

Original Publication

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Intrapartum Maternal Cardiac Arrest: A Simulation Case for Multidisciplinary Providers

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Abstract

Introduction: Cardiac arrest in pregnancy is rare. Advanced Cardiovascular Life Support courses rarely address interventions specific to obstetric patients, and knowledge gaps are frequent among providers. The Society for Obstetric Anesthesia and Perinatology and American Heart Association have published guidelines regarding management of cardiac arrest in pregnancy, and interdisciplinary simulation training has been advocated to reinforce key management points for this clinical scenario. **Methods:** In situ multidisciplinary simulation training was implemented for anesthesia and maternal fetal medicine fellows and obstetric nurses at our hospital. The case was amniotic fluid embolism in a 35-year-old parturient at term. The patient had a witnessed seizure before cardiovascular collapse. Learners were expected to initiate high-quality cardiopulmonary resuscitation and perform a perimortem cesarean delivery within 5 minutes while demonstrating clear communication with each other. The case required a labor room, high-fidelity mannequin, defibrillator, code cart, cesarean section instruments, and simulated medications and intravenous fluids. **Results:** Participants comprised two obstetric anesthesia fellows, three maternal fetal medicine fellows, and three obstetric nurses. Positive feedback about the training and increased perceptions of self-efficacy were received. Potential systems issues were detected and corrected because of the training, highlighting the value of in situ drills. **Discussion:** We found it challenging to implement more frequent multidisciplinary sessions, but participants found the experience highly rewarding. We hope to expand the training to all physicians and nurses covering the unit on a regular basis. Modified scenario versions are being used for nursing-only and obstetric resident-only simulations during protected teaching time for those services.

Appendices

- A. Simulation Case File.docx
- B. Prelearning Slide Presentation.pptx
- C. Simulation Flow Grid.docx
- D. Behavior Checklist.docx
- E. Learner Feedback Survey .doc
- F. Team Follow-up Form.docx
- G. Sample Multiple-Choice Questions.docx

All appendices are peer reviewed as integral parts of the Original Publication.

Keywords

Maternal Cardiac Arrest, Perimortem Cesarean Section, Manual Left Uterine Displacement

Educational Objectives

By the end of this activity, learners will be able to:

1. Perform supportive airway management of the parturient in cardiac arrest.
2. Perform effective chest compressions during cardiopulmonary resuscitation.
3. Perform manual left uterine displacement during cardiopulmonary resuscitation.
4. Initiate timely perimortem cesarean section within 5 minutes of recognized cardiac arrest.
5. Communicate effectively with a multidisciplinary team of anesthesiologists, obstetricians, and nurses during patient management.
6. Increase their confidence regarding the ability to appropriately manage maternal cardiac arrest in clinical practice.

Introduction

Cardiac arrest in pregnancy is a rare event (affecting less than one in 20,000 women)¹; however, a significant proportion of cases have a reversible etiology.² Young, critically ill, pregnant women in cardiac arrest are thus considered to be more salvageable than most patients requiring cardiopulmonary resuscitation. With the rapid implementation of appropriate treatment, a 50% survival rate has been reported.² Advanced Cardiovascular Life Support courses typically devote little or no attention to

addressing interventions specific to obstetric patients, and significant gaps in provider knowledge have been documented in multiple reports.³⁻⁶ In 2014, the Society for Obstetric Anesthesia and Perinatology (SOAP) issued a consensus statement in which the need for health care provider education was emphasized,¹ and in 2015, the American Heart Association (AHA) published its first scientific statement on maternal cardiac arrest.⁷

Maternal cardiac arrest simulation training has been shown to improve learner knowledge and performance,⁸ and multidisciplinary maternal cardiac arrest simulation drills have been recommended to increase emergency preparedness, to address cognitive knowledge deficits, and to improve behavioral and communication strategies.¹ It was within this context that it was proposed to launch regular in situ simulation training for this low-frequency but critical event on our high-risk labor and delivery unit.

