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Acute-on-Chronic Lithium Toxicity: A Simulation Case for Emergency Medicine Residents

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Abstract

Introduction: Simulation-based education has become standard within emergency medicine training. Toxicological clinical presentations are challenging to identify and treat in the emergency department. Recognizing that active teaching methods are superior to standard lecture for learner retention, we created an experiential simulation case for education on lithium toxicity. The case was written after an extensive literature review followed by consultation with a medical toxicologist and an expert in simulation-based education. **Methods:** Fifty-three residents participated in a simulation scenario involving a lithium-poisoned patient over the course of eight simulation sessions. The scenario ran approximately 10 minutes and was followed by postevent debriefing. Debriefing was facilitated by an emergency medicine attending with specialized training in simulation-based education. Following the completion of the scenario, residents received an anonymous educational quality improvement survey assessing residents' perception of their ability to recognize and manage lithium toxicity as well as their comfort level with the lithium-poisoned patient. **Results:** After the simulation, residents reported an increased comfort level with managing lithium-poisoned patients. Residents also self-reported an increased ability to recognize the signs and symptoms of lithium toxicity. Additionally, residents cited the case's educational importance and a desire to include this specific scenario in future simulation sessions. **Discussion:** Compared to other disease processes, toxicological overdoses are infrequently seen in the emergency department. Health care simulation can effectively portray lithium toxicity for emergency medicine resident education in a safe, controlled environment to increase repetitive practice in caring for this challenging population.

Keywords:
Emergency Medicine, Lithium Toxicity, Medical Toxicology, Simulation

Educational Objectives

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

1. Select appropriate laboratory orders for the encephalopathic patient on lithium.
2. Identify tremors, ataxia, mild hyperreflexia, and gastrointestinal symptoms as signs of possible lithium toxicity.
3. Summarize appropriate therapies for the lithium-toxic patient.
4. Determine indications for hemodialysis in the lithium-toxic patient.
5. Appropriately communicate therapy considerations of lithium toxicity with consultants.

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Introduction

Toxicology is an essential part of the core content for emergency medicine residency training, and the ability to manage acutely poisoned patients is essential for the independent practice of emergency medicine. Additionally, simulation-based education is widely accepted as demonstrating improved clinical knowledge, procedural skills, and professional communication in medical schools and residency programs.[1] In 2015-2016, emergency medicine residency programs were surveyed on their toxicology curricula; only 66% of programs reported having a mandatory toxicology rotation, while 21% reported having an elective rotation.[2] Of the surveyed toxicology curricula, most focused on didactic learning rather than case-based learning.[2] Although data on simulation's use for toxicology education are limited, residents have reported more satisfaction with simulation-based toxicologic assessment than with written assessment.[3] Additionally, 3-month

knowledge retention was found to be superior among residents exposed to toxicology cases via simulation rather than those exposed to written-based learning.[4]

Toxicology encompasses a wide range of exposures and envenomations that are not commonplace in the emergency department. Yet emergency medicine physicians are expected to be familiar with diagnosing and managing toxicological emergencies. Lithium toxicity is a clinical presentation that many emergency medicine residents do not have the opportunity to diagnose or manage while in residency. Therefore, we designed a simulation case using a high-fidelity manikin to simulate a patient with acute-on-chronic lithium toxicity.

Our goal was to create a platform where emergency medicine residents could critically think and manage a lithium-poisoned patient in a controlled, reproducible, and safe learning environment. Upon searching for other *MedEdPORTAL* publications related to lithium toxicity, we found only one.[5] This previously published case was developed for medical students on their psychiatric rotation. Additionally, it focused on alcohol withdrawal with concomitant lithium poisoning, with the education centered on developing a broad differential. It is our belief that the toxicologic components of the lithium-toxic patient are too complex for multiple conditions in concert, as previously published. When designing medical education, it is reasonable to consider cognitive load theory, which proposes that simultaneous complex activities, tasks, or (in this case) disease etiologies can exceed a learner's finite working memory capacity and thereby impair learning.[6] Thus, the increased intrinsic cognitive load for two complex disease processes in concert takes away from learning objectives focused solely on the identification and proper treatments for the lithium-poisoned patient. Our scenario focusing solely on the lithium-poisoned patient (Appendices A and B) offers a unique contribution to the existing *MedEdPORTAL* literature as it is aimed specifically at emergency medicine residents and targets a high level of understanding of the pathophysiology, pharmacokinetics, diagnosis, and management of lithium toxicity.

