%
<b>ZAHARA</b>		
<ul style="list-style-type: none"> <li>• Prior arrhythmia</li> <li>• NYHA III/IV</li> <li>• Left heart obstruction</li> <li>• Mechanical valve prosthesis (strongest weighed)</li> <li>• Cyanotic</li> <li>• Cardiac medication before pregnancy</li> <li>• Moderate/severe AVV regurgitation (systemic)</li> <li>• Moderate/severe AVV regurgitation (sub-pulmonary)</li> </ul>	Arrhythmia – 1.5 Cardiac medication – 1.5 NYHA class – 0.75 Left heart obstruction – 2.5 Systemic AVVR – 0.75 Sub-pulmonary AVVR – 0.75 Mechanical valve – 4.25 Cyanosis – 1	>0.5 points – 2.9% 0.51–1.5 points – 7.5% 1.51–2.5 points – 17.5% 2.51–3.5 points – 43% >3.51 – 70%
<b>CARPREG II</b>		
<ul style="list-style-type: none"> <li>• Prior cardiac event (including arrhythmia)</li> <li>• NYHA III/IV or cyanosis</li> <li>• Systemic ventricular dysfunction (EF &lt;40)</li> <li>• Left heart obstruction</li> <li>• Mechanical valve prosthesis (strongest weighed)</li> <li>• Pulmonary hypertension</li> </ul>	Prior event/arrhythmia – 3 NYHA III/IV/cyanosis – 3 Systemic EF <40 – 2 Left heart obstruction – 2 Mechanical valve – 2 Pulmonary hypertension – 2 Coronary artery disease – 2 High risk aortopathy – 2 No cardiac intervention – 1 Late presentation – 1	0–1 point – 5% 2 points – 10% 3 points – 15% 4 points – 22% >4 points – 41%

# CARDIAC EVENT RISK

## Highest risk patients are:

- Older
- Identify as Black or African American
- Acquire heart disease during pregnancy
- Have unrecognized cardiovascular disease and become pregnant



IDENTIFYING  
HEART FAILURE  
IN PREGNANCY



# IDENTIFYING HEART FAILURE IN PREGNANCY

Many symptoms of HF are vague and mimic normal pregnancy symptoms  
(eg: fatigue, SOB, peripheral edema.)

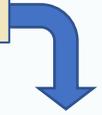


Failure to recognize HF contributes significantly to maternal deaths in the US.

# IDENTIFYING HEART FAILURE IN PREGNANCY

ACOG Practice Bulletin No. 212 *Pregnancy and Heart Disease* contains a table of signs and symptoms which, if reported, require cardiac evaluation ASAP.

If (+): Low threshold to obtain further imaging: TTE, CXR, LUS, ECG



Vital Signs	Physical Exam Signs	History and Symptoms
Heart rate $\geq$ 120 beats/min	Jugular venous pressure visible 2 cm above clavicle at 45°	History of cardiovascular disease
Systolic blood pressure $\geq$ 160 mm Hg	Loud systolic murmur or S4	Shortness of breath at rest, paroxysmal nocturnal dyspnea, orthopnea, refractory pneumonia, or bilateral chest infiltrates on chest radiography
Symptomatic low blood pressure	Wheezing	Chest pain at rest or minimal exertion
Respiratory rate $\geq$ 25 breaths/min	Lung crackles	Exertional or unprovoked syncope or palpitations associated with near syncope or syncope
Oxygen saturation $<$ 95%	Marked peripheral edema	Extreme fatigue

Modified from American College of Obstetricians and Gynecologists.<sup>14</sup>

National Partnership for  
Maternal Safety

## Maternal Early Warning Criteria (MEWC)

- To aid in faster recognition, evaluation, diagnosis, and treatment of signs of developing critical illness, to reduce preventable maternal death.

If (+): Low threshold  
to obtain further  
imaging: TTE, CXR,  
LUS, ECG

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Systolic BP (mm Hg)	<90 or >160
Diastolic BP (mm Hg)	>100
Heart rate (beats per min)	<50 or >120
Respiratory rate (breaths per min)	<10 or >30
Oxygen saturation on room air, at sea level, %	<95
Oliguria, mL/hr for $\geq 2$ hours	<35
Maternal agitation, confusion, or unresponsiveness; Patient with preeclampsia reporting a non-remitting headache or shortness of breath	

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# “Fett Self Test” for Early Identification of Heart Failure

> 4 pts → further workup (BNP & TTE)<sup>27</sup>

Table 1. Self-test for early diagnosis of peripartum cardiomyopathy.

Symptoms	0 points	1 point	2 points
Orthopnea	None	Need to elevate head	Need to elevate 45 degrees or more
Dyspnea	None	Climbing 8 or more steps	Walking on level
Unexplained cough	None	At night	Day and night
Lower extremity swelling	None	Below knee	Above and below knee
Excessive weight gain during last month of pregnancy	Under 2 pounds per week	2–4 pounds per week	Over 4 pounds per week
Palpitations	None	When lying down at night	Day and night, any position

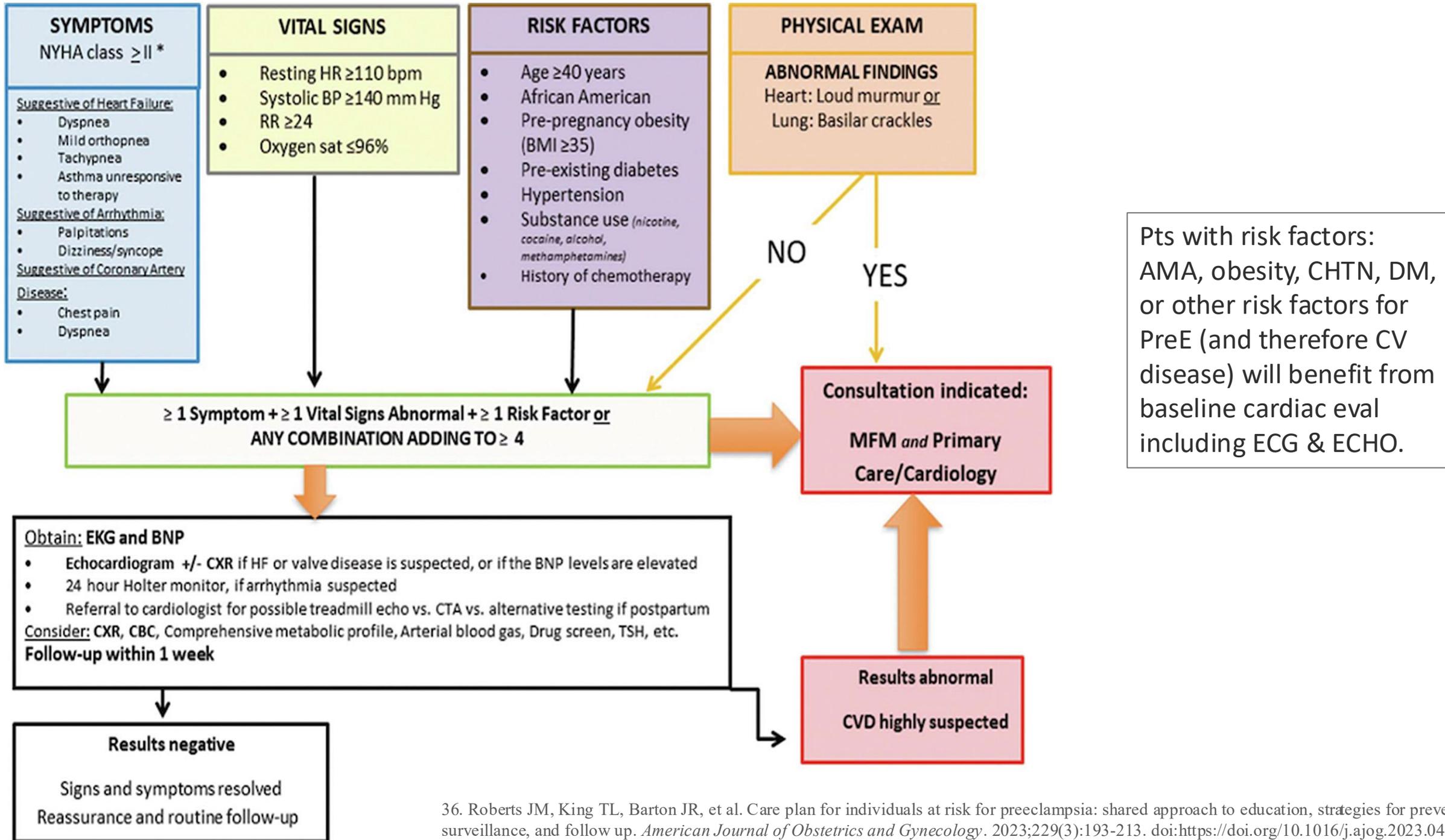
The presence of 4 or more points should prompt additional investigation.  
Data taken from [30].

Davis M, Duvernoy C. *Women's Health*. 2015

In validation study: **100% of women who presented with > 4pts had LV systolic dysfunction.**<sup>27</sup>

26. Davis M, Duvernoy C. Peripartum Cardiomyopathy: Current Knowledge and Future Directions. *Women's Health*. 2015.

27. Fett JD. Validation of a self-test for early diagnosis of heart failure in peripartum cardiomyopathy. *Critical Pathways in Cardiology*. 2011;10(1):44-45. doi:https://doi.org/10.1097/HPC.0b013e31820b887b



# BNP

## Reference Intervals in Pregnancy:

- BNP: **< 50** pg/ml
- NT-proBNP:
  - TM 1&2: **< 200** pg/ml
  - TM 3: **< 150** pg/ml <sup>33, 39</sup>

- BNP shown to improve diagnostic accuracy in women presenting with acute dyspnea.<sup>12</sup>
- BNP =/↓ in pregnancy, despite ↑ plasma volume; as normal adaptations of cardiac remodeling and ↓ SVR leave central filling pressures unchanged,<sup>13</sup> and plasma dilution and ↑ GFR will ↓ circulating levels.<sup>33</sup>
- Pregnant patients have LOWER BNP thresholds for further cardiac evaluation than the traditional guideline of BNP < 100 to rule out HF in non-pregnant patients.
- BNP ↑ in PreE... *as a marker of diastolic dysfunction.*<sup>11</sup>
- **BNP LOWER in obesity and diabetes, with additive lowering effect** <sup>34, 35</sup>

11. Borges VTM, Zanati SG, Peraçoli MTS, et al. *Ultrasound in Obstetrics & Gynecology*. 2018

12. Mueller C, Scholer A, Laule-Kilian K, et al. *N Engl J Med*. 2004

13. Estensen ME, Beitnes JO, Grindheim G, et al. *Ultrasound in Obstetrics & Gynecology*. 2013

33. Stocktree, et al. *J Endocr Soc*. 2021

34. Wang TJ, et al. *Circulation*. 2004

35. Nishikimi T, Nakagawa Y. *Journal of Cardiology*. 2021.

39. Sarma et al. *JACC Advances*. 2022

# EARLY IDENTIFICATION

- Chances of full recovery higher when LVEF > 35%;
  - With early detection, LVEF likely to be higher at time of diagnosis and initiation of treatment.
- Most serious complications of PPCM arise when diagnostic or baseline LVEF < 30-35%
  - Ventricular tachyarrhythmias
  - Thromboembolic events
  - Chronic cardiomyopathy<sup>29</sup>
- ***These complications can be either avoided or decreased with earlier diagnosis...***





*...But women's symptoms of heart failure are frequently misdiagnosed, or dismissed as pregnancy symptoms, which delays treatment and leads to further decompensation.*

# Rachel

s/s 3<sup>rd</sup> TM: excessive swelling – dismissed “bc it’s twins”

Leg swelling after delivery – told “it’s nothing”

Cough developed - told “it’s bronchitis”

Workup 1 month PP

LVEF 15%

Ext defib & cardiac rehab - Recovered

*“And I kept saying something was wrong, and they told me, 'No, you're just carrying multiples. This is what happens with multiples. There's nothing wrong with you'...  
...But come to find out, I was dying.”*

# Claire

Unable to lie flat & severe cough 6d PP after 1<sup>st</sup> delivery.

She went to 8 emergency appts, she saw 5 different doctors and was given incorrect dxs of a PE and gastric asthma.

*Even despite mentioning she thought her s/s were cardiac and could be PPCM*

***“I was told I was just a hormonal, overanxious new mother.”***

S/S worsened: *“SOB, breathless, gasping for air”*

→ ED Echo → EF < 18%

Managed medically

Over 7 years later, EF 48-50%, still medication dependent.

