Simulation Training for In-Flight Medical Emergencies Improves Provider Knowledge and Confidence

Amit Padaki; Waddaa Redha; Todd Clark; Ty Nichols; Leah Jacoby; Rachael Slivka; Claudia Ranniger; Kris Lehnhardt

INTRODUCTION: In-flight medical emergencies require healthcare providers to operate in confined spaces with limited resources and delayed access to definitive care. These emergencies are common, with an estimated frequency of 1 per 100 to 1000 flights. Despite this, training for medical response in these environments is limited. We hypothesize that integrating such education into a pre-existing medical student elective course would improve knowledge and ability to respond appropriately to in-flight medical emergencies.

METHODS: The available literature surrounding in-flight medical emergencies was reviewed. Syncope, respiratory distress, allergic reaction, and cardiac arrest were identified as common and potentially life-threatening complaints. Simulation cases were designed for each of these complaints and a simulation room was modified to mimic an airplane cabin. These simulation cases and accompanying relevant didactic lectures were incorporated into an existing wilderness and extreme environmental medicine course, with multiple-choice tests completed by the students at the beginning and end of the 2-wk course.

RESULTS: Participating in this study were 18 students. The pretest average was 76%, which improved to 87% on the posttest. Qualitative feedback regarding this type of training was overwhelmingly positive.

DISCUSSION: Simulation-based training for in-flight medical emergencies can significantly improve medical students' knowledge. This training was very well received by the students. Opportunities for training to manage in-flight medical emergencies remain limited; incorporating such training into existing curricula could provide a means by which to improve provider knowledge. Such a curriculum could be adapted for use by flight crews and other populations.

KEYWORDS: in-flight emergencies, medical, simulation.

Padaki A, Redha W, Clark T, Nichols T, Jacoby L, Slivka R, Ranniger C, Lehnhardt K. ***Simulation training for in-flight medical emergencies improves provider knowledge and confidence*****. Aerosp Med Hum Perform. 2018; 89(12):1076–1079.**

Medical providers face a unique set of challenges when dealing with in-flight medical emergencies. Between cramped work environments, limited access to supplies, and delays to definitive care, providers often deal with circumstances far removed from conventional practice settings. However, such emergencies are surprisingly common. Recent studies have estimated their frequency at 1 per every 100 to 1000 flights.[4,13] Further studies have shown that diversion to definitive care is required in 2–8% of cases even after efforts at midair treatment have been attempted.[2,13,14] In cases where physicians are involved in care, diversions lead to a higher proportion of hospital admissions—possibly indicative of improved selectivity when diverting flights.[6]

Despite the prevalence of in-flight emergencies and the evidence suggesting that volunteer physicians may prove a valuable resource, education surrounding responses to in-flight medical emergencies remains somewhat rare. Studies have shown that trained airline crews often lack confidence and struggle when responding to mock in-flight medical scenarios.[12] Graduating medical students show similar deficiencies in confidence and competency.[9,10] Efforts to address these

From the Department of Emergency Medicine, Christiana Care Health System, Newark, DE; the Department of Emergency Medicine, King Abdulaziz University, Jeddah, Saudi Arabia; the Department of Emergency Medicine, George Washington University, Washington, DC; the Department of Emergency Medicine, Oregon Health and Science University, Portland, OR; and the Department of Emergency Medicine and Center for Space Medicine, Baylor College of Medicine, Houston, TX.

This manuscript was received for review in July 2017. It was accepted for publication in September 2018.

Address correspondence to: Amit Padaki, M.D., Department of Emergency Medicine, Christiana Care Health System, Newark, DE; amit.padaki@christianacare.org.