Methods

Development

Our learners consisted of emergency medicine residents within a tertiary care teaching hospital. Every year, within a simulation curriculum, 42 EM residents (PGY 1-PGY 3) each participate in five half-day sessions. Lithium toxicity was chosen as one scenario within the simulation curriculum due to limited resident exposure to this rare toxicity. The case (Appendix A) was written after an extensive literature review along with consultation with a medical toxicologist and an expert in simulation-based education. Additionally, asynchronous learning materials consisting of bulleted take-home learning points (Appendix C) and evidence-based literature (Appendix D) were constructed and delivered to residents after the session to assist in their continued education. Providing the residents with these postsession educational materials allowed facilitators the freedom to create learner-centric debriefs focusing on discussion of what was most important to the residents rather than strictly on specific learning objectives. This model decreased learner cognitive load during debriefings and fostered resident engagement in rich discussion while reinforcing learned concepts.

Equipment/Environment

- Environment: community emergency department, not on monitor.
- Manikin: high-fidelity manikin, SimMan 3G (Laerdal Medical).
- Moulage: gown, one peripheral IV.
- Actors: standardized nurse participant. A standardized patient could also be used instead of the manikin if available to the program.
- Video: video clips were included to demonstrate patient ataxia (Appendix E) and tremors (Appendix F).

Personnel

A standardized embedded nurse participant (who wore an earpiece for in-scenario direction) administered medications, crystalloids, and blood products while providing laboratory values and historical patient information to the learner.

Implementation

Each simulation session within the larger residency program simulation curriculum consisted of five scenarios and was attended by six to seven residents. The lithium scenario was used in eight simulation sessions. In each session, one resident led the toxicology scenario, with the other residents watching the scenario unfold via real-time video. The scenario ran approximately 10 minutes, followed immediately by a shared postevent debriefing involving the resident participant and resident observers. This methodology was chosen because it allowed for an increased number of learners during the simulation-based education. Additionally, our residents were familiar with this paradigm (vicarious participation combined with postevent debriefing) as it was used regularly within our larger simulation curriculum. Laboratory values and imaging

(Appendix B) were provided within the case only if the resident asked for this information. Debriefings lasted approximately 30-45 minutes and were conducted by a board-certified emergency medicine attending with specialized training in simulation education. Debriefings explored predetermined learning objectives and provided guided feedback for improvements in future clinical performance. Asynchronous learning materials consisting of bulleted take-home points (Appendix C) and evidence-based literature (Appendix D) were delivered to residents immediately after the session to assist in their continued education.

Assessment

Using expert consensus, three board-certified emergency medicine physicians and one board-certified medical toxicologist created critical action checklists within the case based on ACGME core competencies. Our department's simulation program was designed as a formative rather than summative curriculum, and so, a scoring rubric was not initially available for this case. Designated critical actions, however, were representative of observable behaviors to guide learner feedback and spark specific discussion during debriefings and were generally used as an assessment of completed items. However, a post hoc scoring rubric based on the American Board of Emergency Medicine oral board examination has been created and included in this publication for possible future use for simulation-based assessment (Appendix G). Similar tools have demonstrated high interexaminer agreement for critical actions and performance ratings when used by calibrated raters in an oral board specialty examination.[7-9]

Following the completion of the simulation session, residents received an anonymous educational quality improvement survey (Appendix H) assessing their perception of improved ability to recognize signs and symptoms of lithium toxicity and manage the lithium-poisoned patient, as well as their comfort level when caring for lithium-poisoned patients. The survey was administered only after the simulation session so that residents would not be primed with knowledge of the chosen scenario topic by a presession survey beforehand.