Peripartum Cardiomyopathy:  
Claire's story ISSN 2516-5852 (Online)  
AIMS Journal, 2024, Vol 36, No 2



**Marian**

35y/o

6 months PP: fatigue, bloat, ankle swelling, brief vision loss

1<sup>st</sup> and 2<sup>nd</sup> GPs dismissed s/s as viral:

*“At the second appointment, the physician emphasized that I was young and healthy”*

3rd: ED doc: misdx “severe congestion” as **PNA**

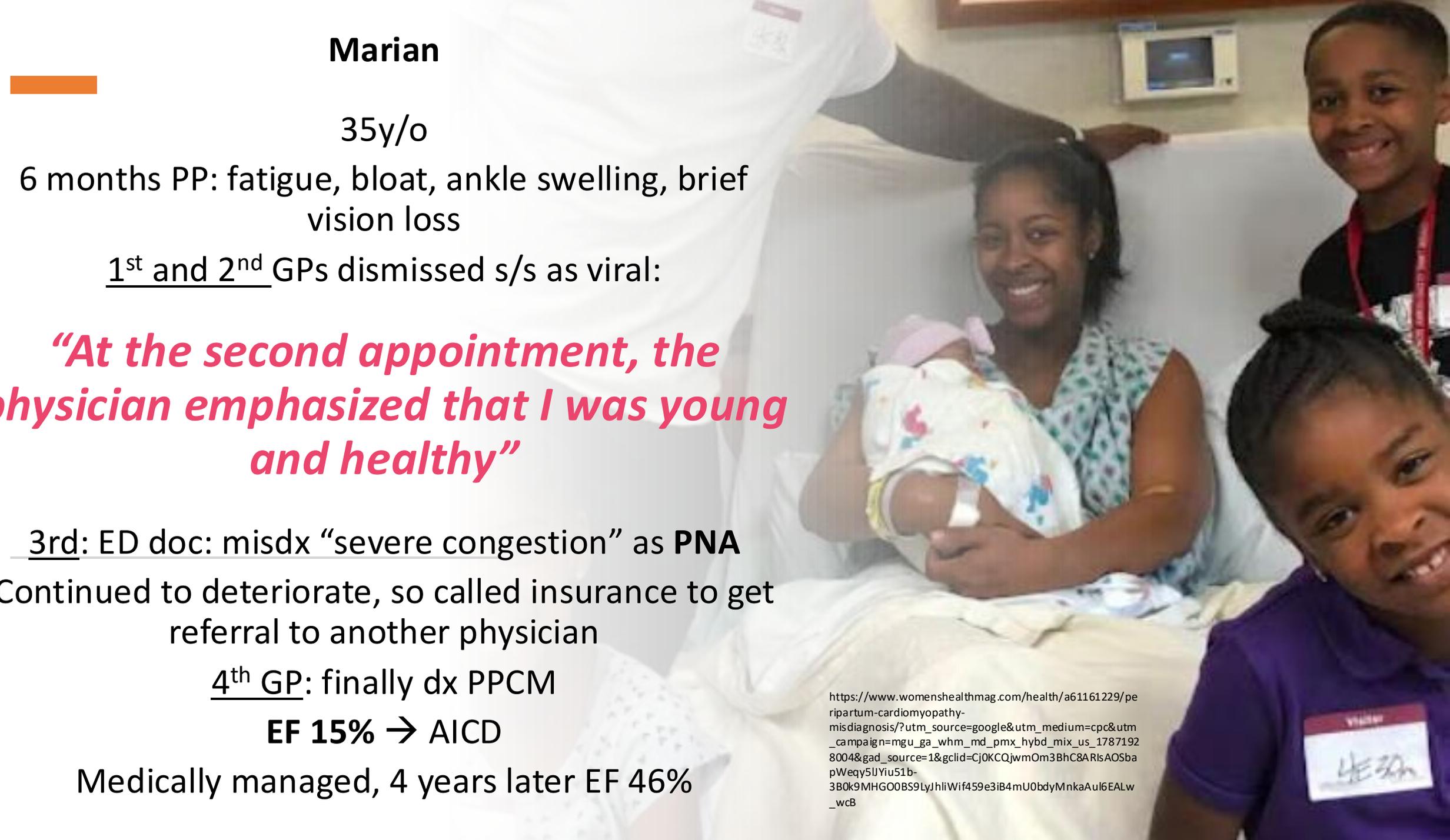
Continued to deteriorate, so called insurance to get referral to another physician

4<sup>th</sup> GP: finally dx PPCM

**EF 15% → AICD**

Medically managed, 4 years later EF 46%

[https://www.womenshealthmag.com/health/a61161229/pe-ripartum-cardiomyopathy-misdiagnosis/?utm\\_source=google&utm\\_medium=cpc&utm\\_campaign=mgu\\_ga\\_whm\\_md\\_pmx\\_hybd\\_mix\\_us\\_17871928004&gad\\_source=1&gclid=Cj0KCQjwmOm3BhC8ARIsAOSbaPWeqy5lYiu51b-3B0k9MHGO0BS9LyjhiWif459e3iB4mU0bdyMnkaAul6EALw\\_wcB](https://www.womenshealthmag.com/health/a61161229/pe-ripartum-cardiomyopathy-misdiagnosis/?utm_source=google&utm_medium=cpc&utm_campaign=mgu_ga_whm_md_pmx_hybd_mix_us_17871928004&gad_source=1&gclid=Cj0KCQjwmOm3BhC8ARIsAOSbaPWeqy5lYiu51b-3B0k9MHGO0BS9LyjhiWif459e3iB4mU0bdyMnkaAul6EALw_wcB)



# Lacresha

31 y/o 2<sup>nd</sup> child

Gained 10 lbs in 1 wk + SOB

***“I couldn’t breathe”***

Dismissed as “normal pregnancy s/s”

Collapsed at home shortly PP

→ cardiogenic shock & MODS

EF 5%

ECMO, Impella, & CRRT

Now LVAD-dependent

***“Though we don't have the medical degree, we know our bodies... And no one knows our bodies better than we do”***



## Brittany

39-y/o avid runner noticed increased SOB during 5<sup>th</sup> pregnancy

**5<sup>th</sup> child: 3<sup>rd</sup> TM SOB: dismissed twice by providers as “normal pregnancy s/s.”**

**6<sup>th</sup> child, significant SOB though pregnancy, dx PPCM PP, and began PO meds for HF. 5 months PP - rapid decompensation.**

**EF 10%**

Heart transplant recipient

*“I’ve had five other pregnancies...from the very beginning, I struggled to breathe...”*  
*I just wish ...that this would have been caught a little earlier, and maybe things could have been different..”*



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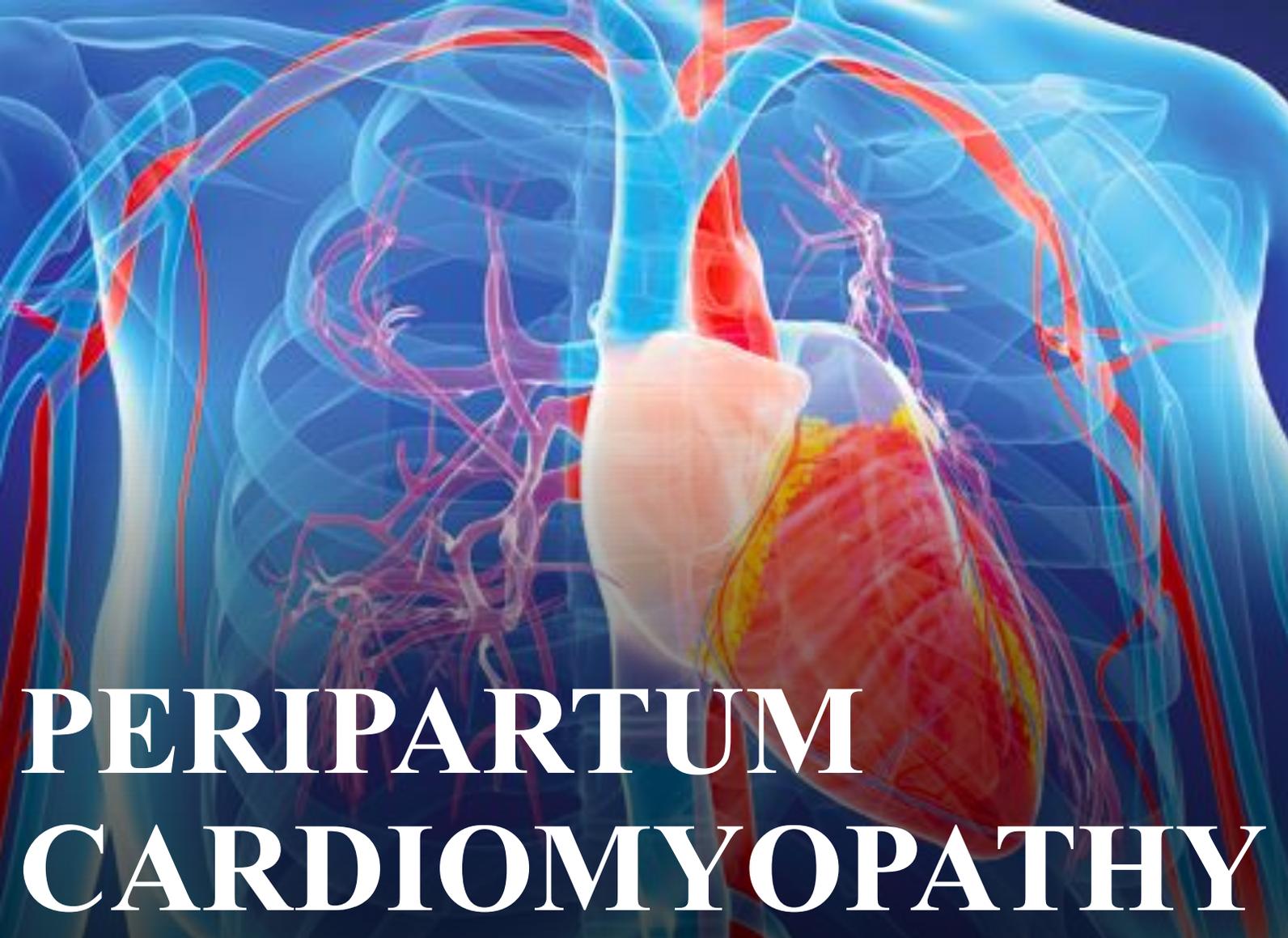
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# PERIPARTUM CARDIOMYOPATHY



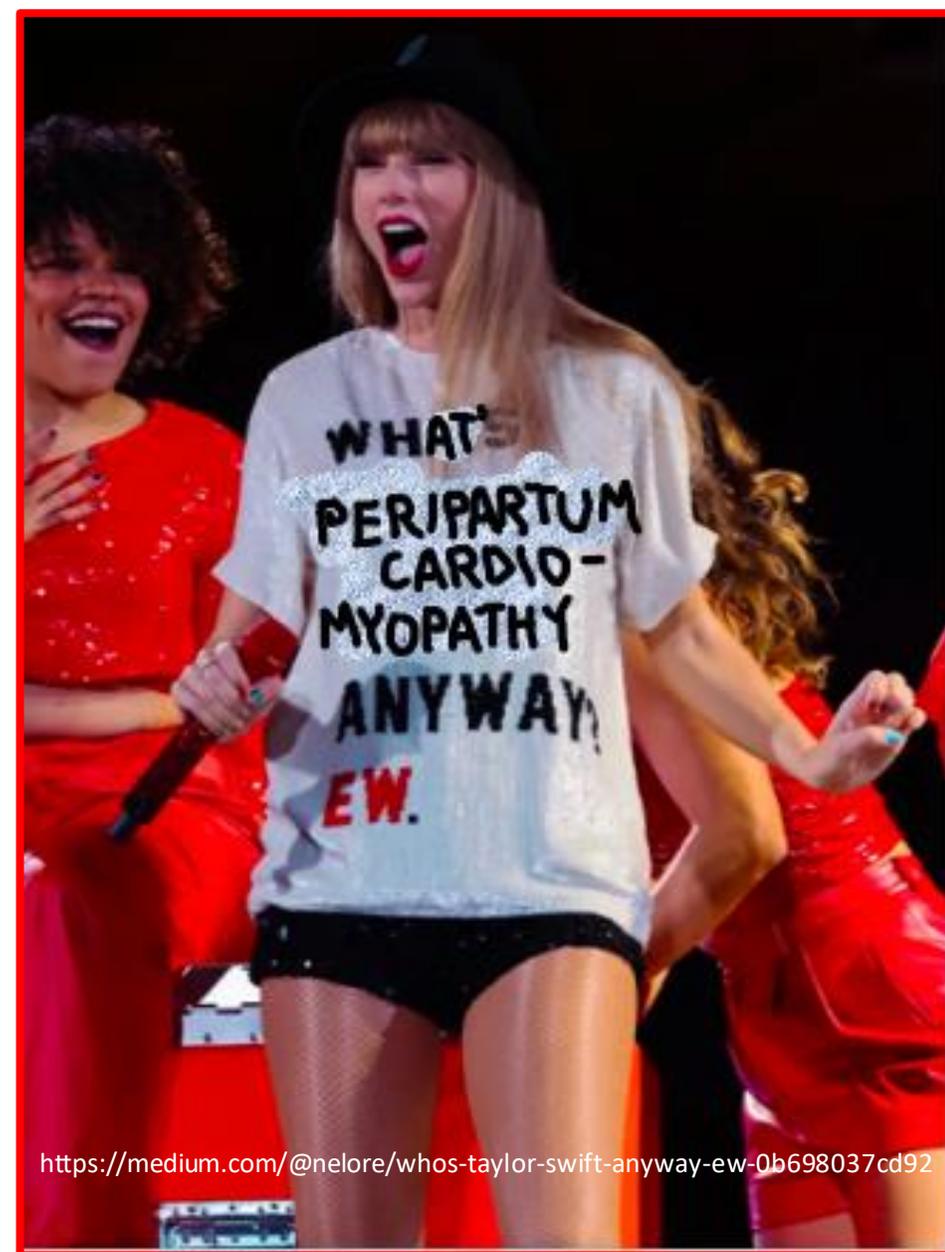
<https://www.health.harvard.edu/womens-health/research-were-watching-womens-hearts-age-differently-than-mens-do>

