

Simulation Patient Design (June, 2020) Case of Mitral Stenosis in L&D

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Introduction

Mitral stenosis (MS) in reproductive aged women is almost always a result of rheumatic heart disease following group A streptococcus (GAS) pharyngitis, and is the most clinically significant valvular lesion in pregnancy worldwide.^{1,2} Rheumatic valvulitis causes scarring of the mitral valve leaflets with fusion of the commissures and subvalvular apparatus over time, resulting in MS. Up to a quarter of women with MS experience their first symptoms during pregnancy, reflecting the unfavorable consequences of the cardiovascular changes of pregnancy in the setting of a stenotic mitral valve. In developed countries such as the United States, Canada and those in Western Europe, GAS infection is rare, so MS accounts for less than 25% of pregnant women with heart disease.^{1,3,4} In contrast, rheumatic heart disease was the underlying cause of valvular abnormalities in 55-88% of 1200 pregnancies reviewed in women from developing countries, and is a major cause of maternal mortality.⁵

Stenotic valves are poorly tolerated in advanced pregnancy due to the inability to increase left sided cardiac output in relation to expanding plasma volume.⁶ The severity of the lesion and superimposed physiologic changes of pregnancy as well as increased cardiac demands of labor and delivery are of importance to the anesthesiologist. Optimization of these patients as they undergo rapid hemodynamic changes can make anesthetic management challenging.

Maternal Complications

Pregnant women with MS are at elevated risk for pulmonary edema, atrial tachyarrhythmias (e.g. atrial fibrillation, atrial flutter, supraventricular tachycardia), thromboembolic disease as a result of left atrial enlargement, pulmonary hypertension, and worsening New York Heart Association (NYHA) class even without frank pulmonary edema.

Fetal Outcomes

Poor fetal outcomes such as fetal growth restriction, low birth weight and preterm birth increase with severity of MS.⁷

Prenatal or Antepartum Cardiovascular Investigation

As early as possible, patients should undergo a detailed history and physical examination to assess for symptoms of heart failure, arrhythmias, pulmonary hypertension, and thromboembolic disease.

These women should have a 12 lead electrocardiogram (EKG) and transthoracic echocardiogram (TTE) in the first and third trimesters. Transmitral gradient will increase as pregnancy progresses due to increased preload, but planimetry and pressure half time are less preload dependent methods to measure mitral valve area (MVA). Chest x-ray (CXR) may demonstrate an enlarged left atrium and/or Kerley B lines in a subset of patients, but demonstrates poor sensitivity for detection of relatively asymptomatic patients.

Risk Stratification

Women at highest risk of maternal cardiovascular complications are those with moderate to severe MS (MVA <1.5 cm², trans-mitral gradient \geq 5 mm Hg), baseline NYHA Class III or IV, history of pulmonary edema or arrhythmias requiring treatment, transient ischemic attack or stroke prior to pregnancy, pulmonary

hypertension (pulmonary artery systolic pressure >50 mm Hg), or central cyanosis.

Monitoring

Women who present to Labor and delivery (L&D) with MS should be monitored with continuous maternal pulse oximetry, EKG and non-invasive blood pressure (NIBP). Pulse oximetry should be measured by plethysmography to ensure the presence of an adequate waveform. An arterial line should be considered if the patient has symptoms of heart failure, history of arrhythmia(s), or superimposed obstetric complications such as preeclampsia.

Central venous access with pulmonary artery catheters are not routinely recommended in these patients, as placement may precipitate cardiac arrhythmias. Also, pulmonary capillary wedge pressure, if used as a surrogate for left atrial pressure, can significantly overestimate the transmitral gradient.

Management

Medical Management

Pulmonary edema should be managed with furosemide, supplemental oxygen and initiation of beta blockers (avoiding atenolol as it is associated with low birth weight) to reduce heart rate and improve left ventricular filling.⁸ Frequent palpitations should be investigated so that atrial tachyarrhythmias can be promptly diagnosed and managed. Rate control of atrial tachyarrhythmias (goal heart rate of 70-90 bpm, to maintain the augmented cardiac output in late pregnancy) can be achieved with beta blockers, digoxin or diltiazem, however diltiazem and digoxin are FDA category C and should only be used when the benefits outweigh the risks. Digoxin also undergoes increased renal clearance during pregnancy. Anticoagulation with heparin or low molecular weight heparin should be promptly initiated in patients at risk for thromboembolic disease. Warfarin should be avoided whenever possible due to fetopathic effects; if used, doses should be restricted to <5 mg/day during weeks 12-36 of pregnancy only.

