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Intraoperative Sepsis: A Simulation Case for Anesthesiology Residents

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Abstract

Introduction: Sepsis is a major cause of morbidity and mortality in medicine and is managed in ICUs daily. Critical care training is a vital part of anesthesiology residency, and understanding the presentation, management, and treatment of septic shock is fundamental to intraoperative patient care. **Methods:** This simulation involved a 58-year-old man undergoing surgical debridement of a peripancreatic cyst with hemodynamic instability and septic shock. We conducted the simulation yearly for clinical anesthesia year 2 residents ($n = 26$) in 1-hour sessions with three to five learners at a time. The simulation covered the six Anesthesiology Milestones related to sepsis and septic shock as outlined in the Anesthesiology Milestones Project. **Results:** To date, 155 anesthesiology residents have completed the simulation. Commonly missed critical actions included failure to recognize the need for invasive lines, provide appropriate volumes of fluid resuscitation, inquire about blood cultures and antibiotics, and recognize the need for the patient to remain intubated. Most participants could appropriately diagnose and treat intraoperative septic shock, but all had moments of action or inaction to discuss and improve upon, and all learned from this scenario. **Discussion:** Simulation is an optimal way to practice the more rare and life-threatening clinical events in medicine. Even though septic shock is commonly managed in the ICU, it is relatively uncommon for it to develop acutely in the OR. This simulation is an effective and educational way to discuss the most recent sepsis/septic shock definition and review evidence-based guidelines for treatment.

Keywords
Sepsis, Simulation, Septic Shock, High Fidelity, Anesthesiology, Critical Care Medicine

Educational Objectives

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

1. Define sepsis and septic shock.
2. Formulate an anesthetic plan for a potentially unstable patient with concern for intraoperative sepsis.
3. Perform the initial fluid resuscitation of a septic patient.
4. Select and manage the appropriate vasopressor support for a septic patient.
5. Decide when a patient who has required aggressive fluid resuscitation should remain intubated and when extubation may be appropriate.

Introduction

Sepsis is a major cause of morbidity and mortality in the medical field and is managed by ICU teams daily.[1] Critical care training is part of, and vital to, postgraduate medical training in anesthesiology, and understanding the presentation, management, and treatment of sepsis and septic shock are fundamental to perioperative care of a critically ill patient. In this simulation, a patient becomes hemodynamically unstable due to an infectious etiology. Anesthesiology residents must recognize, manage, and treat a patient who is suspected to be suffering from septic shock.

All anesthesiology residents need to be able to quickly evaluate and treat causes of shock. This simulation demonstrated the presentation of sepsis and septic shock where the differential could be broad (i.e., hypovolemic shock, cardiogenic shock, septic shock, or anaphylaxis), thus increasing the level of difficulty of the scenario. We therefore targeted clinical anesthesia year 2 (CA2) residents (postgraduate year 3) who had already rotated through the ICU with this scenario. The scenario could be used for anesthesia residents of any level who have completed at least 1 ICU month of training outside of their intern year. The simulation took a common issue found in the ICU and applied it to the OR setting, which is where our trainees spend the majority of their time. This simulation can be personalized for each learner

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depending on the learner's level of knowledge and training, as well as the instructor's areas of specialty. Our goal was to have critical care–trained, practicing anesthesiologists run and debrief this scenario, but it has been run successfully with general anesthesia faculty when critical care anesthesia faculty were not available.

Our simulation's educational objectives addressed several of the Anesthesiology Milestones outlined by the Accreditation Council for Graduate Medical Education and the American Board of Anesthesiology in the Anesthesiology Milestone Project. Specific Anesthesiology Milestones addressed include Patient Care 1 (educational objective 2), Patient Care 2 (educational objectives 2-4), Patient Care 4 (educational objectives 3 and 4), Patient Care 5 (educational objectives 3 and 4), Patient Care 6 (educational objective 5), and Medical Knowledge (educational objectives 1 and 5).[2]

Relatively few peer-reviewed learning activities are published in *MedEdPORTAL* regarding education on sepsis and septic shock. A search performed on July 16, 2019, showed 20 such publications, only one of which included the perioperative setting and anesthesia learners,[3] albeit differently. That publication focused on urosepsis with hemodynamic instability presenting at the conclusion of the case and emphasized education on crisis resource management, whereas our simulation focuses on cardiovascular decompensation due to an abdominal process with a much broader differential diagnosis and emphasizes education on the latest treatment guidelines for sepsis. Only four out of 20 peer-reviewed educational activities regarding sepsis have been published since the revised definition and treatment were published in early 2016.[3-6] Therefore, this simulation scenario is both novel and timely, and it can be used to teach anesthesia residents and adapted for other anesthesia learners across the United States and the world.

