SOAP
Society for Obstetric Anesthesia and Perinatology

Simulation Patient Design (January, 2023)
Case of Pulmonary Hypertension

Author(s): Liliana Goelkel-Garcia, MD[1]; Iryna Chugaieva, MD[1]; Roberto Blanco, MD[1].
1. Department of Anesthesiology, University of Minnesota
Editors: Kokila Thenuwara, MD, MME MHCDS, Jessica Sheeran, MD

Introduction

Pulmonary hypertension (PHTN) has been historically defined as mean pulmonary artery pressure (mPAP) > 25 mmHg at rest, measured by right heart catheterization (RHC). More recently, the 6th World Symposium on Pulmonary Hypertension Task Force reassessed the hemodynamic definitions and clinical classification of PH. A mPAP>20 mmHg is now considered above the upper limit of normal. This task force also proposes to include pulmonary vascular resistance (PVR)>3 Wood units in the definition of all forms of pre-capillary PHTN with mPAP>20mmHg. More importantly, it emphasizes the importance of characterizing the pathological processes that lead to PHTN, its clinical features, and its responsiveness to medical treatments. (1)

The recent advancements in medical therapies allow more women with PHTN to live through child-bearing age. Despite the development of advanced anti-PHTN therapies, women with PHTN are strongly advised against pregnancy since it is associated with severe maternal complications and high mortality. Mortality rates are reported in the range of 17-56%, with significant differences across studies depending on the cause and severity of PHTN, and the presence of additional comorbidities.(2) Most maternal fatalities occur within the first month after delivery, with the main causes of death being heart failure and sudden death, and pulmonary thromboembolism. Women with PHTN more frequently develop preeclampsia/eclampsia and have higher rates of cesarean delivery, obstetric bleeding, postpartum hemorrhage, preterm delivery, and intrauterine fetal demise.(3)

Patients with PHTN must be counseled regarding the high risks of pregnancy. They should be educated regarding their reproductive rights and should be advised to avoid pregnancy. Given the high morbidity and mortality of pregnancy in patients with PHTN, permanent contraception should be strongly recommended. In case of pregnancy, pregnancy termination may be advised due to the risk of maternal mortality.(4) Despite medical advice, some patients with known PHTN might choose to become pregnant or might desire to continue with an incidental pregnancy. In other cases, the physiologic changes of pregnancy might uncover a previously undiagnosed PHTN. In these cases, multidisciplinary management shall be initiated as early as possible. The goal shall be to complete a thorough evaluation and risk stratification and medically optimize the patient in preparation for the highest risk periods: the delivery and early postpartum. PHTN-targeted medications around the pregnancy include calcium channel blockers (CCB), Phosphodiesterase-5 inhibitors (PDE-5 inh), parental and inhaled prostacyclins, anticoagulation, and diuretics. Endothelin receptor antagonists (ERA) are considered to be teratogenic and thus must be avoided in pregnant patients.(4),(5)

While there is not enough data to state that vaginal delivery is contraindicated, a cesarean section under neuraxial is the recommended method of delivery as it avoids the hemodynamic swings associated with labor.(4),(6) Delivery via cesarean section also allows the presence of an expert anesthetic team ready to detect and aggressively manage any cardiovascular and hemodynamic derangements. It is recommended to avoid general anesthesia as it has a higher potential to depress

cardiac contractility and increase pulmonary vascular resistance. Invasive monitoring should be initiated before delivery and continued throughout the early postpartum period. Intraoperative transthoracic echocardiography might be used to early detect volume overload and changes in contractility. [7] Postpartum ICU admission shall be considered in order to monitor for right ventricular failure and arrhythmias. Prophylactic anticoagulation shall be considered since these patients are also at risk for thromboembolic events.

Educational Rationale:
To teach team skills in anticipating and managing hemodynamic changes associated with pulmonary hypertension (PHTN) in pregnant patients.

Target Audiences:
Anesthesiologists, anesthesiology residents, medical students, L&D nurses, midwives, and OB providers.