Invasive interventions

Percutaneous mitral balloon valvuloplasty (PMBV) should be considered in patients with severe symptoms and poor response to medical therapy. It is ideally performed after organogenesis (20 weeks) but before mid/late third trimester as the gravid uterus can make percutaneous access difficult. The fetus should be shielded with lead during the procedure.

Open mitral valve replacement should only be considered in patients with severe symptoms despite medical therapy, who are not candidates for PMBV due to the higher maternal and fetal risk profile.

Peripartum Management

Labor and delivery are accompanied by large hemodynamic changes. In addition to implementing medical therapies as discussed above, anesthesiologists should optimize peripartum hemodynamics by encouraging early labor analgesia (preferably neuraxial) to control heart rate, maintain adequate preload and venous return by avoiding aortocaval compression, and avoiding hypoxia, hypercarbia and acidosis (all of which increase pulmonary vascular resistance). Fluids should be administered judiciously to maintain adequate uteroplacental perfusion with onset of neuraxial analgesia/anesthesia and subsequent sympathectomy, but avoid circulatory overload and pulmonary edema.

With adequate labor analgesia and an assisted second stage, most women with MS can have a successful vaginal delivery. Cesarean delivery should be reserved for obstetrical indications or patients with refractory heart failure requiring intubation and ventilatory support. Maternal care should be extended through several days postpartum, as many women may develop symptoms consistent with pulmonary edema, heart failure or arrhythmias.

Educational Rationale: To teach anesthesiologists and obstetricians how to evaluate for symptoms of decompensated MS in pregnancy and perform cardiovascular risk assessments, as well as identify best practices for peripartum monitoring, administration of analgesia/anesthesia, and management of hemodynamics in pregnant patients with MS.

Target Audiences: Obstetric anesthesiologists, general anesthesiologists, maternal-fetal medicine specialists, obstetricians, L&D nursing

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:

1. State the most common causes of MS in pregnancy
2. Stratify pregnant women at high risk for cardiovascular complications
3. Recognize complications such as atrial arrhythmias, thromboembolic disease, and pulmonary edema and heart failure in pregnant patients

Patient care:

1. Identify clinical symptoms of MS in pregnancy
2. Order relevant antepartum cardiovascular testing
3. Determine appropriate peripartum monitoring, and maintain hemodynamic stability during labor and delivery
4. Select an appropriate analgesia/anesthesia method

Practice-based learning and improvement:

1. Utilize TTE as the diagnostic modality of choice
2. Consider PMBV or open valve replacement as treatment modalities in severe cases with poor response to medical management
3. Evaluate drug dosing for pregnant patients with MS, and the effects of the drugs on the fetus

Interpersonal and communication skills:

1. Discuss anesthetic concerns regarding the patient in a multidisciplinary setting
2. Develop a safe and efficient peripartum plan for delivery
3. Effectively communicate with the team if the patient's care needs escalate

Professionalism:

1. Discuss concerns with the patient in the antepartum period
2. Develop a plan that includes the patient's input and buy-in
3. Execute safe care while being willing to listen to all members of the peripartum team

Systems-based practice:

1. Stratify the risk profile based on NYHA classification and TTE findings
2. Develop a clear anesthetic plan for labor and delivery and possible urgent or emergent cesarean delivery
3. Discuss monitoring considerations and availability of critical care trained nurses with a multidisciplinary team that includes nursing, obstetric, cardiology, and anesthesiology teams

Questions to ask after the scenario:

- Did anyone identify themselves as a team leader?
- Did each individual have a well-defined role?
- Did team members communicate effectively?
- Were all necessary medications and equipment (including crash cart and defibrillator) readily available?
- Was the medical decision-making clear?
- Were cognitive aids available and used?