<https://www.nursingtimes.net/clinical-archive/womens-health/pregnancy-1-effects-on-haematological-and-cardiovascular-systems-29-08-2023/>

# PPCM

Defined as:

- LVEF  $\leq$  45% with **no prior hx cardiac dysfunction**
  - LV systolic dysfunction<sup>14</sup>
- Dx by exclusion
- No serum or biopsy markers:
  - dx by TTE and usually  $\wedge$ BNP
- Usually LV dilation, but not always
  - most-similar to non-ischemic DCM<sup>9</sup>
- Can have RV dysfunction as well, which is a poor prognostic indicator<sup>15</sup>



<https://medium.com/@nelore/whos-taylor-swift-anyway-ew-0b698037cd92>

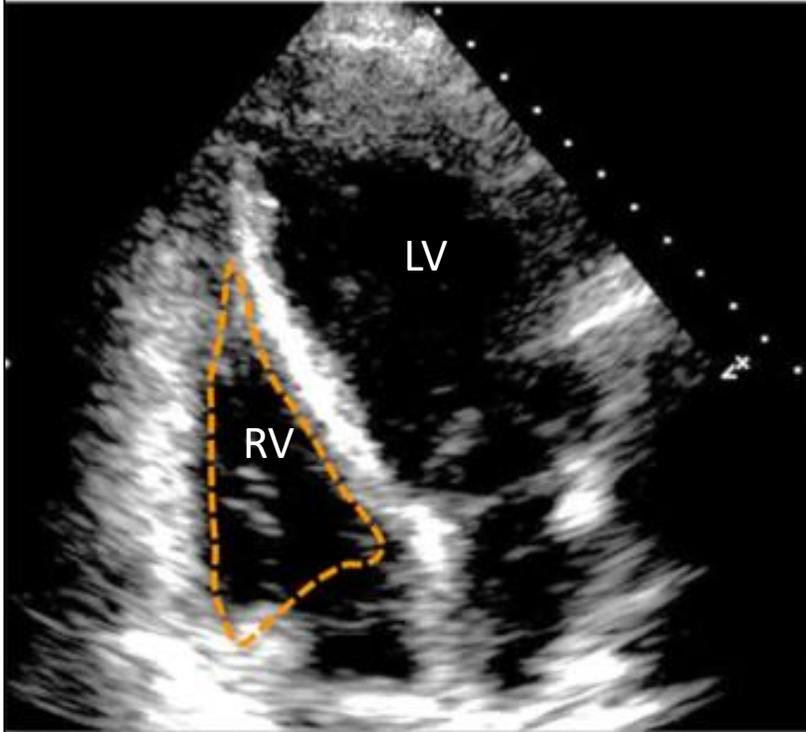
9. Zoltan. *N Engl J Med*, 2024.

14. Bauersachs J, König T, Meer P, et al. *European Journal of Heart Failure*. 2019

15. Blauwet LA, Delgado-Montero A, Ryo K, et al. *Circulation-heart Failure*. 2016

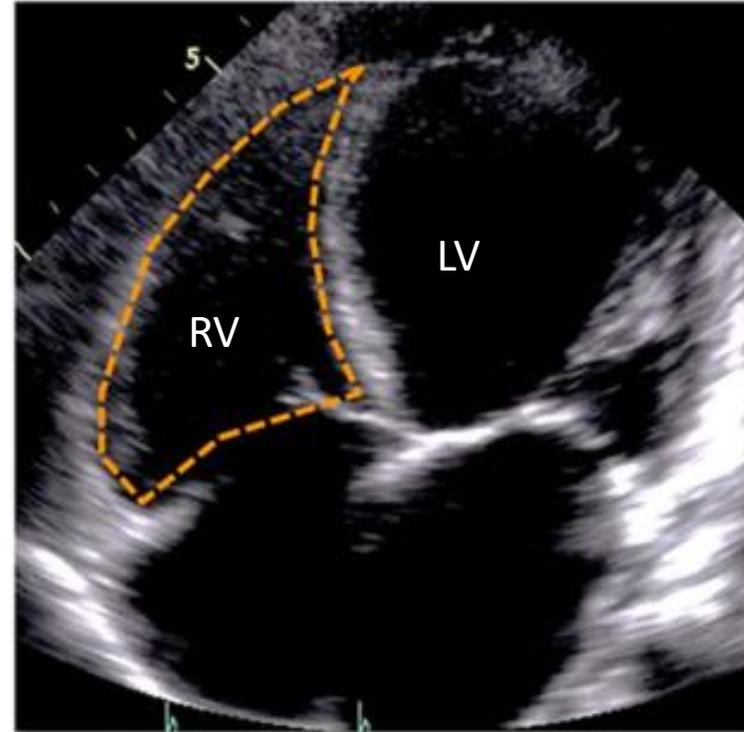
## RV dysfunction in PPCM

**30-year-old PPCM patient**



Baseline LVEF: 32%  
RV EDA: 17.8 cm<sup>2</sup>  
RV ESA: 10.3 cm<sup>2</sup>  
RV FAC: 42%  
Follow-up LVEF: 56%

**22-year-old PPCM patient**

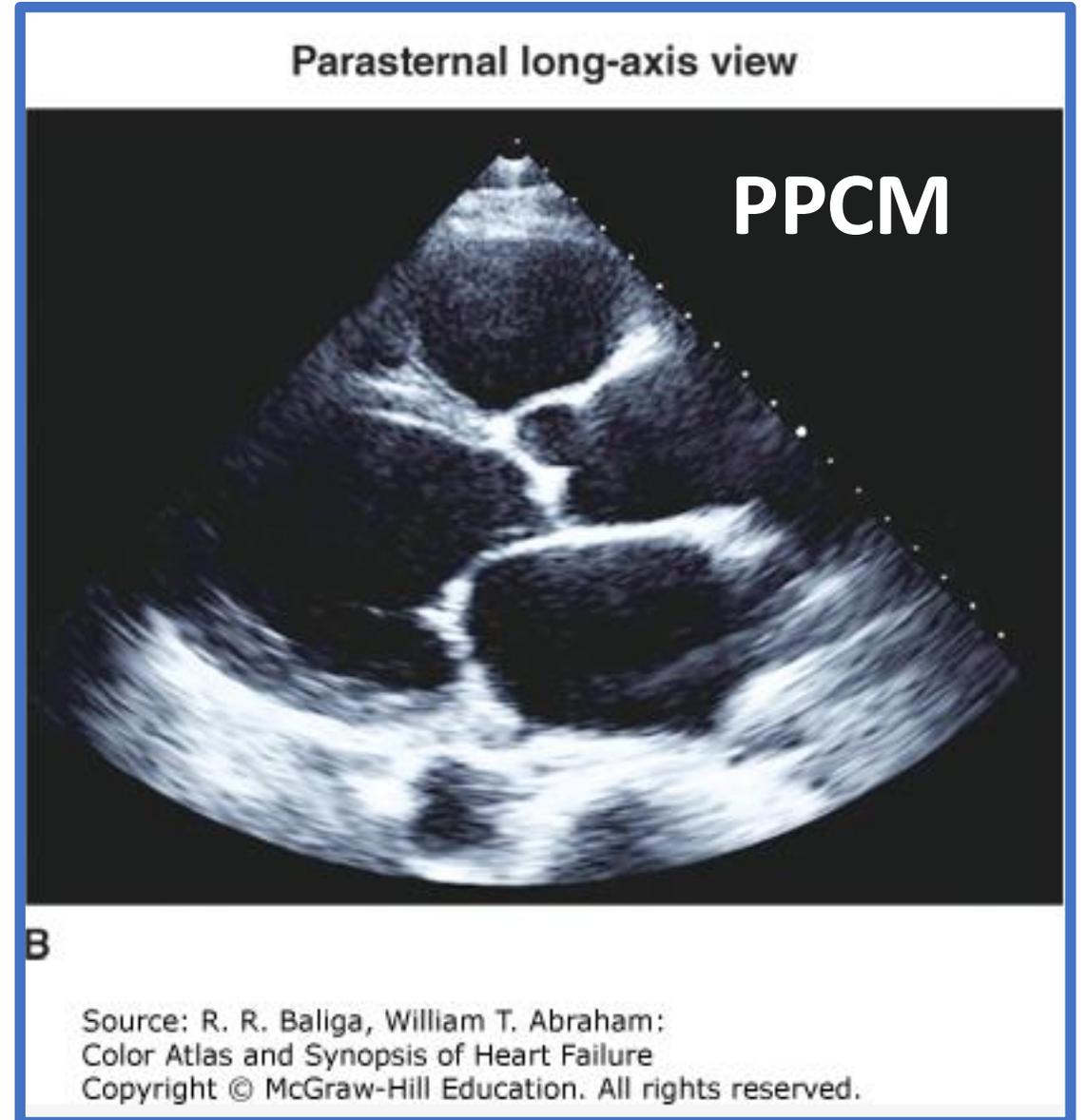


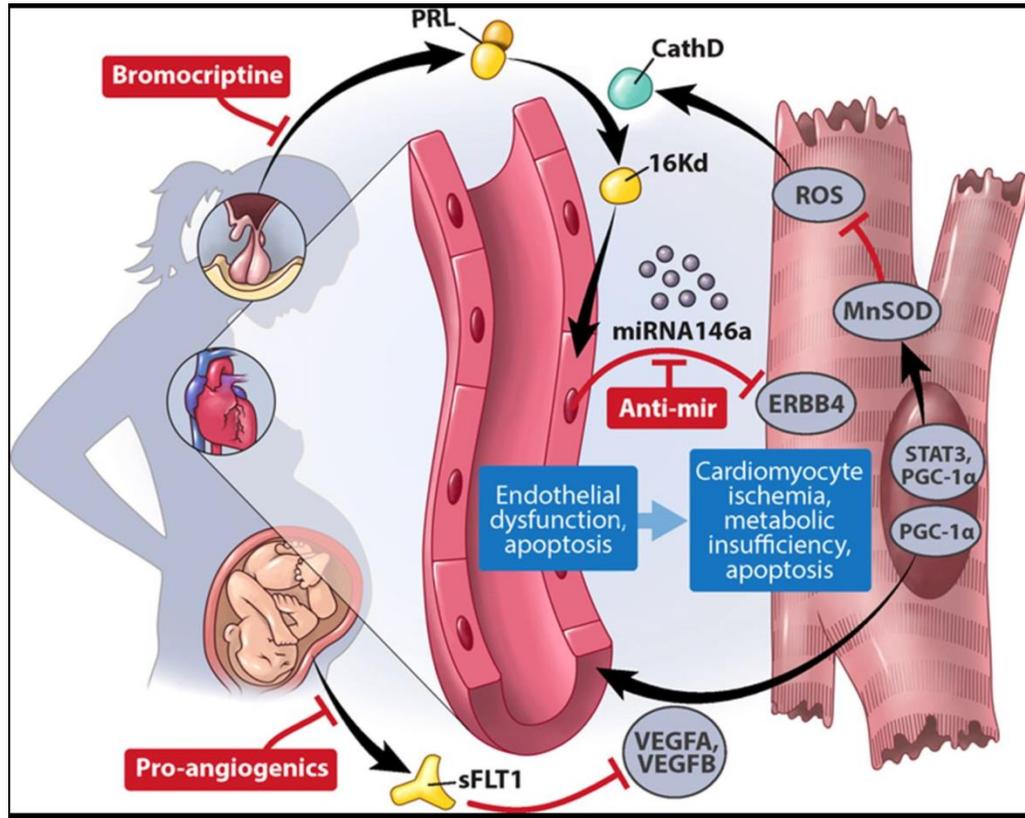
Baseline LVEF: 19%  
RV EDA: 28.6 cm<sup>2</sup>  
RV ESA: 20.0 cm<sup>2</sup>  
RV FAC: 30%  
Follow-up LVEF: 20%

