

Original Publication

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Inappropriately Firing Defibrillator: A Simulation Case for Emergency Medicine Residents

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Abstract

Introduction: Emergency physicians must be able to manage inappropriately firing defibrillators. Many physicians may not experience this high-risk, low-frequency patient presentation during residency. We created this simulation to increase residents' knowledge of basic defibrillator function and confidence in managing patients with malfunctioning defibrillators. **Methods:** Sixteen emergency medicine residents of all levels of training participated in this curriculum. The educational experience began with a lecture. Residents then managed the simulated patient encounter in groups of four. The patient was a 63-year-old male presenting after feeling his defibrillator fire. He was found to have a supraventricular tachycardia with an inappropriately firing defibrillator. Learners needed to recognize the inappropriately firing defibrillator, inactivate it with a magnet, and treat the arrhythmia. Implementation of this scenario required audiovisual equipment and a simulation room equipped with high-fidelity simulator, patient monitor, code cart, defibrillator, and pacemaker magnet. Learners completed pre- and postcourse surveys to assess changes in baseline knowledge of defibrillator function and self-reported confidence in managing these complicated patients. **Results:** After participating in this educational intervention, residents improved their performance on a 10-question quiz from a class mean of 60% to 84% ($p < .001$). Residents also exhibited an increase in self-reported confidence in managing patients with inappropriately firing defibrillators ($p < .001$) and in knowing when to place a magnet over a patient's defibrillator ($p < .001$). **Discussion:** Residents demonstrated increased knowledge of defibrillator function as well as increased confidence in managing patients with malfunctioning defibrillators after participating in this simulation experience.

Keywords

Simulation, Supraventricular Tachycardia, Emergency Medicine, Defibrillator

Appendices

- A. Precourse Survey.docx
- B. Presimulation PowerPoint .pptx
- C. Simulation Case Template .docx
- D. Simulation Laboratory Studies and Radiology Images.docx
- E. Critical Actions Checklist .docx
- F. Debriefing Materials.docx
- G. Postcourse Survey.docx

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

Educational Objectives

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

1. Identify an inappropriately firing implanted cardioverter-defibrillator (ICD) in the setting of a tachyarrhythmia.
2. Demonstrate the correct management of a patient presenting with an inappropriately firing ICD, including the placement of transcutaneous defibrillator pads and the use of a magnet to inhibit further shocks.
3. Develop a differential diagnosis for inappropriate firing or malfunctioning of an ICD, including supraventricular tachycardia (SVT).
4. Demonstrate the correct management of a patient with stable SVT, including vagal maneuvers and chemical or electrical synchronized cardioversion.

Introduction

Emergency medicine physicians must be able to immediately stabilize patients presenting with a wide variety of complaints. The areas of core knowledge that are considered necessary to the effective practice of emergency medicine are described in the Model of the Clinical Practice of Emergency Medicine,¹ a consensus document created by representatives from six major emergency medicine professional groups. This model is designed to be a foundation for developing curricula, assessment tools, and other items necessary for the education, evaluation, and certification of emergency physicians. Defibrillators are listed

as one of the items critical for emergency physicians to master in terms of knowledge base, patient care, and procedural skills. Patients with defibrillators can present to the emergency department frequently, as shown by a study following a cohort of 81 patients with defibrillators over a 10-year period.² Forty-three percent of the study participants presented to the emergency department at least once during the follow-up period, but only 43% of those visits were related to the defibrillator firing. Inappropriately delivered discharges represent a small portion of such presentations, anywhere from 10% to 24%, based on the results of different studies.³⁻⁵ Given these statistics, patient presentations for inappropriately firing defibrillators are relatively uncommon. Many physicians may complete residency without caring for a patient with an inappropriately firing defibrillator. Failing to recognize and treat these patients appropriately can have grave consequences, as inappropriate defibrillator discharges can be proarrhythmic³ and have been linked to increased mortality.⁵

Simulation has been described as an avenue to educate emergency medicine residents in the care of low-frequency, high-risk patient care scenarios.⁶ Simulation has also been shown to be a more effective educational technique for acquisition of patient assessment and management skills than traditional problem-based learning.⁷ For these reasons, simulation is an ideal method for educating residents in the management of patients with malfunctioning defibrillators.

This simulation case is designed for emergency medicine residents of all levels, and its aim is to educate them in the management of an inappropriately firing defibrillator in a low-risk setting. To the best of our knowledge, there is not currently a published simulation case for a patient with an inappropriately firing defibrillator. We aim to make this simulation case available to others in the academic emergency medicine community so that more residents may benefit from its educational content.

