

# PEDIATRIC EMERGENCY MEDICINE PRACTICE

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## Altered Level Of Consciousness: Evidence-Based Management In The Emergency Department

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### Abstract

A child who presents to the emergency department with an altered level of consciousness can be clinically unstable and can pose a great diagnostic challenge. The emergency clinician must quickly develop a wide differential of possible etiologies in order to administer potentially life-saving medications or interventions. The history, physical examination, and appropriate diagnostic tests can aid greatly in rapidly narrowing the differential diagnosis. Once initial stabilization, workup, and first-line interventions are completed, most patients who present with unresolved or unidentified altered level of consciousness should be admitted for further evaluation and close monitoring. This issue provides a review of the etiologies of altered level of consciousness as well as guidance for the management and disposition of patients with this condition.

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## Case Presentations

A 7-year-old previously healthy girl presents to the ED with fever, neck pain, and increased sleepiness since the previous day. The patient's mother reports that she has had a nonproductive cough for the past 2 days, with associated nasal congestion and runny nose. She also notes that the girl has had a decreased appetite since the previous day, a temperature of 38.5°C, neck pain, and has been lethargic. The patient's mother does not report a rash, and the remainder of the review of systems is negative. On examination, the patient is found to be sleepy and slowly arousable to commands. The girl's pupils are equal, 4 mm, and react briskly to light. She winces with extension of her knees and has reflex flexion of her hips and knees upon passive neck flexion. As you discuss the likely diagnosis with the girl's mother, you start to think about the management of this patient: What laboratory studies should be sent? Which medications should be administered? Are imaging studies indicated at this time?

A 14-year-old previously healthy adolescent boy presents to the ED after being found by his parents in his room, unconscious. Hours prior to being found, the patient was reportedly with his friends at the movies and was in his usual state of health. His parents deny any fever, nausea, vomiting, or known trauma. The physical examination is notable for a well-developed male who is lethargic and makes only incomprehensible sounds. His physical examination is otherwise normal. What are the likely etiologies for this patient's altered mental status? What are some interventions that can be initiated to prevent morbidity?

A 9-year-old girl with propionic acidemia presents to the ED with 3 days of nonbloody, nonbilious emesis, and 1 day of lethargy and increased work of breathing. She has not been able to eat anything as a result of the vomiting. Her parents report that she woke up this morning looking very tired and sleepy, which prompted them to bring her to the hospital. The parents deny any fever, diarrhea, or preceding upper respiratory symptoms. The physical examination is notable for disorientation to person, place, and date. She has dry mucous membranes and a capillary refill time of 2 seconds. Her vital signs are as follows: temperature, 37°C; heart rate, 150 beats/min; respiratory rate, 28 breaths/min; and blood pressure, 80/40 mm Hg. You know that you'll need to hydrate this patient, but which intravenous fluids should you use? At what rate should the intravenous fluids run? What other interventions will be needed?

## Introduction

The term *altered level of consciousness* (ALOC) can be used to describe a spectrum of disorders that includes clouding of consciousness, confusion, lethargy, obtundation, stupor, or coma.<sup>1,2</sup> In young children, ALOC may manifest as fussiness or irritability. Due to the varying degrees of altered consciousness, it is important for the emergency clinician to be familiar with the various terms that can be used to

describe a patient's clinical status, and to recognize that there is much similarity among them.

- **Clouding of consciousness** can include a very mild form of ALOC in which there is inattention, decreased alertness, and reduced wakefulness.
- **Confusion** involves a state of disorientation, along with bewilderment and difficulty following commands.
- **Lethargy** describes severe drowsiness, though the patient can still be aroused with moderate stimuli.
- **Obtundation** is similar to lethargy but with slowed responses to stimulation and decreased periods of time spent in wakefulness.
- **Stupor** refers to a mental state when the patient can only be aroused by repeated and vigorous stimuli (such as pain).
- **Coma** is a persistent state of unresponsiveness despite attempts of arousal.<sup>1,2</sup>

ALOC can be induced by traumatic or non-traumatic mechanisms. In a British epidemiological study completed in 2001, the incidence of nontraumatic coma in children aged < 16 years was reported to be 30.8 per 100,000 per year, with a noted increased incidence in children aged < 1 year (160 per 100,000 per year).<sup>3</sup> In other hospital-based studies, nontraumatic coma was noted to be more common in children aged < 6 years than in older children.<sup>4</sup>

Etiologies for ALOC can be numerous, but a broad differential can be reviewed quickly with the aid of mnemonics such as MOVESTUPID, which is adapted from adult emergency medicine practice. (See Table 1.) Other commonly used mnemonics include AEIOU TIPS (alcohol/acidosis, epilepsy, insulin, overdose, uremia, trauma, infection, psy-

**Table 1. Mnemonic For Differential Diagnosis Of Altered Level Of Consciousness<sup>7</sup>**

### "MOVESTUPID"

**Metabolic:** inborn errors of metabolism (eg, urea cycle defects, propionic acidemia)

**Oxygen insufficiency:** hypoxemia of cardiopulmonary etiology, hypercarbia, carbon monoxide poisoning

**Vascular/cardiac causes:** cerebrovascular accident, vasculitis (including myocardial infarction), ventriculoperitoneal shunt malfunction

**Endocrine/electrolytes:** diabetic ketoacidosis, hypoglycemia, electrolyte abnormalities

**Seizures/sepsis/shock**

**Tumor/trauma/temperature/toxins**

**Uremia:** renal failure, liver failure

**Psychiatric/porphyria**

**Infection/intussusception**

**Drugs/drama**

chosis, stroke) or DPT OPV HIB MMR (dehydration, poisoning, trauma; occult trauma, postictal/postanoxia, ventriculoperitoneal shunt; hypoxia/hyperthermia, intussusception, brain masses; meningitis/encephalitis, metabolic, Reye syndrome/rare causes).<sup>5</sup> Of these etiologies, the most common cause of nontraumatic coma is an infectious etiology.<sup>3,6</sup>

This month's issue of *Pediatric Emergency Medicine Practice* will review a broad differential diagnosis for pediatric patients who present to the emergency department (ED) with ALOC, as well as present the initial workup and interventions to stabilize such patients.

## Critical Appraisal Of The Literature

An online literature search was performed using the PubMed and Ovid MEDLINE® databases with the search terms *altered level of consciousness, acute loss of consciousness, altered mental status, and coma*. For literature searches using the search terms *altered mental*

*status and coma*, fields were limited to the age group between 0 and 18 years of age and articles written in the English language. A total of 381 articles were reviewed. In addition, individual literature searches were performed for each of the differential diagnoses listed in **Table 2** and reviewed for relevance to ALOC or altered mental status. The Cochrane Database of Systematic Reviews was searched using the key terms *altered level of consciousness, acute loss of consciousness, and altered mental status*, but no reviews were found; using the key term *coma*, 31 reviews were identified.

## Etiology And Pathophysiology

The awake state of humans is thought to be largely affected by the ascending reticular activating system (ARAS). The ARAS is a network of neurons located in the midbrain, pons, and medulla, and it is responsible for receiving sensory input and modulating wakefulness and alertness. ALOC can result from

**Table 2. Differential Diagnosis Of Altered Level Of Consciousness<sup>7</sup>**

Mechanism/Body System	Differential Diagnosis	Mechanism/Body System	Differential Diagnosis
Toxicologic	<ul style="list-style-type: none"> <li>• Hypoglycemia (secondary to drug effect)</li> <li>• Carbon monoxide</li> <li>• Opioids</li> <li>• Alcohols/ethanol</li> <li>• Accidental ingestion/poisoning</li> <li>• Psychotropic medications</li> <li>• Methemoglobinemia</li> <li>• Substance abuse/overdose</li> </ul>	Pulmonary	<ul style="list-style-type: none"> <li>• Oxygen deficiency/hypoxia/hypoxemia</li> <li>• Hypercarbia</li> </ul>
Trauma	<ul style="list-style-type: none"> <li>• Intracranial hemorrhage</li> <li>• Diffuse cerebral edema</li> <li>• Concussion</li> <li>• Anoxic brain injury</li> <li>• Diffuse axonal injury</li> <li>• Nonaccidental trauma</li> </ul>	Endocrinologic	<ul style="list-style-type: none"> <li>• Hypoglycemia</li> <li>• Diabetic ketoacidosis</li> <li>• Hyperglycemic hyperosmolar state</li> <li>• Hashimoto encephalopathy</li> </ul>
Neurologic	<ul style="list-style-type: none"> <li>• Seizures/epilepsy</li> <li>• Encephalopathy</li> <li>• Complicated migraine</li> <li>• Ruptured arteriovenous malformation, aneurysm</li> <li>• Stroke</li> <li>• Cerebrospinal fluid shunt malfunction</li> <li>• Central nervous system vasculitis (primary vs secondary; eg, lupus cerebritis)</li> <li>• Postinfectious disorders (eg, acute disseminated encephalomyelitis)</li> </ul>	Gastrointestinal	<ul style="list-style-type: none"> <li>• Intussusception</li> <li>• Acute abdomen</li> </ul>
Cardiac	<ul style="list-style-type: none"> <li>• Syncope</li> <li>• Dysrhythmias</li> <li>• Hypertensive crisis</li> <li>• Posterior reversible encephalopathy syndrome</li> <li>• Hypotension</li> <li>• Myocardial infarction</li> </ul>	Renal/genetic/metabolic	<ul style="list-style-type: none"> <li>• Electrolyte abnormalities</li> <li>• Dehydration</li> <li>• Uremia</li> <li>• Inborn errors of metabolism</li> </ul>
		Hematologic/oncologic	<ul style="list-style-type: none"> <li>• Space-occupying lesion</li> <li>• Hyperleukocytosis</li> <li>• Severe anemia</li> </ul>
		Infectious	<ul style="list-style-type: none"> <li>• Meningitis</li> <li>• Encephalitis</li> <li>• Intracranial abscess</li> <li>• Tick-borne diseases</li> <li>• Sepsis</li> </ul>
		Special cases/environmental	<ul style="list-style-type: none"> <li>• Shock (hypovolemic, cardiogenic, distributive, obstructive)</li> <li>• Hyperthermia</li> <li>• Hypothermia</li> <li>• Porphyria</li> <li>• Noninfectious encephalitis</li> <li>• Psychiatric</li> <li>• Thiamine deficiency/Wernicke encephalopathy</li> </ul>

focal lesions within the ARAS, or in areas affecting the ARAS, and, in turn, can affect a person's state of consciousness.<sup>2,8</sup> Additionally, there can be a diffuse dysfunction of the cerebral hemispheres (eg, cerebral edema secondary to diabetic ketoacidosis [DKA]) affecting the ARAS, a focal deficit of the ARAS (eg, stroke), or global abnormalities in the central nervous system (CNS) (eg, encephalitis or meningitis).

## Differential Diagnosis

The etiology of ALOC can be determined by assessing the presenting signs and symptoms within the history gathered, along with a complete and comprehensive physical examination. (See Table 2, page 3.) Emergency clinicians must think quickly and develop a broad differential diagnosis for ALOC to search for reversible or readily treatable causes.

## Toxicologic Etiologies

Toxic exposure or suspected ingestion should be in the emergency clinician's differential diagnosis for patients who present with ALOC of unknown etiology. Toxicologic ALOC may occur either as a direct neurologic effect of the poisoning itself or secondary to other pathological processes (eg, hypoglycemia from ingestion of beta blockers or hyperammonemia as a result of liver failure from acetaminophen toxicity). The 2012 annual report of the American Association of Poison Control Centers' National Poison Database System demonstrated that, overall, carbon monoxide and opioids were responsible for the largest proportion of fatal toxin exposures.<sup>9</sup> More recently, in the 2014 Annual Report of the American Association of Poison Control Centers' National Poison Database System, the 5 substance categories identified to be most frequently involved in the deaths of children aged  $\leq 5$  years included fumes/gases/vapors, analgesics, cleaning substances (household), alcohols, and antihistamines.<sup>10</sup>

Carbon monoxide is a common cause of potentially fatal toxic exposure in both children and adults. At room temperature, carbon monoxide is an odorless, colorless, and tasteless gas that usually remains undetected until injury or death occurs.<sup>11</sup> Sources of carbon monoxide poisoning include smoke from fires of burning charcoal briquettes or wood, as well as from fumes of motor vehicles, portable generators, stoves, gas ranges, and lanterns.<sup>12</sup> Presenting symptoms of carbon monoxide poisoning include dizziness, nausea, vomiting, headache, fatigue, syncope, and confusion.<sup>11</sup> Concomitant illness in family members (and pets) should increase suspicion. For a more in-depth review of this topic, see the September 2016 issue of *Pediatric Emergency Medicine Practice* titled "Carbon Monoxide Poisoning In Children: Diagnosis And Management In The Emergency Department," available at:

[www.ebmedicine.net/COpoisoning2016](http://www.ebmedicine.net/COpoisoning2016).

Opioids are another cause of potentially lethal pediatric poisonings. In a review of 9179 children who were exposed to a prescription opioid, nearly all exposures involved ingestion (99%) and occurred in the home (92%).<sup>13</sup> Eight deaths were noted involving hydrocodone, methadone, or oxycodone, and, of these, presentations to the ED included unresponsiveness and respiratory arrest.<sup>13</sup>

Ethanol toxicity can occur in the pediatric population, and, similar to adults, children and adolescents can present with abnormal gait or speech, somnolence, disorientation, or coma.<sup>14</sup> Emesis and hypothermia can also occur. Laboratory findings can reflect a picture of mild hypokalemia and mild acidosis of mixed respiratory and metabolic etiologies. In small children, there is also an increased risk of hypoglycemia.<sup>15</sup> In addition to alcoholic beverages, children can be exposed to ethanol through common household products such as mouthwash and hand sanitizer.<sup>16</sup> Less commonly, toxic ingestions of other alcohols such as methanol<sup>17</sup> and isopropanol<sup>18</sup> can cause ALOC.

Physical signs or symptoms of toxic exposure may not become apparent immediately or soon after a poison is ingested. Toxins associated with delayed presentation of symptoms include sustained-release or enteric-coated preparations, as well as specific medications such as atropine/diphenoxylate (Lomotil®), carbamazepine, or thyroid hormones.<sup>19</sup> Concurrent ingestion of 2 or more medications can affect the rate of metabolism of 1 or more of the drugs due to potential effects on the cytochrome P450 enzymes that are involved in drug metabolism.

There are other potential complications of co-ingestions. Serotonin syndrome can occur with combinations such as monoamine oxidase inhibitors with dextromethorphan, meperidine, or selective serotonin reuptake inhibitors.<sup>20</sup>

Neuroleptic malignant syndrome (NMS) is on the differential diagnosis of ALOC if there is any suspicion that the patient had access to atypical antipsychotic medications. Changes in mental status can be an early sign.<sup>21</sup> Diagnostic features include patients with exposure to a dopamine antagonist within 72 hours prior to symptoms, elevated temperature, associated profuse diaphoresis, and generalized rigidity.<sup>21</sup> Although NMS is very rare in the pediatric population, symptoms are consistent with those described for adults.<sup>22-24</sup> A literature review of case reports by Neuhut et al reviewed 23 episodes of NMS in 20 subjects with ages ranging from 11 to 18 years. Altered mental status was noted in 61% of the cases. Other findings included an increased creatine phosphokinase level (100% of cases), fever (78% of cases), tachycardia (74% of cases), and rigidity (70% of cases).<sup>24</sup>

Methemoglobinemia occurs when there is oxidation of ferrous iron ( $\text{Fe}^{2+}$ ) to ferric iron ( $\text{Fe}^{3+}$ ).

