SOAP
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Simulation Patient Design (February, 2024)
Case of Malignant Hyperthermia during emergency cesarean section

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Introduction

Malignant hyperthermia (MH) is an inherited muscle disorder characterized by hypermetabolism and is usually triggered after susceptible individuals are exposed to volatile anesthetics and/or depolarizing muscle relaxants. Although the use of succinylcholine is declining during general anesthesia cases for non-obstetric cases, it is still a standard practice during induction and intubation during cesarean section.

According to the Malignant Hyperthermia Society of United States, the incidence of MH is 1/100,000 surgeries. The prevalence of MH-susceptibility is about 1 in 125,000 in cesarean deliveries, similar to the prevalence reported in non-obstetrical surgery inpatients.[1] Certain neuromuscular diseases such as Central core disease, King-Denborough syndrome and mini-core disease are associated with MH. However, the North American MH registry shows that it may occur in patients having non-triggering anesthesia, in the absence of family history, and who have undergone previous anesthesia without problem. Patients with a family history of malignant hyperthermia or a personal history of masseter spasm after succinylcholine administration should be provided with non-triggering anesthesia. Halothane-caffeine contracture test of skeletal muscle is the most accurate diagnostic test for MH.

Clinical malignant hyperthermia is characterized by rapidly increasing body temperature (as high as 1°C /5min), a rapid increase in end-tidal CO_2 despite adequate ventilation, muscle rigidity, tachycardia, ventricular arrhythmias, desaturation, extreme acidosis (because of acute loss of control of intracellular calcium levels), and uncontrolled increases in skeletal muscle metabolism that may proceed to severe rhabdomyolysis.[2] The onset of the syndrome can be extremely variable both in initial symptoms and in the timing of onset of the signs and symptoms. Onset of symptoms can be delayed and may not be overt until the patient is in the recovery room. More than one clinical sign must be observed before making the diagnosis of MH. Other clinical syndromes may present with similar symptoms and need to be ruled out while keeping in mind the importance of timely intervention in a case of MH. Sepsis, thyroid storm, overheating, pheochromocytoma, cocaine overdose, serotonin syndrome and neuroleptic malignant syndrome may present in a similar manner. Complications of MH include cerebral edema, disseminated intravascular coagulation, pulmonary edema, cardiac and renal failure.[2,3] Lack of core temperature monitoring during general anesthesia has been associated with increased mortality in cases of MH.[4]

Because of its rarity and high fatality rate, high index of suspicion is needed for timely and correct diagnosis and treatment. Dantrolene, the only drug effective in reversing the symptoms of MH, works by inhibiting calcium ion release from sarcoplasmic reticulum, thereby, lessening excitation-contraction coupling of muscle cells and reversing symptoms of MH. Before the use of dantrolene, the reported death rate was 61%. However, early diagnosis, use of dantrolene, and education of operation room (OR) personnel, have reduced the mortality to less than 5%.[5]

In hospitals where total delivery and ultimately the number of cesarean section cases utilizing GA with volatile anesthetics are lower, it may not be considered cost-effective to have MH cart in the labor and delivery floor. However, given the rarity of the problem and fatality associated with it, it becomes more important to invest in education and preparedness of MH.

Because dantrolene is essential for the treatment of MH and the prevention of death and complications, the Malignant Hyperthermia Association of the United States has stated that "dantrolene must be available for all anesthetizing locations within 10 minutes of the decision to treat for MH." Additionally, the organization does not recommend "sharing" a supply of dantrolene between anesthetizing locations.[6] Acute therapy for MH includes discontinuing all anesthetic agents, hyperventilating with 100% oxygen, cooling accessible body surface area, and administration of dantrolene until symptoms subside. Metabolic acidosis and hyperkalemia are simultaneously treated. Adequate urinary output should be ensured to protect the kidney from probable myoglobinuria. Post-operatively these patients should be monitored in a critical care unit.

