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A Complicated Opioid Overdose: A Simulation for Emergency Medicine Residents

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Abstract

Introduction: Opioid abuse is a growing problem in the United States. As a result, emergency medicine physicians often use naloxone to reverse opioid overdoses. While normally a safe drug, one potential complication of the antidote's use is flash pulmonary edema. This simulation was created after a patient followed the clinical course described after an opioid overdose. **Methods:** This simulation utilized a high-fidelity simulator to expose resident emergency medicine physicians to flash pulmonary edema secondary to naloxone administration. The simulation involved a 31-year-old male patient presenting with agonal respirations following an opioid overdose. The residents managed the patient appropriately with naloxone. However, he developed progressive dyspnea. The residents soon discovered that the patient was in flash pulmonary edema. They managed his airway, provided mechanical ventilation, and considered extracorporeal membrane oxygenation. **Results:** When this simulation was run for emergency medicine residents at SUNY Upstate Medical University, the learners felt that it was highly useful, and that it expanded their knowledge in this field. Out of 17 learners, the average rating to the question of: "[This simulation] added to my understanding of key concepts and helped the session meet the objectives" was 4.6 on a 1-5 Likert scale. **Discussion:** This simulation is a practical method by which many institutions can help to further physician knowledge on opioid overdose complications. It is relatively straightforward to run, and the educational yield is high.

Keywords

Simulation, Emergency Medicine, Opioid Overdose, ECMO, Naloxone, Flash Pulmonary Edema

Educational Objectives

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

1. Describe one mechanism of opioid-induced pulmonary edema and three mechanisms of naloxone-induced pulmonary edema.
2. Execute appropriate pharmacological and airway management of an opioid overdose patient using available equipment.
3. Execute the best management for a patient in flash pulmonary edema that is difficult to oxygenate.
4. Demonstrate teamwork and communication skills.

Introduction

The educational rationale for this particular case is well-established. The most recent numbers from the Center for Disease Control show that the opioid epidemic is only continuing to worsen.¹ In fact, deaths from opioid overdoses have increased 200% from 2000-2014. As a result, emergency medicine physicians are likely to continue to see opioid overdose patients brought into the emergency department. The treatment of choice for an opioid overdose remains naloxone.² Therefore, it is important that physicians are prepared for any adverse effects associated with the administration of naloxone. One rare, but life-threatening, adverse effect is pulmonary edema.³

Appendices

- A. Simulation Case.docx
- B. Simulation Images.docx
- C. Critical Actions Checklist .docx
- D. Simulation PowerPoint.pptx
- E. Sample Evaluation Form .docx
- F. Debriefing Materials.docx

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

The pathophysiology of pulmonary edema secondary to naloxone administration is believed to be one of, or a combination of, three distinct mechanisms. The primary mechanism is believed to be due to unrestricted catecholamine surge following opioid reversal.^{3,4} It may also be due to constriction of the pulmonary vasculature due to central neurogenic mechanisms, leading to pulmonary hypertension.³ A final possible mechanism is the return of respiratory drive prior to patient control of their own airway, resulting in inspiration against an obstructed glottis, precipitating negative pressure pulmonary edema.^{3,5} Finally, the opioid overdose itself can induce pulmonary edema by inducing histamine release, hypoxia, and acidosis resulting in permeability of the pulmonary vasculature.⁶

Treatment for pulmonary edema following reversal of an opioid overdose focuses on airway management and lung-protective ventilator settings. If oxygenation cannot be maintained with traditional methods alone, advanced ICU management (e.g., prone positioning, advanced ventilator modes, neuromuscular blockade) or extracorporeal membrane oxygenation (ECMO) can be considered.^{7,8}

This simulation was created after a patient followed the clinical course described after an opioid overdose. The clinical course was rapid and emergent, and was therefore considered a good case to review with resident emergency medicine physicians in their first, second, and third years of training. Simulation was determined to be a useful method by which to review the material presented.

Methods

Simulation was chosen as the method by which to impart this clinical knowledge as it is a well-established educational tool.⁹ Specifically, it has been shown that simulation is a strong method by which to teach management of patients for which rapid interventions are required.¹⁰

This simulation is fully presented in the simulation case file (Appendix A). Simulation images (Appendix B) and a critical action checklist (Appendix C) are also included to assist learners during the simulation. The simulation software was programmed to the initial settings described in the simulation case file. The simulation room was set and stocked as described in the Equipment/Environment subsection. An operator was present controlling the simulator following the flow detailed in simulation case. The PowerPoint presentation (Appendix D) was projected on a screen in the simulation room. When learners requested laboratory values, the appropriate slides were provided. These slides may be printed and provided when requested if no screen is available. After proper orientation of the learners to the simulation center, they were returned to the briefing room. At this point, the learners were informed that emergency medical services was bringing in a patient found unresponsive after injecting heroin. The learners were brought into the simulation room, and began the case.

They first administered naloxone and the patient responded to the antidote and regained consciousness. The learners then completed a history and physical exam. When asked, the operator provided the history described in the simulation case. The patient developed progressive dyspnea and his oxygen saturation percentage held in the low 60s. The learners recognized this and reassessed the patient. They discovered rales on exam. The learners ordered a chest X-ray and Figure 1 from Appendix B (chest X-ray with bilateral pulmonary edema) was provided. They attempted both simple oxygen administration and noninvasive positive pressure ventilation to improve oxygenation. However, there was no improvement and the patient gradually declined. The learners recognized the need for intubation. Following intubation, the learners ordered a repeat chest X-ray. Figure 2 from Appendix B (postintubation film) was then provided. Oxygenation did not improve, despite intubation. The learners recognized the need for ECMO in this patient, and then called the appropriate consult.

