Simulation Patient Design (March, 2023)
Case of Pulmonary Edema in the setting of Preeclampsia

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Introduction

About 10% of all pregnancies are complicated by hypertensive disorders of pregnancy, and it remains as one of the leading causes of maternal and perinatal mortality worldwide. Pulmonary edema is one of the defining features of preeclampsia with severe features and is responsible for approximately 25% of the mortality in this setting.[1-3] Knowledge of risk factors and presenting signs and symptoms are imperative for adequate management and minimizing maternal and fetal morbidity and mortality.

Preeclampsia affects 2-8% of all deliveries. It is a multifactorial multisystem disease, characterized by widespread endothelial dysfunction and imbalance of angiogenic factors leading to hypertension associated with proteinuria and/or evidence of impaired liver function, acute kidney failure, neurologic features, thrombocytopenia, or pulmonary edema.[1,2,4,5] Early screening is advocated and comprises a combination of clinical risk factors along with laboratory and ultrasonographic assessment of uteroplacental perfusion.[6] Prevention of preeclampsia relies on identification and monitoring of high-risk patients, along with pharmacologic therapy when indicated. [1,7] Ultimate treatment is delivery, however management with anti-hypertensive therapy, magnesium sulfate, and/or glucocorticoids is often indicated.[6]

Pulmonary edema may arise as a complication in about 3% of women with preeclampsia, and 70% of cases will occur in the postpartum period. The pathophysiology of pulmonary edema associated with preeclampsia is complex and likely a result of the combination of expected physiologic changes of pregnancy, the multifactorial disease process of preeclampsia, and iatrogenic factors such as excessive fluid administration and use of tocolytic agents. Some of the normal physiologic changes of pregnancy that may be predisposing factors include increases in heart rate, cardiac output, blood volume, and capillary permeability along with decreased oncotic pressure. In the presence of preeclampsia, osmotic pressure is further reduced by hypoproteinemia and endothelial dysfunction leads to increased capillary permeability. In addition, there is an increase in hydrostatic capillary pressure and possibly diastolic dysfunction and/or left ventricular myocardial edema, all of it favoring development of pulmonary edema.[3,4,5,8] Some of the associated findings in preeclamptic women who develop pulmonary edema include multiple pregnancy, markers of severe disease (eclampsia, HELLP), treatment with magnesium sulfate, and more liberal fluid management.[4,9]

Clinical signs and symptoms are similar to pulmonary edema outside of pregnancy and include breathlessness, agitation, cough, orthopnea, tachypnea, tachycardia and hypoxemia. On physical exam, findings of crackles and wheezing on auscultation and cardiac S3 gallop may also be present.[4] Pulmonary edema is a clinical diagnosis, but laboratory and imaging tests may assist in the diagnosis and help clarify the etiology. Point of care transthoracic echo (TTE) and lung ultrasonography are invaluable assessment and diagnostic tools and have been increasingly used to aid early diagnosis and help assess cardiac function and identify signs of pulmonary edema at bedside.[4,5,10] In specific situations, additional testing such as formal echocardiography, spiral CT imaging, ventilation/perfusion scan or pulmonary arteriography may be needed to identify additional causes of cardiopulmonary compromise.[4,11,12] Treatment strategy includes restricting fluid administration, decreasing both preload and afterload, and controlling blood pressure while maintaining appropriate oxygenation. Use of supplemental oxygen (including positive pressure ventilation if needed) associated with diuretic, morphine, and vasodilators are usually necessary.

Close fetal monitoring and adequate planning for delivery should be discussed when pulmonary edema develops antepartum.[4,12]

Educational Rationale: To teach team skills in managing pulmonary edema in setting of preeclampsia
Target Audiences: L&D nursing, Obstetric team, Obstetric anesthesiology team, OR personnel.
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*: Review incidence, risk factors, clinical signs, and diagnostic tools of pulmonary edema. Outline treatment options for pulmonary edema in setting of preeclampsia.
- *Patient care*: Recognize presenting signs/symptoms of pulmonary edema in the setting of preeclampsia in order to manage it timely and effectively.
- *Practice-based learning and improvement*: List equipment and medications needed for diagnosis and treatment of pulmonary edema. Incorporate point of care tests to aid on differential diagnosis.
- *Interpersonal and communication skills*: Highlight the importance of interpersonal and interdisciplinary communication in the management of the critically ill parturient.
- *Professionalism*: Demonstrate respect and apply open communication with multidisciplinary care team.
- *Systems-based practice*: Familiarize with institutional protocols for escalation of care in critical situations.

Questions to ask after the scenario:

1. What are the major causes of mortality associated with hypertensive disease of pregnancy?
2. What is the differential diagnosis for dyspnea in a parturient?
3. What are the clinical signs and symptoms of pulmonary edema?
4. How to diagnose pulmonary edema?
5. Describe the expected findings on lung ultrasound in the setting of pulmonary edema.
6. What is the treatment for pulmonary edema in the setting of preeclampsia?
7. Did you identify any barriers to proper diagnosis and/or treatment?
8. Did you identify any issues with communication / team work?

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
Location: L&D OR suite
Personnel : Mannequin or actor/actress, labor and delivery nurse, obstetrician, obstetric anesthesiologist
Equipment:

- Monitors: NIBP, EKG, pulse oximetry, optional: arterial line setup
- Airway equipment: NC/EtCO2, regular face mask, Ambu-bag, Anesthesia machine with suction, intubation supplies including laryngoscope, 6.0 ETT, LMA
- IV fluids in situ, additional IV start kits. Optional: arterial line kit
- Medications: vasopressors, local anesthetics, IV anti-hypertensives, IV diuretics, induction medications.
- Optional: code/crash cart, ultrasound with TTE and curvilinear probes.