Methods

Development

This simulation is conducted for CA2 residents ($n = 26$) yearly in 1-hour sessions with three or four learners. Thus, it is run eight times per year at our institution and has been taught for the past 6 years. The innovative simulation curriculum and write-up were deemed Institutional Review Board exempt (#1801644617, exemption date February 28, 2018, Indiana University Office of Research Compliance Committee IRB-01).

Equipment/Environment

Access to SimMan Essentials or SimMan 3G (Laerdal, Wappingers Falls, New York) and/or other human-patient simulators is necessary. Other necessary equipment includes basic airway supplies (i.e., laryngoscopes and endotracheal tubes) and simulated, real-time vital sign monitors for blood pressure, end-tidal carbon dioxide, EKG, pulse oximetry, temperature, central venous pressure, and arterial blood pressure. If available, radio-frequency identification medicine syringes can be used for anesthesia drugs, and if not, appropriately labeled syringes, vials, and bags can be used. Alternatively, participants can verbalize when they give medications if none of the options mentioned previously are available. The environment should be set up to mimic an OR. This should include associated supplies like IV poles, IV fluid bags, and surgical equipment. The learners should also be encouraged to dress as they would in the OR, which may include appropriate footwear, scrubs, surgical caps, and surgical masks. Gloves should also be available and should be worn as in the OR. The goal is to lend the highest degree of realism possible to the scenario.

Personnel

In addition to having an instructor to facilitate the simulation session, it is also ideal to have a technician or second anesthesia faculty member for the human-patient simulator to manage vital signs in real time. The case should be discussed between the instructor and second instructor/technician before the beginning of the simulation for planning purposes. Although more difficult, it is possible in some institutions that one anesthesia faculty member may run the mannequin, facilitate, and debrief the session. Anesthesia faculty who work in both the OR and ICU are the ideal instructors for this session.

If monies are available for paid embedded participants, current best practice in simulation education would include one to two designated anesthesia learners (playing an anesthesia attending and/or anesthesia resident) and three embedded participants (playing the surgeon, circulating nurse, and scrub nurse or scrub tech).[7] The other learners present watch via video and participate in the debriefing. At our institution, monies are not routinely available and budgeted for all simulation learning events, which we hold weekly. Thus, we have developed a system over the years of placing all learners into the simulated OR, where they all receive the same case information and prebrief. One to two learners play the roles of anesthesia resident and/or anesthesia attending faculty, and the other learners are assigned the roles of surgeon, circulator, and scrub as volunteer embedded participants (VEPs). Two of the VEPs wear earpieces and receive instruction as needed from the facilitator. The use of VEPs as colearners has worked well for us, and considering that it is commonplace for our residents, they quickly adapt to it in the simulation lab. Although not measured, verbal feedback from

those assigned the role of anesthesiologist versus VEP has always been positive, and learning outcomes appear equal in the debriefing sessions. We are planning future studies of the learning that occurs when learners are playing anesthesiologist roles versus VEPs and additionally plan to quantitate what difference in learning, if any, occurs.

Implementation

The case begins preoperatively, when the learners are presented with the patient history by the facilitator. They may ask further questions. Prior to entering the OR and beginning the case, the learners are encouraged to discuss potential complications of the procedure and the plan for induction (i.e., possible need for rapid sequence intubation and potential for hemodynamic deterioration), need for invasive line placement, maintenance, and emergence. Following this discussion, the case moves to the simulated OR.

The case is fully presented for the use of instructors in the simulation case file (Appendix A). Optional supplemental materials (Appendix B), including laboratory values and EKG findings, are available at the request of the learner during the simulation. A critical actions checklist (Appendix C) is included for reference.

Assessment

The learners are assessed on their ability to address the items deemed critical to quality care. A critical actions checklist has been developed (Appendix C) to provide a list of the most important steps in caring for this simulated patient. Learners may provide inappropriate management or pursue the wrong course of treatment. If this happens, the simulation may be modified at the discretion of the instructor (e.g., if an antihypertensive is given to a hypotensive patient, the patient may require chest compressions and advanced cardiovascular life support). It is ideal if an extra person is available to evaluate learner actions via the critical actions checklist in Appendix C; however, it is also possible for the facilitator to quickly check off critical actions as the scenario proceeds. When possible, the time of each event should be noted on the checklist, as this can be useful for discussing the sequence of events and looking at video feedback in the debriefing.

Debriefing

Following the simulation, it is recommended that the learners perform self-reflection. Our debriefing materials serve as a guide tailored to this scenario (Appendix D). Following a review of the course of the events and how the simulation could have run more smoothly (if a plus/delta debriefing method is chosen), the rest of the debriefing materials can be utilized and discussed with the learners.