This disrupts the ability of the hemoglobin molecule to carry oxygen, which, in turn, can cause tissue hypoxemia. Methemoglobinemia can be the result of exposure to oxidizing agents found in certain medications or foods, or due to genetic causes. Ingestion of or skin exposure to an oxidizing agent is the most common cause of methemoglobinemia. Common triggers include medications such as benzocaine, dapsone, and phenazopyridine (Azo-Gesic<sup>®</sup>, Pyridium<sup>®</sup>, Uristat<sup>®</sup>, et al). Foods or well water can also contain high levels of nitrites or nitrates that serve as oxidizing agents. Clinical presentation can vary, depending on the methemoglobin level and whether anemia is concurrently present. Cyanosis can present at methemoglobin concentrations of 1.5 to 3 g/dL (10%-20% of total hemoglobin). Patients with methemoglobinemia may present with ALOC at methemoglobin concentrations of 4.5 to 7.5 g/dL (30%-50% of total hemoglobin), with symptoms such as fatigue, dizziness, or confusion. Coma and seizures can occur at methemoglobin levels of 7.5 to 10.5 g/dL (50%-70% of total hemoglobin).<sup>25</sup>

Consumption or usage of illicit substances can have varying effects in the pediatric population.<sup>26</sup> Many times, patients may present with a toxidrome (a group of physical and laboratory findings that characteristically occur from a type of toxic ingestion), especially when illicit substances are involved.<sup>27</sup> (See Table 3.) This constellation of signs and symptoms may provide clinical clues to the underlying etiology of the ALOC.

## Traumatic Etiologies

ALOC can be the result of direct trauma to the head. Falls and motor vehicle crashes are the most common causes of blunt head trauma in pediatric patients seen in EDs across the United States.<sup>28,29</sup> More than 600,000 ED visits per year are for pediatric head injuries.<sup>30</sup> Patients with closed head injuries may present with variable symptoms. In a retrospective cohort review of all visits to a pediatric hospital ED for closed head injuries from 1999 to 2001 (n = 827), of the 285 patients who were admitted to the observation unit, 26% presented with loss of consciousness, 19% experienced amnesia to the event, 5% had persistent amnesia, and 4% had seizures. In addition, 45% were noted to have altered mental status on physical examination.<sup>31</sup>

In general, trauma to the brain can have a variety of physical sequelae such as intracranial hemorrhage, diffuse cerebral edema, concussion, or diffuse axonal injury. Intracranial hemorrhage can present in different ways. Small epidural hematomas may be asymptomatic initially, but as the hematoma expands and causes mass effect, patients may develop ALOC, along with other signs of increased cranial pressure. Small subdural hematomas may also present without symptoms. Larger subdural hematomas may present with ALOC. Other associated neurological symptoms include headache, vomiting, irritability, visual changes, ataxia, lethargy, or seizures.<sup>32</sup>

In cases of head trauma with an unusual mechanism of injury reported, nonaccidental trauma should

**Table 3. Toxidromes Resulting In Altered Levels Of Consciousness<sup>27</sup>**

Toxidrome	Signs and Symptoms	Specific Agents
Sympathomimetic	<ul style="list-style-type: none"> <li>• Fever</li> <li>• Increased heart rate, blood pressure, respiratory rate</li> <li>• Mydriasis</li> <li>• Diaphoresis</li> </ul>	<ul style="list-style-type: none"> <li>• Stimulants: cocaine, methamphetamine</li> <li>• Club drugs: ecstasy/MDMA</li> <li>• Dissociative drugs: PCP</li> <li>• Hallucinogens: LSD</li> </ul>
Anticholinergic	<ul style="list-style-type: none"> <li>• Fever</li> <li>• Increased heart rate</li> <li>• Mydriasis</li> <li>• Dry mucous membranes</li> <li>• Urinary retention</li> <li>• Anhidrosis</li> </ul>	<ul style="list-style-type: none"> <li>• Jimson Weed (<i>Datura stramonium</i>)</li> <li>• Diphenhydramine</li> <li>• Scopolamine</li> <li>• Tricyclic antidepressants</li> <li>• Atropine</li> </ul>
Cholinergic	"SLUDGE-M": <ul style="list-style-type: none"> <li>• Salivation</li> <li>• Lacrimation</li> <li>• Urination</li> <li>• Diaphoresis</li> <li>• Gastrointestinal symptoms (eg, diarrhea and emesis)</li> <li>• Miosis</li> </ul>	<ul style="list-style-type: none"> <li>• Toxic mushrooms (<i>Amanita</i>)</li> <li>• Insecticides: carbamates, organophosphates</li> </ul>
Opioid	<ul style="list-style-type: none"> <li>• Miosis</li> <li>• Respiratory depression</li> <li>• Decreased heart rate</li> </ul>	<ul style="list-style-type: none"> <li>• Prescription opioids: morphine, codeine, oxycodone, hydrocodone, fentanyl</li> <li>• Heroin, opium</li> </ul>
Sedative-hypnotic	<ul style="list-style-type: none"> <li>• Confusion</li> <li>• Delirium</li> </ul>	<ul style="list-style-type: none"> <li>• Barbiturates</li> <li>• Benzodiazepines</li> </ul>

Abbreviations: LSD, lysergic acid diethylamide; MDMA, 3,4-methylenedioxymethamphetamine; PCP, phencyclidine.

be included in the differential diagnosis. Abusive head trauma can present with nonspecific neurological signs and symptoms such as ALOC, irritability, seizures, and apnea.<sup>33</sup> In such cases, look for other signs and symptoms that may increase suspicion for nonaccidental trauma as the etiology of ALOC, such as retinal hemorrhages, unusual bruises (particularly to the back, abdomen, periorbital region, hands, and forearms), or suspicious fractures.<sup>34</sup>

## Neurologic Etiologies

### Seizures

Include seizures of all types in the differential diagnosis for ALOC. ALOC may occur either during or after a seizure, and it may be the patient's first seizure, a febrile seizure, or due to epilepsy. In cases of nonconvulsive seizures, there may be an absence of associated rhythmic, nonsuppressible movements<sup>35,36</sup> that may keep the clinician from initially considering seizure in the differential diagnosis of a patient with ALOC. History obtained from bystanders or witnesses, particularly regarding preceding events, can be very helpful in such instances. Seizures can cause various alterations in consciousness, including hallucinations, illusions, aphasia, apraxia, amnesia, decreased or absent responsiveness to external stimuli, and loss of postural tone.<sup>37</sup>

### Encephalopathy

*Encephalopathy* is a nonspecific term used to describe any diffuse process that changes the structure or function of the brain. There are many different causes of encephalopathy, including CNS infections, metabolic causes, mitochondrial disorders, toxic exposure, hypoxemia, ischemia, or nutritional deficiencies. Encephalopathies can be static (such as in hypoxic ischemic encephalopathy) or reversible (such as in posterior reversible encephalopathy syndrome [PRES]). Migraine variants can cause patients to present with ALOC. According to the 2013 International Classification of Headache Disorders, a decreased level of consciousness can be a type of brainstem symptom associated with migraines with brainstem aura, previously known as basilar-type migraines.<sup>38</sup>

### Ruptured Aneurysm Or Arteriovenous Malformation

Alterations in consciousness of an abrupt, sudden nature without a traceable mechanism of injury can be an ominous sign that the patient had a pre-existing brain aneurysm or arteriovenous malformation with subsequent rupture. In the pediatric population, CNS arteriovenous malformations present with hemorrhage in 75% to 87.5% of cases, which account for 30% to 50% of intracranial hemorrhages in this age group.<sup>39,40</sup> In such cases, there is already injury to the brain parenchyma, and the severity of the hemorrhage becomes one of the more important factors affecting clinical outcome for patients.<sup>39</sup>

### Stroke

ALOC can occur from stroke, even in the pediatric population. The incidence of childhood stroke ranges from 1.3 to 13 per 100,000 children,<sup>41,42</sup> with a report of childhood ischemic arterial stroke occurring at an incidence as high as approximately 8 in 100,000 children.<sup>43</sup> Causes such as metabolic disorders, Moyamoya disease, hematologic abnormalities, and infection are more common in the pediatric population than in adults. Emboli from atheromatous cervical spine vessels are rare in children but may occur in patients with familial hyperlipidemia.<sup>43</sup> Intracranial venous thrombosis can occur in the superficial venous system, deep venous structures, and the dural venous sinuses. Patients with this condition may present with irritability, headache, seizure, encephalopathy, papilledema, cranial nerve palsies, motor weakness, and ALOC, including coma. The location of the thrombus and whether or not it is partial or complete, or acute or chronic, are the variable factors that can influence clinical presentation. Although patients can present with a variety of signs and symptoms, seizures are the most common presentation of cerebral sinovenous thrombosis. However, the incidence of intracranial venous thrombosis is very low, at  $\leq 1$  per 100,000 individuals between term birth and 18 years of age.<sup>44</sup>

### Cerebrospinal Fluid Shunt Malfunction

In special populations of patients with a cerebrospinal fluid (CSF) shunt (such as a ventriculoperitoneal shunt), malfunction may be a cause of ALOC. CSF shunts are used to treat patients with increased intracranial pressure secondary to hydrocephalus. Mechanical shunt malfunction is reported to occur at a rate ranging from 8% to 64%.<sup>45</sup> In a large multicenter, prospective cohort study from the Hydrocephalus Clinical Research Network, risk factors for initial CSF shunt failure include patient age  $< 6$  months at the time of first shunt placement, the use of an endoscope at the time of initial CSF shunt placement, and a cardiac comorbidity.<sup>46</sup> Patients who have revised shunts may also have a greater risk of shunt failure.<sup>47</sup> Presenting symptoms of CSF shunt malfunction can include lethargy or irritability as well as swelling at the shunt site. Other associated symptoms are headache, fever, and vomiting.<sup>48</sup> Due to the high morbidity and mortality associated with CSF shunt malfunction, early imaging and neurosurgery consultation is recommended. For more information on management of ventriculoperitoneal shunt complications, see the February 2016 issue of *Pediatric Emergency Medicine Practice* titled "Ventriculoperitoneal Shunt Complications In Children: An Evidence-Based Approach To Emergency Department Management," available at [www.ebmedicine.net/VPShunt](http://www.ebmedicine.net/VPShunt).

### Central Nervous System Vasculitis

CNS vasculitis can be a primary process, or it can be associated with systemic diseases such as systemic lupus erythematosus. Neurologic symptoms can be the first presenting features of a rheumatologic process. There are 3 subtypes of primary pediatric CNS vasculitis: (1) angiographic positive nonprogressive disease, (2) angiographic positive progressive disease, and (3) angiographic negative disease. With angiographic positive nonprogressive disease, vessel involvement is usually unilateral and involves only 1 vascular bed. Patients with this subtype are less likely to present with ALOC compared to the other subtypes. More common presentations include sensory changes or hemiparesis. With angiographic positive progressive disease, vessel involvement is bilateral, frequently with involvement of multiple vascular beds. These patients may present with ALOC, headaches, and seizures, in addition to sensory changes and hemiparesis. In cases of angiographic negative disease, although angiography is negative for abnormalities concerning for vessel involvement, magnetic resonance imaging (MRI) may demonstrate abnormalities reflective of signs of inflammation. Although the definitive diagnosis of small-vessel inflammation is made with a brain biopsy, diagnosis is typically suspected based on MRI findings and the patient's overall clinical picture. More severe encephalopathy, headaches, behavior changes, and cognitive decline may be seen.<sup>49</sup>

Secondary CNS vasculitis can also occur and is associated with systemic infections, rheumatologic disease, malignancies, or other inflammatory processes. Common infectious causes include varicella zoster virus, Epstein-Barr virus, parvovirus B19, human immunodeficiency virus, *Mycoplasma pneumoniae*, and *Mycobacterium tuberculosis*. Systemic rheumatologic diseases such as systemic lupus erythematosus, Behçet disease, systemic vasculitis, and juvenile dermatomyositis can also have CNS involvement in the form of CNS vasculitis. Other inflammatory processes such as hemophagocytic lymphohistiocytosis, inflammatory bowel diseases, or periodic fever syndromes can also present with CNS vasculitis.<sup>50</sup>

### Infectious Causes

Postinfectious disorders such as acute disseminated encephalomyelitis can cause changes in mental status. Acute disseminated encephalomyelitis is a monophasic, immune-mediated, inflammatory, demyelinating disorder involving the CNS. Diagnostic criteria include encephalopathy as well as multifocal CNS involvement. Typically, acute disseminated encephalomyelitis can occur from 2 days to 4 weeks following a viral infection. Presenting signs and symptoms depend on the location of the demyelinating process as well as the severity. Pyramidal signs, hemiplegia, ataxia, cranial nerve palsies, changes in

vision, seizures, spinal cord involvement, abnormal speech, hemiparesis, and ALOC ranging from lethargy to coma can occur.<sup>51</sup>

### Cardiac Etiologies

#### Syncope

Syncope is a commonly encountered clinical problem in the ED that, although commonly brief, has usually resolved prior to the time of presentation.<sup>52</sup> In the United States, 0.9% of all pediatric ED visits for patients aged 7 to 18 years are associated with a chief complaint of syncope.<sup>53</sup> Although the cause of syncope in the majority of pediatric patients is benign, with the most common cause being neurally mediated syncope, there are life-threatening cardiac causes that must be recognized. These include dysrhythmias such as long QT syndrome, atrioventricular block, Brugada syndrome, or catecholaminergic polymorphic ventricular tachycardia, as well as undiagnosed structural defects such as cardiomyopathy, anomalous coronary arteries, or valve defects.<sup>52</sup>

#### Posterior Reversible Encephalopathy Syndrome

ALOC and coma can be associated with hypertensive crisis as a sign of end-organ damage.<sup>54,55</sup> In recent years, a constellation of clinical and radiologic findings have been described, leading to recognition of PRES. An acute elevation in blood pressure is a common precipitant of PRES.<sup>56</sup> Patients with PRES present with neurological findings such as ALOC, visual disturbances, headache, and seizures. Transient changes are notable on MRI with diffusion-weighted imaging, including signs of edema, such as hyperintense signals in the cerebral white matter, especially involving structures in the posterior regions of the cerebral hemispheres.<sup>56,57</sup> First described by Hinchey et al in 1996,<sup>58</sup> PRES has been reported in the pediatric literature to be associated with various underlying chronic medical conditions including hematologic diseases such as leukemia and sickle cell disease, autoimmune conditions such as Crohn disease and systemic lupus erythematosus, as well as renal diseases including nephrotic syndrome and poststreptococcal glomerulonephritis.<sup>56,57</sup> Although the causes of PRES are varied, some of the more common triggers include hypertension, fluid retention, renal failure, and the use of immunosuppressive regimens with cytotoxic medications.<sup>56,57</sup>

#### Pericardial Tamponade

There are case reports of pericardial tamponade in pediatric patients with ALOC. Common characteristics in these cases include syncope and ALOC, and vital sign abnormalities including tachycardia and tachypnea, as well as muffled heart sounds, distended neck veins, and fluid resuscitation-refractory hypotension.<sup>59</sup> Pericardial tamponade can occur from both traumatic

and nontraumatic mechanisms. Traumatic causes of pericardial tamponade include blunt and penetrating chest trauma or complications from medical procedures such as cardiac catheterization or central venous catheter placement. Nontraumatic causes of pericardial tamponade include infection, malignancy, uremia, significant injury after an acute myocardial infarction, and postpericardiectomy syndrome.<sup>59</sup>

### **Other Cardiac Etiologies**

Other cardiac causes of ALOC may involve decreased cardiac output progressing into cardiogenic shock, ultimately leading to decreased cerebral perfusion pressure, thereby causing alterations in consciousness. This includes myocardial infarction from such predisposing etiologies as anomalous origin of the left coronary artery from the pulmonary artery, Kawasaki disease, or congenital heart defects.<sup>60</sup>

### **Pulmonary Etiologies**

Any mechanism that decreases oxygen delivery to the brain, whether it is decreased perfusion to the brain or decreased oxygen content in the blood delivered to the brain, can result in ALOC. This includes causes related to hypoxia, hypoxemia, or hypercarbia. Hypoventilation can also lead to neurological changes secondary to hypercarbia.<sup>61</sup> Conversely, hyperventilation can also cause ALOC. For example, acute hyperventilation from anxiety can lead to an acute reduction in the partial pressure of arterial carbon dioxide. This leads to symptoms such as lightheadedness, confusion, syncope, hallucinations, and seizures.<sup>62</sup> Different mechanisms are responsible for different clinical scenarios. Patients with cystic fibrosis may have neurological complications resulting from chronic hypoxia and hypercarbia that include lethargy, somnolence, and coma.<sup>63</sup> In patients with submersion injuries, the extent of neurological injury from hypoxia and ischemia is a large factor in survival.<sup>64</sup> Alteration in consciousness can also be a late finding of hypercarbia in patients with respiratory failure secondary to common illnesses such as croup, bronchiolitis, or asthma.