Debriefing

Curricular debriefing was facilitated by an emergency medicine attending with specialized training in simulation education. Scenario debriefings were designed around a framework of predetermined learning objectives while using the PEARLS model of debriefing.[10] Facilitators consisted of a lead debriefer with 15 years of simulation-debriefing experience and two board-certified emergency medicine content experts to create rich discussion. Prior to the session, the emergency medicine faculty received the predetermined educational debriefing points, detailed in Appendix C, which prepared facilitators to successfully discuss the learning objectives. No debriefing template was created specifically for this scenario; however, the lead debriefer was present at every session, creating uniformity. Additionally, the lead debriefer had extensive expertise using the PEARLS method of debriefing, a methodology ubiquitous in simulation-based educational communities. Finally, using a basic framework for this formative, learner-centric debriefing along with the delivery of postsession asynchronous materials (Appendix D) to residents ensured that all objectives were addressed at some time frame using a blended learning format.

Results

A total of 53 residents (18 PGY 1s, 17 PGY 2s, and 18 PGY 3s) participated in the simulation scenario and subsequent shared debriefing as participant or observer. Only 19% (10 of 53) of residents had previous clinical experience with the care of a lithium-poisoned patient. The remainder (81%) had no clinical experiences with the scenario topic. Survey responses related specifically to the comfort and understanding of caring for lithium-poisoned patients are displayed in the Figure. Prior to the simulation, only 21% (11 of 53) felt comfortable taking care of lithium-poisoned patients. After the simulation, 88% (47 of 53) reported feeling comfortable with caring for lithium-poisoned patients.

Prior to the simulation, only 32% of residents believed they could identify signs and symptoms of lithium toxicity. After the simulation, all residents felt able to recognize the signs and symptoms of lithium toxicity (49% [26 of 53] agreed, and 51% [27 of 53] strongly agreed). Prior to the simulation, most residents did not agree with the statement "I have a good understanding of the diagnosis and management of lithium toxicity" (32% [17 of 53] were neutral, and 43% [23 of 53] disagreed or strongly disagreed). However, after the simulation, resident understanding of the diagnosis and management dramatically improved (38% [20 of 53] strongly agreed, 58% [31 of 53] agreed, and 4% [2 of 53] were neutral).

All residents perceived the simulation session as being important for their education (53% [28 of 53] strongly agreed, and 47% [25 of 53] agreed). Additionally, residents believed this simulation session should be included in future simulation curricula (51% [27 of 53] strongly agreed, 45% [24 of 53] agreed, and 4% [2 of 53] were neutral].