# Current PPCM pathogenesis theory:

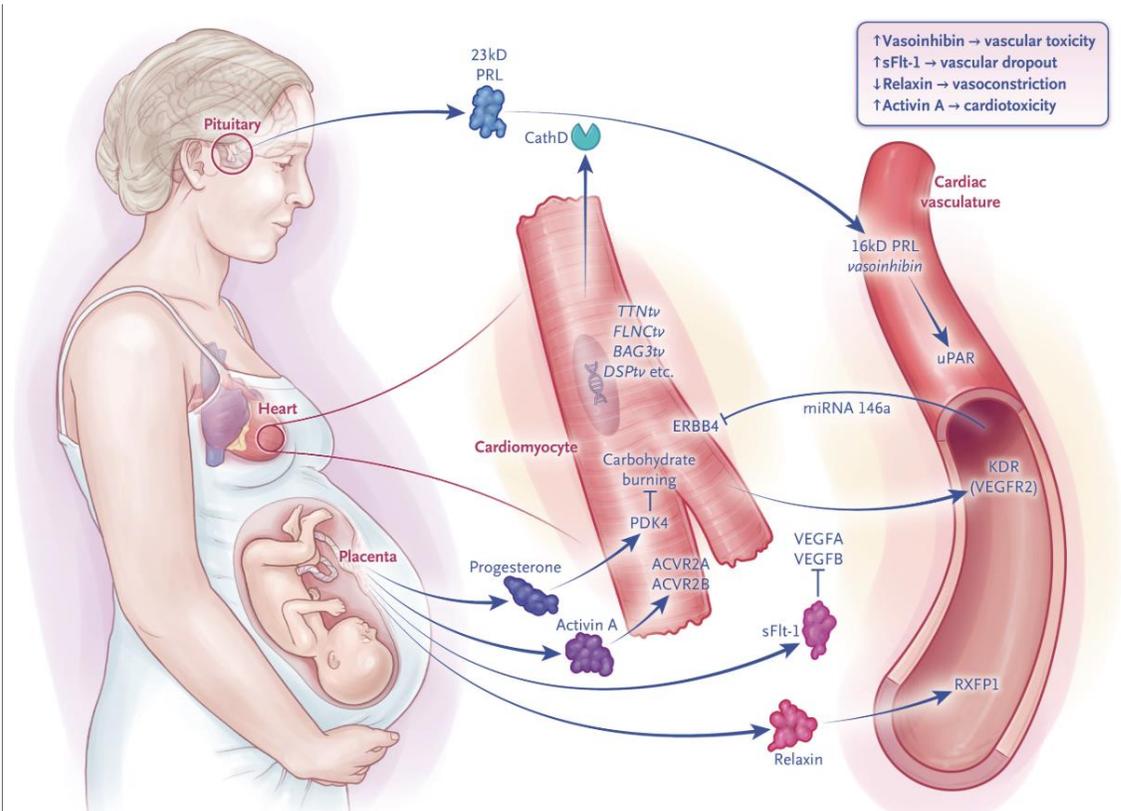
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- “Vasculo-hormonal”
- Imbalances in peripartum hormones secreted by pituitary and placenta
- Causes CV dysfunction via antiangiogenic and vasculotoxic substances, with consequent HF in susceptible women.
- Possible genetic links but remains mostly enigmatic.



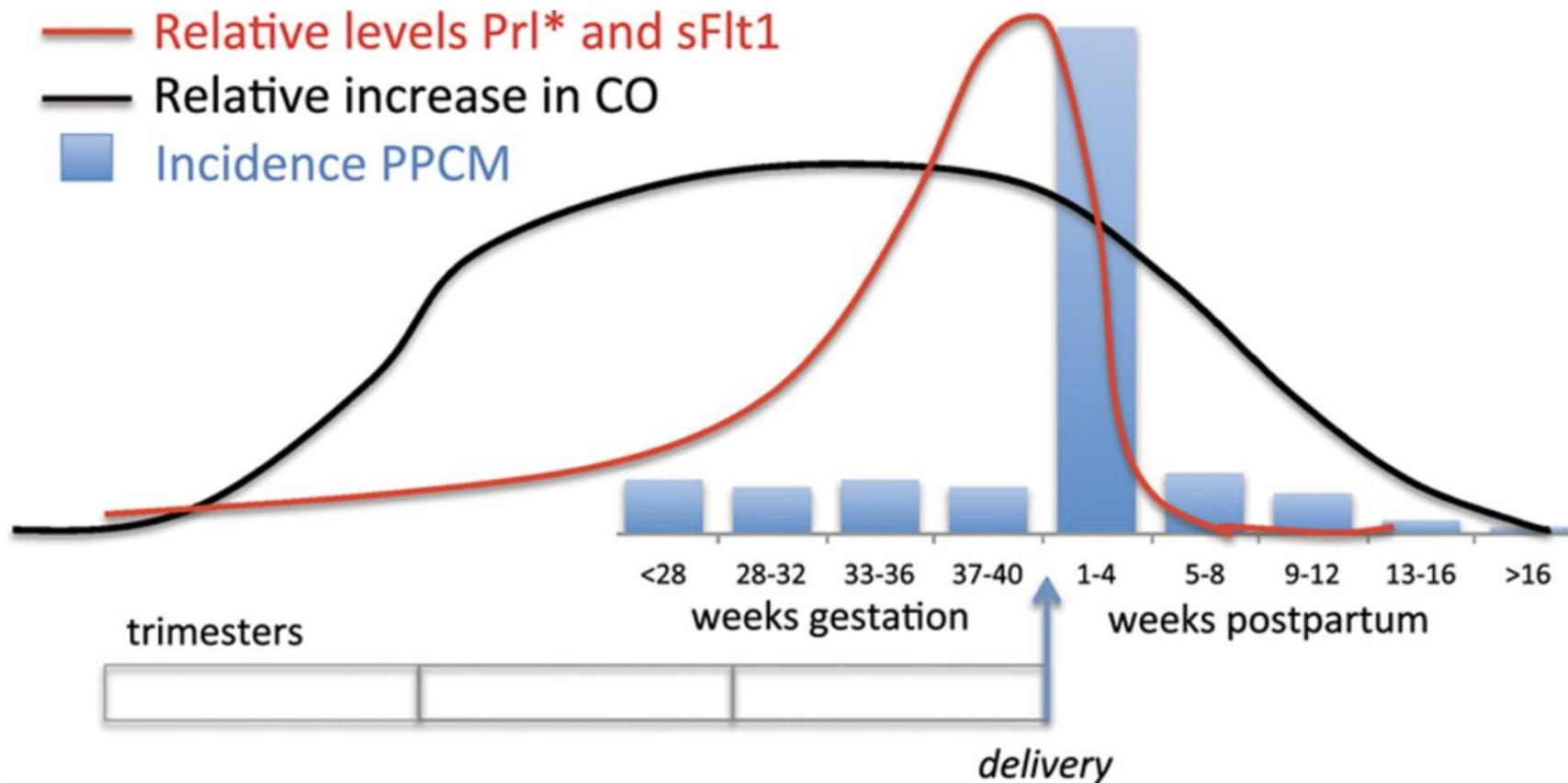


**Figure 4.** Vasculo-hormonal hypothesis of the pathophysiology of PPCM



**Figure 2.** Hormonal Model of PPCM

- sFlt-1 released from placenta inhibits VEGF (vascular endothelial growth factor) by binding to it and reducing its bioavailability, making it anti-angiogenic. (acts as decoy receptor)
  - PPCM pts can have abnormal elevations in sFlt-1, and abnormally low VEGF.
- Prolactin under abnormal oxidative stress can undergo enzyme-driven cleavage from normal full 23 kDa fragment into cardiotoxic 16 kDa fragment → potent anti-angiogenic and apoptotic effect on cardiac microvascular endothelial cells → cardiomyocyte damage → HF



**Figure 2.** Comparison of timing during and after pregnancy of hemodynamic changes, exemplified as cardiac output (CO; in black), elevations in **prolactin** and **soluble Fms-like tyrosine kinase 1 (sFlt1)** hormones (red), and incidence of peripartum cardiomyopathy (PPCM; blue bars).

\*Prolactin levels stay elevated in women who nurse.



# PPCM: Onset and Recovery

## ONSET:

- Can develop **RAPIDLY** over the course of days (to LVEF <45%)<sup>16</sup>
  - Often presents as clinical congestion 2/2 elevated cardiac filling pressures:
    - orthopnea, JVD, leg edema<sup>17</sup>
  - Use acute HF treatment guidelines<sup>18</sup>
- Usually either during last month of pregnancy or most commonly, postpartum.
  - **60-90% of cases occur within 1<sup>st</sup> week PP**
  - **Can occur up to 5 months PP, or later...**<sup>9</sup>

16. Karaye et al. *BMC Cardiovasc Disord.* 2016

17. Heidenreich PA, Bozkurt B, Aguilar D, et al. *Circulation.* 2022

18. Regitz-Zagrosek V, Roos-Hesselink JW, Bauersachs J, et al. *European Heart Journal.* 2018

9. Zoltan. *N Engl J Med,* 2024

# PPCM: Onset and Recovery

## RECOVERY:

- CV function recovers in >50% of patients
  - However, some never recover and need LVAD +/- heart transplant.
- Incomplete recovery:
  - Cardiac cellular and molecular recovery may lag behind LVEF.
    - Despite recovered EF, exercise or dobutamine stress test may reveal persistent cardiac dysfunction.
- **In the US, Black women have twice the risk of persistent cardiac impairment, and if recovery is achieved, it can take twice as long.**

# MANY PPCM PATIENTS NEVER RECOVER LV FUNCTION



## Danecia

24 y/o, 1<sup>st</sup> baby

1 wk PP s/s: chest pain & SOB

EF 25%

AICD

SIX YEARS LATER suffered stroke

Workup: LVEF had declined to 10-15%

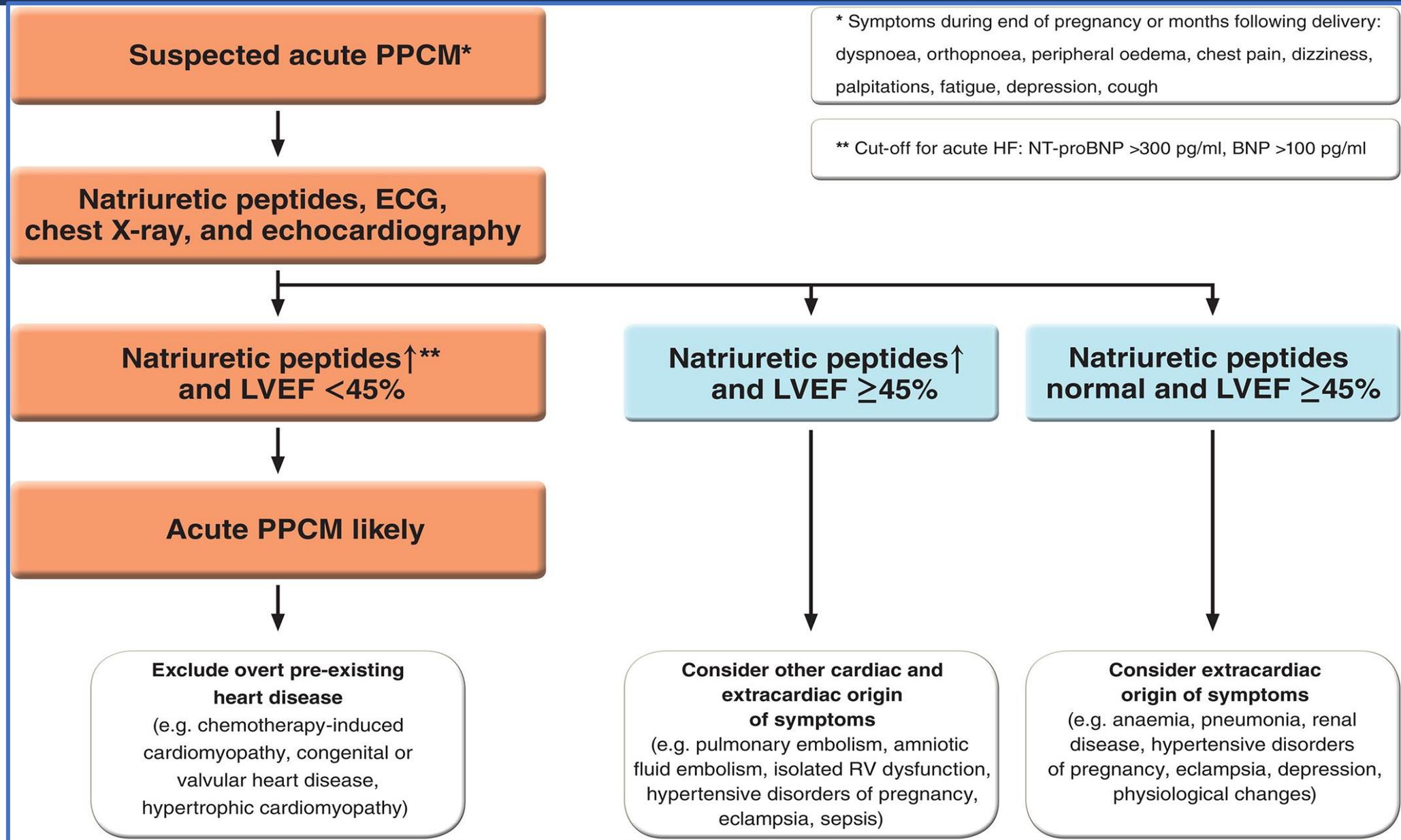
Waited >1yr for heart transplant

LVEF further declined

LVAD while she waited

Then received heart transplant.