### **Endocrinologic Etiologies**

Glucose metabolism disorders, including hypoglycemia, DKA, and hyperglycemic hyperosmolar state (HHS) may result in ALOC.

#### **Hypoglycemia**

In hypoglycemia, patients can present with autonomic changes, including diaphoresis, tremors, weakness, or pallor along with signs of ALOC such as confusion, disorientation, lack of coordination, seizures, or coma. Emesis can be a presenting symptom. Hypothermia may result from hypoglycemia, as well. Often, these findings occur at serum glucose levels < 55 mg/dL.<sup>65,66</sup> Hypoglycemia can be the

result of ingested drugs, including diabetes mellitus medications, class Ia antiarrhythmic medications, beta blockers, pentamidine, antidepressants, and angiotensin-converting enzyme inhibitors. Other rarer etiologies for hypoglycemia include tumors such as insulinoma and rhabdomyosarcoma, as well as other extrapancreatic tumors of mesenchymal origin.<sup>65,67</sup> Hypoglycemia can also be a clinical clue to other processes involved in the patient's ALOC, such as sepsis and adrenal insufficiency.<sup>67</sup> Infants with malnutrition likely have minimal glycogen reserve and, during increased glucose use, can have difficulty maintaining euglycemia.<sup>67</sup>

#### **Diabetic Ketoacidosis**

DKA is defined by a profound insulin-deficient state characterized by a triad of hyperglycemia, accumulation of ketoacids, and acidosis. Clinical presentation can include nausea, vomiting, abdominal pain, Kussmaul breathing, and ALOC. For the emergency clinician, it is important to treat the associated clinical complications of DKA, including dehydration, electrolyte derangements, and hyperosmolarity. DKA remains the most common cause of death in children who have type 1 diabetes mellitus.<sup>68</sup> DKA is also commonly the initial presentation of type 1 diabetes mellitus in pediatric patients. In a retrospective chart review, Neu et al looked at 2121 children aged < 15 years with a new diagnosis of type 1 diabetes mellitus. The initial presentation was DKA in 26% of patients, with a mean age of 7.9 years. Of all patients who presented with DKA, 23.3% presented with an ALOC and 10.9% of these had clinical signs of coma.<sup>69</sup> For patients with DKA who present with ALOC, cerebral edema should be considered and judiciously managed. Symptomatic cerebral edema occurs in approximately 1% of episodes of DKA in children and has a mortality rate of 40% to 90%.<sup>70</sup> Thus, the patient with ALOC in the setting of DKA is critically ill and in need of emergent interventions.

#### **Hyperglycemic Hyperosmolar State**

Although HHS is rare in children, with the growing prevalence of childhood obesity, there is an increase in reports of this condition in the literature. The clinical presentation of HHS may be similar to DKA. Vomiting and abdominal pain can occur in addition to neurologic symptoms such as weakness, confusion, lethargy, dizziness, and changes in behavior. However, the diagnostic features and management of patients with HHS differ slightly. Diagnostic features of HHS include serum glucose levels > 600 mg/dL (33 mmol/L) and serum osmolality > 330 mOsm/kg. In HHS, there is an absence of significant acidosis and ketosis, with serum bicarbonate levels > 15 mEq/L, and urine ketone concentration < 15 mg/dL (1.5 mmol/L).<sup>71</sup>



## Hashimoto Encephalopathy

Hashimoto encephalopathy is a much more rare endocrine etiology for ALOC, but it has been reported to have occurred in children and adolescents. Hashimoto encephalopathy is a steroid-responsive encephalopathy associated with autoimmune thyroiditis. Presenting symptoms can include ALOC, behavioral changes, or neuropsychiatric features including hallucinations and psychosis. Patients with Hashimoto encephalopathy can also have seizures, focal neurological findings, and dystonia.<sup>72-74</sup> Laboratory studies usually reflect an elevated level of antithyroid peroxidase antibodies, although patients with Hashimoto encephalopathy can, at the time of presentation, be in a hypothyroid, euthyroid, or hyperthyroid state in terms of thyroid status.<sup>72</sup>

## Gastroenterological Etiologies

Although lethargy is not part of the classic triad of intussusception (abdominal pain, palpable sausage-shaped mass, and “currant jelly” stool), lethargy or altered consciousness can be a late finding of intussusception, and even a clinical predictor.<sup>75</sup> The more typical presentation of intussusception includes sudden onset of severe, intermittent abdominal pain with intervals of time without pain. Patients may present with flexion of the lower extremities and crying. With worsening intestinal ischemia, the patient may become lethargic and progress to shock. However, there are case reports of patients with intussusception presenting with only lethargy.<sup>76,77</sup>

In addition to intussusception, in intra-abdominal conditions with compromised intestinal blood flow, there are cases in which neurological symptoms may be the first signs of the disease process unfolding before gastrointestinal symptoms are apparent.<sup>76,78</sup> Pumberger et al reviewed medical charts spanning a period of 10 years and observed 13 infants who were found to have basic intra-abdominal diseases whose initial sign of illness was an impaired neurological condition.<sup>78</sup> Shaoul et al described 2 cases of children who presented with encephalopathy as the initial clinical manifestation of an acute abdomen.<sup>76</sup>

## Renal, Genetic, And Metabolic Etiologies

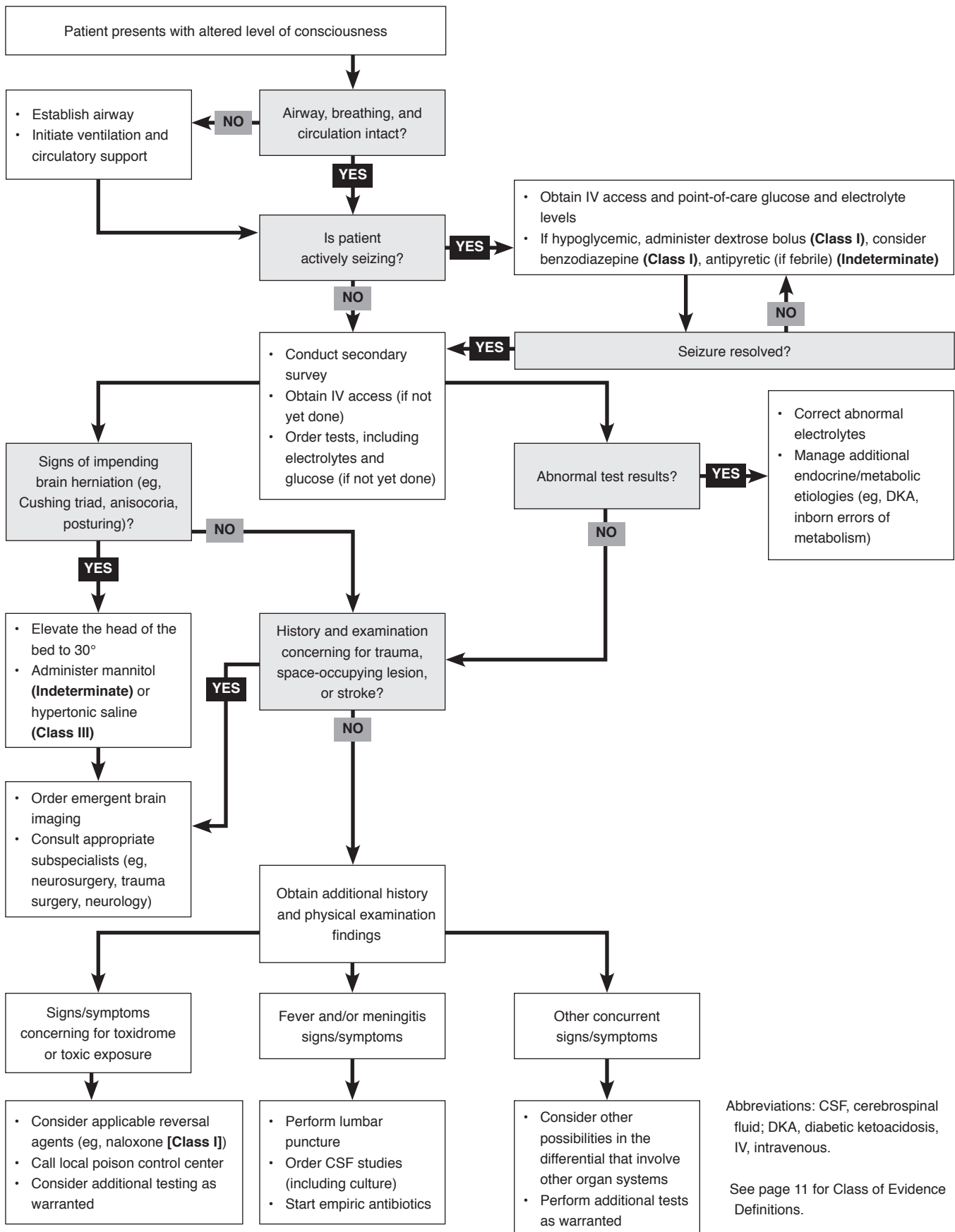
Electrolyte abnormalities from dehydration, toxicity, or other causes can lead to ALOC. Hyponatremia can pose complications due to the movement of water out of cells in the brain as plasma osmolality rises, especially if this occurs acutely and rapidly. Signs can include weakness, lethargy, and irritability, as well as seizures and coma.<sup>32</sup> Hyponatremia can also cause ALOC and is particularly associated with seizures. In infants, hypothermia and breathing difficulty can occur with hyponatremia as well.<sup>79</sup> Hypermagnesemia can cause drowsiness or confusion in addition to other symptoms such as weakness,

paralysis, and ataxia. Hypermagnesemia can be associated with hypotension, with extremely elevated levels potentially causing cardiac dysrhythmias, hypoventilation, and cardiorespiratory arrest.<sup>80</sup> Described in the adult literature, lactic acidosis can lead to ALOC, with a spectrum of neurologic manifestations such as altered mental status, dysarthria, ataxia, abnormal gait, disorientation, and irritability.<sup>81</sup> Dehydration itself can cause ALOC. With moderate dehydration (6%-9%), patients can be irritable with normal-to-low blood pressure, whereas with severe dehydration ( $\geq 10\%$ ), patients may appear lethargic with associated hypotension.<sup>82</sup>

Accumulation of metabolites in the body can cause ALOC. Uremic encephalopathy can occur with renal failure, although there is a lack of correlation with blood concentrations of blood urea nitrogen alone. Clinical features can include lethargy, confusion, hallucinations, irritability, seizures, and coma. Uremic encephalopathy can occur in a matter of several days in cases of acute renal failure, with asterixis being a common initial sign.<sup>63</sup> Hemolytic uremic syndrome can cause acute renal failure, where patients present with neurological symptoms. Hemolytic uremic syndrome includes a triad of hemolytic anemia, thrombocytopenia, and acute kidney injury that is most commonly caused by Shiga toxin-producing organisms such as serotype *Escherichia coli* O157:H7. Presentations of CNS involvement include stupor, coma, visual disturbances, hallucinations, focal neurological findings, seizures, and cognitive changes.<sup>83,84</sup> Similarly, hepatic encephalopathy can occur with liver failure. The liver is responsible for metabolism of ammonia and, in cases of liver failure, ammonia can accumulate to toxic levels. Hepatic encephalopathy due to acute liver failure can be classified based on clinical findings as adapted for young children from birth to 3 years of age: Early (grades I and II): inconsolable crying, change in sleep rhythm, inattention to task; Mid (grade III): somnolence, stupor, combativeness; Late (grades IVa and IVb): comatose but arouses with painful stimuli (IVa) or no response (IVb).<sup>85</sup>

Inborn errors of metabolism are a group of various genetic disorders of metabolic or enzymatic pathways that lead to varying consequences, such as deficiency of an important end product or accumulation of a toxic substrate such as ammonia. These inborn errors of metabolism may present in any age group, including in adulthood. Often, symptoms are nonspecific and may include ALOC upon initial presentation.<sup>86</sup> In young infants, poor feeding and lethargy can be a common presentation. In older patients, lack of improvement with standard therapy can be an important red flag to signal consideration of a metabolic disorder as the etiology for a patient's ALOC.<sup>87</sup> Associated signs and symptoms can include neurological findings such as developmental

# Clinical Pathway For Managing The Patient With Altered Level Of Consciousness In The Emergency Department<sup>151</sup>



Abbreviations: CSF, cerebrospinal fluid; DKA, diabetic ketoacidosis, IV, intravenous.

See page 11 for Class of Evidence Definitions.

delay, hypotonia, seizures, stroke, ataxia, hearing loss, or visual impairment; cardiac findings such as cardiomyopathy or myopathy; and hematologic abnormalities such as pancytopenia. Other associated findings can include failure to thrive, recurrent bouts of lethargy, vomiting, dehydration, liver dysfunction, hypoglycemia, or recurrent ketoacidosis.<sup>86,88</sup> In both liver failure and certain inborn errors of metabolism, hyperammonemia is the cause of ALOC. Ammonia is a byproduct of protein metabolism completed by colonic microflora that convert amino acids and urea into ammonia. The ammonia is then taken up by the liver through the portal circulation and converted via the urea cycle into urea. In normal physiology, urea production is far greater than the rate of free ammonia production. However, in the setting of urea cycle dysfunction or extensive liver damage, hyperammonemia may occur.<sup>89</sup> Clinical signs of hyperammonemia occur at ammonia concentrations > 60 mcg/dL. Alterations to the CNS caused by elevated blood ammonia concentrations seem reversible when levels remain below 200 to 400 mcg/dL. However, irreversible impairment may result when levels exceed 400 mcg/dL.<sup>89</sup>

### Hematologic/Oncologic Etiologies

ALOC can be the presenting symptom of a brain tumor or other space-occupying lesion. Lanphear et al performed a retrospective chart review of 87 pediatric patients who were initially diagnosed in the ED with a CNS tumor. The most frequent symptom was headache (66.7%), but seizures (17.25%) and altered mental status (16.1%) were common.<sup>90</sup> Depending on the location of the tumor, patients may present with signs such as abnormal gait or coordination, papilledema, abnormal eye movements/cranial nerve palsies, squinting, or focal neurological findings.<sup>91</sup> Pediatric oncology patients are also prone to acute neurologic changes due to the high incidence of toxic and metabolic disturbances in addition to their underlying pathology. In pediatric oncology patients, cases of delirium have been identified that

have been attributed to likely medication toxicity and multiorgan failure.<sup>92</sup> In a unique study of neurologic consultations for pediatric patients with cancer and ALOC, the majority of these children were found to be suffering from induced encephalopathy from iatrogenic causes. Medications including opioids, glucocorticoids, benzodiazepines, antiemetics, antihistamines, antiepileptic drugs, and chemotherapy drugs were the most frequent etiology for depressed sensorium in this cohort. The most common cause of ALOC in this study was opioid related.<sup>93</sup>

Hyperleukocytosis secondary to a leukemic process such as acute lymphoblastic leukemia or acute myeloid leukemia can cause CNS effects. Hyperleukocytosis can increase the viscosity of the blood and cause stasis of blood flow within the microcirculation, in turn causing tissue and vascular damage along with hemorrhage. Complications of this process are most notably observed at the time of diagnostic presentation and with patients who had white blood cell (WBC) counts > 4 cells/mcL.<sup>94</sup> Neurological complications of leukostasis include CNS hemorrhage, changes in vision, ALOC, cranial nerve palsy, seizure, and syncope.<sup>94</sup>

Anemia occurs when there is a reduced amount of hemoglobin or red blood cell volume, and, therefore, reduced capacity for oxygen transport to organs such as the brain. Neurological manifestations of severe anemia can include sleepiness and irritability. Other associated findings include pallor and exercise intolerance. With severe anemia, weakness in addition to tachypnea, shortness of breath, tachycardia, and signs of high-output heart failure can occur.<sup>95</sup> Other hematologic abnormalities that can lead to ALOC include severe thrombocytopenia leading to intracranial hemorrhage. Idiopathic thrombocytopenic purpura is one of the most common platelet disorders in children. Intracranial bleeding can occur in patients with platelet counts < 20,000/mL, with an associated traumatic mechanism or additional platelet dysfunction. Serious bleeding in idiopathic

## Class Of Evidence Definitions

Each action in the clinical pathways section of *Pediatric Emergency Medicine Practice* receives a score based on the following definitions.