Instrumentation

The survey instrument—the Satisfaction with Simulation Experience Scale (SSES)—was adapted from previous studies by Levett-Jones and colleagues[8] and Williams and Dousek.[9] The overall survey instrument (SSES) was shortened to include only necessary feedback to encourage completion of the SSES by our learners. The word *sepsis* was inserted into items to focus attention on this specific simulation event. The word *facilitator* was replaced with *anesthesia faculty/staff* to differentiate from simulation center faculty/staff who may have also engaged with learners during the simulation event. Participants rated their level of agreement with each item on a 7-point Likert scale (1 = *strongly agree,* 7 = *strongly disagree*). We also added a section at the end of the survey to include data on how many cases of sepsis each learner had personally seen and on what rotation.

Results

At the time of submission, 155 anesthesiology residents had completed this simulation over 6 years (2013-2019), with feedback and data available for only the past 2 years (16 simulation sessions). Each year included eight iterations of the same scenario with groups of three to five resident learners, for a total of 48 simulation sessions. Although we did not keep data over the years documenting performance of learners via the checklist of critical actions, a discussion by the facilitators noted that commonly missed critical actions included failure to recognize the need for invasive lines, provide appropriate volumes of fluid resuscitation, inquire about blood cultures and antibiotics, and recognize the need for the patient to remain intubated. Most anesthesiology residents who participated in this simulation could appropriately diagnose and treat intraoperative septic shock, but all had moments of action or inaction to discuss and improve upon, and all learned from this scenario.

A total of 36 residents completed the electronic questionnaire. This represents a response rate of approximately 69% for the 2018 and 2019 cohorts of CA2 trainees. The two lowest (1 = *strongly agree,* 2 = *agree*), three middle (3 = *somewhat agree,* 4 = *neutral,* 5 = *somewhat disagree*), and two highest (6 = *disagree,* 7 = *strongly disagree*) categories were combined for data reporting (Table 1). The clear majority of the residents scored the simulation experience highly, with strongly agree and agree responses more than 92% of the time and neutral responses only 3%-8% of the time. All learners scored the faculty teaching this session highly, with no negative scores. Additional

Table 1. Distribution of Responses, Item Mean Scores, and Standard Deviations ($N = 36$)

Item[a]	Percentage (%)			*M*	*SD*
	Agree[b]	Neutral[c]	Disagree[d]		
The sepsis simulation was a valuable learning experience.	97	3	0	1.3	0.5
The sepsis simulation was appropriate for my level of education and training.	97	3	0	1.3	0.5
The sepsis simulation tested my clinical ability.	94	6	0	1.3	0.6
The sepsis simulation caused me to reflect on my clinical ability.	92	8	0	1.6	0.7
The sepsis simulation helped me to recognize patient deterioration early.	97	3	0	1.3	0.5
Participating in the sepsis simulation developed my clinical reasoning and clinical decision-making skills.	94	6	0	1.3	0.6
Reflecting on and discussing the sepsis simulation enhanced my learning.	97	3	0	1.4	0.5
The anesthesia faculty/staff made me feel comfortable and at ease during debriefing.	100	0	0	1.2	0.4
The anesthesia faculty/staff summarized important issues during debriefing.	100	0	0	1.2	0.4
The anesthesia faculty/staff asked questions that helped me to learn.	100	0	0	1.2	0.4
The sepsis debriefing provided an opportunity for me to ask questions.	100	0	0	1.2	0.4

[a]Rated on a 7-point Likert scale (1 = *strongly agree*, 2 = *agree*, 3 = *somewhat agree*, 4 = *neutral*, 5 = *somewhat disagree*, 6 = *disagree*, 7 = *strongly disagree*).
[b]Strongly agree, agree.
[c]Somewhat agree, neutral, somewhat disagree.
[d]Disagree, strongly disagree.

items asked participants to list frequency counts (i.e., number of cases/patients encountered) for application of knowledge and skills in various clinical environments (i.e., rotations) to assess the need of learning this topic (Table 2). Additional items asked participants to list frequency counts (i.e., number of cases/patients encountered) for application of knowledge and skills in various clinical environments (i.e., rotations) to assess transfer of learning (Table 2). All participants reported treating at least one patient with sepsis per clinical rotation category.

Qualitative data were collected from open-response items. Participants were asked to describe additional knowledge, learning outcomes, or applications for the sepsis simulation that they used in clinical practice. One resident commented, "It teaches the importance paying attention to shock states, and correcting what can be corrected prior to induction." Another resident related the knowledge taught in the simulation to board examination preparation topics:

Table 2. Distribution of Frequency Counts of Patients With Sepsis Treated per Clinical Rotation Category (Data Collected After Simulation and by Residents' Best Guess; $N = 36$)

Clinical Rotation	*M*	Maximum[a]	*SD*
General OR	6.5	12	3.7
Cardiovascular anesthesia	1.4	5	1.0
ICU	9.1	12	4.1
Neuroanesthesia	1.5	12	1.9
Obstetrical anesthesia	1.7	6	1.5
Pediatric anesthesia	3.7	12	3.0
Preoperative holding unit and postoperative anesthesia care unit	2.3	12	3.0
Thoracic anesthesia	2.2	12	2.3
Transplant anesthesia	1.5	6	1.2
Trauma anesthesia	1.4	4	0.9

[a]At least one participant reported a minimum of one count for every rotation.