# PPCM Diagnostic Pathway



# PreE and Heart Failure

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- Well-established that diastolic dysfunction can be seen in PreE
  - Especially early-onset PreE < 34wks
  - Increased incidence of LVH, diastolic dysfunction, and higher BNP levels in early –onset PreE, compared with late-onset PreE. <sup>10,11</sup>
- **Despite brief time period of HTN, maternal heart can still adapt to acute and transient ↑ SVR with remodeling and concentric hypertrophy.**<sup>11</sup>
  - In fact, *most women with PreE undergo adaptive myocardial remodeling from ↑SVR, but a small subgroup demonstrate signs of overt decompensation.*
    - Pre-term PreE can lead to severe LVH assc. with advanced cardiac dysfunction.<sup>10, 11</sup>

10. Melchiorre K, Sutherland GR, Watt-Coote I, Liberati M, Thilaganathan B., *Hypertension in Pregnancy*. 2012

11. Borges VTM, Zanati SG, Peraçoli MTS, et al. *Ultrasound in Obstetrics & Gynecology*. 2018

# PreE and Heart Failure

- Compared with normal cohorts, PreE has 71% increased risk of CVD mortality
  - 2.5x higher risk of CAD
  - 4x higher risk of heart failure.<sup>8</sup>
    - PreE and PPCM both exhibit upregulation of antiangiogenic and vasculotoxic hormones secreted by placenta<sup>38</sup>
- PreE with PPCM has been associated with a higher incidence of adverse CV outcomes.<sup>9</sup>



## Madi

17y/o

Emergent c/s 25w5d for severe PreE  
Decompensated HF: dx PPCM  
IABP → ECMO → RVAD & LVAD  
Remains with LVAD

8. Mehta LS, Warnes CA, Bradley E, et al. *Circulation*. 2020

9. Zoltan. *N Engl J Med*, 2024.

38. Lewey et al. *Hypertension*. 2020.

# PreE and Heart Failure with Preserved EF

- Prior to decompensation (reduced EF), echos on preE women often look...  
...*normal*... with normal to increased CO, EF & contractility
- Further investigation often shows:
  - Diastolic dysfunction\*\*
  - Increased pericardial effusions
  - Increased LV wall dimensions compared to healthy parturients<sub>32</sub>
- So a quick cardiac POCUS will probably look normal unless obvious LV hypertrophy (PSA) or LA dilation visible (4C, PLA)
- Formal ECHO with more in-depth assessment needed, esp if symptomatic (SOB, cough, orthopnea, etc r/o pulm edema)

# PreE and Heart Failure with Preserved EF

- Difficult to diagnose and easy to miss.
- A seemingly normal EF on systolic assessment **WITHOUT** assessing diastolic function *can miss diagnosis of HFpEF*
- ***However 9.5 % of PreE pts w severe features found to have HFPEF! Almost 1 in 10!***
  - SOB & pulm edema are common presenting signs of HFpEF
  - Often precipitated by excess IV fluids → pulmonary edema

## Cynthia

G5P4

*“Two weeks after birth, I was back in the hospital with my BP at 215/127.*

*...I couldn't breathe. Every time I lay down, I felt as though I was drowning.”*

EF 25%

Ext defib

Medically managed

Full recovery



# Objectives:

Current Data on Maternal Mortality

Peripartum Hemodynamics Review

Maternal Cardiac Risk Scoring Systems  
& Heart Failure Identification Tools

Heart Failure from  
Preeclampsia & Peripartum Cardiomyopathy

Delivery Management Considerations in:

- **Heart Failure**
- Pulmonary Edema

# Delivery Mode: Vaginal with Neuraxial

## Vaginal delivery best with good neuraxial analgesia.

- Pain control = ↓ catecholamines = ↓ CV stress
- Vaginal delivery has less severe hemodynamic swings
  - ✓ lower EBL & less neuraxial sympathectomy <sup>5</sup>
- Vaginal delivery has lower risk of infection and thrombotic complications than C/S <sup>8</sup>
- ACOG (No. 212): IOL 39-40 wks for women w/ heart dx if no spontaneous labor <sup>8,19</sup>
  - IOL at 39 wks may reduce rates of C/S and improve maternal outcomes by decreasing risk of HTN disorders of pregnancy<sup>9</sup> (ARRIVE & HYPITAT) <sup>20,21</sup>

5. Gimius, A, Meng ML. *Journal of Cardiothoracic and Vascular Anesthesia*, 2021

8. Mehta LS, Warnes CA, Bradley E, et al. *Circulation*. 2020

9. Zoltan. *N Engl J Med*, 2024

19. ACOG Practice Bulletin No. 212: Pregnancy and Heart Disease. *Obstet Gynecol*. 2019

20. Grobman WA, Rice MM, Reddy UM, et al. *New England Journal of Medicine*. 2018

21. Koopmans CM, Bijlenga D, Groen H, et al. *Lancet*. 2009

# Delivery Mode: Vaginal with Neuraxial

## Monitors:

- Continuous pulse oximetry & ECG
- NIBP Q 2-5 min after neuraxial analgesia initiated
  - May require A-line, especially before neuraxial to monitor hemodynamic response
    - AS, MS, HOCM, PPCM or PreE w/ severely reduced EF, RV dysfunction, Pulmonary HTN.
- Consider staffing if L&D RNs are not trained for invasive hemodynamic monitoring or continuous vasoactive gtts, etc.
- **Plan for → ICU if inotropes/vasoactive meds needed peripartum, as they should be maintained through postpartum period to assist ventricles with postpartum fluid shifts.**

# Delivery Mode: Cesarean with Neuraxial

- **Cesarean** reserved for obstetric or fetal indications (malpositioned/breech, FTP, eRPT c/s, FHR)
  - *Or* high-risk maternal lesions:
    - severe aortopathy, severe AS or MS, or any maternal decompensation.<sup>3,5</sup>
- **Neuraxial anesthesia preferred**
  - Spinal may be well-tolerated in mWHO class 1 & 2 lesions
  - Slowly-dosed epidural best for mWHO class 3 & 4 lesions<sup>3</sup>
- **Plan for → ICU if inotropes/vasoactive meds needed peripartum, as they should be maintained through postpartum period to assist ventricles w/ postpartum fluid shifts.**

3. Meng ML, Arendt KW. *Anesthesiology*. 2021

5. Girnius A, Meng ML. *Journal of Cardiothoracic and Vascular Anesthesia*. 2021

# Delivery Mode: Cesarean with GA

- **GA** reserved for emergency requiring ETT for cardiopulmonary indication, or a contraindication to neuraxial in necessary c/s.
- If complex requirements: (eg: TEE, ECMO) use cardiac OR <sup>3</sup>
- PPCM possibly 1<sup>st</sup> sign of rare myopathy:
  - Danon Disease (LAMP2 variants) or Duchenne Muscular Dystrophy variants <sup>9, 22</sup>

3. Meng ML, Arendt KW. *Anesthesiology*. 2021

9. Zoltan. *N Engl J Med*, 2024

22. Ware JS, Li J, Mazaika E, et al. *N Engl J Med*. 2016

# Neuraxial Anesthesia/Analgesia Technique

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- Slow-dosed epidural offers slower sympathectomy
- C/S: IT narcotics via CSE +/- low-dose bupri ~2.5-5mg to improve surgical anesthetic while minimizing hemodynamic swings, then slowly dose epidural.
- Can avoid routine pre-procedure IVF bolus and manage sympathectomy with pressors, as HF patients at higher risk of pulmonary edema
  - or use smaller ~200cc bolus if necessary

# Thromboembolic Risk

- Consider neuraxial timing:
  - LVEF < 35% likely on anticoagulation
  - 5-20% cases develop LV thrombus

<https://www.everydayhealth.com/heart-failure/i-wanted-to-make-it-to-her-first-birthday-new-mom-diagnosed-with-heart-failure-days-after-giving-birth-to-daughter/>



Eloise

32 y/o, 1<sup>st</sup> child

“health nut - 5am gym & green smoothie every day”

s/s heart failure immediately after delivery

C/o persistent cough & SOB.

PPD#6 Dx PPCM.

4 days in ICU, stabilized and sent home.

The day after d/c, **suffered stroke at home**

Lost function of right arm and hand.

PT/OT and has made full recovery.

# Delivery Planning: Maternal Optimization

- **Cardiopulmonary workup**

- Labs: BNP (in addition to standard CBC/CMP/troponin if cp, etc..)
- ECG, TTE, CXR, LUS

- **Diuresis/Fluid restriction**

- To accommodate PP fluid volume

- Targeted tx tailored to conditions (eg,  $\beta$ -blockers for LVOTO or arrhythmias)
- Cautious diuresis in:
  - Volume overload if preload-dependent condition (eg. LVOTO) <sup>3</sup>
  - Pre-E, intravascularly dry 2/2 endothelial damage and capillary leak
- Careful in early PP period, where dramatic fluid shifts and SVR changes may create hemodynamic instability. <sup>8</sup>

3. Meng ML, Arendt KW. *Anesthesiology*. 2021

8. Mehta LS, Warnes CA, Bradley E, et al. *Circulation*. 2020

# Delivery Planning: Maternal Optimization

- Assess ability to **tolerate C/S positioning**:
  - If patient unable to lie flat for c/s (ie: increased SOB, O<sub>2</sub> requirement)
    - May require ETT, as persistent PP fluid shifts can/will acutely worsen condition.
    - Controlled intubation preferred before emergency occurs.<sup>3</sup>
    - Parturients have higher incidence difficult airway, and swelling may be exacerbated by PreE and labor/pushing.<sup>30</sup>
    - *Appropriate airway positioning before start of case\**

# Delivery Planning: Maternal Optimization

- **Inotropic gtts** available in OR, depending on cardiac eval, to assist ventricle with PP fluid load
  - ✓ Norepi, Epi, Dobutamine, Dopamine
  - ✓ Milrinone if BP stable (**↓ SVR esp with bolus**)
- Invasive lines: A-line, CVC if needed.
  - ✓ CCO monitor option if A-line in place.
  - ✓ **A-line during labor recommended in: RV dysfunction, severe LVOTO, severe MS, CM with severely decreased LVEF, pulm HTN, or PreE with HF.**
- Cardiac OR if ECMO, IABP LVAD considered

# INOTROPES

## Milrinone

- 0.125 – 0.375 mcg/kg/min
- Phosphodiesterase-3 inhibitor
- Loading dose can decrease SVR
  - Careful in Pre-E or preload – dependent lesion.
  - Slow titration of loading dose preferred

## Dobutamine

- 5-10 mcg/kg/min
- Beta adrenergic agonist
  - At low doses: Primarily B<sub>1</sub> agonism, some B<sub>2</sub> agonism
- Rapid onset (< 2min)
- Minimal side effects

## Dopamine

- Dose - dependent receptor response
  - D1: 1-2mcg/kg/min
  - B2: 2-10 mcg/kg/min
  - A1: >10mcg/kg/min

## Epinephrine

- Dose –dependent response
- Predominantly B1 & B2 agonism at lower doses
- 0.02-0.1 mcg/kg/min

## Extra points:

- ✓ With contractile dysfunction, maternal heart cannot increase contractility to accommodate increased preload, especially after delivery. May be advantageous to begin inotropes before signs of ventricular failure present (tachycardia, hypoxemia, hypotension). By then, myocytes may be hypoxic and less responsive.  $\Delta O_2$  demand on an already stressed ventricle..
- ✓ CCO monitoring may be beneficial in guiding and balancing vasoactive/inotropic therapy
- ✓ If parturient started on inotropes at any time peripartum (eg, optimization for pulmonary edema, systolic dysfunction, peri-delivery in anticipation of autotransfusion, etc.. **DO NOT WEAN OFF** after delivery/before case ends. **Maintain gtts and transfer to ICU.** Pt will need continued inotropic support to manage the continued increased preload, CO, and fluid volume shifts PP (~ 24-48h) to prevent cardiac decompensation<sub>5</sub>

The sudden ↑ in preload and C.O. on delivery can overwhelm a failing ventricle

*\*If inotropic/vasoactive gtts are needed during labor/delivery to optimize cardiac function, do not d/c in stable patient. Maintain gtts → transfer to ICU*

### Jessica

30 y/o G2P1 HTN at 32w → PO Anti-HTN. IOL 37wk → Breech → c/s.

