Troubleshooting Postintubation Hypoxia: A Simulation Case for Emergency Medicine Residents

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Abstract

Introduction: Opiate overdose is a dangerous but common chief complaint to the emergency department. While many patients with opiate intoxication respond well to opiate reversal agents and noninvasive airway management, some cases involve persistent respiratory failure, hemodynamic instability, and unintentional head trauma that may necessitate airway management. This simulation allows emergency medicine residents to explore an unusual but high-risk disease process: persistent hypoxia in an intubated patient with severe acute respiratory disease syndrome (ARDS) requiring extracorporeal membrane oxygenation (ECMO).

Methods: This case ran for four separate iterations at a simulation center, with a Laerdal 3G Sim Man, respiratory therapist, actor, residents, and attending physician acting as specific confederates for their respective roles. Following each case, learners were debriefed at bedside, discussed a PowerPoint presentation, and underwent a question-and-answer session. Results: Both junior and senior resident groups recognized esophageal intubation, diagnosed ARDS, and proposed treatment goals. Although junior residents recognized that optimal ventilation had not been achieved, they were unable to specifically direct ventilator recruitment maneuvers. Senior residents were more likely to articulate treatment orders, to instruct junior residents to address family members, and to recognize severe ARDS requiring early consultation of the intensive care unit and discussion of disposition. After case completion and debriefing, all learners demonstrated achievement of learning objectives, as well as managing acute dyspnea, treating opiate overdoses, and understanding the role of ECMO in severe ARDS patients. Discussion: Overall, we noted this case worked well for junior EM residents with senior resident backup for supervision and guidance. The presence of a certified respiratory therapist was invaluable and was greatly appreciated by both learner groups, especially during the debriefing section where they discussed various ventilator optimization techniques in conjunction with case instructors.

Keywords

Simulation, Respiratory Distress Syndrome, Esophageal Intubation, Persistent Hypoxia, Opiate Overdose, Adult, ARDS, Extracorporeal Membrane Oxygenation, ECMO

Educational Objectives

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

1. Develop a systematic approach to managing a patient with persistent postintubation hypoxia.
2. Assess for correct endotracheal tube placement.
3. Troubleshoot persistent postintubation hypoxia.
5. Recognize and diagnose severe ARDS.
6. List the differential for acute dyspnea.
7. Describe prehospital management of dyspnea.
8. Recognize and treat opiate overdose.
9. Understand indications, complications, and transfer policies for extracorporeal membrane oxygenation for ARDS.
Introduction

Opiate overdose has become an increasing epidemic problem, affecting over 36 million people worldwide. In 2013, over 4.8 million Americans used heroin, with 8,257 deaths related to heroin overdose. Opioids, whether in the form of oral prescription medication or injectable solution, activate opioid receptors at both the central nervous system (effects including respiratory depression, analgesia, euphoria, and miosis) and the peripheral nervous system (effects including cough suppression and constipation). Not only can the use of opioids lead to significant socioeconomic deterioration but also the mortality of heroin users is 63 times higher than the general population due to overdose and trauma (both intentional and unintentional).

Patients with opioid intoxication symptoms commonly present with slurred speech, pinpoint pupils, depressed mentation, and decreased respiratory drive, at risk for hypoxia and aspiration. Patients with suspected opioid intoxication with apnea or impending airway obstruction should receive naloxone, a pure opioid antagonist that is available in multiple forms, to rapidly reverse opioid effects to achieve adequate ventilation. Naloxone is useful for both diagnostic and therapeutic benefits, while allowing for providers to assess other signs of toxic ingestions, metabolic derangements, and intracranial trauma.

Due to the high risk of severe respiratory diseases and potential head trauma in cases of opioid overdose, patients who remain unresponsive despite naloxone administration are frequently intubated prophylactically in the field by emergency medical services for airway protection. While field intubations can be lifesaving, a recent national study from 2014 showed the overall success rate of prehospital endotracheal intubation is 85.3%, with success rates correlating with the level of paramedic training. As a result, emergency medicine (EM) providers assuming the care of a prehospital endotracheal intubation should always assess the airway with direct visualization, auscultation, and end-tidal CO2 monitoring via visual calorimetric devices or digital capnography.