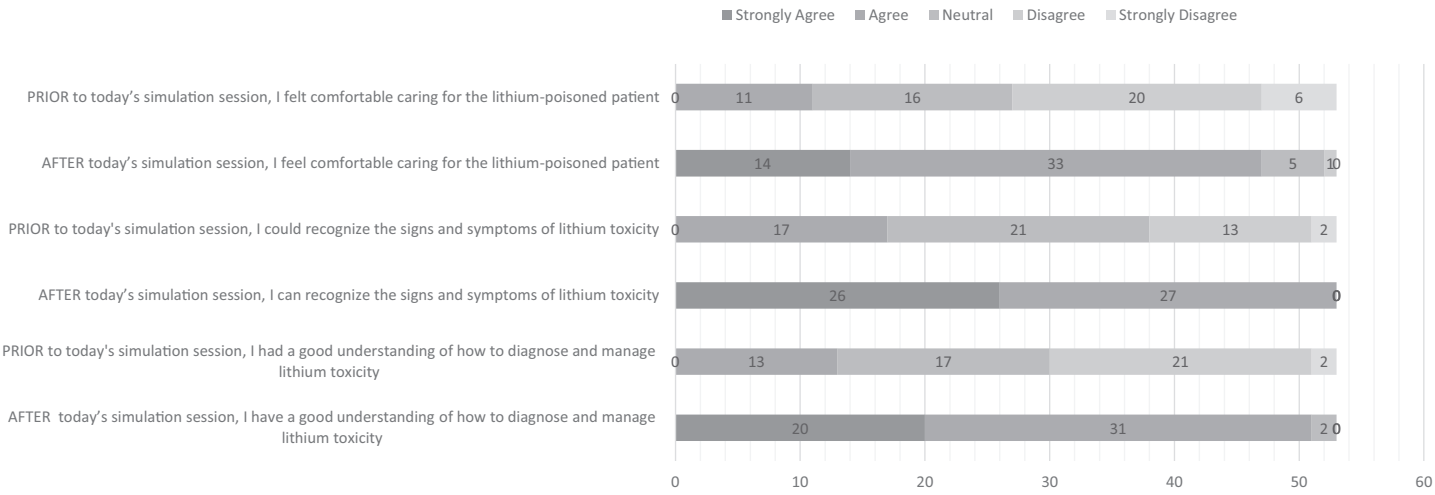

Figure. Responses to survey items related to participants' knowledge and comfort before and after the lithium simulation session.

Discussion

Lithium poisoning is a challenging diagnosis that is infrequently seen in the emergency department. That said, emergency physicians should feel comfortable managing a patient with lithium toxicity. We designed a lithium-poisoning simulation-based scenario for emergency medicine residents to create a platform for education and improved comfort regarding caring for patients with toxicologic overdoses. Based on survey results, the majority of residents who participated in the simulation sessions felt more able to recognize the signs and symptoms of lithium toxicity as well as more comfortable diagnosing and managing the lithium-poisoned patient. Additionally, all residents believed the case was important to their education and should be administered in future simulation curricula. Our data are consistent with previous toxicologic simulation-based education, which has resulted in learner satisfaction and preference over standard lecture formatting.[4] Furthermore, our results are congruent with previous work demonstrating that active learning methods outperform lecture-based education for learner retention of information at the end of a course, knowledge transfer and problem-solving.[11] Our simulated case gave residents the opportunity to critically evaluate a patient with an undifferentiated toxicological overdose, discuss the different types of lithium poisoning, review pharmacokinetics, and manage lithium toxicity appropriately.

Also, it remains our belief that limiting the scenario to include only lithium toxicity improved learning by managing the learners' intrinsic cognitive load. Despite having learners in different PGY training levels, improvement was still perceived for all levels (PGY 1-PGY 3), likely due to the rarity of the lithium-poisoned patient, the case's innate complexity in pharmacokinetics, and the fact that even practicing emergency medicine physicians are not experts in toxicology.

A limitation of our simulation case related to the inability of the manikin to display some of the neurological portions of the exam (tremors, ataxic gait, and hyperreflexia). When a learner asked about these findings, the nurse in the room would verbally describe them. However, in future implementations, video clips demonstrating findings could be used to augment the verbal descriptions. Therefore, in this *MedEdPORTAL* publication, we have included additional video clips demonstrating neurologic findings (Appendices E and F). Another limitation was limited within-scenario resident participation, with most residents observing the case and then participating in a shared postevent debriefing. We do not know how active within-scenario participation alone would have affected the results. However, simulation-based observation has previously demonstrated benefits to learning, particularly when paired with a postevent debriefing.[12-16] Additionally, our methodology involved a larger number of learners than active participation alone and was likely more representative of many simulation-based curricula, which face similar challenges of educating a large number of learners efficiently. Finally, our survey analyses represent lower-level Kirkpatrick data; however, this publication is geared towards providing turnkey components for simulation-based education.

Appendices

A. Simulation Case.docx

B. Simulation Images and Laboratory Values.docx

C. Debriefing Materials.docx

D. Postsession Asynchronous Materials.docx

E. Ataxia Video.mp4

F. Tremors Video.mp4

G. Learner Assessment.docx

H. Educational QI Survey.docx

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

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Ethical Approval

Reported as not applicable.

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