Effective teamwork is essential for successful patient management during cardiac arrest, so this learning activity was designed for a multidisciplinary team of clinical providers including anesthesiologists, obstetricians, and obstetric nurses. The sessions were geared towards advanced learners at our institutions—obstetric anesthesia fellows, maternal fetal medicine (MFM) fellows, and obstetric nurses. The priorities of training were to emphasize clear communication among team members, to initiate early high-quality chest compressions, to provide manual left uterine displacement, and to perform perimortem cesarean delivery within 5 minutes. The in situ setting alleviated the pressure of having to schedule providers to leave the unit, facilitated demonstration of unit-specific educational aspects of training such as the physical location of the code blue button, and helped to identify latent systems issues.

Despite reports in the literature describing the benefits of maternal cardiac arrest simulation training,⁸ comprehensive scenario details are rarely published. No *MedEdPORTAL* publications specifically address the unique issues of management of cardiac arrest in late pregnancy, so we believe this simulation represents a valuable resource for health care educators.

Methods

Development

We developed the learning activity (Appendix A) in 2015 in the context of a busy academic high-risk obstetric center (with more than 4,000 annual deliveries). In addition to obstetric and anesthesiology residents, subspecialty trainees in our center include nine MFM fellows and two obstetric anesthesia fellows. A catalyst for curriculum development had been the 2014 SOAP consensus statement on management of cardiac arrest in pregnancy¹ and the 2015 AHA scientific statement on cardiac arrest in pregnancy⁷; there had also been recent changes to the unit's code blue emergency alert system that created a need for educating staff. In 2011, the lead facilitator, Allison Lee, had managed a term parturient who survived a cardiac arrest due to suspected amniotic fluid embolism and who underwent perimortem cesarean section.⁹ The scenario developed was based on aspects of the real case.

We agreed that the implementation of the simulation training as at least an annual event for advanced learners (anesthesia and MFM fellows) and nurses was an important initial goal. Fellows were expected to have been familiarized with the most recently published maternal cardiac arrest guidelines in their didactic sessions. Nurses were instructed to access prelearning online, which included a 12-slide presentation (Appendix B) summarizing the key points for management of late-pregnancy cardiac arrest and best practices for teamwork and communication; supporting reference articles were provided as optional reading, including the SOAP consensus statement and the AHA scientific statement.^{1,7}

Equipment/Environment

The simulation was conducted in situ in a fully stocked, unused labor room at the NewYork-Presbyterian Morgan Stanley Children's Hospital, New York, NY.

Required equipment included the following:

- High-fidelity birthing mannequin, Victoria s2200r (Gaumard Scientific, Miami, FL).
- Laptop computer with simulator control software.
- Computer monitor for vital signs display.
- Prerecorded scripted patient voice responses (“Hi,” “I’m okay,” and “I don’t feel so good”).
- Mock patient identification wrist band.
- Intravenous infusion giving set with 1L bag of lactated Ringer’s solution attached to mannequin.
- 30 units/500 ml bag of oxytocin solution with intravenous infusion piggyback giving set.
- Two drug infusion pumps.
- Spare lactated Ringer’s 1L bag and intravenous infusion giving set.
- Epidural catheter (taped to mannequin’s back).
- Mock bupivacaine 0.0625%/fentanyl 2 mcg/ml epidural infusion 250 ml solution bag and patient controlled epidural analgesia (PCEA) tubing.
- PCEA pump with bolus dose button.
- External cardiotocography sensors and monitor with elastic abdominal straps.
- Noninvasive blood pressure cuff and cable.
- Pulse oximeter probe and cable.
- Nonrebreather oxygen face mask and tubing.
- Suction canister, suction tubing, and Yankauer suction tip.
- Ambu bag valve mask.
- Fully stocked mock code cart (including airway equipment and backboard).
- Mock code drug tray, including, at minimum, epinephrine 1mg/10ml (five prefilled syringes), atropine 1 mg/10ml (five prefilled syringes), sodium bicarbonate 8.4% 50 meq/50ml (10 prefilled syringes), calcium chloride 1 g/10ml (five prefilled syringes).
- ZOLL M series (ZOLL Medical Corporation, Chelmsford, MA) biphasic defibrillator with ZOLL Stat Padz defibrillator electrodes and 3M 2560 Red Dot monitoring electrodes (3M United States, Saint Paul, MN).
- Simulation/mock drugs: magnesium sulfate solution 4G/1L bag and intravenous giving set, midazolam 2mg/2ml vials (two vials), phenylephrine 40 mcg/ml 10 ml (two prefilled syringes), ephedrine 5 mg/ml 10 ml (two prefilled syringes).
- Mock patient health record summary sheet.
- Mock paper anesthesia preoperative assessment with most recent laboratory results and mock electronic anesthesia record.
- Clipboard and code time sheet.
- Participant name tags displaying the role in the simulation.