Methods

Development

We created this simulation case for use during a weekly educational conference for emergency medicine residents of all levels of training. The case was developed to address a low-frequency, high-stakes patient encounter that most residents will not have the opportunity to manage during their residency: an inappropriately firing defibrillator. We recognized that many residents would not have the background knowledge necessary to appropriately manage the case. To address this knowledge deficit, we gave an informational lecture about normal defibrillator function and a framework for approaching malfunctioning defibrillators. Learners then moved to a simulation room, and the simulation case was conducted. Pre- and postsession surveys were administered to all learners. Our institutional review board deemed this project not human subjects research.

Equipment/Environment

Required equipment included a screen capable of displaying a PowerPoint presentation, a high-fidelity simulator, a pacemaker magnet, and a screen capable of presenting images of an EKG and a chest radiograph (a printer capable of printing these images would also suffice). The simulator was altered with moulage to simulate an in situ defibrillator.

Personnel

A simulation specialist and an emergency medicine or cardiology content expert were both needed to effectively administer this simulation case. During the case, the simulation specialist monitored the interventions that were administered and changed vital signs accordingly. The content expert provided learners with information, including laboratory data, radiology data, and electrocardiograms. The simulation specialist played the roles of nursing staff and patient care technician. The content expert played the role of consulting cardiologist. After the case, both facilitators participated in leading the debriefing, as the simulation specialist had expertise in debriefing techniques and psychological safety while the content expert had expertise in cardiac devices and patient care. Preparatory work for the cardiology fellow included creating the PowerPoint lecture and reviewing the case. The simulation specialist reviewed the

case materials the day before the session and prepared the simulation room as described in the scenario materials.

Implementation

The simulation rooms were prepared with an adult male high-fidelity simulator, a patient monitor, a defibrillator, a code cart with Advanced Cardiac Life Support medications, a stethoscope, a pacemaker magnet, and audiovisual equipment prepared to display an EKG and a chest radiograph. We implemented this simulation scenario with 16 emergency medicine residents of all levels of training during a routine educational conference day. The participants selected were those who were available after taking into account duty hour restrictions and the resident rotation schedule. The emergency medicine residents were gathered in a classroom setting with audiovisual equipment capable of projecting a PowerPoint presentation. Learners completed a presimulation survey (Appendix A) to assess their comfort with caring for patients with malfunctioning defibrillators and their knowledge of basic defibrillator function and troubleshooting methods. An educational lecture (Appendix B) was then given to ensure that all learners had the background knowledge necessary to succeed in the simulation scenario.

Learners next broke into four groups of four residents each and transitioned to the simulation environment, where they were presented with the simulation case (Appendix C) and its associated patient laboratory results and images (Appendix D) and critical actions checklist (Appendix E). Directly following the simulation, content experts with knowledge of cardiac devices and simulation specialists well versed in psychological safety led a debriefing session using the debriefing materials in Appendix F. Residents were then able to ask any remaining questions about emergency management of inappropriately firing defibrillators. Afterward, learners completed the postsimulation survey (Appendix G) to identify changes in knowledge base and physician confidence from the presession survey.

Assessment

We created a list of educational objectives and used this list to produce a survey. The survey contained two parts: a 10-question, multiple-choice quiz to assess knowledge and two questions to assess self-reported confidence managing patients with malfunctioning defibrillators using a 5-point Likert scale (1 = *Strongly Disagree*, 5 = *Strongly Agree*). The data collected were analyzed using a two-sided unpaired *t* test and Mann-Whitney *U* test, respectively, with a *p* value of .05 used as a cutoff for statistical significance. The same survey was administered before and after the implementation of the case scenario, and the change from baseline was examined. A critical action checklist was created in conjunction with cardiology fellows at our institution, using their expert input to determine the most important actions for optimal patient care.

Debriefing

While a number of debriefing techniques could be used successfully for this simulation scenario, we recommend an advocacy-inquiry approach.⁸ This recommendation stems from the unfamiliar nature of the course material. Many learners may not have had formal training about management of malfunctioning defibrillators in the past. The advocacy-inquiry approach assists educators in determining the learner's reasoning for his or her actions, which can help identify any knowledge gaps that need to be addressed.