**Coded in PACU**

10 min CPR, Impella, then ECMO for 2 wks.

Dx: paraganglioma: rare adrenal tumor likely contributed to HF.

*“This pregnancy was different. I was more tired, I got winded easily, and I had terrible headaches when I would lay down at night.”*



<https://www.stroke.org/en/news/2020/11/19/mother-brought-back-to-life-the-day-she-gave-birth>  
<https://www.today.com/health/womens-health/peripartum-cardiomyopathy-mom-30-shares-symptoms-rcna50204>  
<https://thebirthtraumamama.com/jessicas-story-surviving-peripartum-cardiomyopathy/>



# Significant Cardiac Effects of OB Meds

## Oxytocin (Pitocin)

- Usually well tolerated if titrated slowly, but **rapid IV bolus** ↓ SVR, → tachycardia & myocardial ischemia
  - Can give smaller, slower doses to effect. Treat ↓ SVR with pressors. <sup>3,5</sup>
  - Ex: **Rule of 3s**: Dilute 10u in 10cc NS0.9% and give 3u slowly (3cc) Q~3 min to effect. <sup>23</sup>
    - Can prevent over-dosing oxytocin. Reduced dose = reduced side effects <sup>3,23</sup>

## Methylergonovine (Methergine)

- 5-HT, Dopamine, and α-agonist – increases smooth muscle contraction
  - ↑ SVR and **PVR**
  - Can cause HTN, coronary vasospasm, and myocardial ischemia
  - *Relatively contraindicated in HTN conditions, aneurysms, CAD.*
    - If life-threatening bleeding, can give as small DILUTE IV pushes to effect
      - Ex: dilute 0.2mg into 20cc – 10mcg/cc and give 1-2cc at a time.
  - **\*Avoid in Pulm HTN, intracardiac shunts, ischemic heart dx, aortopathy, right heart failure.** <sup>3,5</sup>

# Significant Cardiac Effects of OB Meds

## Carboprost (Hemabate)

- Prostaglandin F<sub>2α</sub> agonist
  - **PGF<sub>2α</sub> induces significant pulmonary vasoconstriction**
    - activates prostaglandin F receptor (GPCR on pulmonary vascular smooth muscle)<sup>40</sup>
      - can double PVR, and increase ↑PAP 125%<sup>3</sup>
      - vasoconstriction is independent of bronchomotor tone & HPV reflex<sup>40</sup>
  - **Induces bronchoconstriction** - can cause bronchospasm → V/Q mismatch, shunting, ↑ PVR
    - **Avoid in asthma, Pulm HTN, intracardiac shunts, right heart failure<sup>3</sup>**

## Misoprostol (Cytotec)

- not for emergency use, no significant CV effects, used prophylactically

# Significant Cardiac Effects of OB Meds

## **Terbutaline:**

- Uterine relaxant
- Selective B<sub>2</sub> agonist
- ↑HR ↑ contractility ↓SVR
  - **Avoid in HOCM and hx tachyarrhythmias**

## • **Nitroglycerin:**

- Rapid uterine relaxation via N.O. mediated smooth muscle relaxation
- Rapid ↓SVR, resultant tachycardia
  - **Caution in HOCM, AS, R→L shunt, etc**

# Additional Considerations

## Epidural IV Test Dose & Tachycardia:

- Epi 15 - 25 mcg (3-5cc 1.5% lido 1:200,000 epi)
- Risk of tachycardia may be problematic in:
  - hx arrhythmias, HCM, AS, MS, or severe aortopathy
- Could instead use fentanyl 50-100 mcg and ask pt to report any s/s of IV opioids.

## Uterine Eversion & RV Strain

- Uterus lifted up and out of abdomen for repair after C/S entrains micro air-emboli, which upon entering pulmonary circulation will ↑ PVR.
  - Theoretical risk of consequent increased RV strain.
- Can repair uterus in situ to mitigate this risk in pts with RV strain, pulm HTN, or shunt lesions.

Education | July 2021

# Obstetric Anesthesia and Heart Disease: Practical Clinical Considerations **FREE**

Marie-Louise Meng, M.D.; Katherine W. Arendt, M.D.

+ Author and Article Information

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# Table 4.