DOI: https://doi.org/10.3357/AMHP.4945.2018

findings have been limited, though it has been shown that even a 90-min curriculum including lecture and simulation could improve student performance in responding to these scenarios.[9,10]

Certainly, in other austere settings, simulation has proven an effective teaching tool. Specifically, simulation has improved learner performance in wilderness medicine scenarios[11,15] and response to mass casualty incidents.[5,8,16] Further, in wilderness scenarios, simulation has been found to be an enjoyable learning experience.[1]

We are aware of multiple medical schools offering electives specifically centered on wilderness and/or austere medicine, and posit that such electives could form an ideal forum for education regarding in-flight medical emergencies. Specifically, we hypothesize that students participating in a wilderness and extreme environmental medicine elective that incorporates training for in-flight medical emergencies would show improved knowledge in responding to such scenarios.

METHODS

Curriculum Development

The curriculum was designed as a simulation-based course. A literature review was conducted using search terms such as flight, airplane, airline, emergency, and resuscitation in SCOPUS, which identified two articles describing the frequency of medical conditions during in-flight emergencies. Zero articles describing in-flight medical emergency simulations were found. Case topics were selected to match common (e.g., syncope, respiratory illness) or commonly fatal (e.g., cardiac arrest) in-flight presentations.[13] The cases were designed to encourage prudent resource management and to force learners to engage in decisions regarding airplane diversion. In each case, the progressive decompensation of an initially stable patient enabled faculty to assess both over- and under-utilization of resources at different times in the simulation. Summaries of the cases and key actions may be seen in **Table I**.

A 15-item multiple choice quiz to assess knowledge was developed for use as a pre- and posttraining instrument. The quiz questions were created by members of the study team based upon the planned simulation sessions and the list of emergency medical equipment required by the Federal Aviation Administration (FAA) for most commercial airline flights.[7] The components of our simulation medical kit are listed in **Table II**.

Equipment

Simulation of an airplane cabin was challenging in the setting of limited funding and, as such, a low-cost, low-fidelity room design was developed. We identified the following characteristics of the cabin's design as relevant to providing medical care on an airplane:

- Height of the luggage compartment.
- Seat pitch—the distance from any point on one seat to the exact same point on the seat in front or behind it.
- Dimensions of the galley area.
- Aisle width.

We estimated approximate dimensions of these parameters from published data for the Boeing 737,[3] recognizing that individual airlines use custom seating designs with variable spacing. Colored tape was placed on the floor of the simulation environment to delineate the dimensions of the aisle and galley area, and groups of seats were tied together and spaced

Table I. Simulation Cases and Expected Learner Actions.

CASE	SUMMARY	EXPECTED ACTIONS
Hypotension/ Syncope	50 y/o man with syncope in aisle. Persistent orthostatic hypotension despite all interventions	Check vitals; Obtain history of antihypertensive medications; Administer IV fluids
		Increasing Complexity: Recognize lack of response to fluids; Discuss diversion
Allergic Reaction	20 y/o woman develops urticarial rash after in-flight meal. After initial evaluation, progresses to oropharyngeal swelling and anaphylaxis	Check vitals; Skin, cardiopulmonary, and oropharyngeal exam; Treat for simple allergic reaction
		Increasing Complexity: Administer IM epinephrine for worsening symptoms; Discuss diversion
Cardiac Arrest	50 y/o man with multiple risk factors presents with typical chest pain. After initial exam and intervention, patient develops ventricular fibrillation (VF).	Check vitals; Administer oxygen; Obtain IV access; Give Aspirin
		Increasing Complexity: Provide CPR; Defibrillate with AED; Administer ACLS medications; Consider diversion on ROSC
COPD / Pneumothorax	70 y/o man with COPD develops respiratory distress. After initial exam and treatment, reports chest pain and develops unilateral pneumothorax.	Check vitals; Conduct cardiopulmonary exam; Administer oxygen and albuterol
		Increasing Complexity: Reassess patient in face of worsening symptoms; Identify and treat PTX with needle decompression; Consider diversion

IV: intravenous; IM: intramuscular; CPR: cardio-pulmonary resuscitation; AED: automated external defibrillator; ACLS: advanced cardiac life support; ROSC: return of spontaneous circulation; COPD: chronic obstructive pulmonary disease; PTX: pneumothorax.

Table II. Components of the Simulation Medical Kit.