Personnel

To successfully run the multidisciplinary simulation, the minimum personnel required were two anesthesia fellows, given roles of anesthesia resident (to be called first to the scene) and attending anesthesiologist; three MFM fellows, taking the roles of obstetrics resident, MFM fellow, and MFM attending; and three nurses, with roles of primary labor nurse, secondary labor nurse, and charge nurse. One confederate actor (Stacey Richards) played a nurse at the end of her shift signing the case over to the primary labor nurse participant; another confederate actor played the role of the simulated patient’s family member.

Implementation

After two face-to-face meetings to discuss the design of the simulation, the facilitators met with the simulation technician in the simulation center to review the flow of the scenario (Appendix C), rehearse expected vital signs changes, and plan strategies to move the scenario forward if participants failed to recognize key events.

Sessions were scheduled to be conducted over 1 hour, starting at 8:00 a.m. on a Monday morning around the midpoint of the academic year, during the usual protected teaching time slot for the MFM fellows. The anesthesia fellows were given nonclinical assignments that day. Nurses were selected for participation in the simulation at the discretion of the perinatal safety nurse and patient care director. The labor room was set up for the simulation by the three multidisciplinary facilitators and two simulation technicians 1 hour in advance of the start of the session.

Prior to the start of the activity, participants were assembled in the labor room, and a 10-minute prebriefing was conducted by Allison Lee. During the prebriefing, participants were welcomed and attendees asked to individually introduce themselves by giving their name and their title. Reassurance was provided to encourage a sense of psychological safety and emphasize the confidentiality of the learning activity. Participants were oriented to the mannequin, room setup, and location of equipment. Participants were asked not to actually press the code blue button, which would initiate the notification calls throughout the hospital, but instead to verbalize that they would like to press the code blue button. A brief description of the setting and patient history (35-year-old G3 P1 woman, with gestational age 40 weeks, in active labor, receiving PCEA) were provided, the roles for the scenario were assigned, and the primary nurse was asked to remain in the room while other participants waited outside.

Stacey Richards, the facilitator playing the role of a labor nurse at the end of her shift, gave a sign-out to the primary labor nurse participant. As part of the report, it was disclosed that the patient had recently received an epidural top-up dose for breakthrough pain. After 1-2 minutes of interaction, the patient complained of not feeling well and then had a generalized seizure lasting 10 seconds. The confederate playing the role of the patient's sister became alarmed.

The nurse called for help from the obstetric and anesthesia residents and charge nurse (Stacey Richards stepped outside the room to call in the other participants). The first responders initially performed immediate postseizure management before the patient developed complete cardiorespiratory arrest. The primary nurse indicated that she would like to press the code blue button, which would notify the hospital code team, composed of internal medicine physicians and respiratory therapists. Cardiopulmonary resuscitation maneuvers, including chest compression and bag-mask ventilation, were begun, and the other participants and code cart were brought to the room. Along with tracheal intubation, other actions were medication administration and electrocardiogram rhythm analysis and defibrillation for ventricular fibrillation; perimortem cesarean delivery was performed within 5 minutes, upon which return to spontaneous circulation occurred. Following the simulation, which lasted about 15 minutes, a 30-minute debriefing was conducted by the three co-debriefers.

Assessment

The critical action checklist (Appendix D) was developed for the domain Management of Cardiac Arrest in Late Pregnancy, based on the input of content experts, Allison Lee, Jean-Ju Sheen, and Stacey Richards. The guidelines provided in the SOAP consensus statement¹ and AHA scientific statement⁷ were used as the primary reference material for development of behavior checklist items.