Equipment/Environment

This case is best run in a simulation center set up as an emergency room with high-fidelity simulator. The manikin should have a blood-pressure cuff, pulse oximeter, capnograph, three-lead EKG, ventilator, laryngoscope, endotracheal tube, bag-valve mask, defibrillator, IV catheters, IV tubing, and simulated drugs (succinylcholine, rocuronium, etomidate, naloxone). Also available in the room are chest X-rays demonstrating flash pulmonary edema and tables containing lab findings.

Personnel

This simulation required one simulation technician to run the equipment and one standardized patient to play the voice of the patient. These two roles may be completed by a one individual if they feel they can adequately perform both tasks.

Assessment

Learners were assessed based on the critical action checklist. The checklist was developed based on steps deemed essential to the survival of the patient. The individual organizing the simulation observed the learners participating, took note of their performance, and discussed ways to improve during the debrief session. Additionally, the learners assessed the value of the simulation using the sample evaluation form provided (Appendix E).

Debriefing

The debriefing session of this simulation took 15-20 minutes. The organizer of the simulation, who had observed the learners and took note of the critical actions conducted or missed, asked the learners what they felt went well and what they felt could have been done better. The facilitator then led a discussion that paralleled the stated learning objectives.

Specific questions considered for discussion can be found in the debriefing materials (Appendix F) and included the following items:

- What is the antidote of choice for opioid overdose?
- What is the differential for dyspnea in an IV drug abuser?
- What is the mechanism of naloxone-induced pulmonary edema?
- What is the mechanism of opioid-induced pulmonary edema?
- What is the general treatment approach to severe pulmonary edema or acute respiratory distress syndrome (ARDS)?
- What is the rationale behind ECMO treatment for severe pulmonary edema or ARDS?

Results

The simulation described was run for emergency medicine residents and student acting interns. A standardized evaluation form was used to obtain feedback from the learners on their experiences. A total of 17 session evaluation forms were completed. Among the participants were one emergency medicine acting intern, four first-year residents, two second-year residents, three third-year residents, and seven who did not disclose their education level.

The results were overwhelmingly positive. For the collection of five questions posed to the learners, almost all of the responses averaged 4.6 on a 1-5 scale with 5 being “strongly agree” (Table). These questions sought learner opinions on the design of the simulation and debrief, the realism of the simulation, the expansion of knowledge gained by the debriefing session, and the ease by which ideas flowed between members during the debriefing session. Only one evaluation question received an average response of 4.5, which described the constructive team critiques during the debriefing session. Overall, the learners felt that the simulation was successful. On the evaluation forms, students repeatedly praised the review of ventilator settings as a highlight of the session. Based on the feedback from the learners, it appears that this simulation was effective at reaching the educational objectives described.

Table: Simulation Session Evaluation Results

Evaluation Question	M ^a	n
The scenario was well designed to help meet the objectives outlined in the debriefing session.	4.6	17
The scenario was realistic in setting and manner conducted.	4.6	16
The debriefing was helpful because it:		
Allowed for critique of my teams performance in a constructive manner.	4.5	17
Added to my understanding of key concepts and helped the session meet the objective.	4.6	17
Facilitated the exchange of ideas and comments among team members	4.6	17

^aFive-point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*).

Discussion

The simulation met all educational objectives proposed. Running the simulation allowed the residents to explore an unfamiliar case, and the debriefing allowed for expansion of the residents' knowledge. This is supported by feedback obtained from the learners after the simulation. It is felt that a similar result would be seen at other institutions.

The case was designed to be used at any institution. No additional equipment is required beyond what would be found at a standard simulation center. Although the case is best represented in a simulation, it is possible to use this case in a discussion format at institutions that do not have a simulation center. Educators also have the option to adapt the simulation to the educational level of the learners. The case can be stopped after naloxone administration, after successful intubation, or after initiation of ECMO. Medical students, residents, and fellows could all benefit from this case.

Future expansion of this case could involve complete simulation of ECMO. If institutions have this capability, this simulation would be a great way to incorporate the procedure. However, this would be limited by institutional policies on ECMO initiation in the emergency department.

Evaluation development with this case could involve more advanced investigation into the effectiveness of the simulation. One option could include a posttest, perhaps some time after the simulation is performed. Another option is to run the simulation again 6 months to 1 year later. Educators could evaluate the performance of the learners and compare their performance to the previous performance.

Simulation has intrinsic limitations. One of these limitations is the challenge of placing the learners into an environment as similar to real life as possible. Improvements in high-fidelity simulators will help narrow the divide between simulation and actual patients. Likewise, utilizing a space either in a hospital or replicating a hospital room will help to further mimic the environment where the training will be implemented. Another limitation observed more in learners new to simulation is convincing them to treat the case scenario as they would a real patient in similar conditions. This can be overcome with orientation to the simulator and the equipment available, as well as discussion of the approach to simulations prior to the scenario.

Limitations unique to this particular simulation include the relative rarity of the case. Many residents may not have learned about flash pulmonary edema secondary to naloxone administration and therefore would not know how to appropriately manage the patient. Ideally, these residents would fall back on their training in critical care. However, if the residents become stuck, methods are in place to provide a tip regarding the proper course of action, or to end the case and proceed to debriefing. Another unique limitation to this case is the variety of final pathways depending on the institution's resources or protocols. Some institutions would initiate ECMO in the emergency department, some would admit the patient immediately to the ICU, and some would transfer the patient to a hospital with a higher level of care. The simulation was written so that the individual institutions can adapt the template to their own protocols.

This resource will be useful to teach the management of acute pulmonary edema secondary to naloxone administration. This simulation is relatively straightforward to run, and the educational yield is high. Learners stated that they thought the simulation was useful, and an overwhelming majority felt that they had expanded their knowledge as a result of this simulation.

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Ethical Approval

Reported as not applicable.

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