

Original Publication

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Isoniazid Overdose: A Pediatric Simulation Case

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Abstract

Introduction: Unintentional toxic ingestions are a common occurrence in the pediatric population, and it is therefore important for resident physicians to learn to both recognize and effectively manage these events. Seizures caused by isoniazid overdose are a well-described clinical entity for which pyridoxine serves as an effective antidote. We developed a pediatric simulation case using a high-fidelity patient simulator to engage learners in a case of status epilepticus in a toddler caused by accidental isoniazid ingestion. **Methods:** The learning objectives of this activity are for participants to recognize that toxic ingestion has occurred, execute appropriate initial management of status epilepticus, and administer pyridoxine as an antidote. Equipment and personnel needed for this activity include a high-fidelity patient simulator, simulated medical supplies, a patient simulator operator, and one actor. **Results:** This simulated case debuted among resident physicians at a simulation competition event within the emergency medicine residency program of an academic medical center. Feedback elicited after the event included a high proportion of respondents agreeing that the cases used were “sufficiently complex” and “relevant for my clinical practice.” **Discussion:** Despite some barriers to effective implementation, this simulation case was well received and may serve as a valuable educational tool for training resident physicians to effectively manage toxic ingestions. The effectiveness of this simulation in accomplishing its specific learning objectives was not formally assessed, but participant evaluations suggest that it was well received by its target audience.

Keywords

Simulation, Overdose, Seizures, Status Epilepticus, Isoniazid, Ingestion, Eating, Pediatrics, Case, Drug Overdose, Toxic

Appendices

- A. Simulation Case.docx
- B. Lab Data and Imaging .pptx
- C. Evaluation Form.pdf

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

Educational Objectives

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

1. Elicit risk factors for accidental toxic ingestion when gathering a history in a pediatric patient encounter.
2. Assess the airway, obtain IV or intraosseous infusion access, administer a benzodiazepine, and check a serum glucose level when encountering status epilepticus in a pediatric patient.
3. Administer an appropriate dose of pyridoxine to a critically ill patient with acute isoniazid overdose.
4. Utilize closed-loop communication, assignment of clear roles, and shared mental models to facilitate effective teamwork.

Introduction

Toxic ingestions are a common occurrence in the pediatric population, afflicting over one million children in the United States.¹ The majority of these events occur among children who are under 6 years of age, and an estimated 85% of pediatric toxic ingestions are unintentional.² While most of these incidents can be safely managed at home with the guidance of a local poison control center, some toxic ingestions can result in critical illness. It is therefore important for emergency physicians to maintain a high index of

suspicion for occult toxic ingestion in children presenting with a variety of complaints. Seizures are one potential manifestation of unintentional toxic ingestion, and in some cases may be the sole chief complaint. In fact, an estimated 6.1% of new onset seizures are caused by medications or drugs.³ Therefore, toxic ingestion should be suspected in a child who presents with seizure, and assessing a child's ingestion risk and eliciting a list of what medications are in the child's home are important components of gathering a thorough history in such cases.

Isoniazid is an antibiotic that is used as a first-line treatment for both latent and active pulmonary tuberculosis.⁴ However, acute toxic ingestion of isoniazid can result in altered mental status, recurrent seizures, or status epilepticus.^{5,6} Seizures often occur approximately 30 minutes after ingestion, and can lead to status epilepticus that is refractory to benzodiazepines and antiepileptic medications.⁷ An estimated 6% of all drug-induced seizures are caused by isoniazid toxicity.⁸

Isoniazid induces seizures via a mechanism that includes inhibition and depletion of pyridoxine. Isoniazid both inactivates pyridoxine and prevents its activation, which subsequently inhibits the pyridoxine-dependent formation of the neurotransmitter gamma amino butyric acid (GABA). Low levels of GABA are ultimately responsible for the seizures seen in acute isoniazid overdose. The treatment for isoniazid-induced seizures is repletion of pyridoxine, at a dose of one gram of intravenous pyridoxine per gram of isoniazid ingested if known, or at a dose of 70 mg/kg of pyridoxine up to a maximum of five grams if the amount of isoniazid ingested is not known.⁹ If a sufficient amount of intravenous pyridoxine is not immediately available, an equivalent amount can also be administered crushed through an enteral tube or orally if the patient is cooperative. Furthermore, within the United States, consultation with a medical toxicologist for overdose cases is available at all times through a local poison control center by calling 1-800-222-1222.¹⁰

To the best of our knowledge, there does not yet exist a simulated case of pediatric isoniazid overdose that is published in MedEdPORTAL. Intentional isoniazid overdose in an adult causing status epilepticus is described well in "A Simulated Patient Encounter of Status Epilepticus,"¹¹ but its emphasis is on the management of seizure in adults and therefore does not address educational objectives such as the management of a critically ill child or recognition of accidental toxic ingestion. There also exist other simulated cases of pediatric seizure in MedEdPORTAL, but these do not specifically address the management of acute isoniazid overdose or the administration of pyridoxine as an antidote.^{12,13} Recognizing the availability of these related resources, we sought to develop an entirely new simulation case that challenged participants to manage a critically ill and seizing child, recognize that toxic ingestion has occurred, and administer pyridoxine as an antidote for isoniazid overdose.

Methods

This educational activity is targeted towards resident physicians in emergency medicine and pediatrics, as these are the two specialties most likely to encounter a pediatric case of isoniazid overdose. In order to emulate the real-life clinical management of such a scenario, we chose to use a high-fidelity patient simulator with a group of four to five learners.

