Society for Obstetric Anesthesia and Perinatology

Simulation Patient Design (July 2024)
Case: Intraoperative Hypoxia in a Pregnant Patient

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Introduction

Definition and Measurement:

The terms hypoxia and hypoxemia are not synonymous. Hypoxemia is defined as decrease in the partial pressure of oxygen in the blood, whereas hypoxia is defined by reduced levels of oxygen in body tissues (1). Hypoxemia is defined as low levels of oxygen in the blood, usually < 60 mm Hg, (which is also the threshold number for hypoxia); but does not automatically indicate tissue hypoxia (1). In general, hypoxia results due to either defective delivery or defective utilization of oxygen by the tissues. Normal arterial oxygen level in a healthy pregnant patient is 75-100 mm Hg (1).

The amount of oxygen carried by the red blood cells is often measured with a pulse oximeter, which is based on the principle that O_2Hb and HHb differentially absorb red and near-infrared (IR) light. (2, 3).

Physiologic and compensatory mechanisms in pregnant patients:

Hypoxia leads to compensatory mechanisms, such as tachypnea and acid base disturbances. Depending on its magnitude and circumstances, hypoxia can evoke a spectrum of changes from alkalosis (high altitude) to acidosis in severe hypoxia, or poor perfusion (ischemia) metabolic hypercapnic acidosis with lactate production (4).

In a pregnant patient, hypoxia not only poses a threat to multiple lives (mother and fetus(es)), but is also associated with significant co-morbidities, ranging from acute respiratory failure in the mother to less subtle changes that contribute to development of preeclampsia and intrauterine growth restrictions in the fetus (5). Hypoxia is particularly difficult to manage acutely in a pregnant patient, due to potentially difficult airway, risk of aspiration, physiologic changes in respiratory status, etc. Symptoms of hypoxia vary linearly with severity and acuteness of drop in oxygen saturations. In awake pregnant patients, tachypnea, tachycardia or bradycardia, cough, confusion, sweating, and wheezing might be present. Changes in the color of the skin, ranging from blue to cherry red, with the concomitant decrease in oxygen saturation. The effects on the fetus include those of intrauterine growth restriction (IUGR), asphyxia, multiorgan failure, premature delivery, and perinatal demise (6).

Respiratory adaptations are necessary for increasing metabolic demands of a healthy pregnant patient. Toward the end of the third trimester, functional residual capacity (FRC) decreases by 20 % to 30%, as do its subcomponents, expiratory reserve volume (ERV;15 % to 20%) and residual volume (RV; 20% to 25%). Patients with underlying conditions and co-morbidities (e.g., smoking or obesity which affect closing volumes), might experience early airway closure with resulting hypoxemia.

In healthy pregnant patients, airway resistance usually remains unchanged and there is an increase in minute ventilation starting at the beginning of pregnancy due to progesterone effects, increasing tidal volume and producing a slight tachypnea. Alveolar dead space increases, such that the ratio dead space/tidal volume remains unchanged (7). In patients with underlying conditions and comorbidities, alveolar dead space maybe increased, airway resistance maybe increased, or increase in minute ventilation may not be well tolerated, leading to either acute or gradual onset of hypoxia. Furthermore, with increased survival of those patients that have congenital cardiac diseases and have reached reproductive age, patients might need specialized cardiac-obstetric anesthesiologists to manage hemodynamics and avoid hypoxia.

Maternal effects:

Hypoxia during gestation is associated with a significant incidence of maternal complications and preeclampsia. There is an increased vascular resistance and placental hypoxia in preeclampsia, and fetal intrauterine growth restriction (FRG/IUGR) associated with gestational hypoxia. While V/Q mismatch is the most common mechanism involved, most diseases states have more than one mechanism contributing to hypoxemia especially in the pregnant woman with their added mentioned contributing factors (8).

Another factor for consideration is a pulmonary aspiration risk (NPO status, GERD (1)). The chance of inhalation of gastric content increases in pregnant women, particularly if difficulty occurs with airway management and or manipulation. The risk is further heightened with opioid administration, onset of labor, pain, trauma, as well as the presence of comorbidities including obesity, history of difficult intubation or prior tracheostomy, pulmonary disease, or cardiovascular disease, placing them and their fetus (es) at higher risk if hypoxia ensues.