### Class I

- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

#### Level of Evidence:

- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

### Class II

- Safe, acceptable
- Probably useful

#### Level of Evidence:

- Generally higher levels of evidence
- Nonrandomized or retrospective studies: historic, cohort, or case control studies
- Less robust randomized controlled trials
- Results consistently positive

### Class III

- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

#### Level of Evidence:

- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

### Indeterminate

- Continuing area of research
- No recommendations until further research

#### Level of Evidence:

- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

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thrombocytopenic purpura is rare, but an important consideration for the patient presenting with acute ALOC with signs of ecchymosis or petechiae.

Patients with sickle cell disease are known to have silent strokes leading to neurocognitive deficits over a prolonged period of time. However, a patient with sickle cell disease can also present to the ED with an acute stroke. Risk for an acute stroke is up to 10% in the first 20 years of life and has a peak incidence in children aged between 4 and 8 years. Patients with sickle cell disease are more likely to have ischemic strokes, although hemorrhagic strokes can occur.<sup>96</sup> Unlike adults with sickle cell disease, the biggest risk factor for stroke in children is hypertension.<sup>97</sup> In the acute setting, symptoms can include aphasia, hemiparesis, facial droop, stupor, or seizure. Of note, the clinician examining the patient should clarify the cause of a sickle cell disease patient's isolated weakness. For example, it is crucial to determine whether limb weakness is due to pain from a vaso-occlusive crisis or from motor weakness from an acute stroke, as diagnostic and treatment pathways would greatly differ.<sup>96</sup>

### Infectious Etiologies

Meningitis, encephalitis, and brain abscesses are types of CNS infections that can cause ALOC. Infectious pathogens can cause infections from hematogenous routes with breaching of the blood-brain barrier. Bacteria can cause CNS infection through direct extension from contiguous foci such as otitis media, sinusitis, or mastoiditis.<sup>98-101</sup> CNS infection can also occur with trauma, neurosurgical procedures, congenital malformations, or any disruptions in the integrity of the skull and meninges. In addition, viral pathogens can cause CNS infections through a neuronal route, as seen with viruses such as herpes simplex viruses or rabies.<sup>102</sup>

#### Meningitis

Neurological complications of meningitis include increased intracranial pressure and subdural effusions, which can present as ALOC, seizures, or focal neurologic deficits. The most common bacterial pathogens that cause meningitis differ based on age group. In the neonatal period, group B *Streptococcus* is the predominant etiology for bacterial neonatal meningitis, with other bacterial pathogens including *Listeria monocytogenes* and *E coli*. In infants and children, *Streptococcus pneumoniae* and *Neisseria meningitidis* are the more common bacterial pathogens. Viral meningitis can be caused by viral pathogens such as herpes simplex viruses and enteroviruses.<sup>103</sup>

#### Encephalitis And Encephalopathy

Encephalitis is an inflammatory disorder of the CNS resulting in clinical presentations such as ALOC, seizures, or focal neurological deficits. Encephalitis

can be caused by a variety of etiologies, both infectious and noninfectious.<sup>104</sup> Infectious etiologies can include bacterial, viral, or fungal sources. Noninfectious etiologies for encephalitis are primarily mediated by autoimmune processes; specifically, the development of autoantibodies.

Encephalopathy entails a change in a patient's neurologic state, such as ALOC, or subtle findings, such as a simple change in a patient's behavior. Other findings may not be required to describe a patient as being "encephalopathic." In contrast, *encephalitis* can be defined as encephalopathy plus 2 or more of the following: (1) history of fever, seizures and/or focal neurological findings; (2) cerebrospinal fluid pleocytosis (> 4 WBC/mcL); (3) electroencephalogram findings indicating encephalitis; or (4) neuroimaging with findings consistent with encephalitis.<sup>105</sup> However, in many cases of patients with encephalitis, finding an etiology can be difficult. In a retrospective cohort study of 190 patients with outcomes available at discharge, 128 patients (67.4%) recovered and 62 (32.6%) had incomplete recovery, including 13 deaths (6.8%). No etiology was identified for 93 (48.9%) patients. Of the confirmed infectious etiologies, enterovirus was the most common. Of known noninfectious etiologies, anti-N-methyl-D-aspartate (NMDA) receptor encephalitis was most common.<sup>106</sup>

#### Intracranial Abscess

Intracranial abscesses can be categorized based on the focal area of involvement: epidural abscesses, subdural empyemas, and brain abscesses. Common presenting signs and symptoms include headache, fever, nausea, vomiting, ALOC, focal neurological deficits, and seizures. In most cases of intracranial abscesses, treatment often involves multiple modalities, including long-term antibiotic therapy and, possibly, surgical intervention for drainage.<sup>107</sup>

#### Tick-Borne Diseases

Tick-borne diseases causing ALOC, such as Lyme disease and rickettsial diseases, pose unique challenges for diagnosis. Lyme disease is carried by the *Ixodes* tick and caused by the *Borrelia burgdorferi* spirochete. Clinical manifestations of Lyme disease include erythema migrans (rash with a "bull's-eye" appearance), arthritis, facial palsy, meningitis, or carditis. Serological testing can be completed with confirmatory immunoblotting.<sup>108</sup> Of note, Lyme meningitis presents with similar symptoms as aseptic meningitis from viral sources, but requires antibiotic treatment. In a prospective validation of a clinical prediction model created by Avery et al for Lyme meningitis in children,<sup>109</sup> Garro et al demonstrated that a longer duration of headache, presence of a cranial nerve palsy, and CSF cell count demonstrating mononuclear cell predominance were associated with Lyme meningi-

tis.<sup>110</sup> Such findings can aid in distinguishing viral meningitis from Lyme meningitis.

Rickettsial disease such as Rocky Mountain spotted fever (RMSF) can also have neurological manifestations. RMSF is a tick-borne disease caused by *Rickettsia rickettsii*, an intracellular gram-negative coccobacillus. Clinical manifestations include fever, headache, and a diffuse, blanching, pink macular-to-maculopapular rash that begins in the periphery on the forearms, wrists, and ankles, and involves the palms as well as soles. The rash then spreads centrally, often turning petechial in the process. Complications of the disease include tissue necrosis, coagulopathy, renal failure, and cerebral edema.<sup>111</sup> In a retrospective study looking at 92 children hospitalized with RMSF, 33% had altered mental status, 17% had seizures, 16% had meningismus, and 10% were comatose.<sup>112</sup> Other tick-borne diseases that can cause meningitis or meningoencephalitis include ehrlichiosis, anaplasmosis, Colorado tick fever, tick-borne relapsing fever, *Borrelia miyamotoi*, deer tick virus, and Powassan viruses.<sup>113</sup>

### Sepsis

ALOC can also be a presenting symptom in patients with sepsis. *Severe sepsis* is defined as the presence of sepsis combined with organ dysfunction.<sup>95</sup> Signs of neurologic dysfunction can include a Glasgow Coma Scale (GCS) score < 11 or an acute change in mental status, with a drop in GCS score > 3 points from abnormal baseline.<sup>95</sup> When this occurs, patients may have signs of ALOC that may include restlessness, apathy, anxiety, agitation, confusion, stupor, and coma.<sup>95</sup> Sepsis-associated encephalopathy is a syndrome defined by diffuse cerebral dysfunction that occurs with sepsis, not associated with any other type of encephalopathy, and without actual direct CNS infection or structural abnormality.<sup>114</sup> Clinical presentations of sepsis-associated encephalopathy range from mild delirium to coma. Sepsis-associated encephalopathy is primarily a diagnosis of exclusion. Described mainly in adult literature, there is a dearth of literature demonstrating the frequency of sepsis-associated encephalopathy in children.

### Environmental, Autoimmune, And Psychiatric Etiologies

ALOC can present with septic shock or with hypovolemic, cardiogenic, distributive, or obstructive shock. Due to decreased end-organ perfusion, in particular cerebral hypoperfusion, the patient may develop ALOC, where neurological findings can include irritability, agitation, confusion, hallucinations, stupor, or coma.<sup>32</sup> In addition, extremes in core temperatures can cause ALOC. Hyperthermia and exertional heat stroke can lead to CNS abnormalities such as delirium, seizures, or coma.<sup>115</sup> Hypothermia occurs when

the core body temperature cannot be maintained at its normal homeostatic range. When this occurs, brain dysfunction can occur. Neurologic signs and symptoms of hypothermia include lethargy, weakness, confusion, and loss of coordination.<sup>116</sup> Porphyrria is also a rare cause of ALOC in children.<sup>117,118</sup>

In addition to infectious causes of encephalitis, autoimmune etiologies for encephalitis can occur. In autoimmune encephalitis, antibodies against extracellular or intracellular antigens are formed and bind to receptors, thus altering receptor function, causing clinical disease. These antigens can be associated with a neoplasm or intrinsic structures such as GABA receptors, NMDA receptors, or voltage-gated potassium channels. It is thought that molecular mimicry is responsible for the binding of such antibodies to physiologic receptors. Subsequently, autoimmune encephalitis is also associated with terms such as paraneoplastic encephalitis or limbic encephalitis.<sup>119</sup> Of these, anti-NMDA receptor encephalitis has been increasingly recognized. The clinical presentation of anti-NMDA receptor encephalitis varies with seizures, movement disorders, psychiatric symptoms (such as mood imbalances or psychosis), and catatonia described in the literature.<sup>120</sup> Emergency clinicians should keep anti-NMDA receptor encephalitis in the differential diagnosis of a patient presenting to the ED with psychotic symptoms or ALOC, as cases have been reported where medical toxicologists had been consulted for patients who presented with delirium initially attributed to suspected poisoning.<sup>119</sup>

There are also psychiatric or psychogenic causes for ALOC. Psychogenic nonepileptic seizures cause ALOC or observable changes in a patient's behavior with characteristics similar to epileptic seizures but not demonstrating the electrophysiologic changes involved in epileptic seizures.<sup>121</sup> Psychogenic nonepileptic seizures, also known as pseudoseizures, can be considered a manifestation of conversion disorder. Catatonia can also include a wide range of neuropsychiatric symptoms that are types of alterations in consciousness. Considered an independent syndrome, catatonia is typically marked by a wide range of signs and symptoms that can include stupor, mutism, negativism, rigidity, excitement, echopraxia/echolalia, impulsivity, or stereotypy.

### Prehospital Care

The primary goal of prehospital care for patients with ALOC includes stabilization of the patient en route to the ED. Initial assessment should include evaluation of the ABCs (airway, breathing, and circulation). The patient's airway should be evaluated and interventions to maintain patency should be applied. In cases of ALOC, hypoxia or hypercapnea can be causes or exacerbating factors, and respirato-

ry support should be provided as needed. This may include placing the patient on supplemental oxygen or giving bag-valve mask ventilation. Endotracheal intubation should be considered to protect the airway in patients with a GCS score  $\leq 8$ .

Stabilization efforts should be in accordance with the Advanced Pediatric Life Support or Pediatric Advanced Life Support (PALS) guidelines. Intravenous access may be required in order to provide pharmacologic agents or fluids. In patients who present with clinical signs of dehydration or hypoperfusion, a normal saline bolus may be indicated. Neurologic disability can be further assessed using the GCS,<sup>122</sup> with various modified versions available for infants and young children.<sup>123,124</sup> In cases of ALOC, emergency medical services can also perform a rapid glucose test and, in cases of hypoglycemia, administer a dextrose bolus. In patients who have ALOC due to seizures, an initial dose of a benzodiazepine should be given if the patient is actively seizing. In cases of head trauma, cervical spine precautions are indicated, because a cervical spine injury may be associated with head injury.<sup>30</sup>

## Emergency Department Evaluation

### Initial Management

Upon arrival to the ED, emergency clinicians should quickly ascertain whether the patient requires further measures of stabilization such as securing of the airway or supportive ventilator measures. If endotracheal intubation is warranted, rapid sequence intubation should be considered in patients who are suspected to have aspiration risks.

### History

The history provided by accompanying caregivers, witnesses, or prehospital teams can provide critical information in creating an appropriate differential of possible diagnoses. It is imperative to obtain a thorough history to develop a well-defined differential, and also to obtain the history quickly in order to identify reversible or immediately treatable causes. The patient's age can help differentiate possible causes from less plausible diagnoses based on appropriate developmental milestones (particularly in cases in which nonaccidental trauma may be suspected). The time and acuity of onset, course and nature of symptoms, and possible environmental or toxic exposures are vital details to consider. Any history of trauma, including falls or the possibility of ingestions are also important details.

Upon review of systems, symptoms associated with ALOC can include the following: headache, fever, seizures, hallucinations, motor activity changes, changes in speech content/pattern, alterations in alertness, changes in sleep pattern, visual changes, memory loss, changes in elimination patterns,

syncopal symptoms, nausea, vomiting, and sensory changes. Past medical history should include any history of similar events, chronic medical conditions (especially neurological conditions such as a seizure disorder or psychiatric diseases), and surgical history. Medications for all members of the household are important to review. Family history should include any history of neurologic, psychiatric, endocrine, genetic, or cardiac diseases. For adolescent patients who present with ALOC, it is important to review social history, particularly for any drug or alcohol use and for any descriptions of possible suicidal tendencies or depression as well as any major stressors in the patient's life.

### Physical Examination

The physical examination should include an evaluation of vital signs, including temperature, heart rate, respiratory rate, blood pressure, and oxygen saturation.

The neurological examination should include evaluation of the patient's posture, tone, and reflexes. The prehospital team may have provided an initial GCS score, and a repeat assessment of the patient's GCS score in the ED can provide relevant information regarding clinical status and whether there are signs of improvement or deterioration. Cranial nerves II and III can be evaluated by assessing pupillary light reflexes, whereas reflex eye movements (or abnormal findings such as nystagmus or dysconjugate gaze) can provide information regarding cranial nerves III, IV, and VI. Motor weakness and slurred speech may indicate stroke or a space-occupying lesion. Any focal neurological finding should raise suspicion of a pathological process.

