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High-Fidelity Simulation Scenario: Pyridoxine-Dependent Epilepsy and Treatment

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Abstract

Introduction: Treatment of seizures in the neonatal patient is urgent and time sensitive. Effective and timely treatment of this life-threatening condition is vital in preventing mortality and long-term morbidity. This simulation-based curriculum involves the identification and management of a seizure in a 4-day-old neonate with pyridoxine-dependent epilepsy. The target audience is emergency medicine and pediatric residents, pediatric emergency medicine fellows, and medical students. **Methods:** The primary objectives for this simulation are to (1) rapidly initiate stabilization techniques for a seizing neonate, (2) recognize the importance of checking a glucose level in a seizing neonate, (3) demonstrate understanding of antiepileptic medications and dosing, and (4) identify status epilepticus and initiate pyridoxine once initial seizure management has failed. The goals of this simulation are for residents to treat a seizing infant in an emergency department setting, identify status epilepticus, develop a differential diagnosis that includes vitamin B6 deficiency, and correctly administer pyridoxine. Requirements of this simulation include a high-fidelity patient simulator, medical supplies, a patient simulator operator, and one actor. **Results:** This simulation case was performed at the simulation lab at the State University of New York Upstate Medical University with emergency medicine and pediatric residents. Feedback evaluations for the case showed that it improved resident education and clinical skills. **Discussion:** This simulation case was well received and helped residents develop a systematic approach to seizure management of a newborn. Residents reported increased confidence in treating a seizing neonate and increased comprehension of pyridoxine-dependent epilepsy.

Keywords

Emergency Medicine, Seizure, Neurology, Pediatrics, Endocrinology, Neonatal Seizure, PDE, Pyridoxine Deficiency, Vitamin B 6 Deficiency

Appendices

- A. PDE Case Template.docx
- B. PDE Case Overview.docx
- C. Supplemental Materials .pptx
- D. Survey.docx

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

Educational Objectives

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

1. Identify pyridoxine-dependent epilepsy and implement treatment.
2. Recognize the need to identify metabolic etiologies for seizures.
3. Learn appropriate antiepileptic drugs and dosing.
4. Implement proper resuscitation interventions.

Introduction

Neonatal seizures require prompt medical attention. They are life-threatening events that have potential lifelong complications for the developing brain. Clinicians are expected to stabilize patients in a timely manner while simultaneously investigating the etiology of the event. Because there is an extensive list of differentials for seizures in a newborn, it is important to have an organized approach for both seizure treatment and the workup.¹

The causes of neonatal seizures include neurologic, congenital, infectious, metabolic, traumatic, and toxins. Neonatal seizures are common and occur in 0.15% to 1.50% of newborns.² Therefore, having a comprehensive understanding of seizure management is essential to both emergency medicine physicians and pediatricians. This simulation allows learners to develop a systematic approach to status

epilepticus that does not respond to anticonvulsant medication. This permits learners to broaden their differential diagnosis, which should include metabolic etiologies, specifically, pyridoxine-dependent epilepsy (PDE).

PDE is an important diagnosis to make because the most effective treatment is the simple administration of pyridoxine (vitamin B6), which often leads to a rapid reversal of the seizure episode. Patients present in the neonatal period, typically the first few days of life, with an intractable seizure that does not respond to standard anticonvulsants.³ Complete blood count and electrolytes are usually unremarkable, and there is no rapid test to assess for this disorder. Initial diagnosis is made by administration of pyridoxine, which leads to rapid reversal of the seizure episode both clinically and by EEG. It is important that once pyridoxine has been administered and the seizure resolved, pyridoxine supplementation continues to be given or the patient will seize again.⁴

Most cases of PDE are due to alpha-aminoadipic semialdehyde (alpha-AASA) dehydrogenase (also known as antiquitin or ATQ) deficiency, an autosomal recessive inborn error of metabolism caused by defects in the *ALDH7A1* gene that lead to accumulation of alpha-AASA and pipercolic acid in plasma, urine, and cerebrospinal fluid. Testing for PDE is done by testing for levels of elevated pipercolic acid and AASA in urine, plasma, and cerebrospinal fluid. Genetic testing can confirm mutations in the *ALDH7A1* gene, but these tests usually take a lengthy time to obtain results. If PDE is suspected, the patient should receive daily pyridoxine until the diagnosis is confirmed.⁵

In *MedEdPORTAL*, there are several simulations involving seizures in infants and newborns due to fever, sepsis, electrolyte imbalances, and drug ingestion.⁶⁻⁸ To the best of our knowledge, there are no simulations involving reversible inborn errors of metabolism, specifically, PDE. We chose high-fidelity simulation as our teaching approach to create a realistic patient encounter requiring learners to act in an emergent situation. The target audience for this simulation was emergency medicine residents, pediatric residents, and fellows.

Methods

Development

The purpose of this simulation was to help learners develop a systematic approach to the identification and treatment of epilepsy in an emergency department setting while coming up with a broad differential diagnosis for the etiology. Status epilepticus is a life-threatening situation, and it is important for learners to be organized so that they can identify the underlying etiology and appropriately treat the condition. For this simulation, we included all supplemental materials for the instructor in the Appendices.

Equipment and Environment

We placed the setting of this simulation in the simulation center. However, the location could be in the emergency department or on the floors in a mock code scenario. We used a high-fidelity infant mannequin that was controlled by an operator. The trainees in the simulation lab were given a brief description of the patient's presentation by the instructor, and vital signs were present on the monitors. EKG and chest X-ray findings were available for trainee interpretation. Clinical changes and lab findings were verbally provided by the instructor throughout the case.