The initial recommended dose of dantrolene is 2.5 mg/kg (total body weight). The median dose of dantrolene used to control an MH event is 5.9 mg/kg. The Malignant Hyperthermia Association of the United States recommends stocking 36 vials (each vial contains 20 mg; therefore, 36 vials approximates to 10 mg/kg for a 70-kg individual) in the MH cart. A new formulation of dantrolene, Ryanodex™ (Eagle Pharmaceuticals, USA), is formulated with 250 mg/vial; therefore, stocking three vials is recommended. Using a conservative weight estimation (100-kg individual), the initial dose of dantrolene is 13 vials (260 mg) of the older formulation and 1 vial of the newer formulation. Preparation of dantrolene is labor intensive especially if Dantrium is used.[6] Regular simulations on detection, management, and reconstitution of dantrolene, help to be prepared for this rare but fatal condition.

Educational Rationale: To teach team skills in managing malignant hyperthermia during emergency cesarean section.

Target Audiences: Nursing, OB, Anesthesiology, 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*: Recognize clinical signs and symptoms and describe treatment of MH following general anesthesia for emergency cesarean section.
- *Patient care*: Understand risk factors that predispose patients to MH.
- *Practice-based learning and improvement*: Identify the setting, equipment, and medications necessary to manage MH during general anesthesia in your labor and delivery unit. Have MH cart available within 10 minutes of the decision to treat MH.
- *Interpersonal and communication skills*: Assign roles such as a team leader who will coordinate the team to provide optimal care to the patient and maintain ongoing communication about the evolution of the clinical situation among the providers.
- *Professionalism*: Understand and demonstrate mutual respect for team members.
- *Systems-based practice*: Ensure all personnel, resuscitation equipment, medications, and protocols are readily identifiable and available in delivery locations including airway management, anesthesia induction/emergency medications, and vascular access. Include identification of barriers within the hospital system such as staffing.

Questions to ask after the scenario:

1. What are the clinical symptoms of malignant hyperthermia?
2. What is the treatment of MH?
3. How do you reconstitute dantrolene?

4. Is MH cart available within 10 minutes of diagnosis in your institution?
5. What are the risk factors for malignant hyperthermia?
6. Was the emergency response appropriately activated?
7. Did each member of the response team have well-defined roles?
8. Were the next steps for management clearly outlined by the care team?
9. Were there any barriers or system issues identified when caring for the patient?
10. Were opportunities for improvement(s) identified during the scenario

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

1. Mannequin set-up in operating room table, standard C-section set-up
2. One 18G IV setup with fluids attached and multiple access ports on the line
3. Standard monitors (e.g. 5- lead EKG, NIBP, SpO2, arterial line, temperature probe, end tidal capnography)
4. General anesthesia set up
5. Emergency code cart
6. Malignant hyperthermia cart

Simulation Scenario Set-up:

The case

Mrs. Rava Smith is a 25-year-old G1P0 at 39 weeks gestational age. She has no significant past medical problems. Her pregnancy has been uneventful so far. Her paternal uncle had a cardiac arrest during surgery; however, details are unknown. She had tonsillectomy during childhood without any problems. She is admitted to labor and delivery unit. On exam, she has ruptured membranes and prolapsing umbilical cord. The obstetrician has her hand in the vagina as the patient is taken emergently to the OR for a stat cesarean delivery under general anesthesia.

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 on OR Table, with an 18G PIV in situ	Patient is awake and responsive. HR 95 bpm BP 127/85 mm Hg SpO_2 97% (air) Resp 16/min Temp 37.1^{o}C	☐ The obstetrician confirms reassuring fetal heart tones while palpating the umbilical cord. ☐ Standard ASA monitors are applied. ☐ Left uterine displacement. ☐ Preoxygenation with 100% oxygen			