Hypoxemia during non-obstetric procedures and its effects on mother and fetus:

Roughly 1-2 % female patients who undergo anesthesia for surgical procedures unrelated to delivery in the United States, have unrecognized pregnancy at the time of surgery (3). Most non - obstetric surgeries include appendicitis, cholelithiasis, ovarian cyst or torsion, breast tumors, trauma and more rarely for threatening neurosurgical conditions or organ transplantation, or car accidents. The airway management in these population is also more technically difficult due to the increased anteroposterior diameter, breast enlargement, laryngeal edema and weight gain that affects the soft tissues of the neck (1).

Management of hypoxemia:

It is important to consider the amount of time in which the anesthesiologist must secure the airway is shortened due to the physiologic (and possible pathologic changes) in these patients. Additional patient characteristic necessitating a swift ETT placements in a pregnant patient may include obesity, obstructive sleep apnea, history of difficult airway, history of tracheostomy, etc. (2).

Educational Rationale: This simulation is designed to review and educate learners on the causes and potentially devastating consequences of hypoxia on both mother and the fetus(es). Additionally, hypoxia during gestation is associated with a significant incidence of maternal complications and preeclampsia, adversely impacting the fetal development and subsequent risk for cardiovascular and metabolic disease (7). Therefore, in pregnant patients, prevention of hypoxia, high level of suspicion for underlying acute or chronic etiology, and swift management are crucial for successful intervention.

Target Audiences: OB Nursing, OB team, Anesthesiology personnel, OR personnel, medical and nursing students, respiratory therapists, intensivists

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: Identify signs and symptoms of hypoxia in a pregnant patient intraoperatively. Treat hypoxia in peri-delivery setting, or Operating Room for non-labor related surgery. Review the management of parturient with hypoxia and the factors that play a role in this management. Utilize appropriate monitors, laboratories and equipment.

• Patient care: Effectively recognize and effectively provide treatment for hypoxia for both pregnant patient and her fetus.

• Practice-based learning and improvement: Identify location of emergency equipment, familiarize with algorithms and local policies in management hypoxia in a pregnant patient.

• Interpersonal and communication skills: Practice closed-loop communication, team dynamics, calling for help early, and role assignment / delegation during peri-delivery management of a patient in thyroid storm.

• Professionalism: Demonstrate professionalism and respect for all team members while managing an

emergency, validate and recognize the difficulty and stress of the situation.
• Systems-based practice: Review activating additional help in a setting of perioperative emergency and discuss local policies and procedures.

Questions to ask after the scenario
1) How do you think this scenario went? What do you think your team did well? Provide specific examples. What do you think the team could have done better?
2) What problems or concerns have you noticed regarding professionalism? Regarding environmental safety and system-based practice?
3) What differential diagnoses do you, as a team, consider when presented with this scenario?
4) Discuss hypoxia management, including what are the factors contributing to hypoxia, in a pregnant patient with intraoperative hypoxia.

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
- Anesthesia machine
- Ventilator
- Arterial line equipment
- Access to ABG machine for POC ABG results
- Epidural kit with medications or Spinal kit, depending on patient's disposition
- Adult and pediatric code carts, including defibrillator
- Airway equipment
- IV medications, fluid, and set up
- Monitors: 5 lead EKG, NIBP, temperature, HR, $EtCO_2$, invasive blood pressure monitoring

Simulation Scenario Set-up:
The case
35-year-old patient G2P1, at term, obese, BMI 47 with history of sleep apnea with variable CPAP compliance. She had lower back surgery previously and has hardware in place. Alternative labor analgesia with nitrous oxide is given as the team was unable to place a labor epidural due to hardware presence. Due to failure to progress, meconium, and late decelerations she is taken to the OR for cesarean section, with plan for general anesthesia.
Initial exam:
General appearance:
-Obese patient, complaining of pain with contractions
-BP=149/83, HR=99, RR=18, temp 36.6 C, saturations 98% on RA.
-First obstetric exam: 3.5 cm dilated, cervix is closed, long, meconium present
-Uteroplacental tracing shows late decelerations.