Signs of papilledema suggestive of increased intracranial pressure or retinal hemorrhages concerning for possible nonaccidental trauma can provide additional information regarding the etiology or the mechanism for ALOC. There should also be examination for signs of trauma, including any bony stepoff, ecchymosis, hemotympanum, septal hematoma, periorbital hematoma, and clear rhinorrhea or otorrhea.

The cardiac examination should include auscultation for unusual heart sounds, such as gallops. The respiratory examination can give clues to the neurologic status, where respiratory patterns such as Cheyne-Stokes respirations can be an ominous finding, indicating damage to the brainstem as part of Cushing triad. A careful abdominal examination may demonstrate mass effects seen in intussusception, as well as the presence of guaiac-positive stool. Rashes or skin lesions can be the dermatologic manifestation of certain infections (eg, meningococemia, mycoplasma, or herpes simplex virus). Neurocutaneous stigmata can be associated with certain genetic conditions that predispose individuals to epilepsy (eg, neurofibromatosis or tuberous sclerosis). The presence of jaundice

can indicate hepatic dysfunction as a possible cause of the patient's ALOC. Other physical examination findings may also be present based on the etiology of the patient's ALOC and other symptoms.

## Diagnostic Studies

In a patient with ALOC, laboratory and imaging diagnostic studies should be focused on finding reversible and treatable causes as quickly as possible. Since the causes of ALOC are broad, selected diagnostic studies should be performed based on the history and physical examination and likely diagnoses.

## Laboratory Studies

A point-of-care glucose level can be obtained to assess for hypoglycemia. Alternatively, obtaining a point-of-care blood gas with electrolytes (including sodium and glucose levels) can be an expedient method for assessing the patient's acid-base status and to determine whether hypoxemia, hypercarbia, or electrolyte derangements are present. A complete blood cell count with differential can demonstrate findings such as leukocytosis or thrombocytosis/thrombocytopenia suggestive of an infectious, inflammatory, or hematologic process underlying the etiology for a patient's ALOC. In addition, a comprehensive metabolic panel can reflect laboratory findings suggestive of hypoglycemia, hyponatremia, hypermagnesemia, or hypocalcemia (if seizures are present); or elevated transaminases or blood urea nitrogen if hepatic encephalopathy or uremia is the cause. A serum ammonia level can be obtained for metabolic causes. Plasma ammonia levels should be collected without using a tourniquet and without a clenched fist during collection as much as possible, since muscular exertion can increase venous ammonia levels. Once collected, samples should be immediately placed on ice and transported to the laboratory.

If toxic ingestion or exposure is suspected, a local poison control center may help guide the emergency clinician in determining the appropriate laboratory testing warranted per individual case. The initial chemistry panel may reflect that the patient has metabolic acidosis. With a wide differential for causes of ALOC and metabolic acidosis, looking at the anion gap can be useful. Causes of elevated anion gap metabolic acidosis can be reviewed using the mnemonic "MUDPILES" (methanol, uremia, DKA, paraldehyde, ibuprofen/inborn errors of metabolism/inhalants/iron overdose/isoniazid, lactic acidosis, ethanol/ethylene glycol, salicylates/solvents/starvation). If alcohol ingestion is a suspected etiology for ALOC in the setting of an elevated anion gap metabolic acidosis, serum ethanol levels can be measured in addition to obtaining serum osmolality levels. Serum osmolal-

ity levels can be used to calculate serum osmolality gaps (osmolality gap = measured osmolality – calculated osmolality). When a single agent of alcohol ingestion is suspected, an elevated osmolality gap can be used to calculate predicted serum concentrations using the following formula:

$$\text{Predicted serum concentration} = (\text{osmolality gap} - 10) \times \text{molecular weight of the alcohol} / 10$$

[Ethanol has a molecular weight of 46, methanol has a molecular weight of 32, ethylene glycol has a molecular weight of 62, and isopropanol has a molecular weight of 60.<sup>125</sup>]

When meningitis or encephalitis is suspected, a lumbar puncture should be performed to obtain samples of CSF. CSF tests of interest include cell count with differential, Gram stain, protein level, glucose level, and culture. The results from these tests can also be helpful diagnostic tools in cases of secondary CNS vasculitis or postinfectious disorders. Other CSF tests that can be ordered include herpes simplex virus polymerase chain reaction, other viral polymerase chain reactions, oligoclonal bands, or other tests as indicated. In cases where anti-NMDA receptor encephalitis is suspected, anti-NMDA receptor antibody levels in the CSF should be obtained.

Other laboratory studies that may be helpful in the diagnostic workup of a patient presenting with ALOC may include blood and urine cultures, as well as urinalysis in cases of possible sepsis, bacteremia, or pyelonephritis.

## Imaging Studies

Different imaging modalities can be used to assess the patient with ALOC. For the critically ill pediatric patient with ALOC, once stabilized, a computed tomography (CT) scan can provide emergent brain imaging. A CT scan of the brain without contrast is useful to evaluate for midline shift, ventricle size, ruptured aneurysms, and intracranial hemorrhage. A CT scan with contrast can assess brain perfusion for older ischemic or infarcted areas, as well as signs of inflammation, abscess, mass, or venous thrombosis. However, MRI provides better detail of soft tissue and is considered to be the superior imaging modality for evaluation of CNS infections and the posterior fossa.<sup>126,127</sup> In cases of suspected childhood stroke, a CT scan can be the initial imaging modality used. However, a CT scan may miss early ischemic infarcts, and MRI with diffusion-weighted imaging and magnetic resonance angiography of the head and neck should be done if acute ischemic stroke is suspected.<sup>128</sup> Conventional angiography is the gold standard for evaluating CNS vasculitis, but magnetic resonance angiography/venography may be suf-

ficient to make the diagnosis.<sup>49</sup> In cases of acute disseminated encephalomyelitis, MRI of the brain with T2-weights and fluid-attenuated inversion recovery sequences may show poorly defined, patchy areas of increased signal intensity with multiple lesions typically being large, globular, and asymmetric.<sup>51</sup> For neonates with encephalopathy, a cranial ultrasound for screening followed by MRI may be a reasonable initial approach compared to a CT scan.<sup>129</sup> In pediatric patients with CSF shunts who present to the ED with concerns for possible shunt malfunction, emergent brain imaging is usually necessary, and either limited CT or rapid-sequence MRI scans can be performed, focusing on ventricular size.<sup>130,131</sup>

When there is suspicion that the primary etiology for ALOC is from other areas of the body, additional studies may be indicated. Abdominal imaging (x-ray, ultrasound, or CT) may be helpful to assess for a primary abdominal process (eg, perforation leading to sepsis, intussusception, or hepatomegaly). In patients with ALOC of possible cardiac etiology (such as in patients presenting with syncope), an electrocardiogram can be performed to assess for life-threatening dysrhythmias.<sup>52,132</sup> When nonaccidental trauma is suspected, a skeletal survey can provide information regarding skull fractures and other bony abnormalities (both old and new) that may be consistent with traumatic mechanisms.

## Treatment

### General Treatment Strategies

Early treatment steps in the patient with ALOC should include providing supplemental oxygen. Hypoxemia can be both a primary or secondary mechanism involved in a patient's altered presentation, and supplemental oxygen should be given as needed, especially if the pulse oximetry reading is low or if the patient is hypoventilating. The empiric administration of dextrose should be considered in the patient with ALOC, especially if the patient is a neonate. Hypoglycemia can be addressed by administering 0.25 g/kg of dextrose as a resuscitative dose. This is equivalent to 2.5 mL per kg of 10% dextrose, although providers can give as much as 4 to 5 mL per kg of 10% dextrose fluid intravenously every 5 to 10 minutes as needed.<sup>7,32</sup> Following this, a goal glucose infusion rate of 6 to 8 mg/kg/min can be used to maintain euglycemia.<sup>7</sup> Usually, 10% dextrose fluid at 1.5 times maintenance rate achieves an adequate glucose infusion rate.<sup>7,32</sup> Plasma glucose checks should be completed frequently until a stable level > 70 mg/dL is attained more than once.<sup>32</sup>

### Condition-Specific Treatment

Once the patient is stabilized and the differential diagnosis has been narrowed using findings from the history, physical examination, and laboratory and im-

aging studies, suspected etiologies can be addressed, if this has not already occurred during the course of stabilization. Treatment for patients with ALOC is largely contingent on the etiology for ALOC.

### Electrolyte Abnormalities

Once recognized, electrolyte abnormalities should be promptly corrected based on the etiology. Hyponatremia should be corrected slowly due to risk of central pontine myelinolysis. The patient's sodium (Na) deficit can be calculated using the following formula:

$$\text{mEq Na deficit} = (\text{desired Na} - \text{measured Na}) \times 0.6 \\ (\text{volume of distribution of Na}) \times \text{weight in kg}$$

The patient's serum sodium level should not rise more than 12 to 15 mEq/L (12-15 mmol/L) over a 24-hour period.<sup>82</sup> For more information about hyponatremia and hypernatremia, see the October 2012 issue of *Emergency Medicine Practice* entitled "Sodium Disorders In The Emergency Department: A Review Of Hyponatremia And Hypernatremia," available at [www.ebmedicine.net/SodiumDisorders](http://www.ebmedicine.net/SodiumDisorders).

### Ingestion Or Exposure

For patients with suspected toxic ingestion or exposure, activated charcoal can be considered if the patient presents within 1 hour of suspected ingestion, is amenable to this therapy, and is not at risk for aspiration.<sup>133</sup> The dose of activated charcoal is 0.5 to 1 g/kg for children aged up to 12 years. For adolescents and adults, the recommended dose of activated charcoal ranges from 25 to 100 grams.<sup>134</sup> Absolute contraindications include patients with an unprotected airway or those with disruption of the integrity of the gastrointestinal tract anatomy or intestinal obstruction.<sup>135</sup> When opioids or benzodiazepines are suspected as causal agents for a patient's ALOC, reversal agents such as naloxone and flumazenil, respectively, can be administered. Typical dosing for naloxone is 0.1 mg/kg for infants and children up to 20 kg. For patients weighing > 20 kg, a dose of 2 mg of naloxone can be given. Doses may be repeated for optimal reversal of opioid toxicity.<sup>136</sup> Although flumazenil has been demonstrated to be safe to use for reversal of benzodiazepine-induced procedural sedation in pediatric patients, the safety profile for its use in pediatric poisonings is less well defined.<sup>137</sup> For more information about the management of pediatric ingestions, see the April 2016 issue of *Pediatric Emergency Medicine Practice* entitled "Pediatric Ingestions: Emergency Department Management," available at [www.ebmedicine.net/Ingestions](http://www.ebmedicine.net/Ingestions).

### Fever

In patients presenting with fever and ALOC, empiric broad-spectrum antibiotics should be administered,



with consideration of adding acyclovir for cases of suspected herpes simplex virus infection. Although obtaining CSF for cultures would aid in tailoring antimicrobial therapy in patients with infectious meningitis or encephalitis, the inability to obtain CSF should not cause unnecessary delay of the administration of antimicrobial therapy.

### **Elevated Intracranial Pressure**

For patients with signs of increased intracranial pressure, the head of the patient's bed should be elevated to 30° to promote central venous drainage and so hyperosmotic agents can be administered. Choices of fluids include 20% mannitol (0.25-1 g/kg/dose over 3-5 minutes) or 3% saline, while consulting neurosurgical services.

### **Seizure**

In patients with suspected seizures, benzodiazepines can be utilized. Common lorazepam dosing is 0.05 to 0.1 mg/kg (maximum 4 mg) followed by a loading dose of an antiepileptic medication such as fosphenytoin (20 mg phenytoin equivalents/kg) or intravenous levetiracetam (Keppra® 20 mg/kg).<sup>138</sup> For more information about the management of seizures in pediatric patients, see the March 2015 issue of *Pediatric Emergency Medicine Practice* entitled "Emergency Department Management Of Seizures In Pediatric Patients," available at [www.ebmedicine.net/Seizures](http://www.ebmedicine.net/Seizures).

### **Neurologic Conditions**

In cases of CNS vasculitis, postinfectious disorders, or noninfectious encephalitis, key elements of treatment will include immunosuppressive therapies. In certain cases of primary CNS vasculitis, there may be a role for anticoagulative therapy as well.<sup>50</sup> Treatment modalities for anti-NMDA receptor encephalitis include surgical resection of the neoplasm (if present and found), steroids, intravenous immunoglobulin therapy, plasma exchange, and immunotherapy agents such as cyclophosphamide or rituximab.<sup>105</sup> For patients who present with symptoms of catatonia, common treatment modalities include anticonvulsants with particular use of benzodiazepines and electroconvulsive therapy. Treatment regimens may also include immunosuppressive therapies in addition to psychotropic medications as adjunctive therapy.<sup>139</sup> For patients with specific conditions, such as sickle cell disease, treatment modalities may include interventions specific to their disease process. For patients with sickle cell disease who present with an acute stroke, treatment goals include rapidly reducing the percentage of hemoglobin S in the blood using blood transfusions or automated exchange transfusions under the guidance of a hematology specialist.<sup>96</sup>

### **Diabetic Ketoacidosis/ Hyperglycemic Hyperosmolar State**

ALOC from complications of DKA can be addressed with fluids, insulin, and other corrective measures. Interventions to specifically improve cerebral edema in the setting of DKA can include administration of mannitol 1 g/kg over 15 minutes or 3% hypertonic saline 5 mL/kg over 5 to 10 minutes.<sup>140</sup> For more information about the management of DKA, see the March 2013 issue of *Pediatric Emergency Medicine Practice* entitled "Pediatric Diabetic Ketoacidosis: An Outpatient Perspective On Evaluation And Management," available at [www.ebmedicine.net/DiabeticKetoacidosis](http://www.ebmedicine.net/DiabeticKetoacidosis).

The treatment of pediatric patients with HHS also includes fluid resuscitation, although there are subtle differences in the management of HHS and DKA that should be noted. Fluid resuscitation is typically more aggressive and longer and, in contrast to DKA management, early insulin administration is unnecessary. Insulin therapy can be considered when serum glucose concentrations are no longer decreasing with fluid therapy alone or earlier in cases of patients with more severe acidosis and ketosis.<sup>71,141</sup>

### **Hypertensive Encephalopathy**

The goal of addressing hypertensive encephalopathy includes using antihypertensives to correct elevated blood pressure. Initial utilization of benzodiazepines may provide an acceptable drop in blood pressure, often providing valuable time when considering more specific autonomic agents. To manage emergent cases of severe hypertension, intravenous agents with short half-lives are commonly used. Labetalol is a alpha blocker and beta blocker, which are contraindicated in patients with asthma and should be used cautiously in patients with heart failure, as the possible side effect of bradycardia can exacerbate heart failure. Nicardipine is a calcium-channel blocker that is also commonly used as an antihypertensive in emergent cases. Delivered as a nicardipine intravenous infusion that may be infused via large peripheral intravenous line (though central intravenous access is preferred) the initial rate of infusion may be started at 0.5 to 1 mcg/kg/min. Hydralazine is an arteriolar vasodilator that has the added benefit of being an agent that can be given either intravenously or via an intramuscular route.<sup>142,143</sup> For more information about the management of pediatric hypertension, see the April 2012 issue of *Pediatric Emergency Medicine Practice* entitled "The Evidence-Based Emergency Management Of Pediatric Hypertension," available at [www.ebmedicine.net/Hypertension](http://www.ebmedicine.net/Hypertension).