Even in the setting of optimal identification and attempts to reverse opiate overdose, patients can still develop acute respiratory disease syndrome (ARDS), a life-threatening condition characterized by diffuse alveolar damage resulting in widespread lung inflammation, decreased gas exchange, decreased lung compliance, pulmonary hypertension, pulmonary edema, shock, and even death; the mortality can be as high as 58%. Specific diagnostic criteria for ARDS include rapidly worsening symptoms within 48-72 hours after the inciting event, with a bilateral opacity appearance on chest radiograph (not explained by cardiopulmonary etiologies or failures), as well as severe hypoxemia with PaO2/FiO2 < 100mm Hg on ventilator settings with positive end-expiratory pressure (PEEP) > 5cm H2O. The treatment of ARDS incorporates improved supportive care through a carefully studied approach to mechanical ventilation strategies (including low tidal volume ventilation, high PEEP, and recruitment maneuvers), neuromuscular blockade, and nutritional support based on widely studied and conducted multicenter randomized controlled trials supported by the National Institute of Health’s ARDS Network in order to determine the most efficacious and safe therapy for ARDS. Postintubation hypoxia should also be addressed in a systematic fashion, using mnemonics such as DOPES (displacement, obstruction, pneumothorax, equipment, stacked breaths) to determine whether the etiology is secondary to ventilator or patient anatomy dysfunctions. Providers can address hypoxia due to ventilator-related issues by disconnecting the ventilator and allowing the patient to exhale fully to avoid stacked breaths (in cases of chronic obstructive pulmonary disease or asthma) while manually bagging and manipulating the endotracheal tube to ensure it is not in one bronchus. Physiological causes of postintubation hypoxia may be addressed with aggressive suction through the endotracheal tube or auscultating for diminished breath sounds (in cases of pneumothorax) and considering emergent needle thoracotomy.

Patients with severe ARDS that is refractory to ventilator optimization may be candidates for extracorporeal membrane oxygenation (ECMO), a surgical procedure that bypasses the native cardiopulmonary system by artificially removing the patient’s blood while providing extracorporeal oxygenation and removing carbon dioxide before returning the blood back into the patient’s blood stream. Indications for ECMO for ARDS include respiratory collapse that is unresponsive to optimal ventilator care in the absence of any major immunosuppression, hemorrhages, or nonrecoverable
In order for a hospital to be accredited as an ECMO center, there must be an existing multidisciplinary team consisting of surgeons, intensivists, engineers, nurses, and techs that can be mobilized at short notice to perform the delicate surgery while managing the unique complications and challenges associated with ECMO. Despite these challenges, initial findings suggest an increased survival rate in adult patients with ARDS on ECMO from 50% to 70% based on observational clinical trials. Regardless of individual institutional ECMO policies, it is helpful to have an early consultation with the appropriate surgical services to expedite transition to ECMO care.

Because of the rare but potentially life-threatening presentation of persistent hypoxia due to opiate-associated ARDS, this case incorporates multiple aspects of EM training that make it an ideal simulation case for EM residents. This simulation case covers multiple Accreditation Council for Graduate Medical Education (ACGME) emergency milestones, including (but not limited to) Emergency Stabilization, Airway Management, Diagnostic Studies, Diagnosis, Disposition, and Team Management. A MedEdPORTAL review using the terms airway management and emergency airway did not reveal postintubation troubleshooting methods. Searching the terms acute respiratory distress syndrome, respiratory failure, respiratory distress, post intubation hypoxia, and post intubation hypoxemia did not reveal any cases or educational modules discussing postintubation troubleshooting or the management of ARDS. A previous MedEdPORTAL publication entitled “Orotracheal Intubation Training Module” lists the complications of airway management, which include esophageal intubation, but does not address troubleshooting techniques, postintubation hypoxemia, or management of esophageal intubation. As a result, we feel that this is a valuable case to illustrate a systematic review and management of persistent hypoxia secondary to opiate-induced ARDS, requiring multiple levels of intervention and consultation, while fulfilling various sets of learning milestones per ACGME requirements.

Methods

Medical simulation is a valuable tool in medical education as it allows learners to think and react dynamically based on changing clinical scenarios as well as providing a forum for case discussion and debriefing. This simulation case (Appendices A & B) is based on an actual case of a man with severe ARDS secondary to opiate overdose who was intubated in the emergency department (ED) of a community hospital and ultimately transferred to a tertiary ECMO center due to persistent hypoxia despite ventilator optimization, with a great outcome. The details of the case were adjusted by a panel consisting of four EM attending physicians to create a simulated case that allowed the learners to explore an unusual but high-risk disease process—persistent hypoxia in an intubated patient with severe ARDS requiring ECMO—while learning how to assess and manage difficult airways, troubleshoot persistently abnormal vital signs, and communicate amongst family and health care providers for management of a critically ill patient in a safe, simulated environment. Esophageal intubation was added to provide an additional layer of troubleshooting and to emphasize the teaching point of always checking the tube of a patient intubated prior to arrival in the ED.

Setup

1. Lab: simulation lab emulating an ED bay (stretcher, IV pole, monitor, medication, ventilator, audiovisual room, and debrief room/area).
2. Sim Man 3G: esophageal intubation, distended abdomen, 18 gauge IV in the right AC, track marks on arms and disheveled, with street clothes.
3. Distractor: patient’s family member.

Personnel/Roles

4. Patient’s family member (optional): actor/resident/nurse.
Please see Appendix A for detailed roles for each actor.

Learners are assessed based on their active participation in both the case scenario and case debriefing. A case-specific checklist (Appendix C) is also available for instructors to use for evaluation purposes.