Appendix A is the case outline for the patient simulator operator and actor to review prior to beginning the case. This document details all of the status changes that the simulated patient undergoes throughout the case. Appendix B includes laboratory data and imaging that the participants may request during the simulation. It is a PowerPoint file designed to be displayed on a computer screen that is visible to the participants at the bedside. Appendix C is the evaluation form distributed to all participants after this simulation was implemented in our institution.

Equipment and Environment

This educational activity is intended to take place in a room the approximate size of a hospital room or resuscitation bay, or in a dedicated simulation center. Equipment required to implement this activity

include a pediatric high-fidelity patient simulator, hospital bed, IV and intraosseus infusion access kits, simulated IV medications, glucometer, code cart, airway cart, simulated telemetry equipment, and two computer screens visible from the patient's bedside.

Personnel

Personnel required to carry out this activity include one person to operate the patient simulator and one actor to play the role of the patient's mother. The role of the pediatric intensive care unit admitting physician is also voiced by the patient simulator operator. Our implementation of this case also includes a second actor playing the role of the emergency department nurse, although this role is optional. Another optional role is that of a dedicated observer who assesses the participants' performance and leads the debriefing session after the case.

Assessment

Assessment of the participants' performance is to be accomplished by direct observation of their actions in real-time during the simulated case. A list of critical actions for learners to be evaluated against is listed in the simulation case file. Assessment should be performed by the patient simulator operator, or alternatively by a dedicated observer. To evaluate the effectiveness of this case in communicating its learning objectives, a survey should be sent to all participants within 5 days of the activity eliciting both quantitative ratings of this activity's efficacy as well as qualitative feedback regarding its strengths and weaknesses.

Debriefing

Debriefing should take place together with all participants immediately after the case ends. The ideal facilitator for the debriefing session would be the person who performed the assessment, either the patient simulator operator or a dedicated observer. In order to allow for learners to voice their initial reactions and feelings, the facilitator should start the session by asking the group, "How did that feel?" If the participants did not recognize that isoniazid overdose was the cause for the patient's seizure by the end of the case, the topic can be approached by asking participants to formulate a differential diagnosis for new onset seizure in a previously healthy toddler. Other topics that can be explored during the debriefing session include the importance of obtaining blood glucose in a critically ill child, the need to establish a dosing weight in pediatric emergencies, the management of status epilepticus, the role of pyridoxine as an antidote for isoniazid overdose, consideration of pyridoxine as empiric treatment for any case of refractory seizures, and the leadership and communication styles that were exhibited by participants during the case. Optionally, the actor playing the patient's mother can also participate in the debriefing to provide feedback to learners regarding their communication with the patient's mother throughout the case.

Results

This simulation case was debuted at the University of Wisconsin's UW Sim Wars 2016, an annual event within the institution's emergency medicine residency program. UW Sim Wars involves teams of residents and attending physicians completing challenging simulation cases while their peers and colleagues observe remotely and judge their performance. Two teams, each consisting of five emergency medicine residents, completed this particular simulation case without knowledge of or witnessing the other team's performance. Each team was given only the chief complaint immediately prior to entering the simulation room. Two actors played the roles of the patient's mother and the emergency department nurse.

After the session, evaluations were elicited from the residents regarding the entire event, which consisted of two other simulation cases in addition to this one. All 17 respondents selected "agree" or "strongly agree" when asked if the "scenarios used in this training session were sufficiently realistic." All respondents also agreed or strongly agreed that these cases "were sufficiently complex for my learning purposes" and "required medical knowledge and decision making that is relevant for my clinical practice." Free-text written feedback included comments such as "great cases" and "yes, do more cases like this!"

However, one respondent did note, “not sure how often we see isoniazid. . . .” Five of the 17 respondents listed either “communication” or “team training” as the element “most useful for you about this session.” Ninety-four percent of respondents rated the entire UW Sim Wars session as either “very good” or “excellent.”

Discussion

Because of the high incidence of toxic ingestions in the pediatric population and the potentially serious sequelae of not recognizing their occurrence, we believe it is important for resident physicians to learn how to successfully manage these types of cases. In designing this simulation case, we sought to engage learners in a sufficiently realistic yet challenging scenario that promoted appreciation of a child’s risk of accidental toxic ingestion, demonstrated the successful management of a seizing child, and taught the specifics of managing isoniazid overdose. Effective communication and teamwork were also objectives of this activity, and it is therefore intended for a group of learners participating together. UW Sim Wars provided an excellent venue to debut this new case with its target audience while maintaining a low-pressure and low-risk atmosphere.

During UW Sim Wars, two potential barriers to effective implementation of this case were uncovered. First, a toddler-sized high-fidelity patient simulator was not available at our simulation center. Instead, the Laerdal SimBaby was used, which more closely resembles an infant in size and appearance than it does a toddler. Second, the actor playing the mother did not consistently disclose the key history of isoniazid being present in the home when prompted by the teams’ questions. As a result of this observation, the case file was edited to further clarify what questions should prompt the mother to reveal the presence of isoniazid in the home. The current case file reflects this change. Furthermore, any future implementation of this simulation case should include adequate briefing of the actor playing the mother to ensure consistency in providing the history.

The effectiveness of this simulation case in accomplishing its specific learning objectives was not formally assessed. However, participant evaluations suggest that this simulated case was well received by its intended target audience. Overall, the feedback we received was positive and both the simulation session format and the case content itself seemed to appeal to learners. Future research may further evaluate this activity against its specific learning objectives. Nevertheless, this simulation case has already proven its potential as a valuable educational tool for resident physicians.

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Ethical Approval

Reported as not applicable.

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