Learning Objectives:
As per Accreditation Council for Graduate Medical Education (ACGME) Core Competencies. Upon completion of this simulation (including the debrief) learners will be able to:

- *Medical knowledge*: Recognize clinical conditions associated with pulmonary hypertension (PHTN). Identify the most updated clinical classification of PHTN. Recognize that the physiologic changes of pregnancy are poorly tolerated in women with PHTN. Identify the mechanisms by which labor and delivery will further worsen pre-existing PHTN.
- *Patient care*: Recognize presenting symptoms and clinical features of PHTN. Identify the need for early multidisciplinary evaluation, early interventions, and periodic follow-ups throughout this high-risk pregnancy. Formulate an anesthetic plan with the least hemodynamic implications. Understand that the highest risks of adverse maternal outcomes are during peripartum and immediate postpartum periods.
- *Practice-based learning and improvement*: Recognize echocardiography as a paramount diagnostic and assessment tool in pregnant patients with PHTN. Identify available anti-PHTN therapies and their implications and/or contraindications in pregnancy. Understand the need for multidisciplinary management in an appropriate level of care.
- *Interpersonal and communication skills*: Communicate with all team members maintaining closed-loop communication in critical situations.
- *Professionalism*: Demonstrate the ability to communicate the risks and benefits of the proposed anesthetic plan to the patient. Maintain a professional attitude while in a stressful situation. Understand the need to call for help if needed given a life-threatening scenario.
- *Systems-based practice*: Develop a multidisciplinary delivery plan. Anticipate potential hemodynamic problems and additional tools needed to ensure patient safety.

Questions to ask after the scenario:

1. What is the differential diagnosis of new onset of dyspnea in a pregnant patient? What are the clinical signs of PHTN? What diagnostic tools are available to diagnose and risk stratify PHTN?
2. How will the physiologic changes of pregnancy affect an existing PHTN?
3. What anti-PHTN medical therapies can be safely used in pregnancy? Which ones should be avoided?
4. What are the current recommendations regarding PHTN and Pregnancy? Which delivery method is preferred and why?

5. What type of monitoring and access should be obtained? Is central access needed? Is there an indication for placing a pulmonary artery catheter?
6. For how long after delivery should we monitor this patient? Does this patient need ICU admission?

Assessment Instruments:

1. Learner Knowledge Assessment form (Appendix 1)
2. Simulation Activity Evaluation form (Appendix 2)

Equipment Needed and Set-up:

In-situ set-up

- OR with standard equipment including OR bed, standard ASA monitors, airway equipment, medications for cesarean sections, and ventilator
- Simulation mannequin - Female, pregnant.
- One 20G PIV in place to start
- Vascular access equipment available including large bore PIVs, arterial line, and central line.
- Ultrasound either in the OR or "available upon request". Will need a vascular probe and a cardiac probe.

Simulation Scenario Set-up:

The case:

33-year-old G2P1001 parturient at 36 weeks gestational age with a recent diagnosis of pulmonary hypertension 5 weeks ago after coming to the ED with new onset shortness of breath. She has been an inpatient since her PHTN diagnosis, and is currently on SQ Trepostinil 39ng/Kg/min and Sildenafil 40mg TID. She is also receiving prophylactic enoxaparin 40mg SQ Q24H with her last dose yesterday morning. She initially required diuretics, but those have been stopped now. She reports that she has not noted any significant improvement in her exercise tolerance, but she feels fine at rest. The patient had one prior uneventful vaginal delivery 3 years ago at an outside institution. Her PMHx is otherwise unremarkable.

She was just brought to the OR because she started having painful contractions and her cardiologist had recommended against vaginal delivery. The on-call OB team is in the OR with the patient and calls the Obstetric Anesthesia team to evaluate her for cesarean section.