## Hemodynamic Effects of Pregnancy and Anesthetic Management Considerations in Specific Cardiovascular Diseases

Effects of Pregnancy and Delivery	Management Considerations	Pulmonary hypertension	Valvular lesions	Mitral stenosis	Aortic stenosis/hypertrophic obstructive cardiomyopathy	Mitral/aortic insufficiency
<p><b>Coronary artery disease</b></p> <ul style="list-style-type: none"> <li>(-) Decrease in SVR can result in reduced diastolic blood pressure and thereby decreased coronary perfusion pressure</li> <li>(+) Increase in heart rate can result in decreased coronary filling time</li> <li>(-) Cardiac work can increase significantly during labor</li> </ul>	<p><b>Normal heart rate (avoid tachycardia):</b></p> <ul style="list-style-type: none"> <li>Maintain effective neuromuscular labor analgesia</li> <li>Continue <math>\beta</math>-blockade through labor and delivery</li> <li>Avoid <math>\beta</math>-agonist agents (e.g., terbutaline)</li> </ul> <p><b>Maintain afterload:</b></p> <ul style="list-style-type: none"> <li>Consider intraarterial blood pressure monitoring</li> <li>Consider phenylephrine for vasopressor of choice</li> <li>Carefully titrate neuraxial anesthesia onset for labor or cesarean delivery</li> <li>Consider prophylactic phenylephrine infusion for cesarean delivery</li> <li>Titrate oxytocin carefully</li> <li>Early recognition and aggressive response to hemorrhage</li> </ul> <p><b>Monitor for and avoid ischemia:</b></p> <ul style="list-style-type: none"> <li>Five-lead electrocardiographic monitoring for cesarean delivery or labor</li> <li>Avoid methylergonovine</li> <li>Recognize and carefully treat hypertensive disorders of pregnancy (e.g., consider intraarterial monitoring)</li> </ul> <p><b>Postpartum monitoring:</b></p> <ul style="list-style-type: none"> <li>Monitor for postpartum ischemia or heart failure</li> </ul>	<p><b>(+) Increased cardiac output may not be accommodated by the fixed pulmonary vasculature resulting in right heart failure</b></p> <p><b>(-) Decrease in SVR can result in reduced diastolic blood pressure and thereby decreased coronary perfusion pressure especially in a dilated and failing right ventricle</b></p> <p><b>(-) Hypocoagulable state can result in pulmonary emboli which can exacerbate pulmonary hypertension</b></p> <p><b>Minimize maternal plasma catecholamines:</b></p> <ul style="list-style-type: none"> <li>Administer supplemental oxygen</li> <li>Avoid oversedation, hypercapnia</li> <li>Maintain effective neuromuscular labor analgesia</li> <li>Assure well-controlled ventilation if intubated</li> <li>Avoid carboprost</li> </ul> <p><b>Maintain adequate blood volume and venous return:</b></p> <ul style="list-style-type: none"> <li>Strict monitoring of fluid balance</li> <li>Recognize and carefully treat hypertensive disorders of pregnancy (e.g., consider intraarterial monitoring)</li> <li>Early recognition and aggressive response to hemorrhage</li> </ul> <p><b>Avoid myocardial depression:</b></p> <ul style="list-style-type: none"> <li>Avoid <math>\beta</math>-blockade if possible</li> </ul> <p><b>Maintain afterload:</b></p> <ul style="list-style-type: none"> <li>Five-lead electrocardiographic monitoring for cesarean delivery or labor</li> <li>Consider intraarterial blood pressure monitoring</li> <li>Careful titration of onset of neuraxial anesthetic for labor or cesarean delivery</li> <li>Consider phenylephrine for vasopressor of choice</li> <li>Titrate oxytocin carefully</li> </ul> <p><b>Invasive pulmonary artery catheter monitoring as well as vasoactive agents may be necessary:</b></p> <ul style="list-style-type: none"> <li>Consider partnership with cardiovascular anesthesiologist</li> </ul> <p><b>Postpartum monitoring:</b></p> <ul style="list-style-type: none"> <li>Monitor for postpartum heart failure</li> </ul>	<p><b>(+) Hypercoagulable state of pregnancy increases risk of valve thrombosis</b></p> <p><b>(-) Vitamin K antagonists (most effective way to prevent valvular clot formation) are teratogenic. Suboptimal anticoagulation regimens may be used during pregnancy</b></p> <p><b>Balance risk of anticoagulation therapy and anesthesia technique:</b></p> <ul style="list-style-type: none"> <li>Perform general anesthesia for cesarean delivery in patients who are anticoagulated</li> </ul> <p><b>Recognize anticoagulation also increases risk of intrapartum and postpartum hemorrhage:</b></p> <ul style="list-style-type: none"> <li>Select and/or titrate uterotonics carefully depending on underlying cardiac disease</li> <li>Recognize that oxytocin decreases SVR, methylergonovine behaves as an adrenergic <math>\alpha</math> agonist and carboprost increases pulmonary vascular resistance significantly</li> <li>Postpartum monitoring</li> <li>Monitor for postpartum valvular clotting or obstetric bleeding</li> </ul>	<p><b>(+) Elevation in blood volume and heart rate increases left atrial pressure which may lead to atrial fibrillation and pulmonary edema</b></p> <p><b>(-) Because of relatively fixed preload to the left ventricle, the heart may not adequately generate increased cardiac output</b></p> <p><b>(-) Decreased oncotic pressure further increases risk of pulmonary edema</b></p> <p><b>Normal heart rate (avoid tachycardia):</b></p> <ul style="list-style-type: none"> <li>Maintain effective neuromuscular labor analgesia</li> <li>Continue <math>\beta</math>-blockade through labor and delivery</li> <li>Five-lead electrocardiographic monitoring for cesarean delivery or labor</li> <li>Avoid <math>\beta</math>-agonist agents (e.g., terbutaline)</li> <li>Early recognition and aggressive response to hemorrhage</li> <li>Avoid Atrial fibrillation</li> <li>In new-onset atrial fibrillation, cardioversion should be considered</li> <li>In failed cardioversion and in cases with chronic atrial fibrillation, treat rapid ventricular rate with medical therapy</li> </ul> <p><b>Prevent and monitor for pulmonary edema:</b></p> <ul style="list-style-type: none"> <li>Careful fluid balance</li> <li>Continuous pulse oximetry throughout labor and peripartum (including postpartum)</li> <li>Recognize and carefully treat hypertensive disorders of pregnancy (e.g., consider intraarterial monitoring)</li> </ul> <p><b>Manage pulmonary edema:</b></p> <ul style="list-style-type: none"> <li>Consider diuresis</li> <li>Administer supplemental oxygen</li> <li>Labor in upright position</li> <li>If necessary, consider intubation with positive end expiratory pressure and controlled ventilation</li> </ul> <p><b>Postpartum monitoring:</b></p> <ul style="list-style-type: none"> <li>Monitor for postpartum pulmonary edema</li> </ul>	<p><b>(-) Decrease in SVR can result in reduced diastolic blood pressure and therefore decreased coronary perfusion pressure to the thickened left ventricle myocardium</b></p> <p><b>(-) Left ventricle diastolic dysfunction and excess volume can lead to pulmonary edema</b></p> <p><b>Maintain afterload (avoid hypotension and hypovolemia):</b></p> <ul style="list-style-type: none"> <li>Consider intraarterial blood pressure monitoring</li> <li>Carefully titrate neuraxial anesthesia onset for labor or cesarean delivery</li> <li>Treat hypotension with phenylephrine</li> <li>Avoid non-specific <math>\beta</math>-agonist agents (e.g., terbutaline)</li> <li>Early recognition and aggressive response to hemorrhage</li> </ul> <p><b>Normal heart rate (avoid tachycardia):</b></p> <ul style="list-style-type: none"> <li>Maintain effective neuromuscular labor analgesia</li> <li>Prevent and monitor for ischemia</li> <li>Five-lead electrocardiographic monitoring for cesarean delivery or labor</li> <li>Recognize and carefully treat hypertensive disorders of pregnancy (e.g., consider intraarterial monitoring)</li> </ul> <p><b>Prevent and monitor for ischemia:</b></p> <ul style="list-style-type: none"> <li>Strict monitoring of fluid balance</li> <li>Postpartum monitoring</li> <li>Monitor for postpartum hypotension or ischemia</li> </ul>	<p><b>(+) Decreased SVR results in a lower regurgitant volume</b></p> <p><b>(-) Pregnancy can worsen ventricular dilation</b></p> <p><b>Avoid increases in SVR and decreases in contractility:</b></p> <ul style="list-style-type: none"> <li>Maintain effective labor analgesia</li> <li>Avoid bradycardia</li> <li>In cesarean delivery under spinal anesthesia, if prophylactic phenylephrine administered, carefully titrate and treat bradycardia. Alternatively, consider norepinephrine</li> </ul> <p><b>Maintain sinus rhythm:</b></p> <ul style="list-style-type: none"> <li>Maintain effective neuromuscular labor analgesia</li> <li>Consider afterload reduction</li> <li>Neuraxial anesthesia/anesthesia typically well tolerated if preserved ventricular function</li> </ul>
<p><b>Severe left ventricular dysfunction (e.g., dilated or peripartum cardiomyopathy)</b></p> <ul style="list-style-type: none"> <li>(-) Increase in cardiac output and blood volume can result in heart failure and pulmonary edema</li> <li>(-) Decrease in oncotic pressure can result in pulmonary edema</li> <li>(+) Patients with previous episode of peripartum cardiomyopathy are at risk for further deterioration in left ventricular function with subsequent pregnancies</li> <li>(-) Angiotensin-converting enzyme inhibitors are discontinued due to teratogenicity</li> </ul>	<p><b>Normal heart rate (avoid bradycardia):</b></p> <ul style="list-style-type: none"> <li>Treat bradycardia with epinephrine or glycopyrrolate</li> </ul> <p><b>Maintain afterload (avoid hypotension or hypotension):</b></p> <ul style="list-style-type: none"> <li>Consider intraarterial blood pressure monitoring</li> <li>Maintain effective neuromuscular labor analgesia</li> <li>Carefully titrate neuraxial anesthesia onset for labor or cesarean delivery</li> <li>Treat hypotension with epinephrine or norepinephrine</li> <li>Titrate oxytocin carefully</li> <li>Recognize and carefully treat hypertensive disorders of pregnancy (e.g., consider intraarterial monitoring)</li> <li>Early recognition and aggressive response to hemorrhage</li> </ul> <p><b>Maintain contractility:</b></p> <ul style="list-style-type: none"> <li>Consider epinephrine for vasopressor of choice</li> <li>If low cardiac output syndrome develops, consider milrinone or dobutamine with the addition of epinephrine or norepinephrine to maintain blood pressure</li> </ul> <p><b>Prevent and monitor for pulmonary edema:</b></p> <ul style="list-style-type: none"> <li>Careful fluid balance</li> <li>Continuous pulse oximetry throughout labor and peripartum (including postpartum)</li> </ul> <p><b>Manage pulmonary edema:</b></p> <ul style="list-style-type: none"> <li>Consider diuresis</li> <li>Administer supplemental oxygen</li> <li>Labor in upright position</li> <li>If necessary, consider intubation with positive end expiratory pressure and controlled ventilation</li> </ul> <p><b>Monitor for and avoid ischemia or arrhythmia:</b></p> <ul style="list-style-type: none"> <li>Five-lead electrocardiographic monitoring for cesarean delivery or labor</li> </ul> <p><b>Manage automatic implantable cardioverter defibrillator, if present:</b></p> <ul style="list-style-type: none"> <li>Keep antiarrhythmic function of automatic implantable cardioverter defibrillator active in labor and may be kept active in the event of emergent cesarean delivery</li> </ul> <p><b>Minimize pulmonary vascular resistance:</b></p> <ul style="list-style-type: none"> <li>Administer supplemental oxygen</li> <li>Avoid oversedation</li> <li>Assure well-controlled ventilation if intubated</li> <li>Avoid carboprost</li> </ul> <p><b>Postpartum monitoring:</b></p> <ul style="list-style-type: none"> <li>Monitor for postpartum heart failure</li> </ul>	<p><b>(-) Pregnancy, labor, and delivery may increase dilation of aortic root and increase the risk of aortic dissection</b></p> <p><b>(-) Maternal Valsalva maneuver may result in increased aortic shear stress</b></p> <p><b>Minimize aortic wall tension:</b></p> <ul style="list-style-type: none"> <li>Maintain effective neuromuscular labor analgesia</li> <li>Continue <math>\beta</math>-blockade through labor and delivery</li> <li>Cardio-Obstetrics may recommend cesarean delivery or no Valsalva during second stage</li> </ul> <p><b>Minimize hemodynamic fluctuations:</b></p> <ul style="list-style-type: none"> <li>Carefully titrate neuraxial anesthesia onset for labor or cesarean delivery</li> <li>Consider intraarterial blood pressure monitoring</li> <li>Avoid methylergonovine and carboprost</li> <li>Titrate oxytocin carefully</li> <li>Recognize and carefully treat hypertensive disorders of pregnancy (e.g., consider intraarterial monitoring)</li> <li>Early recognition and aggressive response to hemorrhage</li> </ul> <p><b>Postpartum monitoring:</b></p> <ul style="list-style-type: none"> <li>Monitor for postpartum hemodynamic instability</li> </ul>	<p><b>(+) Decreased SVR increases right-to-left shunting and possible cyanosis</b></p> <p><b>(-) In unrepaired tetralogy of Fallot and normal right ventricle function, the increase in blood volume is beneficial because adequate right ventricular preload is necessary to eject blood past the outflow obstruction and increase pulmonary blood flow*</b></p> <p><b>Shunt lesions</b></p> <p><b>Right-to-left shunt (e.g., tetralogy of Fallot, Eisenmenger syndrome)</b></p> <p><b>Maintain afterload and recognize worsening cyanosis:</b></p> <ul style="list-style-type: none"> <li>Continuous pulse oximetry throughout labor and peripartum (including postpartum)</li> <li>Treat cyanotic episodes with phenylephrine</li> <li>Consider intraarterial blood pressure monitoring</li> <li>Carefully titrate neuraxial anesthesia onset for labor or cesarean delivery</li> <li>Titrate oxytocin carefully</li> <li>Minimize pulmonary vascular resistance</li> <li>Administer supplemental oxygen throughout labor and delivery</li> <li>Avoid oversedation</li> <li>Maintain effective neuromuscular labor analgesia</li> <li>Assure well-controlled ventilation if intubated</li> <li>Avoid carboprost</li> </ul> <p><b>Maintain adequate blood volume and venous return:</b></p> <ul style="list-style-type: none"> <li>Strict monitoring of fluid balance</li> <li>Avoid supine position</li> <li>Early recognition and aggressive response to hemorrhage</li> </ul> <p><b>Avoid myocardial depressants because any decrease in right ventricular contractility can decrease pulmonary circulation:</b></p> <ul style="list-style-type: none"> <li>Avoid <math>\beta</math>-blockade if possible</li> <li>Five-lead electrocardiographic monitoring for cesarean delivery or labor</li> </ul> <p><b>If pulmonary vascular disease is present, invasive pulmonary artery catheter monitoring, as well as vasoactive agents, may be necessary:</b></p> <ul style="list-style-type: none"> <li>Consider partnership with cardiovascular anesthesiologist</li> </ul> <p><b>Avoid paradoxical embolism:</b></p> <ul style="list-style-type: none"> <li>Place filters on intravenous lines</li> <li>Perform epidural loss of resistance technique with saline not air</li> <li>Postpartum monitoring</li> <li>Monitor for postpartum cyanosis</li> </ul> <p><b>Avoid excessive fluid administration, overtransfusion, and Trendelenburg position:</b></p> <ul style="list-style-type: none"> <li>Strict monitoring of fluid balance</li> <li>Early recognition and careful response to hemorrhage</li> <li>Avoid increases in afterload</li> <li>Maintain effective neuromuscular labor analgesia</li> </ul> <p><b>Avoid paradoxical embolism:</b></p> <ul style="list-style-type: none"> <li>Place filters on intravenous lines</li> <li>Perform epidural loss of resistance technique with saline not air</li> </ul>	<p><b>Left-to-right shunt (e.g., ventricular septal defect or atrial septal defect)</b></p> <p><b>(+) Decrease in SVR decreases left-to-right shunting</b></p> <p><b>(-) Increase in blood volume can precipitate failure because the patient is in a state of compensatory hypervolemia</b></p>		

# Objectives:

Current Data on Maternal Mortality

Peripartum Hemodynamics Review

Maternal Cardiac Risk Scoring Systems  
& Heart Failure Identification Tools

Heart Failure from  
Preeclampsia & Peripartum Cardiomyopathy

Delivery Management Considerations in:

- Heart Failure
- **Pulmonary Edema**

# Delivery Management Considerations For Pulmonary Edema

# Pulmonary Edema in Pregnancy

## Parturients with heart disease are at high risk of pulmonary edema.

- Cardiogenic: heart failure, or fluid overload (can be iatrogenic)
- Non-cardiogenic: increased vascular permeability 2/2 damaged endothelium.
- Mixed: Parturient with PPCM and PreE/Eclampsia

## Heart failure can increase pulmonary capillary hydrostatic pressure

- further increased risk of transudation of fluid into pulmonary interstitium.

## Preparation for potential emergent delivery in acute pulmonary edema 2/2 heart failure includes:

- Rapid management of hypoxemia to prevent maternal or fetal compromise
- diuresis, +/- inotropic support, O<sub>2</sub> supplementation and possible tracheal intubation.

# DIAGNOSTIC TESTS

## PULMONARY EDEMA

BNP

TTE, POCUS: PLA,  
PSA, 4-chamber  
view

POCUS lung US

CXR

ECG

High BNP suggests  
HF and warrants  
further workup →  
TTE, POCUS

BNP > 50\*

NT- proBNP >  
150\*

Original Investigation | Emergency Medicine

## Diagnostic Accuracy of Point-of-Care Lung Ultrasonography and Chest Radiography in Adults With Symptoms Suggestive of Acute Decompensated Heart Failure A Systematic Review and Meta-analysis

Anna M. Maw, MD, MS; Ahmed Hassanin, MD; P. Michael Ho, MD, PhD; Matthew D. F. McInnes, MD, PhD; Angela Moss, MS; Elizabeth Juarez-Colunga, PhD; Nilam J. Soni, MD, MS; Marcelo H. Miglioranza, MD, MHSC, PhD; Elke Platz, MD, MS; Kristen DeSanto, MSLS, MS, RD; Anthony P. Sertich, MD; Gerald Salame, MD; Stacie L. Daugherty, MD, MSPH

### 2019 SRMA: 6 prospective cohort studies, 1827 patients

- Lung US more sensitive than CXR for detection of cardiogenic pulmonary edema, with similar specificity:
  - 15% absolute difference in sensitivity found between LUS and CXR (0.88 vs 0.73) ( $P < .001$ )
    - In other words: Q 100 patients c/c dyspnea 2/2 cardiogenic pulmonary edema, LUS can dx 15 more cases than CXR without increase in false (+).
- Additional Benefits: LUS easier to see real-time edema resolution, as confirmatory CXR images can lag behind both development and resolution. There is no radiation exposure, and learning curve for use is quick.