Assessment Instruments:

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

Equipment needed and set up**L&D:**

EKG, pulse oximeter, NIBP

TTE

Epidural kit

Crash cart

OR:

EKG, pulse oximeter, NIBP, arterial line

Airway equipment - video laryngoscope, ETTs, oral airways, suction

Crash cart with resuscitation drugs and drips

Defibrillator

Simulation Scenario

20 year old female, G2P0101 presents at 37 weeks gestational age to OB triage with intermittent contractions that began this morning, and she endorses worsening shortness of breath (SOB) and lower extremity swelling over the last three weeks. She currently reports 3-pillow orthopnea and SOB, and palpitations with mild exertion. She had a previous vaginal delivery in Guatemala at 34 weeks gestation without neuraxial labor analgesia. She reports a history of pharyngitis as a child that was treated with penicillin. No prior investigational information available.

Simulation pre-brief

- Read the scenario and instruct team members on their roles during the simulation
- One nurse and one OB resident are inside the L&D room with the patient
- The learners take their places outside the L&D room

Scenario Details

Trigger	Patient Condition	Action	Done	Time	Comments
Nurse calls OB resident as O ₂ sat is 91% (room air) + patient complains of 'heart racing'	Sitting at 45° Oriented Appropriately responsive	In OB triage: <ol style="list-style-type: none"> OB listens to patient's lungs (focus on lung bases for crackles or wheezing, and comments on presence or absence) Counts respiratory rate Checks for work of breathing, accessory muscle use, + sternal retractions Assesses deep tendon reflexes – normal Administers supplemental oxygen via non-rebreather face mask Calls anesthesiology team leader 			
Anesthesiologist arrives Patient noted to have irregularly irregular rhythm on 5 lead EKG	Complains of difficulty breathing	<ol style="list-style-type: none"> Anesthesiologist checks HR, NIBP, pulse ox and identifies atrial fibrillation on 5 lead EKG Patient transferred out of OB triage to a high-risk area, or L&D room Orders 12 lead EKG Reassesses respiratory status Sends ABG, calls for CXR Asks OB to assess fetal heart tracing (FHT) Administers IV beta blocker if there is rapid ventricular response 			
ABG result returns pH 7.45 PaO ₂ 57 PaCO ₂ 28	Patient O ₂ sat is 93% on 4L/min O ₂	<ol style="list-style-type: none"> Interprets ABG as hypoxia with hypocarbia due to increased work of breathing Evaluates CXR Orders TTE Consults cardiology Discusses differential diagnosis, including pulmonary embolism, pulmonary edema, pneumothorax 			

<p>30 min later, CXR + TTE completed</p> <p>Dx: <i>Severe MS</i> CXR: <i>Mild interstitial edema</i></p>	<p>BP stable EKG NSR FHT normal</p> <p>Patient is now in significant pain from contractions + requesting epidural</p>	<ol style="list-style-type: none"> 1. Labor epidural placed with continuous monitoring 2. Test dose negative for intrathecal or intravascular placement 3. Consider IV diuretics + fluid restriction 			
<p>Patient has spontaneous rupture of membranes followed by prolonged variable deceleration</p> <p>Category 3 FHT</p> <p>OB calls an urgent cesarean delivery</p>	<p>Mom in left lateral position</p> <p>FHT responds appropriately to maneuvers</p>	<ol style="list-style-type: none"> 1. Assess maternal BP, administer phenylephrine as needed to maintain adequate mean arterial pressures 2. Maintain lower heart rate for adequate filling time - verbalize hemodynamic goals 3. Maintain left uterine displacement 4. Assess EKG for arrhythmia 5. Administer GI prophylaxis 6. Determine anesthetic + monitoring plan 7. Begin titrating epidural boluses SLOWLY (being cognizant to avoid maternal tachycardia) with 2% lidocaine (with 1:200,000 epinephrine ± bicarbonate), or 3% chloroprocaine, with/without epidural fentanyl 			
<p>Patient is transported to the OR</p>	<p>After patient is positioned and prepped, she feels palpitations</p>	<p>In OR:</p> <ol style="list-style-type: none"> 1. Ensure patient has the following monitors: 5 lead telemetry, arterial line, pulse ox 2. Assess EKG for arrhythmia 3. Access: 2nd IV started 4. Start low dose phenylephrine drip 5. Double concentrated oxytocin prepared 6. Left uterine displacement 			
<p>Patient again found to be in atrial fibrillation with RVR (HR 160s)</p>	<p>BP 140/90 mm Hg</p>	<ol style="list-style-type: none"> 1. Rate control with IV metoprolol (2.5 mg-5 mg over 2-5 min) or esmolol (0.5 mg/kg bolus followed by infusion) 2. Ask for crash cart to be outside OR in case of unstable SVT 			