### **Inborn Errors Of Metabolism**

Generally, for patients with inborn errors of metabolism, 10% dextrose fluid at 1.5 times maintenance rate is started empirically to reverse the patient's

catabolic state. The patient should be ordered to have nothing by mouth to eliminate exposure to potentially harmful sugars or proteins. After initiating fluid therapy, depending on the metabolic condition, other therapies may be warranted. In hyperammonemic crises, pharmacologic treatments such as sodium phenylacetate and sodium benzoate can be used to provide alternative metabolic pathways.<sup>144</sup> The dose of sodium phenylacetate or sodium benzoate is an initial 0.25 g/kg bolus over 2 to 4 hours, then at an infusion rate of 0.25 g/kg over 24 hours.<sup>145,146</sup> Arginine hydrochloride (10%) is also given in combination with sodium phenylacetate and sodium benzoate, with doses varying depending on the patient's underlying condition. Of note, the intravenous forms of sodium phenylacetate and sodium benzoate are approved only for urea cycle defects but can still be clinically indicated in cases of

severe hyperammonemia until the etiology is determined.<sup>145</sup> Care must be taken to ensure proper dosage of medications, as fatal overdoses can occur.<sup>147</sup> If pharmacologic treatments fail and hyperammonemia that is greater than 10 times normal persists, hemodialysis should be considered as the next step in management.<sup>145</sup> For ALOC secondary to accumulation of toxic metabolites, dialysis or hemofiltration may be necessary, and requires referring to institutional protocol for acute liver failure or acute renal failure. In cases of hepatic encephalopathy, bowel-cleansing agents such as lactulose or neomycin can be used to reduce ammonia levels by decreasing colonic bacteria colonies responsible for producing ammonia, although this is a second-tier approach.<sup>148</sup> For more information about the management of metabolic emergencies in pediatric patients, see the October 2009 issue of *Pediatric Emergency Medicine*

## Risk Management Pitfalls In Patients With Altered Level Of Consciousness (Continued on page 19)

1. **"The patient was drinking alcohol while driving and got into a car accident. His altered mental status must be from his intoxication."**  
Although alcohol intoxication may contribute to the patient's ALOC, it is important to rule out any other concomitant etiologies for the patient's ALOC, including, but not limited to, intracranial injury due to the motor vehicle crash.
2. **"I thought that this was her neurological baseline."**  
In special populations that include developmentally delayed patients, it is imperative to ask the caretaker(s) what the patient's neurological baseline is in order to correctly assess and evaluate any changes in levels of consciousness.
3. **"The patient was still seizing after the first 4 doses of lorazepam and 2 doses of fosphenytoin, so we proceeded to place the patient in a phenobarbital coma without further investigation."**  
The differential for a patient presenting with seizures includes electrolyte derangements—including hyponatremia and hypoglycemia— as potential etiologies. The emergency clinician should not only prepare to administer benzodiazepines and other antiepileptic agents, but also to correct any potential electrolyte derangements that may be the cause of seizure. Other causes for seizures can include toxic exposures or ingestions that may need to be considered as well.

4. **"Even though her GCS score was 7, I needed a CT scan emergently, so I sent her for the scan without further stabilizing her."**  
Unless the patient's mental status is quickly improving and returning to neurological baseline, patients with a persistent GCS score of  $\leq 8$  should be intubated in order to protect their airway, given their unstable neurological status.
5. **"I could not obtain cerebrospinal fluid from the lumbar puncture, so I held off on antibiotics."**  
If infectious causes are highly suspected in a patient with ALOC, the inability to obtain CSF should not cause unnecessary delay to administration of antibiotic therapy.
6. **"I knew the diagnosis, so I did not do a complete neurological examination."**  
Once the ABCs of a patient with ALOC are stabilized, details of the neurological examination can provide critical information. For example, anisocoria can reflect signs of impending brain herniation and papilledema can serve as a sign indicating increased intracranial pressure secondary to mass effect on the brain.

*Practice* entitled “Evidence-Based Management Of Metabolic Emergencies In The Pediatric Emergency Department,” available at [www.ebmedicine.net/Metabolism](http://www.ebmedicine.net/Metabolism).

## Special Populations

Patients with cognitive developmental delays and underlying neurological disorders may present with reports of ALOC by the caregiver. For the emergency clinician, it may be difficult to understand or ascertain the patient’s baseline neurological status for comparison, and the presenting signs or symptoms of ALOC may be subtle. In these cases, history from the patient’s primary caretakers and guardians is imperative.

## Controversies And Cutting Edge

For cases of cerebral sinovenous thrombosis, anticoagulation is one possible therapeutic intervention, although therapeutic management for this disease process remains controversial.<sup>149,150</sup>

## Disposition

Any patient presenting with unresolved ALOC or ALOC without a clear cause should be admitted for observation and further evaluation. Criteria for admission to the intensive care unit rather than the inpatient floor may include the following: (1) Concerns regarding the patient’s cardiopulmonary status; (2) the need for mechanical ventilation; (3) increased intracranial pressure; and/or (4) the need for more frequent or intensive patient care (eg, DKA

## Risk Management Pitfalls In Patients With Altered Level Of Consciousness (Continued from page 18)

7. **“I thought the patient’s irregular breathing was due to his mental status.”**

Emergency clinicians should not focus solely on the patient’s neurological presentation, as this could result in failure to piece together other presenting signs and symptoms to ascertain the correct diagnosis. For example, respiratory changes can be important clinical findings to indicate Kussmaul breathing, as seen in DKA, or erratic or irregular breathing, as seen in Cushing triad.

8. **“The patient initially presented with hypoglycemia, and a dextrose bolus was given. Once the hypoglycemia was addressed, I did not think to start dextrose-containing intravenous fluids.”**

Patients who present with hypoglycemia should not only be given a dextrose bolus, but should also have their glucose level rechecked and monitored closely. In addition, if hypoglycemia persists, dextrose-containing fluids should be started at 1.5 times maintenance rate to ensure a steady glucose infusion rate until the etiology for hypoglycemia can be ascertained. Plasma glucose checks should be completed frequently until a stable level > 70 mg/dL is attained more than once.<sup>32</sup>

9. **“The patient was hyponatremic and altered. I subsequently gave a 20 mL/kg normal saline bolus and started the patient on normal saline intravenous fluids at 1.5 times maintenance rate.”**

Correcting hyponatremia should be done slowly, due to the risk of central pontine myelinolysis. The recommended rate of correction is such that the patient’s serum sodium levels should not rise more than 12 to 15 mEq/L (12-15 mmol/L) over a 24-hour period.

10. **“He initially came into the ED looking intoxicated. I did not think that there would have been any issues with cervical spine instability.”**

In all patients presenting with ALOC, trauma must be considered in the differential. If trauma is highly suspected as the etiology for the patient’s ALOC, care must be taken to ensure proper cervical spine precautions. Similarly, it is important to fully undress the patient with ALOC to avoid missing skin findings, signs of trauma, or other cutaneous clues that may otherwise be hidden underneath clothing.

requiring frequent laboratory evaluation). Other patients with ALOC may also require a higher level of care and admission to the intensive care unit, and this should be considered on a case-by-case basis. In situations where the etiology of presentation is definitively identified and addressed (eg, seizure in a known epileptic patient who missed doses of home antiepileptic medications), the emergency clinician may potentially discharge the patient with close outpatient follow-up.

## Summary

Patients who present with ALOC can be a diagnostic challenge, given the wide differential of possible diagnoses. A comprehensive history, complete physical examination, as well as the aid of selected laboratory and imaging tests can help delineate the underlying etiology for the change in the patient's level of consciousness. Management approaches should be based on suspected etiologies, and reversible and readily treatable causes might be identified and treated rapidly, such as treating hypoglycemia with dextrose fluids or seizures with anticonvulsants. All children presenting with ALOC should be monitored until they return to baseline, and admission to the hospital should be strongly considered for further observation and evaluation. Children exhibiting continued alteration in mental status or return of altered states should be monitored in the intensive care unit. With consideration of a wide differential of possibilities, the emergency clinician will be able to successfully manage patients who present with ALOC.

## Case Conclusions

*You determined that the 7-year-old girl had presented with signs and symptoms concerning for possible meningitis. A lumbar puncture was performed, and the results from the CSF cell count were 396 WBCs and 1 RBC, low CSF glucose, and high CSF protein values. A CSF culture was also sent. Doses of vancomycin and ceftriaxone were administered. The patient was admitted to the intensive care unit. A few days later, you ran into the girl's parents who reported that their daughter was still on intravenous antibiotics therapy, but back to neurological baseline.*

*It was determined that the mental status of the 14-year-old boy was altered due to intoxication. There was high clinical suspicion that he may have lost consciousness after ingesting narcotics and drinking alcohol, based on what was found near him at the time he was found. Given his initial presentation with ALOC and low GCS score, you decided to secure the airway via rapid sequence induction and intubation. You obtained a bedside electrocardiogram, serum electrolytes, urine toxicology test, serum ethanol, serum acetaminophen, and serum salicylate levels in addition to obtaining a CT scan of his brain. All*

*of the test results returned within normal limits, except the urine toxicology test and serum ethanol test, and the patient was admitted. You learned from the critical care team that the patient was extubated soon afterwards, and returned back to neurological baseline. The boy admitted to the critical care team that he took several prescription pain medications and a couple of shots of whiskey before he lost consciousness.*

*In the 9-year-old girl with propionic acidemia, a bedside blood gas test was obtained that included evaluation of a set of electrolytes, which demonstrated a low bicarbonate level. In addition to normal saline boluses run concurrently through a "Y" connector, intravenous fluids containing 10% dextrose were started, running at a rate of 1.5 times maintenance.<sup>145</sup> Additional laboratory studies were sent, including a serum ammonia level that returned highly elevated. Sodium phenylacetate and sodium benzoate were given and the patient was admitted to the intensive care unit. She was discharged several days later after returning to neurological baseline.*

## Time- And Cost-Effective Strategies

- Not all patients who present to the ED with ALOC need emergent brain imaging. Brain imaging should be selective and based on the evaluation and suspicion for intracranial causes of ALOC.
- By obtaining electrolyte levels early in the evaluation of undifferentiated ALOC in the ED, unnecessary additional tests may be avoided.
- Most patients with ALOC should be admitted to the hospital for further monitoring and evaluation. However, there are select cases in which a patient's medical history is known and the etiology for ALOC is addressed during the ED visit. If the patient returns to neurological baseline and the causative agent for the ALOC is completely resolved, hospital admission may be avoided.

## References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study is included in bold type following the references, where available. The most informative references cited in this paper, as determined by the authors, are noted by an asterisk (\*) next to the number of the reference.

- 1.\* Avner JR. Altered states of consciousness. *Pediatr Rev.* 2006;27(9):331-338. **(Review article)**
2. Tindall SC. Level of Consciousness. In: Walker HK, Hall WD, Hurst JW, eds. *Clinical Methods: The History, Physical, and Laboratory Examinations*. Boston: Butterworth Publishers, a division of Reed Publishing; 1990. **(Textbook)**
3. Wong CP, Forsyth RJ, Kelly TP, et al. Incidence, aetiology, and outcome of non-traumatic coma: a population based study. *Arch Dis Child.* 2001;84(3):193-199. **(Prospective, epidemiologic, population-based study; 283 episodes representing 278 children)**
4. Seshia SS, Bingham WT, Kirkham FJ, et al. Nontraumatic coma in children and adolescents: diagnosis and management. *Neurol Clin.* 2011;29(4):1007-1043. **(Review article)**
5. Schunk JE. The pediatric patient with altered level of consciousness: remember your "immunizations." *J Emerg Nurs.* 1992;18(5):419-421. **(Review article)**
6. Ahmed S, Ejaz K, Shamim MS, et al. Non-traumatic coma in paediatric patients: etiology and predictors of outcome. *J Pak Med Assoc.* 2011;61(7):671-675. **(Cross-sectional study; 100 patients)**
7. Hoffman R, Wang V, Scarfone RJ, eds. *Fleisher and Ludwig's 5-Minute Pediatric Emergency Medicine Consult*. 1st ed. Philadelphia: Lippincott, Williams & Wilkins; 2012. **(Textbook)**
8. Zeman A. Consciousness. *Brain.* 2001;124(Pt 7):1263-1289. **(Review article)**
9. Calello DP, Fine JS, Marcus SM, et al. 2012 pediatric fatality review of the National Poison Database System. *Clin Toxicol (Phila).* 2014;52(2):93-95. **(Database review; 50 patients)**
10. Mowry JB, Spyker DA, Brooks DE, et al. 2014 annual report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 32nd annual report. *Clin Toxicol (Phila).* 2015;53(10):962-1147. **(Annual report)**
11. Kurt F, Bektas O, Kalkan G, et al. Does age affect presenting symptoms in children with carbon monoxide poisoning? *Pediatr Emerg Care.* 2013;29(8):916-921. **(Retrospective study; 261 patients)**
12. Mendoza JA, Hampson NB. Epidemiology of severe carbon monoxide poisoning in children. *Undersea Hyperb Med.* 2006;33(6):439-446. **(Epidemiologic study; 250 consecutive children)**
13. Bailey JE, Campagna E, Dart RC. The underrecognized toll of prescription opioid abuse on young children. *Ann Emerg Med.* 2009;53(4):419-424. **(Descriptive; 9179 pediatric exposures)**
14. Tonisson M, Tillmann V, Kuudeberg A, et al. Acute alcohol intoxication characteristics in children. *Alcohol Alcohol.* 2013;48(4):390-395. **(Prospective study; 256 children)**
15. Lamminpaa A. Acute alcohol intoxication among children and adolescents. *Eur J Pediatr.* 1994;153(12):868-872. **(Review article)**
16. Rayar P, Ratnapalan S. Pediatric ingestions of household products containing ethanol: a review. *Clin Pediatr (Phila).* 2013;52(3):203-209. **(Literature review)**
17. Sutton TL, Foster RL, Liner SR. Acute methanol ingestion. *Pediatr Emerg Care.* 2002;18(5):360-363. **(Case report)**
18. Slaughter RJ, Mason RW, Beasley DM, et al. Isopropanol poisoning. *Clin Toxicol (Phila).* 2014;52(5):470-478. **(Review)**
19. Barry JD. Diagnosis and management of the poisoned child. *Pediatr Ann.* 2005;34(12):937-946. **(Review article)**
20. Malone DC, Abarca J, Hansten PD, et al. Identification of serious drug-drug interactions: results of the partnership to prevent drug-drug interactions. *J Am Pharm Assoc (2003).* 2004;44(2):142-151. **(Cross-sectional; 54 drug-drug interactions)**
21. American Psychiatric Association DSM-5 Task Force. *Diagnostic and Statistical Manual of Mental Disorders: DSM-5*. 5th ed. Washington, D.C.: American Psychiatric Association; 2013. **(Classification and diagnostic manual)**
22. Croarkin PE, Emslie GJ, Mayes TL. Neuroleptic malignant syndrome associated with atypical antipsychotics in pediatric patients: a review of published cases. *J Clin Psychiatry.* 2008;69(7):1157-1165. **(Literature review)**
23. Ty EB, Rothner AD. Neuroleptic malignant syndrome in children and adolescents. *J Child Neurol.* 2001;16(3):157-163. **(Review article)**
24. Neuht R, Lindenmayer JP, Silva R. Neuroleptic malignant syndrome in children and adolescents on atypical antipsychotic medication: a review. *J Child Adolesc Psychopharmacol.* 2009;19(4):415-422. **(Literature review)**
25. Wright RO, Lewander WJ, Woolf AD. Methemoglobinemia: etiology, pharmacology, and clinical management. *Ann Emerg Med.* 1999;34(5):646-656. **(Review article)**
26. Appelboam A, Oades PJ. Coma due to cannabis toxicity in an infant. *Eur J Emerg Med.* 2006;13(3):177-179. **(Case report)**
27. Holstege CP, Borek HA. Toxicodromes. *Crit Care Clin.* 2012;28(4):479-498. **(Review article)**
28. Quayle KS, Powell EC, Mahajan P, et al. Epidemiology of blunt head trauma in children in U.S. emergency departments. *N Engl J Med.* 2014;371(20):1945-1947. **(Letter to the editor, secondary analysis; 43,399 patients)**
29. Atabaki SM. Pediatric head injury. *Pediatr Rev.* 2007;28(6):215-224. **(Review article)**
- 30.\* Schunk JE, Schutzman SA. Pediatric head injury. *Pediatr Rev.* 2012;33(9):398-410. **(Review article)**
31. Holsti M, Kadish HA, Sill BL, et al. Pediatric closed head injuries treated in an observation unit. *Pediatr Emerg Care.* 2005;21(10):639-644. **(Retrospective cohort review; 285 patients)**
- 32.\* Fleisher GR, Ludwig S, eds. *Textbook of Pediatric Emergency Medicine*. Wolters Kluwer/Lippincott Williams & Wilkins Health; 2010. **(Textbook)**
33. Hinds T, Shalaby-Rana E, Jackson AM, et al. Aspects of abuse: abusive head trauma. *Curr Probl Pediatr Adolesc Health Care.* 2015;45(3):71-79. **(Review article)**
34. Ewing-Cobbs L, Kramer L, Prasad M, et al. Neuroimaging, physical, and developmental findings after inflicted and noninflicted traumatic brain injury in young children. *Pediatrics.* 1998;102(2 Pt 1):300-307. **(Prospective, longitudinal study; 40 children)**
35. Benson PJ, Klein EJ. New-onset absence status epilepsy presenting as altered mental status in a pediatric patient. *Ann Emerg Med.* 2001;37(4):402-405. **(Case report)**
36. Amin OS. A prolonged altered mental status: is it absence status epilepticus? *BMJ Case Rep.* 2013. **(Case report)**
37. Luders H, Amina S, Bailey C, et al. Proposal: different types of alteration and loss of consciousness in epilepsy. *Epilepsia.* 2014;55(8):1140-1144. **(Consensus opinion article)**
38. The International Classification of Headache Disorders, 3rd edition (beta version). *Cephalalgia.* 2013;33(9):629-808. **(Classification criteria)**
39. Wong ST, Fong D. Ruptured brain arteriovenous malformations in children: correlation of clinical outcome with admission parameters. *Pediatr Neurosurg.* 2010;46(6):417-426. **(Retrospective review; 40 patients)**
40. Bristol RE, Albuquerque FC, Spetzler RF, et al. Surgical management of arteriovenous malformations in children. *J Neurosurg.* 2006;105(2 Suppl):88-93. **(Retrospective review; 82 patients)**
41. Krishnamurthi RV, deVeber G, Feigin VL, et al. Stroke prevalence, mortality and disability-adjusted life years in children and youth aged 0-19 years: data from the Global