		☐ Anesthesia provider reassures the patient			
General anesthesia induced : Propofol, succinylcholine followed by successful intubation, Maintenance with Sevoflurane, oxygen	Lab results from initial presentation (30mins ago): Hb 11.2 g/dL Plt 130 x10^9/L INR 1.0 Fib 450 mg/dL	☐ Ob team scrubbed and ready for surgery. ☐ Patient prepped with betadine; drapes are up. ☐ Anesthesia induced ☐ Closed loop communication between Ob and anesthesia team.			
Delivery of fetus. Anesthesia team has MH high on the differential list	HR 110 bpm BP 90/60 mmHg SpO_2 92% (50% oxygen) EKG- occasional PVCS Steadily but rapidly rising End-tidal CO_2- 55mm HG Temp 38.9^{o}C Patient's muscles feel rigid on palpation.	☐ Anesthesiologist calls for help and MH cart. Begin to mix dantrolene when cart arrives. ☐ Turns off the triggering volatile agent ☐ Hyperventilate with 100% oxygen. Increase minute ventilation. ☐ Call for cold saline for irrigation and ice packs ☐ Inform Ob team of the changes in vital signs. ☐ Place an arterial line ☐ Sends ABG, labs. ☐ Start propofol infusion for maintenance of anesthesia. ☐ OB and anesthesia teams discuss differential diagnoses.			
After 5 minute, worsening hemodynamics	HR-140 bpm BP-90/70 mmHg, Spo2-80% on 100% oxygen End-tidal CO2-64 mmHg Temp -39.9^{o}C Repeat lab results (Intraoperative): Hb 9.8 g/dL Plts 98 x10^9/L INR 1.3	1. Call for MH cart (if not already in OR) 2. Change soda lime, circuit, non-rebreather bag 3. Apply charcoal filter. ☐ Dantrolene* reconstituted. 2.5mg/kg given. 4. Continue cooling measures, IV normal saline at 4 degree centigrade, ice packs in exposed areas. 5. Consider sodium bicarbonate for acidosis 6. Send repeated stat labs (include			

	Fib 208 mg/dL ABG- PH 7.1, 78, 55, -12 K=5.9	TEG/ROTEM/ABG) creatinine kinase, blood and urine for myoglobin. 7. Treat hyperkalemia- calcium gluconate, 50% glucose and insulin 10 units IV 8. Treat ventricular arrhythmia with amiodarone, lidocaine, beta-blockers as necessary 9. Avoid calcium channel blocker 10. Additional assistance called. 11. Monitor renal function- maintain urine output >1ml/kg/hr 12. Consider calling MH hotline 13. Consider additional IV access			
First dose of dantrolene is completed. 10 minutes has elapsed since diagnosis.	HR 140 bpm BP 88/55 mm Hg SpO_2 88% End tidal CO2 improving to 50 mmHg Resp 20/min Temp 38^{o}C Fibrinogen-220	1. Expedite surgical closure. 2. Continue administering cold fluid in IV 3. Consider second dose of dantrolene 2.5mg/kg. Repeat q5 mins until symptoms subside. 4. Treat metabolic acidosis with sodium bicarbonate if not done previously. 5. Rapid infuser set up and connected to large bore IV access. 6. Vasopressors as needed. 7. Send repeat arterial blood gas.			
5 more minutes have elapsed. Patient is stabilizing hemodynamically.	HR 121 bpm BP 98/45 mm Hg SpO_2 98% End- tidal CO2-36 mmHg (intubated) Temp 37.5^{o}C	1. Consult with ICU for postoperative admission. 2. Vasopressors continued as indicated. 3. Treat electrolyte abnormalities 4. Watch for complications including DIC 5. Once crisis is under control, consider contacting MH hotline for further management if not done previously. 6.			
Scenario Ends Awating ICU bed	Vital signs continue to stabilize	1. Plan to transfer patient to ICU intubated (awaiting ICY bed). 2. Family updated.			

	HR 100 bpm BP 95/48 mm Hg SpO_2 98% (intubated) Temp 36.9^{o} C	3. Dantrolene 1mg/kg q4-8hrs for 24-48 hrs. 4. Plan to observe for 72 hours 5. Ultimately refer patient for MH testing			

*Dantrolene reconstitution depends on type of dantrolene

Dantrium, available in 20mg vial, needs 60cc of sterile water to reconstitute. For 70kg woman, 180mg is required. 8 vials reconstituted in 540 cc sterile water.

Ryanodex, available in 250mg vial needs 5cc of sterile water to reconstitute for the initial dose.

Considerably expensive

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 malignant hyperthermia?

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 ability to access MH cart and use cognitive aids?

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 malignant hyperthermia?

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 reconstitution and administration of dantrolene?

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 malignant hyperthermia?

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:

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