Patient responds to rate control with beta blockers	BP stable Patient unable to lie flat + becomes restless + agitated	<ol style="list-style-type: none"> 1. Preoxygenate patient 2. Assess for high block 3. Plan for conversion to GETA given hemodynamic instability + pulmonary edema: Sniffing position (head-of-bed 45°) Video laryngoscope RSI with etomidate + succinylcholine Small-sized ETT Phenylephrine in line 			
After intubation, PIP increased (50 cm H ₂ O), SpO ₂ 90%		<ol style="list-style-type: none"> 1. Increase FiO₂ to 100% 2. Check circuit for kinks 3. Auscultate + rule-out bronchospasm, mainstem, pneumothorax, pulm edema 4. Suction ETT + rule-out aspiration, mucus plug, pulm edema 5. Paralyze with non-depolarizing neuromuscular blocker 			
ETT suctioned + copious frothy fluid from lungs	SpO ₂ improves to 94%	<ol style="list-style-type: none"> 1. Diagnose severe pulmonary edema 2. Maintain 100% oxygen 3. PPV with PEEP 4. Immediate delivery 5. Administer lasix IV 			
After delivery OB notifies team that there is uterine atony	PPH secondary to atony	<ol style="list-style-type: none"> 1. Administer concentrated oxytocin 2. Administer misoprostol PR 3. Consider early administration of tranexamic acid 4. Call for blood products 5. Weigh risk/benefit of 2nd-line uterotonics 6. Assess EBL + urine output 			
Postoperative		<ol style="list-style-type: none"> 1. Transfer to ICU (intubated) 2. Consider repeat TTE 3. Consult cardiology for possible emergency balloon valvuloplasty within 24-48 hours 4. ICU handoff verbalization 5. Report to family regarding patient status + explain why she is intubated post-delivery 			

Appendix 1

**Learner Knowledge Assessment
Obstetrics Interdisciplinary Team Simulation**

Name of simulation: *Management of pregnant patient with mitral stenosis*

Date: _____

Anesthesiology

Obstetrician

Nursing

Support Personnel

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 impact of mitral stenosis on pregnancy?

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

2. How would you rate your knowledge of risk stratification of mitral stenosis?

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

3. How would you rate your knowledge of the location of the nearest crash cart?

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

4. How would you rate your knowledge of the management of acute atrial fibrillation in the OR?

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

5. How would you rate your knowledge of managing uterine atony in the setting of mitral stenosis?

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

Appendix 2

Simulation Activity Evaluation Form

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
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PHYSICAL SPACE

Realism of the simulator space	1	2	3	4	5	N/A
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EQUIPMENT

Satisfaction with the mannequin	1	2	3	4	5	N/A
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SCENARIOS

Realism of the scenarios	1	2	3	4	5	N/A
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Ability of the scenarios to test technical skills	1	2	3	4	5	N/A
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Ability of the scenarios to test behavioral skills	1	2	3	4	5	N/A
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Overall quality of the debriefings	1	2	3	4	5	N/A
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DID YOU FIND THIS USEFUL?

To improve your clinical practice?	1	2	3	4	5	N/A
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To improve your teamwork skills?	1	2	3	4	5	N/A
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To improve your VERBAL communication?	1	2	3	4	5	N/A
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To improve your NONVERBAL communication?	1	2	3	4	5	N/A
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FACULTY

Quality of instructors	1	2	3	4	5	N/A
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Simulation as a teaching method	1	2	3	4	5	N/A
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COMMENTS

References:

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