Simulation Scenario Set-up:
The case

Ms. Mary Smith is a previously healthy 37yo G1P1, presenting for urgent dilation and curettage due to retained placenta. She has no known allergies and last ate 12h ago with clear liquids until 4h ago. Ms. Smith underwent induction of labor at 37-week gestation due to preeclampsia with severe features (based on severe range blood pressures, headache unrelieved by analgesics, and an increase in her creatinine to 1.2mg/dL) and had an uneventful vaginal delivery 3h prior. The quantitative blood loss is 540mL and she received 500mL of crystalloids after delivery. Patient has a labor epidural in place and assessment shows bilateral T12 level to cold sensation. She is on Magnesium sulfate maintenance infusion at 1g/h and Plasmalyte infusion at 75mL/h.

Ms Mary Smith, 37yo
Weight: 91Kg, Height 1.68m, BMI 32.2
Access: 18G left forearm, 20G right hand

Baseline labs (prior to delivery): Hb 14.8 g/dL, Plt: $102x10^3/\mu L$, creatinine 1.2mg/dL, T&S: O+, no antibodies
Baseline physical exam (at epidural placement):
HEENT / Airway: MP3, full ROM of neck, good dentition
CV: RRR, no murmur
Respiratory: Clear to auscultation
Abdomen: gravid, otherwise soft and non-tender
Neuro: alert and oriented, no focal deficits
Ext: pitting edema 2+

Simulation Pre-brief

- Read the scenario and instruct team members on their role during the simulation.
- Encourage learners to verbalize their thought process and action plans, including description of any equipment and medication/dosage used.
- The learners take their places in the operating room.

Scenario Details

Trigger	Patient Condition	Action	Done	Time	Comments
Patient in OR for urgent dilatation and curettage. Labor epidural in place with T12 sensory level to cold bilaterally	Supine, awake and responsive HR 118 bpm BP 147/95 mm Hg SpO_2 94% (room air) Resp 20/min Temp 36.9ºC Block will rise to T10 bilaterally after a bolus of local anesthetic	1. Entire team: ensure correct patient and procedure 2. OB anesthesiologist confirms all equipment needed is available 3. Places monitors and obtains baseline vital signs 4. Considers options for anesthetic management including using neuraxial in place versus general anesthesia 5. Uses appropriate medications and dosing per institution preference to raise epidural block level for surgical procedure 6. Ensures adequate block for procedure 7. Surgical team prepares and positions patient in lithotomy position 8. Surgical team places foley catheter			
Patient in OR, ready for procedure	Lithotomy, awake and oriented, tachypneic, says she is nervous /anxious HR 120 BP 142/86mmHg SpO2 92% (room air)	1. Provides verbal reassurance 2. Notices decline in oxygen saturation 3. Provide supplemental oxygen and end tidal CO_2 monitor on patient 4. Auscultate lungs: bilateral wheezing, fine bibasilar crackles 5. Communicates concerns with surgical team 6. Surgeon requests trendelenburg to initiate procedure			
Procedure starts, patient complains of shortness of breath	Lithotomy with trendelenburg, awake and oriented, tachypneic HR 125 bpm BP 138/86 mmHg SpO_2 84% (room air)	1. Recognizes continued desaturation 2. Flattens bed/ elevates head of bed 3. Communicates with patient and surgeon 4. Provides supplemental O2 if not done earlier 5. Considers differential diagnosis including pulmonary edema, decompensated heart failure,			

	Resp 25/min Temp 36.9ºC	bronchospasm, pulmonary embolism, amniotic fluid embolism			
Patient complains of worsening shortness of breath	Lithotomy, flat, awake, moderate distress, tachypneic, coughing Frothy sputum is noticed when coughing HR: 125 bpm BP: 152/94mmHg SpO2 88% on 4L nasal cannula Resp 28/min TTE shows normal systolic function, no wall motion abnormalities, no major valvular disease, no pericardial effusion Lung Ultrasound shows >3 B-lines in a lung field ABG: pH 7.46, PaO2 58, PaCO2 25mmHg	1. Auscultate lungs: crackles 2. Considers/performs TTE and/or lung US 3. Recognizes pulmonary edema 4. Treats pulmonary edema: support including O2 per face mask, considers non-invasive / invasive positive pressure ventilation; administers diuretic (furosemide 20-40mg IV), orders chest imaging 5. Obtains ABG 6. Places arterial line 7. Adds vasodilators if severe range blood pressure (nitroglycerin, nicardipine) 8. Prepare intubation equipment and medications in case respiratory status worsens			
Procedure ends. Patient reports SOB still present but stable.	Supine with elevated head of bed, awake, tachypneic HR: 120 BP: 150/92mmHg SpO2 93% on simple face mask	1. Patient stable on respiratory support 2. Interdisciplinary discussion on care plan and transfer to intensive care unit 3. Scenario ends with report being called to ICU			

	Resp 25/min Urinary output starts to increase (50 ml now in foley catheter)				

Appendix 1

Learner Knowledge Assessment
Labor and Delivery Multidisciplinary Team Simulation

Name of simulation: Pulmonary edema in setting of preeclampsia 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 risk factors for pulmonary edema in setting of preeclampsia?

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 pulmonary edema in setting of preeclampsia?

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 signs and symptoms of pulmonary edema in setting of preeclampsia?

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 treatment of pulmonary edema in setting of preeclampsia?

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 pulmonary edema in setting of preeclampsia?

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:

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