<u>Relevant exams/labs</u>:

Hb 10.2 g/dl, Plt 126 $x10^9$/L
T&S done.
INR 0.98, Fibrinogen 373 mg/dL
BUN 4/ Creat 0.52. Estimated GFR >90
Electrolytes: WNL

<u>RHC</u> at time of diagnosis/~31 wks:

- R-sided filling pressures elevated. Moderately elevated PAH. Left-sided filling pressures are mildly elevated. Normal cardiac output.
- RA: –/–/8, RV 60/8, PA 60/30/40, PCWP –/–/15, Fick 5.5/3.5, TD 5.9/3.7, PVR 4.2

TTE at time of diagnosis/~31 wks: LVEF 60-65%, Hyperdynamic, normal global LV function. Moderate tricuspid insufficiency. Paradoxical septal motion is consistent with RV pressure and volume overload. Moderate RV dilation. RV function reduced. RVSP 110mmHg above RAP. Estimated RAP 8.

Simulation Pre-brief

- Read the scenario and instruct team members on their role during the simulation.
- The learners take their places.
- One OB staff and one OB resident are at the bedside with the patient. Other members of the OB and operating room team are available if called.
- Simulation driver plays the patient.

Scenario Details

Trigger	Patient Condition	Action	Done	Time	Comments
Patient in OR. OB team ready for C-section.	Patient laying comfortably on the OR bed. Vitals stable/normal. SpO2 97 on room air, HR=90 bpm, BP=124/74. She wants her husband to be in the OR with her. Reassuring fetal heart rate tracing-130 bpm with accelerations.	1. Discuss the anesthetic plan with the patient. 2. Ensure OR is prepared to manage hemodynamic instability and/or obstetric hemorrhage. – Delegate tasks and have a backup staff if help is needed. – Ensure other members of the team are available including OB, NICU, +/- RT, +/- perfusionist – Ensure T&S and blood are available vs blood in the OR – Vasopressors in OR vs in-line -Discuss availability of Epoprostenol (Flolan) – Have US in the OR or available upon request for TTE & line placement – Discuss availability of CV surgeon/perfusionist in the hospital – Discuss ECMO as a reasonable backup plan if all other interventions fail? 3. Place Large Bore IVs 4. Place arterial line 5. Plan to avoid any increases in PVR: avoid sedatives and maternal respiratory depression, avoid hypothermia, avoid hypoxia/hypercarbia, avoid acidosis.			

Patient in OR, lines and monitors in place	Vitals remain stable Arterial line correlates well with BP cuff. SpO2 97 on room air, BP 130/85, HR 77 bpm	Prepare for neuraxial - Plan for CSE vs. Epidural - Decide dose and if additives in spinal - IV fluid bolus with pressure bag available			
Neuraxial done. The patient just repositioned to supine with LUD.	Awake and oriented, but feeling nauseated. HR 101 bpm BP 100/67 mm Hg SpO_2 97% (air) Resp 12/min Temp 36.^{o}C	1. Ensure adequate bed tilt/Left uterine displacement. 2. Manage hypotension. - Start the vasopressor of choice: Vasopressin. Infusion started at 0.02 units/min and titrated. - Avoid phenylephrine as can increase PVR - Check arterial line transducer location. - Trend CVP if CVL in place 3. Check sensory block level. T4 level to cold. 4. Communicate when abdomen/ skin prep can be started 5. If not done: give perioperative antibiotics.			
Patient is supine with a left tilt. States it is difficult to breathe.	SpO2 97-98% on room air. BP remains stable since the initiation of vasopressor infusion. HR 107 bpm BP 102/69 mm Hg SpO_2 97% (air) Resp 17/min	1. Reassess patient: - Inquire about SOB. - Ask about other symptoms - Recheck oximetry - Recheck sensory level- remains T4 level to cold. 2. Consider TTE assessment dependent on symptoms. 3. Reassure the patient if no major concerns. 4. No need for supplemental O2 if SpO2 is normal.			
Case started uneventfully until delivery of fetus. NICU assessing newborn. OB describes poor uterine tone, with	- Baby was just delivered 2 mins ago. - Patient is still feeling ok. - BP stable at expense of raising vasopressor infusion rate. HR 130 bpm	1. Uterotonic drugs administered - Oxytocin infusion started at cord clamping. - Increase infusion rate due to poor uterine tone. 2. A first-year OB resident asks to give Methlyergonovine - Explain that it might raise PVR and worsen PHTN. Also avoid			