The effectiveness of the simulation at achieving the educational objectives was determined by verbal feedback during the debrief, when participants were invited to share their perceptions of the session. At the end of the activity, learners were asked to each state one thing they had learned from the activity. An example of a shared response by some learners was that they had not known about the bed lever that instantaneously flattens the labor bed to the horizontal position and facilitates rapid initiation of cardiopulmonary resuscitation efforts. An anonymous paper survey was also completed by participants in 2018 (survey template, Appendix E).

Debriefing

The preview advocacy-inquiry debriefing model was utilized at the conclusion of the simulation.¹⁰ The structure involving multidisciplinary co-debriefers (an anesthesiologist, MFM obstetrician, and perinatal safety nurse educator) contributing differing perspectives, targeted at the different types of learners, was believed to be highly valuable. The content of the debriefing was geared to achieving the stated learning objectives and guided by learner adherence to actions on the behavior checklist. Outcomes and summary points of the debriefing, systems issues that were identified, and plans for follow-up were documented (Appendix F).

The debriefing began with a reactions phase, in which Allison Lee asked participants to share their emotional response to the simulation. The simulation's purpose and learning objectives were made clear to the learners, and they were asked to describe their perceptions of how the scenario had unfolded. The co-debriefers took turns commenting on aspects of the simulation that had gone well and discussed observed performance gaps, taking the approach of having sincere curiosity about the learners' frames. By conducting a conversational formative assessment, facilitators were able to address performance gaps on the spot. Participants were specifically asked about their perception of team communication and whether or not a leader had been established during the event. Because the number of MFM fellows exceeded the number required for the scenario, the more senior fellows (particularly any who had experienced the simulation previously) were asked to be peer observers and were provided with copies of the behavior checklist. They were invited to make any additional comments towards the end of the debriefing.

Results

This multidisciplinary in situ simulation has been conducted on an annual basis since 2015, and the experiences have been highly valued by the labor and delivery unit staff. The facilitators are simulation educators with almost 2 decades of experience combined; Allison Lee and Stacey Richards have received formal instructor training from the Center for Medical Simulation. For each session, active participants included two obstetric anesthesia fellows, three to four MFM fellows, and three to four obstetric nurses. Cardiac arrest is a rare event, and the drills uncovered important latent systems hazards and staff training gaps.

Systems Issues Revealed

At the initial event, it was discovered that the universal cable on the defibrillator (which connects the unit to the disposable electrodes) had been cinched with plastic zip ties, leading to a delay in defibrillation since the ties had to be cut in order to release the cable for use. This issue has since been corrected. Also at the initial event, a participant had to rush to the operating room area to obtain surgical instruments, resulting in a delay in making the incision. A scalpel is now stored in a lockable cart in each labor room. The third event revealed that nursing staff had difficulty opening the lowest compartment on the code cart and that there had been a decay in knowledge regarding the use of the defibrillator. This prompted a modified version of the scenario for nursing-only drills in which multiple nurses, utilizing an empty labor room, received training; the goal was to reach all nurses on staff. Obstetric resident-only drills, also using a modified version of the scenario, are being conducted at the medical school simulation center during the residents' scheduled didactic time.

Learner performance was assessed using a behavior checklist, with actions rated as not done, partially done, or done well. The checklists were helpful for formative assessment and keeping track of performance gaps that needed to be addressed in the debriefing. The anesthesia fellows consistently initiated prompt bag-mask ventilation with equipment located at the bedside; however, the first time the scenario was conducted, there was a delay in intubation of the trachea due to uncertainty about where the nearest airway equipment was located. In the debrief, participants were shown the exact location of invasive airway equipment in the mock code cart and were informed about a portable airway equipment bag stored in the anesthesia work room. Participants performed early and vigorous chest compressions

but failed to use the backboard in all sessions except the last one in 2018. In the first session, participants incorrectly performed chest compressions at the mid-sternum level and were taught in the debrief that hand placement at the level of the lower sternum is recommended for pregnant women. Teamwork has been consistently strong in the simulation sessions, and participants have called for help early in every case. There has been inconsistent use of closed-loop communication and poor role clarity at times. In the debrief, strategies such as closed-loop communication and readback have been encouraged. The importance of identifying a team leader and of team members assuming specific roles, such as being a scribe or timekeeper, has been reinforced at each session.