Personnel

The participants in the simulation were emergency medicine residents, pediatric residents, and fellows. The simulation was meant for four to eight learners at a time. Specific roles were assigned by the instructor or the participant who was leading the case. There were no prerequisites for trainees prior to participating in the case. The case required one instructor who acted as both moderator and parent and one operator of the simulation mannequin. Preparation for the instructor was minimal and included reviewing the case 5-10 minutes before the simulation began.

Implementation

This simulation was implemented during the resident weekly didactic sessions. The simulation was approximately 20 minutes in length, with a 10-minute debriefing session. There were three sessions per day over a 3-week period. Each large group of emergency medicine and pediatric residents was divided into smaller teams of four to eight people. At the start of each simulation, a group leader was selected, and team roles were designated by the group leader or by the instructor. One person acted as preceptor, parent, and consulting physician. An additional person was the simulator operator responsible for running the mannequin and vital signs.

The case is fully outlined in the simulation case file (Appendix A). The critical actions checklist, laboratory values, and debriefing plan are found in the case overview (Appendix B). Images displayed for the participants during the activity included EKG, chest X-ray, and lab values; these are also included (Appendix C).

Assessment

Evaluation of participants' performance was done by instructor observation during the simulation. The instructor followed the critical actions checklist, using it as a guide to subjectively measure the participants' clinical and decision-making skills. Items on the checklist were selected based on the primary and secondary educational objectives of the simulation. To assess the effectiveness of this case in obtaining its objectives, a survey was filled out by the participants after the simulation and debriefing sessions were complete. This survey (Appendix D, adapted from Rideout and Raszka's survey⁹) was used for resident self-assessment following the case, and participants were given 5 minutes to complete it.

Debriefing

Once the simulation was finished, a debriefing session was initiated to discuss the scenario. The instructor and the simulation operator led the debriefing session. We found it was best to start the session with the instructor asking the participants how they felt the session had gone. Participants were asked about specific areas in which they felt they had done well and areas where they could improve. If they had not identified pyridoxine deficiency as the etiology of the seizure, then a discussion on how they could have come to that conclusion was held. Other topics we discussed during the session included the importance of obtaining blood glucose in any critically ill child, the need to obtain a weight for dosing in pediatric patients (Broselow tape should have been used since the exact weight was not known), the management of status epilepticus, consideration of pyridoxine as empiric treatment for any case of refractory seizures, and the leadership and communication styles exhibited by participants during the case.^{10,11} Items on the critical actions checklist that had been missed took precedence in the discussion.

Results

This simulation was run nine times over the course of 3 weeks with 32 emergency medicine pediatric residents and fellows at all levels of training. Instructors of the simulation included senior residents, fellows, and emergency medicine and pediatric emergency medicine attendings.

All 32 participants filled out the postsimulation survey, and their feedback was positive. Participants felt they had reinforced their ability to manage a status epilepticus case while at the same time broadening the depth of differential diagnosis. This was particularly useful for participants who failed to identify pyridoxine deficiency as the etiology of the epilepsy. One junior resident stated that the simulation "helped me develop a systematic approach to a seizing neonate," while a senior resident commented, "I feel more comfortable broadening my differential diagnoses while working up a seizing patient." Twelve residents wrote that although PDE was a less common condition, they felt this disorder was important to be aware of for neonatal seizures.

Average scores on the postsimulation survey for competency for treating and working up a neonatal seizure were 4.40 and 4.56, respectively, on a 5-point Likert scale. Competency for placement of IV, IO, or

intubation was also evaluated, with an average score of 4.62. Secondary learning objectives were evaluated, and clinical decision-making, ability to work as a team, and ability to manage a difficult patient averaged 4.42, 4.80, and 4.32, respectively. The overall rating for the simulation being a beneficial learning experience was 4.72.

Discussion

This simulation allows participants to practice the status epilepticus treatment algorithm in a realistic and safe setting. It is important for residents to practice simulation cases in which the initial interventions do not improve the patient's condition because doing so helps residents expand on differentials and etiologies.

As in all simulations, effective communication and teamwork were secondary objectives of the activity, and it was important for the group of learners to participate together.

This simulation worked well in both a simulation center and an inpatient setting and had positive response from both emergency medicine and pediatric residents. There were some limitations we found in the case. Even though we used a high-fidelity infant mannequin, there was lack of the urgency that a clinician would feel in a real-world scenario. In the future, we plan on incorporating a vibration device to simulate the seizing infant. Time constraints were another limitation due to limited time in the simulation center and limited staff. Some groups were large enough that not every participant had an active role in the simulation. We plan on incorporating more staff into our simulations to add time for the participants. We did have a 100% response from our 32 participants, and our results successfully addressed the primary and secondary learning objectives, but we were limited to student self-assessment (Kirkpatrick's pyramid level 1).¹² For more in-depth assessment, we plan on incorporating a pre- and postsimulation test as well as facilitator evaluations for the participants.

Though PDE is less common, it is an important differential to be aware of in a neonate with status epilepticus because of rapid reversal of the seizure event if treated properly. While airway management and pediatric ICU admission are important steps for status epilepticus, timely reversal of the seizure is vital to prevent lasting brain damage in the neonate. This simulation also shows that when participants are involved in a simulation with a rare etiology, their ability to work through the more common causes of neonatal status epilepticus improves.

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Ethical Approval

Reported as not applicable.

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