moderate bleeding.	BP 98/65 mm Hg SpO_2 97% (air) Resp 15/min	Carboprost for same reason. 3. Other Uterotonics: Misoprostol 4. Consider TXA 5. Increase IV fluid rate. Use a pressure bag if needed. 6. Reassess: visually inspect the surgical field and/or ask about uterine tone and QBL so far. 7. Consider rechecking labs and calling for blood in the room.			
OB reports that the uterine tone has greatly improved. QBL ~1.2 L I/O: UO 200ml Crystalloids: 2L given so far	Patient remains awake and calm. Reports feeling well. Vasopressor requirement remains stable. HR 100 bpm BP 100/65 mm Hg SpO_2 94% (air) Resp 20/min Temp 36.^{o}C	1. Continue monitoring. 2. Clinical assessment: auscultate lungs, look for JVD, recheck BP, recheck location of arterial line 3. Consider TTE exam: - Explain to the patient that a basic echo will be done. - TTE: parasternal views show slightly dilated RV. LV normal. Unable to obtain subcostal & IVC views. 4. Consider diuresis. 5. Maintain vasopressors. - Consider need to start acsecond vasopressor - Consider inotropic support based on (limited) TTE results - Discuss role for restarting IV epoprostenol if she is already on SC Treprostinil			
- C-section close to completion. QBL 1.5 L -NICU cleared baby and he is laying on mom's chest.	-Patient reports feeling great! She would like to go to a regular room to enjoy her baby and to be allowed to receive family visits. -She received a one-time dose of IV Furosemide. -She is off pressors now. Vitals stable. HR 88 bpm BP 106/75 mm Hg SpO_2 94% (air) Resp 20/min	1. Discuss with OB team and explain to the patient that she remains at risk for hemodynamic decompensation. 2. Recommend transfer to ICU to continue monitoring.			

Appendix 1

Learner Knowledge Assessment
Pulmonary Hypertension Multidisciplinary Team Simulation

Name of simulation: _____ Date: _____

OB Nursing Anes

Each item has two components. The "Before the simulation" column (left side) examines your perspective at the beginning of the simulation. The "End of Simulation" column (right side) is to evaluate your perspective at the completion of the simulation.

1. How would you rate your knowledge of the signs and symptoms of PHTN?

BEFORE THE SIMULATION	END OF SIMULATION
1 2 3 4 5 6 7 Little/none Knowledgeable	1 2 3 4 5 6 7 Little/none Knowledgeable

2. How would you rate your knowledge of differential diagnosis of PHTN in a pregnant patient?

BEFORE THE SIMULATION	END OF SIMULATION
1 2 3 4 5 6 7 Little/none Knowledgeable	1 2 3 4 5 6 7 Little/none Knowledgeable

3. How would you rate your knowledge of how the physiologic changes of pregnancy affect PHTN?

BEFORE THE SIMULATION	END OF SIMULATION
1 2 3 4 5 6 7 Little/none Knowledgeable	1 2 3 4 5 6 7 Little/none Knowledgeable

4. How would you rate your knowledge of recommended delivery planning for a patient with PHTN?

BEFORE THE SIMULATION	END OF SIMULATION
1 2 3 4 5 6 7 Little/none Knowledgeable	1 2 3 4 5 6 7 Little/none Knowledgeable

5. How would you rate your overall confidence when confronted with a pregnant patient with known PHTN?

BEFORE THE SIMULATION	END OF SIMULATION
1 2 3 4 5 6 7 Little/none Knowledgeable	1 2 3 4 5 6 7 Little/none Knowledgeable