The debriefing is separated into three components: (1) bedside teaching, (2) presentation, and (3) Q&A format. At the end of the case, the instructor should request and gather information about the delegation of roles and responsibilities during the case while eliciting a case summary from the team leader. Instructors can also request supplemental case information as to participant performance, specifically, strengths and opportunities for improvement from the team members or observers (if available). Instructors should emphasize communication techniques (summaries, shared decision making, and closed-loop communication) and discuss methods of engaging a concerned family member without interrupting the patient’s care. Instructors should run through the Critical Action Checklist (Appendix C) with questions such as “What is a methodical way to assess postintubation hypoxia?” See also the Debriefing PowerPoint (Appendix D) reviewing opiate overdose, systematic techniques to troubleshoot persistent hypoxia in an intubated patient (i.e., DOPES), ARDSnet, and indications for ECMO. Learners are encouraged to participate and conclude with each offering one example of a take-home message they have drawn from the simulation case that they intend to apply at work.

Results

Investigators found that both junior (PGY 1-PGY 2) and senior (PGY 3-PGY 4) EM residents were able to recognize esophageal intubation, reintubate the patient, diagnose ARDS, and propose goals of treatment (i.e., optimizing ventilator settings). Both the junior and senior resident groups elected to secure a definitive airway by immediately reintubating the hypoxic patient, as opposed to providing noninvasive ventilation after removing the endotracheal tube from the esophagus. The junior residents were not consistently able to direct treatment with specific orders (i.e., increasing PEEP from 5 to 10), and they required nursing prompts for sedation and paralysis medications during reintubation. Junior residents were also unaware of positive pressure recruitment or turning the simulated patient into a prone position in order to optimize ventilation. Senior residents (PGY 3-PGY 4) were more likely to be able to articulate treatment orders and instruct junior residents to address the family member during the case. The senior residents also voiced the severity of ARDS based on the chest X-ray and arterial blood gas values and consulted the medical intensive care unit fellow earlier during the case for patient admission. One senior resident considered ECMO in the light of persistent hypoxia but was unclear of the associated indications, complications, or transfer policies. Both junior and senior residents appreciated the presence of an actual respiratory therapist, who participated in the case and explained the nuances of managing ventilator settings during case debriefing. During debriefing, open-ended questions, and take-home-message summarization, learners demonstrated understanding of the learning objectives: management of acute dyspnea, treatment of opiate overdoses and understanding the role of ECMO in severe ARDS patients.

Discussion

This simulation is based on a real case of a young man with opiate overdose and ARDS requiring ED intubation and transfer to an ECMO facility for persistent hypoxia, who was ultimately discharged within 1 week without neurological deficits. Rapid-onset ARDS, especially cases requiring ECMO, is both high risk and low incidence, making it an ideal simulation case study for EM residency education. After a thorough review, we did not find any MedEdPORTAL cases or educational modules discussing postintubation troubleshooting or the management of ARDS and created this simulation case to teach learners to systematically troubleshoot persistent postintubation hypoxia, diagnose and manage severe ARDS, and understand indications for transfers for ECMO for respiratory distress.

After four separate case iterations, we noted that both junior and senior residents were able to assess the improperly placed endotracheal tube and recognize persistent hypoxia after proper reintubation, but the junior residents had a greater knowledge gap in terms of ARDS severity and advanced ventilator optimization and needed more frequent prompting from either the nurse, respiratory therapist, or senior
resident. We also noted that when the respiratory therapist initially offered ventilator optimization options, the junior residents were more likely to request additional nonspecific ventilation changes from respiratory therapists, as opposed to directing ventilator changes. Senior residents, in contrast, demonstrated greater understanding of the disease process and were able better direct and coordinate care between the nurses, respiratory therapist, and intensive care fellow for disposition planning.

Overall, we noted this case worked well for junior EM residents with senior resident backup for supervision and guidance. The presence of a certified respiratory therapist was invaluable and was greatly appreciated by both learner groups, especially during the debriefing section where they discussed various ventilator optimization techniques in conjunction with case instructors. However, we recommend future case iterations to encourage learners to direct ventilator changes, as opposed to requesting nonspecific recommendations. Nevertheless, both groups of learners found that utilizing the nurse, respiratory therapist, and medical intensive care unit fellow to suggest further maneuvers was helpful for case progression and to avoid unnecessary interventions or procedures. Finally, while some learners were distracted by the history of opiate use and persistent hypoxia, we found that providing additional history of failure to respond after multiple doses of naloxone helped steer learners to consider other differential diagnoses, such as ARDS.

There were a small number of participants from a single program. The case was presented as a training session; there were no control groups. Results were observational. It would be reasonable to expect that senior residents, especially those with more intensive care unit experience, would more specifically direct ventilator management than junior residents. Nonetheless, the active engagement of all participants suggests that elements of the case can apply to all EM residents, regardless of level of training.

As ECMO continues to develop, this simulation case may incorporate additional information regarding ECMO protocols, transport policies, and expanded indications for ECMO.

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References