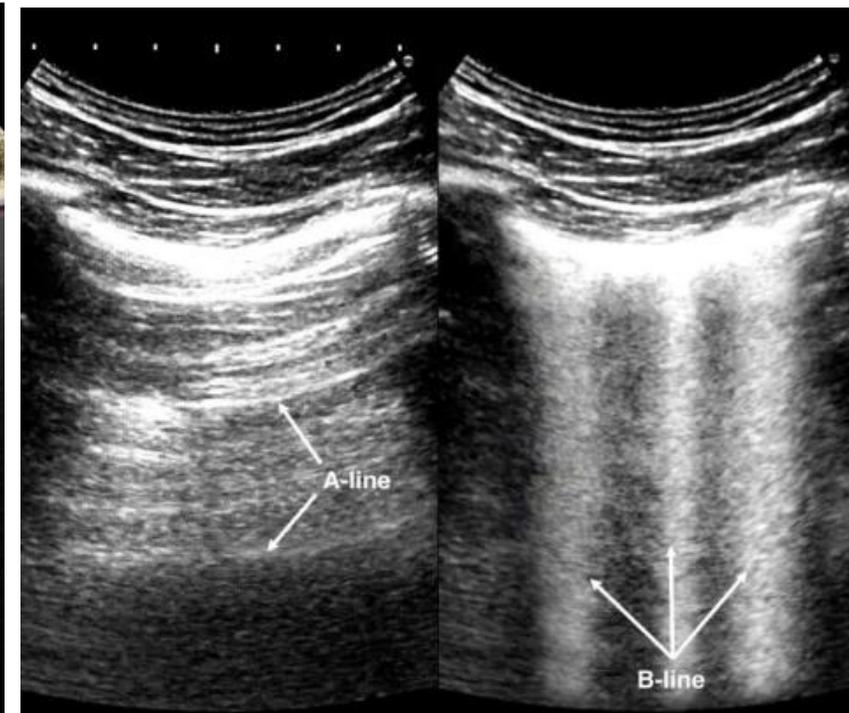
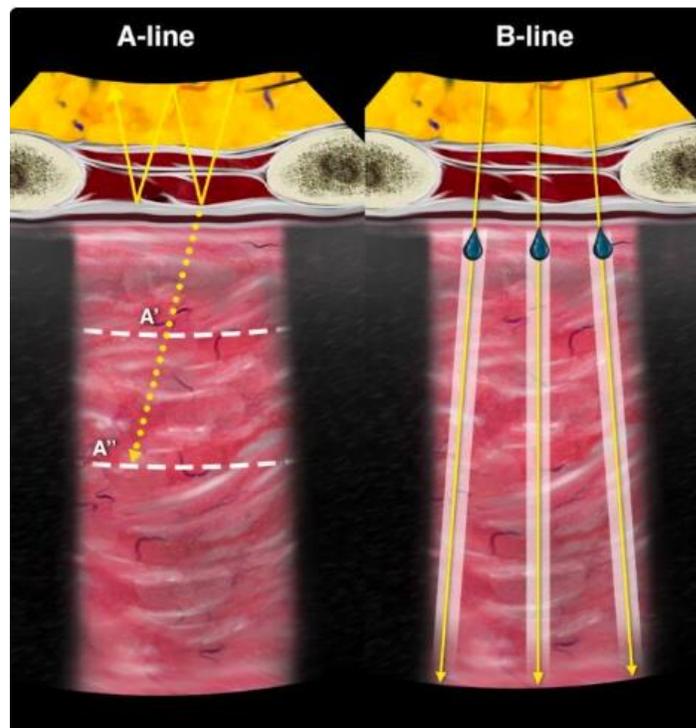
# POCUS LUNG ULTRASOUND

## **A-LINE:**

horizontal evenly-spaced hyperechoic reverberation air artifacts of the pleural line.

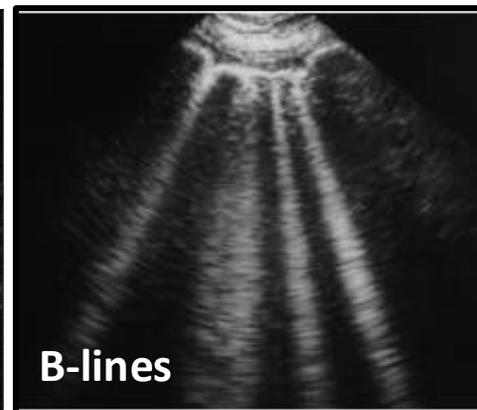
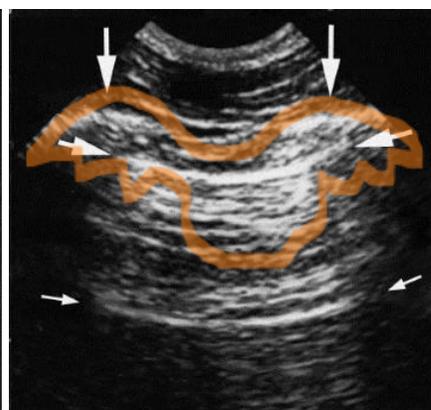
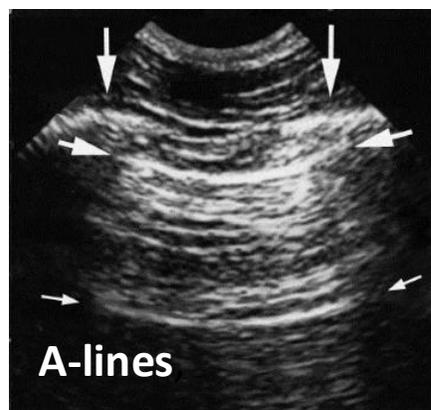
## **B-LINE:**

well-defined, hyperechoic water artifacts extending from the pleural line down to bottom of screen without fading, obliterating A-lines.<sup>25</sup>



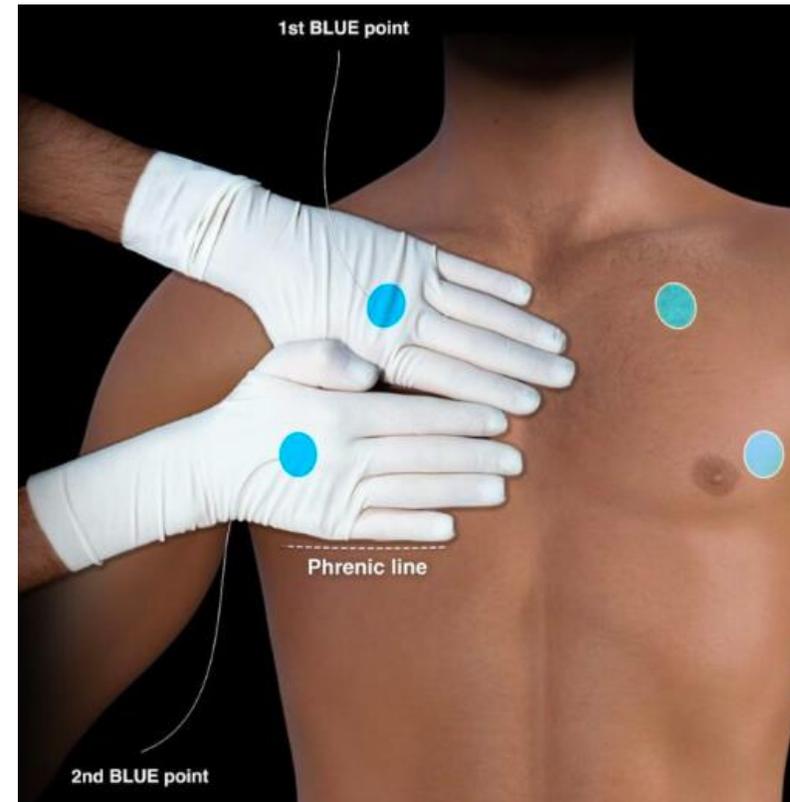
25. NYSORA. Acute respiratory failure: The BLUE protocol. *NYSORA*. 2023.

“bat sign” of rib shadows and pleural line



# POCUS LUNG ULTRASOUND

- 3+ B-lines in one field = “wet” lung.
  - 1-3 B-lines in bases can be normal finding in pregnancy.
- Visualized lung sliding\*, **with:**
  - **3+ B-lines at all 4 points** → likely pulmonary edema
    - lack of lung sliding suggests pneumonia
      - ❖ [BLUE protocol – Bedside Lung Ultrasound in Emergency]



# Pulmonary Edema: *Maternal Optimization*

## Diuresis

- Careful with high doses in PreE – intravascularly dry patient 2/2 3<sup>rd</sup> spacing

## Supplemental O2

- HFNC, CPAP, BiPAP: +PEEP

## Fluid restriction during delivery (C/S or VD)

- Careful IVF titration
- Smaller reconstitution doses for antibiotics (eg: 20cc syringe slow IVP vs 250cc NS bag for azithromycin)
- **Pitocin:** (instead of 10u over 10min ~ 166cc in 30u/500cc bag)
  - Instead:
    - “Rule of 3s”: 10u Pitocin in 10cc NS: Administer 3u Q3min to effect.
    - OBGYN can give IU Pitocin in C/S in lieu of IV bolus

# Pulmonary Edema: *Maternal Optimization*

## HYPERTENSION MANAGEMENT

- In PreE: IV BBs, hydralazine, or oral nifedipine often 1<sup>st</sup> line anti-HTN agents.
- However, **when PreE is associated with pulmonary edema, IV nitroglycerin preferred**.<sup>18</sup>
- ***Especially in Pre-E/HTN with LV systolic dysfunction/PPCM:***
  - Titrated NTG gtt can offload ventricles without affecting contractility, while inotropes (eg: dobutamine) can augment contractility and improve forward flow.
    - NTG benefit: tighter HD control with rapid onset and short  $t_{1/2}$
    - Dose: **IV gtt: 5 mcg/min, titrated Q 3–5 min to max dose of 100 mcg/min**.<sup>18</sup>
      - Initiation of high-dose BBs may be detrimental in setting of poor LV contractile function/HR-dependent CO.

**IMPORTANCE OF BNP → +/- TTE to assess which agents would be most beneficial if myocardial dysfunction present.**

# Heart Failure: Where to Look

**WE MUST BE AWARE OF POSSIBILITY OF HEART FAILURE IF S/S PRESENT PERIOD IN PREGNANT OR POSTPARTUM WOMEN**

- ✓ S/S on labor floor :
  - ↓SpO<sub>2</sub>, tachycardia, positioning, pt c/o not feeling right:
    - ✓ Maternal Early Warning Criteria/ACOG criteria/Fett Self Test.
    - ✓ Pulmonary edema: Cardiac workup, BNP, +/-TTE.
- ✓ Postpartum tubals, D&C for PPH – can occur in days, weeks PP
- ✓ Postpartum non-obstetric elective surgery/procedure
- ✓ Ante-/Postpartum urgent or emergent surgery

# Heart Failure: Where to Look

- In women of childbearing age, asking pre-op if any recent pregnancies:
  - If within 6mos, prudent to ask pointed cardiac questions:
    - ✓ METs, SOB, palpitations, chest pain, abnormal fatigue, s/s at rest vs active, peripheral edema, able to lay flat at night? Etc..

After 6wk PP checkup with OBGYN,  
we may be the *only* other providers women see during PP  
period who know to look for this.

# “Fett Self Test” for Early Identification of Heart Failure

> 4 pts → further workup (BNP & TTE)<sup>27</sup>

Table 1. Self-test for early diagnosis of peripartum cardiomyopathy.

Symptoms	0 points	1 point	2 points
Orthopnea	None	Need to elevate head	Need to elevate 45 degrees or more
Dyspnea	None	Climbing 8 or more steps	Walking on level
Unexplained cough	None	At night	Day and night
Lower extremity swelling	None	Below knee	Above and below knee
Excessive weight gain during last month of pregnancy	Under 2 pounds per week	2–4 pounds per week	Over 4 pounds per week
Palpitations	None	When lying down at night	Day and night, any position

The presence of 4 or more points should prompt additional investigation.  
Data taken from [30].

Davis M, Duvernoy C. *Women's Health*. 2015

In validation study: **100% of women who presented with > 4pts had LV systolic dysfunction.**<sup>27</sup>

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“Although it is possible that a fulminant myocarditis/cardiomyopathy can suddenly appear without prior warning and awareness, ***almost all of these women, upon reflection, can recognize that they experienced signs and symptoms earlier by days and weeks.***”

“My incessant theme is this: Physicians, nurses and patients must be alert to the possibility that ***a young woman, despite the lack of any type of heart problem in her medical history, may develop a serious cardiomyopathy with acute onset of heart failure in the setting of pregnancy***”

- James D Fett, MD, MPH

## TLDR: Key Points Summary

- Cardiomyopathy is a significant cause of maternal death in the United States.
- During pregnancy and postpartum, heart failure from either HTN or PPCM can develop rapidly and acutely over just days, in otherwise low-risk women. The condition is both under-screened and under-diagnosed.
- Pulmonary edema may be presenting sign of heart failure, and pulmonary ultrasound is a fast and reliable diagnostic tool.
- The significantly increased cardiac demands of labor, delivery, and **especially the postpartum period**, can push an impaired ventricle into failure.
- Uterotonic and tocolytic agents given peripartum can have **significant and deleterious cardiac effects in patients with heart failure**.
- Pregnancy-induced heart failure develops most commonly within 6 months postpartum, so it is prudent to include directed cardiac questions in pre-op eval for women who have recently been pregnant.
  - Fett Test is a useful, validated tool.



OK  
THANK YOU

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