- and Regional Burden of Stroke 2013. *Neuroepidemiology*. 2015;45(3):177-189. **(Epidemiologic study; 97,792 cases)**
42. Lynch JK, Hirtz DG, DeVeber G, et al. Report of the National Institute of Neurological Disorders and Stroke workshop on perinatal and childhood stroke. *Pediatrics*. 2002;109(1):116-123. **(Workshop report)**
  43. Delsing BJ, Catsman-Berrepoets CE, Appel IM. Early prognostic indicators of outcome in ischemic childhood stroke. *Pediatr Neurol*. 2001;24(4):283-289. **(Retrospective review; 31 children)**
  44. Hedlund GL. Cerebral sinovenous thrombosis in pediatric practice. *Pediatr Radiol*. 2013;43(2):173-188. **(Review article)**
  45. Wong JM, Ziewacz JE, Ho AL, et al. Patterns in neurosurgical adverse events: cerebrospinal fluid shunt surgery. *Neurosurg Focus*. 2012;33(5):E13. **(Literature review)**
  46. Riva-Cambrin J, Kestle JR, Holubkov R, et al. Risk factors for shunt malfunction in pediatric hydrocephalus: a multicenter prospective cohort study. *J Neurosurg Pediatr*. 2015:1-9. **(Multicenter prospective cohort study; 1036 children)**
  47. McGirt MJ, Leveque JC, Wellons JC 3rd, et al. Cerebrospinal fluid shunt survival and etiology of failures: a seven-year institutional experience. *Pediatr Neurosurg*. 2002;36(5):248-255. **(Retrospective review; 353 patients)**
  48. Kim TY, Stewart G, Voth M, et al. Signs and symptoms of cerebrospinal fluid shunt malfunction in the pediatric emergency department. *Pediatr Emerg Care*. 2006;22(1):28-34. **(Retrospective review; 352 patients)**
  - 49.\* Van Mater H. Pediatric inflammatory brain diseases: a diagnostic approach. *Curr Opin Rheumatol*. 2014;26(5):553-561. **(Review article)**
  50. Benseler S, Pohl D. Childhood central nervous system vasculitis. *Handb Clin Neurol*. 2013;112:1065-1078. **(Textbook)**
  51. Alper G. Acute disseminated encephalomyelitis. *J Child Neurol*. 2012;27(11):1408-1425. **(Review article)**
  52. Johnsrude CL. Current approach to pediatric syncope. *Pediatr Cardiol*. 2000;21(6):522-531. **(Review article)**
  53. Anderson JB, Czosek RJ, Cnota J, et al. Pediatric syncope: National Hospital Ambulatory Medical Care survey results. *J Emerg Med*. 2012;43(4):575-583. **(Retrospective observational study; 627,489 ED visits from 2003-2007)**
  54. Chandar J, Zilleruelo G. Hypertensive crisis in children. *Pediatr Nephrol*. 2012;27(5):741-751. **(Review article)**
  55. Yang WC, Wu HP. Clinical analysis of hypertension in children admitted to the emergency department. *Pediatr Neonatol*. 2010;51(1):44-51. **(Retrospective review; 99 patients)**
  56. Endo A, Fuchigami T, Hasegawa M, et al. Posterior reversible encephalopathy syndrome in childhood: report of four cases and review of the literature. *Pediatr Emerg Care*. 2012;28(2):153-157. **(Report of 4 cases and literature review)**
  57. Raj S, Overby P, Erdfarb A, et al. Posterior reversible encephalopathy syndrome: incidence and associated factors in a pediatric critical care population. *Pediatr Neurol*. 2013;49(5):335-339. **(Retrospective cohort study; 10 patients)**
  58. Hinchey J, Chaves C, Appignani B, et al. A reversible posterior leukoencephalopathy syndrome. *N Engl J Med*. 1996;334(8):494-500. **(Retrospective review; 15 patients)**
  59. Milner D, Losek JD, Schiff J, et al. Pediatric pericardial tamponade presenting as altered mental status. *Pediatr Emerg Care*. 2003;19(1):35-37. **(Case report)**
  60. Lane JR, Ben-Shachar G. Myocardial infarction in healthy adolescents. *Pediatrics*. 2007;120(4):e938-e943. **(Retrospective review; 9 patients)**
  61. Goldstein B, Shannon DC, Todres ID. Supercarbia in children: clinical course and outcome. *Crit Care Med*. 1990;18(2):166-168. **(Retrospective review; 5 patients)**
  62. de Groot EP. Breathing abnormalities in children with breathlessness. *Paediatr Respir Rev*. 2011;12(1):83-87. **(Review article)**
  63. Piña-Garza JE. *Fenichel's Clinical Pediatric Neurology: A Signs and Symptoms Approach*. 7th ed. Elsevier Science Health Science Division; 2013. **(Textbook)**
  64. Falk JL, Escowitz HE. Submersion injuries in children and adults. *Semin Respir Crit Care Med*. 2002;23(1):47-55. **(Review article)**
  - 65.\* Casaletto JJ. Is salt, vitamin, or endocrinopathy causing this encephalopathy? A review of endocrine and metabolic causes of altered level of consciousness. *Emerg Med Clin North Am*. 2010;28(3):633-662. **(Review article)**
  66. Pershad J, Monroe K, Atchison J. Childhood hypoglycemia in an urban emergency department: epidemiology and a diagnostic approach to the problem. *Pediatr Emerg Care*. 1998;14(4):268-271. **(Retrospective review; 31 patients)**
  67. Losek JD. Hypoglycemia and the ABC'S (sugar) of pediatric resuscitation. *Ann Emerg Med*. 2000;35(1):43-46. **(Cross-sectional study; 9 patients)**
  68. Cooke DW, Plotnick L. Management of diabetic ketoacidosis in children and adolescents. *Pediatr Rev*. 2008;29(12):431-435. **(Review article)**
  69. Neu A, Willasch A, Ehehalt S, et al. Ketoacidosis at onset of type 1 diabetes mellitus in children—frequency and clinical presentation. *Pediatr Diabetes*. 2003;4(2):77-81. **(Retrospective review; 2121 children)**
  70. Glaser N, Barnett P, McCaslin I, et al. Risk factors for cerebral edema in children with diabetic ketoacidosis. The Pediatric Emergency Medicine Collaborative Research Committee of the American Academy of Pediatrics. *N Engl J Med*. 2001;344(4):264-269. **(Retrospective, multicenter)**
  71. Rosenbloom AL. Hyperglycemic hyperosmolar state: an emerging pediatric problem. *J Pediatr*. 2010;156(2):180-184. **(Review article)**
  72. Erol I, Saygi S, Alehan F. Hashimoto's encephalopathy in children and adolescents. *Pediatr Neurol*. 2011;45(6):420-422. **(Case report)**
  73. Mamoudjy N, Korff C, Maurey H, et al. Hashimoto's encephalopathy: identification and long-term outcome in children. *Eur J Paediatr Neurol*. 2013;17(3):280-287. **(Retrospective observational study; 42 children)**
  74. Vasconcellos E, Pina-Garza JE, Fakhoury T, et al. Pediatric manifestations of Hashimoto's encephalopathy. *Pediatr Neurol*. 1999;20(5):394-398. **(Report of 2 cases and literature review)**
  75. Weihmiller SN, Buonomo C, Bachur R. Risk stratification of children being evaluated for intussusception. *Pediatrics*. Vol 2011;127(2):e296-e303. **(Prospective, observational, cohort study; 310 patients)**
  76. Shaoul R, Gazit A, Weller B, et al. Neurological manifestations of an acute abdomen in children. *Pediatr Emerg Care*. 2005;21(9):594-597. **(Report of 2 cases)**
  77. Godbole A, Concannon P, Glasson M. Intussusception presenting as profound lethargy. *J Paediatr Child Health*. 2000;36(4):392-394. **(Case report)**
  78. Pumberger W, Dinshob I, Dremsek P. Altered consciousness and lethargy from compromised intestinal blood flow in children. *Am J Emerg Med*. 2004;22(4):307-309. **(Retrospective review; 13 patients)**
  79. Farrar HC, Chande VT, Fitzpatrick DF, et al. Hyponatremia as the cause of seizures in infants: a retrospective analysis of incidence, severity, and clinical predictors. *Ann Emerg Med*. 1995;26(1):42-48. **(Retrospective review; 47 patients)**
  80. Vanden Hoek TL, Morrison LJ, Shuster M, et al. Part 12: cardiac arrest in special situations: 2010 American Heart Association guidelines for cardiopulmonary resuscitation

and emergency cardiovascular care. *Circulation*. 2010;122(18 Suppl 3):S829-S861. **(Guidelines)**

81. Uribarri J, Oh MS, Carroll HJ. D-lactic acidosis. A review of clinical presentation, biochemical features, and pathophysiologic mechanisms. *Medicine (Baltimore)*. 1998;77(2):73-82. **(Case report and literature review)**
82. Powers KS. Dehydration: isotremic, hyponatremic, and hypernatremic recognition and management. *Pediatr Rev*. 2015;36(7):274-283. **(Review article)**
83. Hahn JS, Havens PL, Higgins JJ, et al. Neurological complications of hemolytic-uremic syndrome. *J Child Neurol*. 1989;4(2):108-113. **(Retrospective review; 78 children)**
84. Bauer A, Loos S, Wehrmann C, et al. Neurological involvement in children with *E. coli* O104:H4-induced hemolytic uremic syndrome. *Pediatr Nephrol*. 2014;29(9):1607-1615. **(Retrospective review; 50 patients)**
85. Squires RH Jr, Shneider BL, Bucuvalas J, et al. Acute liver failure in children: the first 348 patients in the pediatric acute liver failure study group. *J Pediatr*. 2006;148(5):652-658. **(Prospective multicenter case study; 348 children)**
86. Kamboj M. Clinical approach to the diagnoses of inborn errors of metabolism. *Pediatr Clin North Am*. 2008;55(5):1113-1127. **(Review article)**
87. Levy PA. Inborn errors of metabolism: part 1: overview. *Pediatr Rev*. 2009;30(4):131-137. **(Review article)**
88. Ficiocioglu C, An Haack K. Failure to thrive: when to suspect inborn errors of metabolism. *Pediatrics*. 2009;124(3):972-979. **(Review article)**
- 89.\* Galal NM, Fouad HM, Saied A, et al. Hyperammonemia in the pediatric emergency care setting. *Pediatr Emerg Care*. 2010;26(12):888-891. **(Observational study; 50 cases)**
90. Lanphear J, Sarnaik S. Presenting symptoms of pediatric brain tumors diagnosed in the emergency department. *Pediatr Emerg Care*. 2014;30(2):77-80. **(Retrospective review; 87 patients)**
91. Wilne S, Collier J, Kennedy C, et al. Presentation of childhood CNS tumours: a systematic review and meta-analysis. *Lancet Oncol*. 2007;8(8):685-695. **(Literature review)**
92. Combs D, Rice SA, Kopp LM. Incidence of delirium in children with cancer. *Pediatr Blood Cancer*. 2014;61(11):2094-2095. **(Retrospective review; 7 patients)**
93. Antunes NL. Mental status changes in children with systemic cancer. *Pediatr Neurol*. 2002;27(1):39-42. **(Review of 546 consultations)**
94. Lowe EJ, Pui CH, Hancock ML, et al. Early complications in children with acute lymphoblastic leukemia presenting with hyperleukocytosis. *Pediatr Blood Cancer*. 2005;45(1):10-15. **(Retrospective review; 178 children)**
- 95.\* Kliegman, RM, Stanton BMD, St. Geme J III, et al. *Nelson Textbook of Pediatrics*. 19th ed. Philadelphia, PA: Elsevier Saunders; 2011. **(Textbook)**
96. McCavit TL. Sickle cell disease. *Pediatr Rev*. 2012;33(5):195-204. **(Review article)**
97. DeBaun MR, Kirkham FJ. Central nervous system complications and management in sickle cell disease. *Blood*. 2016;127(7):829-838. **(Review article)**
98. Brook I. Brain abscess in children: microbiology and management. *J Child Neurol*. 1995;10(4):283-288. **(Review article)**
99. Gelabert-Gonzalez M, Aran-Echabe E. Management of brain abscess. *Turk Neurosurg*. 2013;23(5):692. **(Retrospective review; 28 patients)**
100. Sennaroglu L, Sozeri B. Otogenic brain abscess: review of 41 cases. *Otolaryngol Head Neck Surg*. 2000;123(6):751-755. **(Retrospective review; 41 cases)**
101. Sun J. Intracranial complications of chronic otitis media. *Eur Arch Otorhinolaryngol*. 2014;271(11):2923-2926. **(Retrospective review; 17 patients)**
102. Mace SE. Central nervous system infections as a cause of an altered mental status? What is the pathogen growing in your central nervous system? *Emerg Med Clin North Am*. 2010;28(3):535-570. **(Review article)**
103. Mann K, Jackson MA. Meningitis. *Pediatr Rev*. 2008;29(12):417-429. **(Review article)**
104. Lewis P, Glaser CA. Encephalitis. *Pediatr Rev*. 2005;26(10):353-363. **(Review article)**
105. Lim M, Hacohen Y, Vincent A. Autoimmune encephalopathies. *Pediatr Clin North Am*. 2015;62(3):667-685. **(Review article)**
106. DuBray K, Anglemeyer A, LaBeaud AD, et al. Epidemiology, outcomes and predictors of recovery in childhood encephalitis: a hospital-based study. *Pediatr Infect Dis J*. 2013;32(8):839-844. **(Retrospective cohort study; 190 patients)**
107. Bonfield CM, Sharma J, Dobson S. Pediatric intracranial abscesses. *J Infect*. 2015;71 Suppl 1:S42-S46. **(Review article)**
108. Sood SK. Lyme disease in children. *Infect Dis Clin North Am*. 2015;29(2):281-294. **(Review article)**
109. Avery RA, Frank G, Glutting JJ, et al. Prediction of Lyme meningitis in children from a Lyme disease-endemic region: a logistic-regression model using history, physical, and laboratory findings. *Pediatrics*. 2006;117(1):e1-e7. **(Clinical prediction model; 175 children)**
110. Garro AC, Rutman M, Simonsen K, et al. Prospective validation of a clinical prediction model for Lyme meningitis in children. *Pediatrics*. 2009;123(5):e829-e834. **(Prospective validation study; 50 children)**
111. Glaser C, Christie L, Bloch KC. Rickettsial and ehrlichial infections. *Handb Clin Neurol*. 2010;96:143-158. **(Textbook)**
112. Buckingham SC, Marshall GS, Schutze GE, et al. Clinical and laboratory features, hospital course, and outcome of Rocky Mountain spotted fever in children. *J Pediatr*. 2007;150(2):180-184. **(Retrospective review; 92 patients)**
113. Shah RG, Sood SK. Clinical approach to known and emerging tick-borne infections other than Lyme disease. *Curr Opin Pediatr*. 2013;25(3):407-418. **(Review article)**
114. Gofton TE, Young GB. Sepsis-associated encephalopathy. *Nat Rev Neurol*. 2012;8(10):557-566. **(Review article)**
115. Bergeron MF. Reducing sports heat illness risk. *Pediatr Rev*. 2013;34(6):270-279. **(Review article)**
116. Centers for Disease Control and Prevention. Hypothermia-related deaths--United States, 2003-2004. *MMWR Morb Mortal Wkly Rep*. 2005;54(7):173-175. **(Epidemiological report)**
117. Anyaegbu E, Goodman M, Ahn SY, et al. Acute intermittent porphyria: a diagnostic challenge. *J Child Neurol*. 2012;27(7):917-921. **(Case report)**
118. Puy H, Gouya L, Deybach JC. Porphyrins. *Lancet*. 2010;375(9718):924-937. **(Review article)**
119. Punja M, Pomerleau AC, Devlin JJ, et al. Anti-N-methyl-D-aspartate receptor (anti-NMDAR) encephalitis: an etiology worth considering in the differential diagnosis of delirium. *Clin Toxicol (Phila)*. 2013;51(8):794-797. **(Report of 2 cases)**
120. DeSena AD, Greenberg BM, Graves D. Three phenotypes of anti-N-methyl-D-aspartate receptor antibody encephalitis in children: prevalence of symptoms and prognosis. *Pediatr Neurol*. 2014;51(4):542-549. **(Report of 8 cases and literature review)**
121. Reilly C, Menlove L, Fenton V, et al. Psychogenic nonepileptic seizures in children: a review. *Epilepsia*. 2013;54(10):1715-1724. **(Seminal article)**
122. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. *Lancet*. 1974;2(7872):81-84. **(Seminal article)**