MEDICATIONS	EQUIPMENT
Analgesic, nonnarcotic, oral	Automated External Defibrillator (AED)
Antihistamine, oral	Bag-valve mask
Antihistamine, injectable	CPR mask
Aspirin, oral	Gloves
Atropine, injectable	IV fluid bag
Bronchodilator, inhaled	IV start kit
Dextrose, injectable	Needles
Epinephrine 1:1000, injectable	Oxygen tank
Epinephrine 1:10,000, injectable	Oropharyngeal airway
Lidocaine, injectable	Scissors
Nitroglycerin, sublingual	Sphygmomanometer
	Stethoscope
	Syringes
	Tape
	Tourniquets
List of medications and instructions for use	Basic life support cards
	Advanced life support cards

CPR: cardio-pulmonary resusciation; IV: intravenous.

appropriately on either side of the aisle. A code cart was used to simulate the galley drawers and the in-flight medical kit and automated external defibrillator (AED) were placed in the galley. Contents of the in-flight medical kit were selected to meet FAA guidelines. The luggage compartment was not simulated due to cost and logistical constraints. The simulation mannequin (HAL S3201, Gaumard, Miami, FL) was placed in the aisle seat of the second row. A diagram of our experimental layout can be seen in **Fig. 1**.

Procedure

After IRB approval, medical students participating in a wilderness and extreme environmental medicine elective were approached for participation, and informed consent was obtained. Students then completed the 15-item multiple choice quiz to assess precourse knowledge. Students participated in the 3.5-h educational sessions on 1 of 2 d. They were divided into groups of four or five participants, and each group participated in a total of four simulation events facilitated by Emergency Medicine faculty and senior residents familiar with the principles of in-flight medical care. Debriefing was conducted after each simulation case using critical actions, resource management, and diversion decisions to guide the discussion. Students repeated the 15-item multiple choice quiz approximately 10 d after the session to assess knowledge gained.

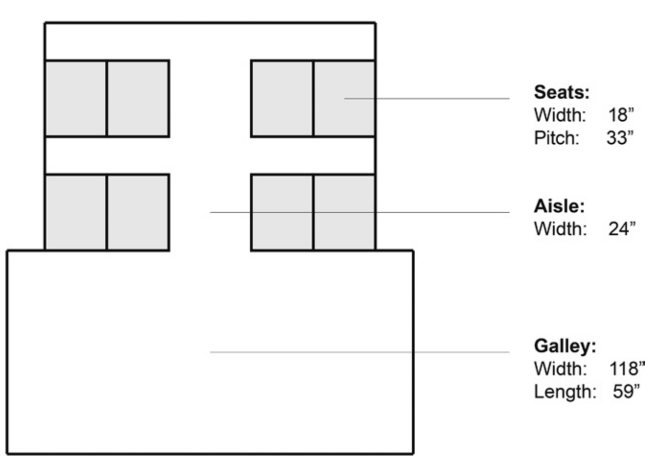

Fig. 1. Simulation room design.

Statistical Analysis

Pre- and posttraining quiz scores were compared using a Student *t*-test (one sided). Individual items were analyzed for relevance and question quality. Anonymous participant feedback was solicited for purposes of course improvement.

RESULTS

There were 18 students (3 third-year and 15 fourth-year medical students) enrolled in the elective, all of whom volunteered for this study and completed the pretest, simulation scenarios, and the 2-wk posttest. A paired sample *t*-test revealed that the simulation training significantly increased student performance, from a mean pretest score of 75.6% to a mean posttest score of 87.0%. This can be seen in **Fig. 2**.

Advanced statistical analysis confirmed a significant difference, with results as follows (when applicable, given as questions correct, out of 15): $t(17) = 4.23$, $P = 0.001$, Cohen's $d = 0.94$, $M_{diff} = 1.72$, $SE_{diff} = 0.40$, $CI_{diff} = 0.87, 2.57$, such that students scored higher on the in-flight simulation quiz after training ($M = 13.06$, $SD = 1.47$) than before training ($M = 11.33$, $SD = 2.11$). While the sample size was relatively small, these results suggest that a brief simulation training session can significantly increase both familiarity and knowledge with respect to physician response to common in-flight medical emergencies. Qualitative student response to the in-flight curriculum was overwhelmingly positive, showing both a high level of enjoyment of the training as well as improvement in confidence in handling in-flight medical emergencies as a whole.