Patient is brought to OR. Plan is for a general anesthetic.

Simulation Pre-brief
- Read the scenario and instruct team members on their role during the simulation.
- The learners take their places.

Scenario Details

Trigger	Patient Condition	Action	Done	Time	Comments
Patient arrived at the hospital at term with painful contractions, failure to progress, meconium and late decelerations. Patient to operating room for urgent cesarean delivery	Patient is awake and responsive. HR 95 bpm BP 148/85 mm Hg SpO_2 97% (air) Resp 16/min Temp 37.1ºC	1. L&D triage nurse performs initial patient evaluation and examination. ☐ Calls the OB to prepare for cesarean delivery. ☐ Informs the anesthesiology and pediatric team. ☐ Places 18G IV + sends labs. ☐ Initiates IV fluid infusion.			
Anesthesiology manages the airway.	After successful rapid sequence induction, a video laryngoscopy performed. Grade 2 view is obtained, and airway secured with 7.0 ETT. Bilateral but distant breath sounds. Procedure starts. After further table positioning changes, patient starts to desaturate. SpO_2 89%	☐ Procedure continues as labor nurse and anesthesiologist call for help while assessing airway placement. ☐ Increase FiO2 to 100 % ☐ Perform lung recruitment maneuvers. ☐ Call for help.			
Baby is delivered, pediatric team available. OG with small amount of gastric content noted.	Patient continues to slowly desaturate; saturations are now 84%. Patient looks husky. HR =110 BP 130/80 No ECG changes. Ventilated and anesthetized.	☐ Prepare for hypoxia / diagnosis and management. 1. Call for fiberoptic bronchoscope 2. Plan to check ETT positioning, including tip above carina 3. Suction ETT 4. Check ventilator settings, adjust accordingly. 5. Consider differential diagnosis: circuit			

		disconnect, mucous plug, main stem intubation, ventilator dis-synchrony; others include AFE, PE, aspiration. 7. Place arterial line and send ABGs.			
Fiberoptic bronchoscopy reveals ETT tip in the right main stem bronchus. ETT suctioning without any significant secretions. Tip ETT moved 2cm above carina. Ob reports surgical uterine bleeding.	Saturations at 84 % still on FiO2 100%, slowly improving. ABG prior to ETT repositioning shows: 7.23/58/35 PO2 89	1. Auscultate for bilateral breath sounds 2. Re-secure ETT so that does not move with table positioning changes 3. Re-confirm tip remains above the carina 4. Check for any gastric contents in the airway 5. Adjust ventilator settings: treat acidosis, hypoxia (include changes in RR, PEEP, I:E ratio, TV as needed) 6. Check HH; administer uterotonic agents as needed after discussion with surgical team.			
OB reports that the uterine tone has improved, and bleeding is controlled. Patient is hemodynamically stable. Minute ventilation is higher with normal airway pressures.	Patient's color is improving. Saturations > 95% on 100% FiO2 Blood pressure is 120/80 Hb is 9 No EKG changes; HR 80s	1. Continue current ventilator strategies for the remainder of the procedure. 2. Draw another ABG prior to extubating to check all electrolytes and re-check HH. 3. Consider extubation at the end of case if extubation criteria are met.			
Patient improves saturations and overall hemodynamics. Baby is doing well Apgar scores of 7 and 9	Patient's color is at baseline. HR 76 bpm BP 128/65 mm Hg SpO_2 98% Temp 36.6ºC	1. Patient successfully extubated to non-rebreather 2. Transferred to PACU			

	Repeat ABG 7.30/45/28 PO2 295 (on FiO2 80%)				
Patient transported to PACU	Saturations 98% on non-rebreather. Weaned to 2L/min O2 via NC. AVSS.	1. Patient stable 2. Arterial line removed in PACU prior to transferred to the floor. 3. Episode debriefed to patient.			

Appendix 1

Learner Knowledge Assessment
Labor and Delivery 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 risk factors for intraoperative hypoxia?

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 intraoperative hypoxia?

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 intraoperative hypoxia?

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 delivery planning for intraoperative hypoxia?

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 episode of intraoperative hypoxia?

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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