123. Reilly PL, Simpson DA, Sprod R, et al. Assessing the conscious level in infants and young children: a paediatric version of the Glasgow Coma Scale. *Childs Nerv Syst.* 1988;4(1):30-33. **(Literature review)**
124. James HE, Anas NG, Perkin RM, eds. *Brain Insults in Infants and Children: Pathophysiology and Management.* New York: Grune & Stratton; 1985. **(Textbook)**
125. Chabali R. Diagnostic use of anion and osmolal gaps in pediatric emergency medicine. *Pediatr Emerg Care.* 1997;13(3):204-210. **(Review article; 2 case reports)**
126. Yock-Corrales A, Barnett P. The role of imaging studies for evaluation of stroke in children. *Pediatr Emerg Care.* 2011;27(10):966-974. **(Review article)**
127. Hunter JV, Morriss MC. Neuroimaging of central nervous system infections. *Semin Pediatr Infect Dis.* 2003;14(2):140-164. **(Review article)**
128. Elbers J, Wainwright MS, Amlie-Lefond C. The Pediatric Stroke Code: early management of the child with stroke. *J Pediatr.* 2015;167(1):19-24.e1-4. **(Review article)**
129. Barnette AR, Horbar JD, Soll RF, et al. Neuroimaging in the evaluation of neonatal encephalopathy. *Pediatrics.* 2014;133(6):e1508-e1517. **(International multicenter database study; 4171 infants enrolled)**
130. Boyle TP, Paldino MJ, Kimia AA, et al. Comparison of rapid cranial MRI to CT for ventricular shunt malfunction. *Pediatrics.* 2014;134(1):e47-e54. **(Retrospective cohort study; 698 ED visits for 286 unique patients)**
131. Kim I, Torrey SB, Milla SS, et al. Benefits of brain magnetic resonance imaging over computed tomography in children requiring emergency evaluation of ventriculoperitoneal shunt malfunction: reducing lifetime attributable risk of cancer. *Pediatr Emerg Care.* 2015;31(4):239-242. **(Retrospective case series; 365 patients)**
132. Guse SE, Neuman MI, O'Brien M, et al. Implementing a guideline to improve management of syncope in the emergency department. *Pediatrics.* 2014;134(5):e1413-e1421. **(Quasi-experimental study; 349 children)**
133. Lapus RM. Activated charcoal for pediatric poisonings: the universal antidote? *Curr Opin Pediatr.* 2007;19(2):216-222. **(Review article)**
134. Chyka PA, Seger D, Krenzelok EP, et al. Position paper: Single-dose activated charcoal. *Clin Toxicol (Phila).* 2005;43(2):61-87. **(Position paper)**
135. American Academy of Clinical Toxicology; European Association of Poison Centres and Clinical Toxicologists. Position statement and practice guidelines on the use of multi-dose activated charcoal in the treatment of acute poisoning. *J Toxicol Clin Toxicol.* 1999;37(6):731-751. **(Position statement)**
136. American Academy of Pediatrics Committee on Drugs: naloxone dosage and route of administration for infants and children: addendum to emergency drug doses for infants and children. *Pediatrics.* 1990;86(3):484-485. **(Addendum)**
137. Kreshak AA, Tomaszewski CA, Clark RF, et al. Flumazenil administration in poisoned pediatric patients. *Pediatr Emerg Care.* 2012;28(5):448-450. **(Retrospective cohort study; 83 patients)**
138. Lexi-Comp Online™. Pediatric & Neonatal Lexi-Drugs Online™, Hudson, Ohio: Lexi-Comp, Inc. November 22, 2015. **(Reference manual)**
139. Dhossche DM, Wachtel LE. Catatonia is hidden in plain sight among different pediatric disorders: a review article. *Pediatr Neurol.* 2010;43(5):307-315. **(Review article)**
140. Watts W, Edge JA. How can cerebral edema during treatment of diabetic ketoacidosis be avoided? *Pediatr Diabetes.* 2014;15(4):271-276. **(Review article)**
141. Zeitler P, Haqq A, Rosenbloom A, et al. Hyperglycemic hyperosmolar syndrome in children: pathophysiological considerations and suggested guidelines for treatment. *J Pediatr.* 2011;158(1):9-14, 14.e11-2. **(Guidelines)**
142. Adelman RD, Coppo R, Dillon MJ. The emergency management of severe hypertension. *Pediatr Nephrol.* 2000;14(5):422-427. **(Review article)**
143. Baracco R, Mattoo TK. Pediatric hypertensive emergencies. *Curr Hypertens Rep.* 2014;16(8):456. **(Review article)**
144. Bergmann KR, McCabe J, Smith TR, et al. Late-onset ornithine transcarbamylase deficiency: treatment and outcome of hyperammonemic crisis. *Pediatrics.* 2014;133(4):e1072-e1076. **(Case report)**
145. Claudius I, Fluharty C, Boles R. The emergency department approach to newborn and childhood metabolic crisis. *Emerg Med Clin North Am.* 2005;23(3):843-883, x. **(Review article)**
146. Summar M. Current strategies for the management of neonatal urea cycle disorders. *J Pediatr.* 2001;138(1 Suppl):S30-S39. **(Review article)**
147. Batshaw ML, MacArthur RB, Tuchman M. Alternative pathway therapy for urea cycle disorders: twenty years later. *J Pediatr.* 2001;138(1 Suppl):S46-S54. **(Review article)**
148. Cochran JB, Losek JD. Acute liver failure in children. *Pediatr Emerg Care.* 2007;23(2):129-135. **(Review article)**
149. Jackson BF, Porcher FK, Zapton DT, et al. Cerebral sinovenous thrombosis in children: diagnosis and treatment. *Pediatr Emerg Care.* 2011;27(9):874-880. **(Review article)**
150. Wasay M, Dai AI, Ansari M, et al. Cerebral venous sinus thrombosis in children: a multicenter cohort from the United States. *J Child Neurol.* 2008;23(1):26-31. **(Retrospective study; 70 children)**
151. Xiao HY, Wang YX, Xu TD, et al. Evaluation and treatment of altered mental status patients in the emergency department: life in the fast lane. *World J Emerg Med.* 2012;3(4):270-277. **(Prospective observational cohort study; 1934 patients)**

## CME Questions



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1. Late on a cold winter night, 3 children are brought to the ED with the chief complaint of altered level of consciousness (ALOC). Another child was pronounced dead at the scene. The 3 children are comatose upon arrival. History reveals that they were all well prior to presentation. Which of the following is the most likely etiology of the symptoms?
  - a. Codeine
  - b. Carbon monoxide
  - c. Propionic acidemia
  - d. Hyponatremia
  - e. Hypoglycemia
  
2. A 17-year-old adolescent girl with ALOC is brought to the ED from a rave party. Her friends said that she received some pills from an acquaintance and, after taking them, she became agitated and began to sweat. In the ED, her vital signs are: temperature, 38°C; heart rate, 130 beats/min; respiratory rate, 24 breaths/min; and blood pressure, 150/90 mm Hg. The girl's pupils are dilated and she is diaphoretic. What is the most likely cause of her symptoms?
  - a. Gamma hydroxybutyrate
  - b. Fentanyl
  - c. Toxic mushrooms
  - d. Ecstasy
  - e. Jimson weed
  
3. A 15-year-old boy is brought to the ED for ALOC by emergency medical services. The boy works on his father's farm every afternoon, and he has had vomiting and diarrhea for the last few hours. In the ED, he is diaphoretic, drooling, and tearing. His pupils are constricted. The most likely cause of his symptoms is:
  - a. Imipramine overdose
  - b. Jimson weed ingestion
  - c. Toxic mushroom ingestion
  - d. Ketamine ingestion
  - e. Insecticide exposure
  
4. A 12-year-old girl presents to the ED with ALOC. She was doing homework at home when she complained of a headache and then suddenly became altered. She had no preceding trauma or fever, and is an otherwise healthy child. What is the most likely cause of her symptoms?
  - a. Meningitis
  - b. Encephalitis
  - c. Arteriovenous malformation rupture
  - d. Intracranial abscess
  - e. Astrocytoma
  
5. An 8-month-old boy is brought to the ED for lethargy. Over the last 3 days, he has had recurrent episodes of crying, flexing his hips and knees. His mother states that his stool seems slightly bloody. He has not had fever, and does not currently have an episode. His examination is normal except for mild tenderness and fullness of his abdomen. The most likely cause of this patient's lethargy is:
  - a. Meckel diverticulum
  - b. Intussusception
  - c. Botulism
  - d. Meningitis
  - e. Septic arthritis
  
6. A 7-year-old girl with astrocytoma presents with ALOC. She underwent cranial surgery 1 month ago and she is currently undergoing chemotherapy. She is afebrile and her physical examination is otherwise normal. You obtain a brain CT scan, which shows no new changes from her brain imaging done postoperatively. Which of the following causes is the most likely cause of her ALOC?
  - a. Ondansetron
  - b. Vincristine
  - c. Polyethylene glycol
  - d. Diazepam
  - e. Morphine sulfate
  
7. A 7-week-old infant is brought to the ED for high fever and lethargy. The results from his cerebrospinal fluid tests show an elevated white blood cell count, normal red blood cell count, elevated protein, and decreased glucose. Which of the following organisms is the most likely etiology of this patient's condition?
  - a. Group B *Streptococcus*
  - b. *Listeria monocytogenes*
  - c. *Neisseria meningitidis*
  - d. Lyme disease
  - e. Ehrlichiosis
  
8. A 1-month-old infant was brought to the ED for concerns of ALOC. He is sleeping through the night and requires his parents to wake him to feed. On examination, he is difficult to arouse, but his examination is otherwise normal. One of the first laboratory evaluations you should obtain for this patient is:
  - a. Point-of-care glucose level
  - b. Serum ammonia level
  - c. Complete blood cell count
  - d. Comprehensive metabolic panel
  - e. Urine toxicology screen

9. A 4-month-old boy is being transferred to your medical center for further care. He had been fed diluted apple juice for the last 3 days. He has been lethargic, has had decreased urine output, and no tears. He was found to have a sodium level of 121 mEq/L and was given hypertonic saline to correct his sodium deficit. He is at risk for developing:
- Renal failure
  - Dysrhythmia
  - Increased intracranial pressure
  - Central pontine myelinolysis
  - Intussusception

10. A 5-year-old boy presented to the ED with ALOC. The parents say he has a metabolic disorder, but cannot name the specific condition. He has been vomiting for 2 days, and he appears lethargic on examination. His vital signs are: temperature, 37°C; heart rate, 120 beats/min; respiratory rate, 26 breaths/min; blood pressure, 110/70 mm Hg; oxygen saturation, 99% on room air. His airway is intact, and his breaths are equal and adequate. The most important next step in treatment should be administration of:
- Sodium phenylacetate IV
  - Sodium benzoate IV
  - Dextrose 10% IV at 1.5 times maintenance rate
  - Ceftriaxone IV
  - Oxygen via nonrebreather mask

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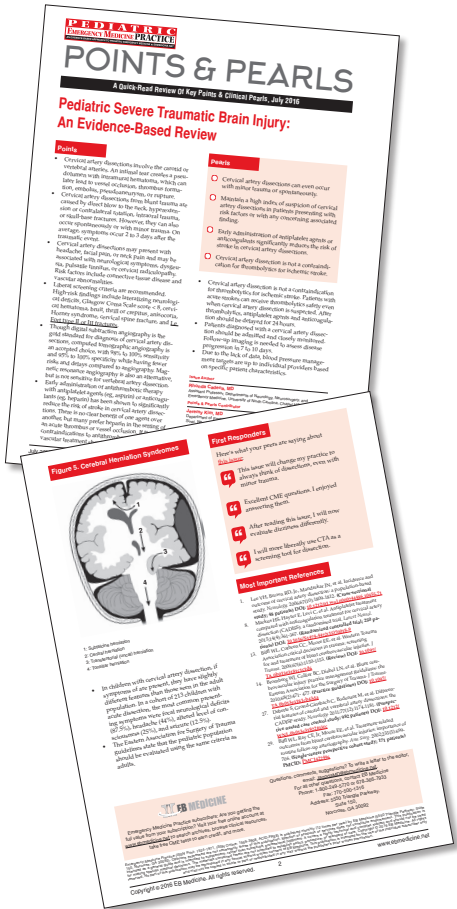
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