DISCUSSION

Our study proposes a practical, low-fidelity simulation-based curriculum for education on in-flight medical emergencies. Our quantitative findings suggest that this curriculum improves learners' knowledge regarding the management of disease processes that may be encountered in an in-flight setting.

Our study has a number of limitations. First, it occurred during a single elective course, and our total study sample size was limited to 18. Repetition over additional courses would increase study power. Additionally, our study tested retention at the immediate end of the course, within days or weeks of the included instruction, and did not test longer term retention.

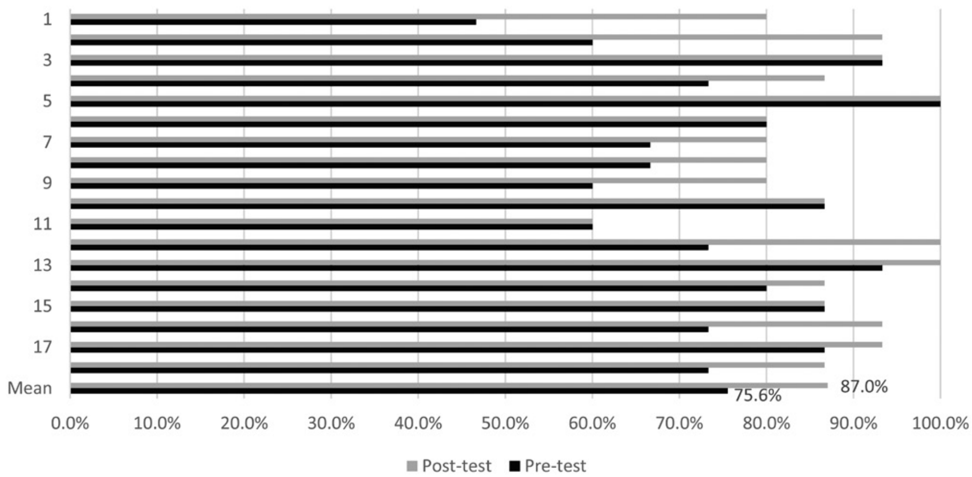

Fig. 2. Student performance in pre- and post-testing.

Authors and affiliations: Amit Padaki, M.D., M.S., Department of Emergency Medicine, Christiana Care Health System, Newark, DE; Waddaa Redha, M.D., Department of Emergency Medicine, King Abdulaziz University, Jeddah, Saudi Arabia, and Ty Nichols, M.D., Leah Jacoby, M.D., Rachael Slivka, M.D., and Claudia Ranninger, M.D., Ph.D., Department of Emergency Medicine, George Washington University, Washington, DC; Todd Clark, M.D., Department of Emergency Medicine, Oregon Health and Science University, Portland, OR; and Kris Lehnhardt, M.D., Department of Emergency Medicine and Center for Space Medicine, Baylor College of Medicine, Houston, TX.

Repetition of the posttest at a later date, such as 6 or 12 mo would provide a more complete assessment of long-term knowledge retention. Further, we selected the study scenarios based upon their frequency and high acuity, but acknowledge that other important emergent conditions could present in-flight. Also, the authors felt it was important to include chronic obstructive pulmonary disease (COPD) with a tension pneumothorax as a scenario, as this is a rare but fatal complication of a common condition. However, we acknowledge that during an actual flight, the noise and vibrations may make diagnosis with a stethoscope challenging. Finally, the multiple-choice exam itself may have been somewhat limited. On combined analysis, questions showed a wide range of difficulties and improvements between pre- and posttesting. Reviewing and replacing poorly performing questions in the future may yield an improved testing tool. It is also unclear how well multiple-choice testing corresponds to real-world performance. Including graded simulation as part of the assessment could address this issue. Despite these limitations, our study demonstrates that simulation training for in-flight medical emergencies may be a welcome addition to medical educational opportunities for senior-level medical students.