Additional questions that may push learners to further critical thinking include the following:

- What could be a complication of placing the magnet over the defibrillator?
 - >Answer: The patient could develop sustained ventricular tachycardia or ventricular fibrillation, and his defibrillator would not be able to terminate the rhythm.
- Should the magnet be removed after the supraventricular tachycardia has resolved?
 - Answer: The magnet should be removed if the inciting cause for the inappropriate firing has resolved, or the patient should be placed on defibrillator pads in case sustained ventricular tachycardia or ventricular fibrillation should develop.

- What should you do if the patient developed sustained ventricular tachycardia or ventricular fibrillation?
 - Answer: The magnet should be removed to allow the defibrillator to function appropriately. External defibrillator pads should also be placed on the patient (not over the site of the implanted defibrillator) in case of failure of the implanted device to terminate the rhythm.

Results

Informal qualitative feedback from residents indicated that they felt this was a valuable educational experience. One learner reported, “This was really beneficial. I wish we did more of these cases. We are seeing more and more cardiac devices in the ED.” Another commented, “Very thorough. Nice that it was more from an Emergency Medicine perspective.” Several residents requested similar cases in the future. After all educational conferences at our institution, participants receive a standard electronic survey that they complete anonymously. This survey form asks about presentation and value of content using a 5-point scale (1 = *Inadequate*, 2 = *Below Average*, 3 = *Satisfactory*, 4 = *Above Average*, 5 = *Outstanding*). Residents rated this educational experience as an average of 4.29 for presentation and 4.41 for content.

The 16 participants also filled out the simulation-specific pre/post surveys (Appendices A & G) described above in the Methods section. Resident scores on the 10-question quiz improved from 60% presimulation to 84% postsimulation ($p < .001$). Self-reported confidence also improved, with an increase in mean score on a 5-point Likert scale (1 = *Strongly Disagree*, 5 = *Strongly Agree*) from 2.69 presimulation to 4.06 postsimulation ($U = 23.0$, $z = -3.93$, $p < .001$) for confidence managing a patient with an inappropriately firing defibrillator and an increase from 2.69 presimulation to 4.13 postsimulation ($U = 30.5$, $z = -3.66$, $p < .001$) for confidence knowing when to place a magnet over a patient’s defibrillator.

Discussion

The simulation scenario described here addresses a low-frequency, high-risk patient encounter that emergency medicine physicians must have the skills to appropriately manage. Simulation is an ideal teaching method for this type of subject matter. It has been described as an effective teaching methodology for procedural competence and team training and allows learners to experience rare, high-risk cases in a safe learning environment.⁶ Simulation training in medical education is also associated with positive changes in learners’ knowledge, skill, and behavior, as well as in patient outcomes,⁹ and has been found to be superior to problem-based learning for the acquisition of critical assessment and management skills.⁷ To the best of our knowledge, no previous simulation scenarios addressing the topic of an inappropriately firing defibrillator have been published. Making these materials available to educators at other institutions can aid in the education of emergency medicine residents in these rare but important patient care encounters. Comparison of the pre- and postsimulation survey results indicates that learners exhibited an increase in knowledge and improvement in self-reported confidence as a result of this educational intervention.

This simulation exercise was well received by emergency medicine residents of all educational levels, and we feel that it could be used successfully with emergency medicine residents at other institutions. The scenario utilizes materials available in most simulation centers associated with academic institutions. We realize that it may be difficult for some educators to engage cardiology experts to assist with the implementation of a simulation scenario. To ameliorate this, we have provided a PowerPoint presentation and debriefing materials to aid emergency medicine physicians in successfully implementing this scenario without additional assistance. The case could also be adapted to an oral boards format, used with a standardized patient, or used in a classroom setting with minimal adjustment.

Limitations of this simulation exercise include the inability to monitor changes in clinical practice after the educational intervention, given the rare nature of the presenting complaint. Also, the instruments used to assess changes in resident knowledge and confidence were created by us and have not been rigorously studied for reliability and validity. In addition, the sample size is small. Due to scheduling constraints, only

16 residents were able to participate. A larger sample size might yield different results or uncover problems with the comprehensiveness of the simulation scenario or debriefing materials.

Based on the results obtained after implementing this simulation curriculum, as well as on learner feedback, we have found that this simulation scenario is a useful and enjoyable educational tool for emergency medicine residents. We plan to keep utilizing this educational material with other learners to continue to refine and improve the curriculum. Future work with the curriculum could also include repeating the questionnaire and/or simulation case with the junior residents at an interval of 1 to 2 years to evaluate knowledge retention and durability of the improvement in their self-reported confidence in managing patients with inappropriately firing defibrillators.

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Ethical Approval

The Palmetto Health Institutional Review Board approved this study.

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