> The most recent guidelines in terms of fluids (how much and how soon), antibiotics (same), MAP [mean arterial pressure] goals, use of pressors, complications, SOFA [Sequential Organ Failure Assessment] score and its composition, and other options if first-line fails. These are the sepsis related questions I continue to get when studying for boards.

Discussion

Simulation is an optimal way to practice the more rare and life-threatening clinical events in medicine. Even though septic shock is commonly managed in the ICU, it is relatively uncommon for it to develop acutely in the OR.[10] However, as supported by frequency-count data in Table 2, our anesthesia residents reported treating septic patients on all other clinical rotations in addition to the ICU rotation. This substantiates the need for teaching sepsis due to the importance of the topic to the practice of anesthesiology, as well as demonstrating the various clinical settings in which residents and practicing physician anesthesiologists must care for septic patients. This simulation provided a learning opportunity to discuss the most recent sepsis/septic shock definition and review evidence-based guidelines for treatment. Guidelines will continue to evolve over time as best practice is informed by emerging evidence, and this scenario will have to be updated to keep pace with newer discoveries.

Implementation of this simulation has caused few problems over the years. It has been best taught by critical care–trained anesthesiologists, who are sometimes few in number in academic anesthesia departments and may have limited nonclinical time due to ICU service obligations. Therefore, it is ideal to maintain fidelity of implementation by having multiple critical care

anesthesiologist faculty members trained in the art of facilitating a simulation and running a debriefing. If this is not possible, a department could send two anesthesiologists—one who is a trained simulation instructor and a second who is a critical care anesthesiologist—to add content expertise and validation. It should also be noted that our learners rotate through the ICU at various times of the year and have different patients and experiences on their ICU rotations, with some having done the rotations at other hospitals during their intern year. The learners therefore came to our simulation with differing levels of knowledge about sepsis prior to the start of the scenario. There was also a time delay in running weekly simulations, and in general, our learners did a good job of not sharing scenarios with their classmates who had not been to the simulation lab yet, but it is impossible to know if, over the years, some learners scheduled in the later simulation sessions were given hints by their classmates.

Teams and individuals who struggled and made key errors subsequently left the debriefing stating that they would be able to appropriately recognize and manage intraoperative septic shock in the future. Although we did not validate this teaching by following future clinical practice of these residents when faced with septic patients and patient outcomes (which is nearly impossible), the results indicate that learners felt the scenario and debriefing were valuable and enhanced their learning more than 92% of the time. As seen in Table 1, all learners were either neutral or agreed with the questions asked, and no learners disagreed that the simulation was valuable to their learning. Table 1 also shows that our simulation faculty and facilitators of this event scored exceptionally well, with all learners strongly agreeing or agreeing that facilitators made them feel comfortable and at ease, summarized important issues, and asked questions to help them learn. This validates our choice of faculty to teach this simulation and has been used as evidence to leadership that the simulation is worth those faculty members' time and leadership's support.

Even with the limitations of our evaluation and not being able to demonstrate clinical change, we still believe that this is a worthwhile educational experience for our residents and that it is appropriately placed with other ICU-based CA2 simulations in our simulation curriculum. Our sepsis simulation has had continued educational success, and although other simulations have been dropped or adjusted, this one has remained as a staple in our simulation curriculum for the past 6 years.

Future iterations of this simulation scenario could be improved by involving paid embedded participants to play all roles other than anesthesiologists. Future data collection should include detailed data on learner activity during the scenario using the critical actions checklist, and a quiz or repeat scenario could be added to the curriculum in CA3 to test how long knowledge gained from this simulation on sepsis is retained. Given that our results show that our residents encounter septic patients on almost all rotations, we have moved this simulation scenario earlier in CA2 to best meet their educational needs. In the future, we could work with simulation educators in emergency medicine, ICUs, and internal medicine to adapt this scenario for their use, possibly giving it an ICU setting versus an intraoperative setting. Sepsis and septic shock have high morbidity and mortality, making the diagnosis a cannot-miss clinical event. Teaching about sepsis and septic shock and current evidence-based treatment is essential to all anesthesia residents, and this simulation scenario can be used across the country for this critical learning.

Appendices

A. Sepsis Simulation Case.docx

B. Sepsis Supplemental Materials.docx

C. Sepsis Critical Actions.docx

D. Sepsis Debriefing Materials.docx

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

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Ethical Approval
The Indiana University Office of Research Compliance Committee approved this study.

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