Existing training opportunities for in-flight medical emergencies remain limited. Avenues for training in wilderness medicine and, more broadly, emergency medicine are far more widespread. Incorporating in-flight training into wilderness and emergency medicine electives could prove a convenient way to increase health care provider performance when responding to in-flight medical events. Furthermore, this type of simulation curriculum could be modified for educating other populations, such as airline flight crew.

ACKNOWLEDGMENTS

We would like to acknowledge the George Washington University Clinical Learning and Simulation Skills (CLASS) center for providing us with the simulation environment and all the technical support needed for execution of this study.

No competing financial interests exist.

REFERENCES

1. Andrews L, Biles B, Taylor I. Effective and transferable teaching methods from wilderness medicine: the students' perspective. Clin Teach. 2009; 6(3):147–151.
2. Baltsezak S. Clinic in the air? A retrospective study of medical emergency calls from a major international airline. J Travel Med. 2008; 15(6):391–394.
3. Boeing. 737 Airplane Characteristics for Airport Planning. 2013. [Accessed January 2016.] Available from: http://www.boeing.com/assets/pdf/commercial/airports/acaps/737.pdf.
4. Chandra A, Conry S. In-flight medical emergencies. West J Emerg Med. 2013; 14(5):499–504.
5. Cicero MX, Auerbach MA, Zigmont J, Riera A, Ching K, Baum CR. Simulation training with structured debriefing improves residents' pediatric disaster triage performance. Prehosp Disaster Med. 2012; 27(3):239–244.
6. Delaune EF, Lucas RH, Illig P. In-flight medical events and aircraft diversions: one airline's experience. Aviat Space Environ Med. 2003; 74(1):62–68.
7. Federal Aviation Administration. AC 121-33B - Emergency Medical Equipment. 2006. [Accessed January 2016.] Available from: https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC121-33B.pdf.
8. Franc-Law JM, Ingrassia PL, Ragazzoni L, Della Corte F. The effectiveness of training with an emergency department simulator on medical student performance in a simulated disaster. CJEM. 2010; 12(1):27–32.
9. Katzer RJ, Duong D, Weber M, Memmer A, Buchanan I. Management of in-flight medical emergencies: are senior medical students prepared to respond to this community need? West J Emerg Med. 2014; 15(7):925–929.
10. Katzer RJ, Frumin E, Silverman D, Koenig KL, Schultz CH. In-flight medical emergencies: creation of a novel simulation based medical student curriculum. Med Teach. 2013; 35(10):874.
11. Lareau SA, Kyzer BD, Hawkins SC, McGinnis HD. Advanced wilderness life support education using high-technology patient simulation. Wilderness Environ Med. 2010; 21(2):166–170.e2s.
12. Mahony PH, Griffiths RF, Larsen P, Powell D. Retention of knowledge and skills in first aid and resuscitation by airline cabin crew. Resuscitation. 2008; 76(3):413–418.
13. Peterson DC, Martin-Gill C, Guyette FX, Tobias AZ, McCarthy CE, et al. Outcomes of medical emergencies on commercial airline flights. N Engl J Med. 2013; 368(22):2075–2083.
14. Sand M, Bechara FG, Sand D, Mann B. Surgical and medical emergencies on board European aircraft: a retrospective study of 10189 cases. Crit Care. 2009; 13(1):R3.
15. Saxon KD, Kapadia AP, Juneja NS, Bassin BS. How to teach emergency procedural skills in an outdoor environment using low-fidelity simulation. Wilderness Environ Med. 2014; 25(1):50–55.
16. Wilkerson W, Avstreih D, Gruppen L, Beier KP, Woolliscroft J. Using immersive simulation for training first responders for mass casualty incidents. Acad Emerg Med. 2008; 15(11):1152–1159.