In 2018, learners were asked to provide anonymous feedback about their perceptions of the simulation and level of confidence after training in managing this situation. Widely positive responses were received, with all nine respondents reporting that they agreed (slightly or strongly) that the simulation was a valuable learning experience and that they were likely to apply what had been learned to patient care. Eight of nine respondents agreed (slightly or strongly) that the simulation increased their confidence in managing cardiac arrest in pregnancy; only one respondent selected a neutral rating for the latter (Table).

Table. Feedback Survey Responses (N = 9)

Objective	Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly
This simulation was a valuable learning experience.	0	0	0	1	8
This simulation would be worth repeating.	0	0	0	1	8
The time allotted for this simulation was appropriate.	0	0	0	2	7
The simulation was realistic and applicable to clinical practice.	0	0	0	1	8
This simulation increased my confidence.	0	0	1	3	5
The learning environment was nonthreatening.	0	0	0	0	9
Facilitation, feedback, and instruction stations were helpful to my learning.	0	0	0	2	7
How likely are you to apply what you have learned today to patient care?	0	0	0	2	7

Discussion

This report provides a detailed description of the design and implementation of multidisciplinary simulation training in maternal intrapartum cardiac arrest for advanced learners (fellows) and nurses. We consider this to be a core learning activity for our physicians and labor nursing staff, and indeed for any labor and delivery unit. Because of the natural decay in knowledge over time, regularly scheduled training in this rare but critical event is imperative to ensure preparedness.

Our evaluation was limited to participant self-report of perceptions of the training session. The behavior checklist was developed for formative evaluation of the participants overall and to help guide debriefing. Facilitator checklist notes were not preserved as the session was designed for teaching purposes and it was not anticipated that a formal report would be made in the future. The absence of such data is a limitation of this report. Sample multiple-choice questions that may be utilized as a pre- and/or postsimulation knowledge assessment are provided (Appendix G).

With repeated trainings, our drills have become more seamless. The scenario has been slightly simplified since the initial session. The initial narrative included recent penicillin administration prior to the collapse, complicating the potential differential diagnosis to include anaphylaxis. This aspect is now seen as adding unnecessary complexity and does not necessarily aid in achieving the learning objectives. It was desirable to have staff physically complete management steps to mimic a real-life situation; however, we wanted to avoid the potential risk of mixing real drugs with simulated drugs. No simulated drugs were placed in the automated drug dispenser; instead, clearly labeled simulated medications were to be accessed in a bucket left in the locked room with the drug-dispensing machines.

The major limitation of this multidisciplinary training activity has been the difficulty with scheduling more frequent sessions among three services; we received feedback from learners that they wished the trainings occurred more often. With in situ training, the risk of not securing a free room at the time of the

training and/or the staff being too busy to participate in the training always exists. For this reason, we prepared a backup plan of moving the drill to the simulation center, if needed. With a 3-year MFM fellowship, it is inevitable that some fellows will have experienced the simulation in the past. To increase the challenge of the simulation, we have experimented with blindfolding the team leader to emphasize the importance of clear, closed-loop communication among the participants.

Based on the in-person feedback during the debrief, where each participant was asked to convey what new information had been learned during the simulation, and on anonymous survey responses to date (Table), we conclude that the sessions have been very effective in meeting the learning objectives. We will continue to collect feedback via surveys with future sessions. The sessions have been successful in identifying systems issues, resulting in important system changes geared toward improving patient safety. Finally, the sessions have identified performance gaps that illuminated a need for additional staff training. The template provided has detailed instructions for implementation and should be easily generalizable to other institutions. In the future, we hope to find opportunities to expand the learning activity to include anesthesiology and obstetric residents, as the scenario could also be generalized to less experienced learners. We intend to implement pre- and posttesting for participants to objectively document the increments in learning following the training.

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Informed Consent

All identifiable persons in this resource have granted their permission.

Ethical Approval

Reported as not applicable.

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