Appendix 2

Simulation Activity Evaluation

DATE OF SIMULATION: _____

OCCUPATION:

Consultant PG Yr 1 2 3 4 STUDENT NURSE MIDWIFE OTHER

SPECIALTY:_____ YEARS IN PRACTICE: _____

Please rate the following aspects of this training program using the scale listed below:

1 = Poor 2 = Suboptimal 3 = Adequate 4 = Good 5 = Excellent

Use "N/A" if you did not experience or otherwise cannot rate an item

INTRODUCTORY MATERIALS						
Orientation to the simulator	1	2	3	4	5	N/A
PHYSICAL SPACE						
Realism of the simulator space	1	2	3	4	5	N/A
EQUIPMENT						
Satisfaction with the mannequin	1	2	3	4	5	N/A
SCENARIOS						
Realism of the scenarios	1	2	3	4	5	N/A
Ability of the scenarios to test technical skills	1	2	3	4	5	N/A
Ability of the scenarios to test behavioral skills	1	2	3	4	5	N/A
Overall quality of the debriefings	1	2	3	4	5	N/A
DID YOU FIND THIS USEFUL?						
To improve your clinical practice?	1	2	3	4	5	N/A
To improve your teamwork skills?	1	2	3	4	5	N/A
To improve your VERBAL communication?	1	2	3	4	5	N/A
To improve your NONVERBAL communication?	1	2	3	4	5	N/A
FACULTY						
Quality of instructors	1	2	3	4	5	N/A
Simulation as a teaching method	1	2	3	4	5	N/A

COMMENTS/SUGGESTIONS:

References:

1. *Simonneau G, Montani D, Celermajer DS, Denton CP, Gatzoulis MA, Krowka M, Williams PG, Souza R. Haemodynamic definitions and updated clinical classification of pulmonary hypertension. Eur Respir J. 2019 Jan 24;53(1):1801913. doi: 10.1183/13993003.01913-2018. PMID: 30545968; PMCID: PMC6351336.*
2. *Pieper PG, Hoendermis ES. Pregnancy in women with pulmonary hypertension. Neth Heart J. 2011 Dec;19(12):504-8. doi: 10.1007/s12471-011-0219-9. PMID: 22068738; PMCID: PMC3221745.*
3. *Thomas E, Yang J, Xu J, Lima FV, Stergiopoulos K. Pulmonary Hypertension and Pregnancy Outcomes: Insights From the National Inpatient Sample. J Am Heart Assoc. 2017 Oct 24;6(10):e006144. doi: 10.1161/JAHA.117.006144. PMID: 29066439; PMCID: PMC5721838.*
4. *Hemnes, Anna R., et al. "Statement on Pregnancy in Pulmonary Hypertension from the Pulmonary Vascular Research Institute." Pulmonary Circulation, vol. 5, no. 3, 2015, pp. 435–65. JSTOR, https://doi.org/10.1086/682230. Accessed 6 Dec. 2022.*
5. *Huang S, DeSantis ER. Treatment of pulmonary arterial hypertension in pregnancy. Am J Health Syst Pharm. 2007 Sep 15;64(18):1922-6. doi: 10.2146/ajhp060391. PMID: 17823103.*
6. *Corbach Nadine, Berlier Charlotte, Lichtblau Mona, Schwarz Esther I., Gautschi Fiorenza, Groth Alexandra, Schüpbach Rolf, Krähenmann Franziska, Saxer Stéphanie, Ulrich Silvia. Favorable Pregnancy Outcomes in Women With Well-Controlled Pulmonary Arterial Hypertension. Frontiers in Medicine. Vol 8, 2021. DOI=10.3389/fmed.2021.689764. ISSN=2296-858X*
7. *Nagre AS. Focus-assessed transthoracic echocardiography: Implications in perioperative and intensive care. Ann Card Anaesth. 2019 Jul-Sep;22(3):302-308. doi: 10.4103/aca.ACA_88_18. PMID: 31274494; PMCID: PMC6639886.*