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Pediatric Foreign Body Ingestions

I started my emergency medicine practice prior to the widespread availability of pediatric-sized fiberoptic endoscopes. At that time, esophagoscopy using rigid endoscopes was a therapeutic option, but the availability of trained practitioners was limited in many communities. I remember with vivid detail wrapping the toddler in the papoose board, passing the Foley catheter through the nose, turning the child face down with the head lower than the feet, then inflating the Foley balloon and pulling it down the nose in an effort to extract the impacted object. It often took several passages, but was usually successful. But the experience was traumatic for all involved.

During that period, the impacted objects in the esophagus were coins, and we did not see button battery ingestions. If we had, then the Foley catheter extraction technique might have been dangerous. Fortunately, retrieval techniques have dramatically improved and such procedures are rarely necessary. But the increased availability of button batteries makes it important to identify and localize ingested foreign bodies. This article provides a comprehensive review of pediatric foreign body ingestions.

— J. Stephan Stapczynski, MD, Editor

This article is adapted from one that originally appeared in the November 2012 issue of Pediatric Emergency Medicine Reports.

Case Scenario

A 15-month-old presents to the emergency department for difficulty feeding and irritability. The child was noted to be unwell appearing, drooling, and sitting up and leaning forward. Vital signs were notable for tachypnea and tachycardia. The mother reported a symptom duration of about 12 hours and said the child had been well prior to that time. The radiograph of the patient is shown in Figure 1.

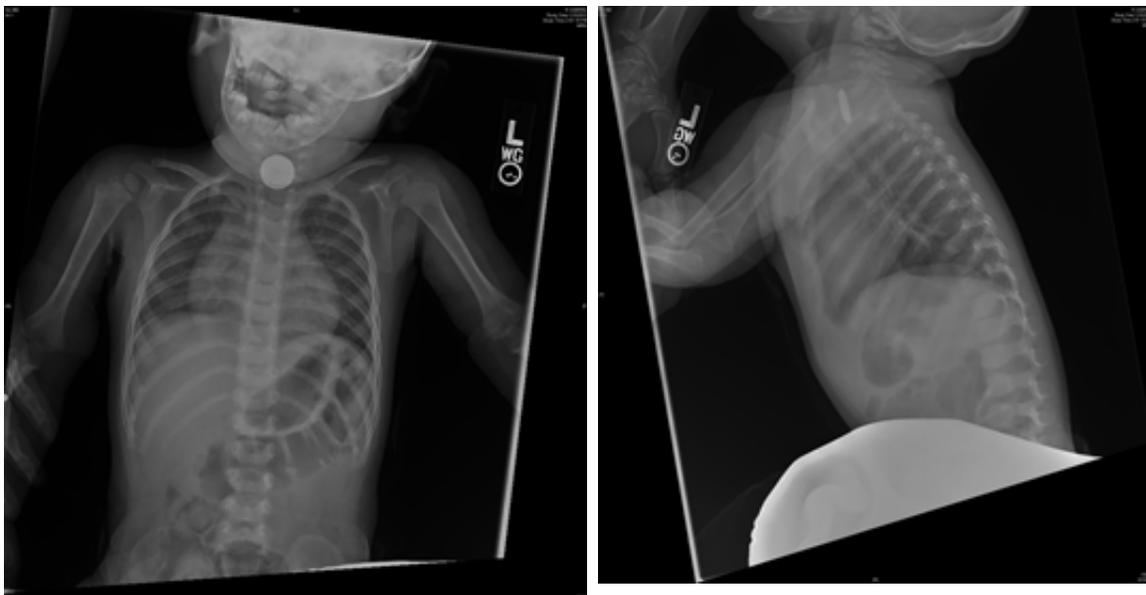
Introduction

The ingestion of foreign bodies by children is a common problem, with an estimated 86,426 cases reported to poison control centers in 2010.¹ The exact incidence of the problem is unknown and is likely much greater than reported. The great majority of these cases occur in children between 6 months and 3 years of age, and the most common ingested object in the United States is a coin. Thankfully, most cases result in uneventful outcomes, with either the spontaneous passage of the object or prompt removal by a physician. However, there exists the potential for serious complications and even death if managed incorrectly. Associated morbidity is estimated at less than 1%, with an average of 1500 deaths per year.² Complications include perforation, fistula, stricture, mediastinitis, and exsanguination. There has been a great deal of literature on this topic and varying guidelines regarding methods of removal and criteria for doing so. Despite this, management has remained relatively unchanged, with most guidelines supporting a short period of observation for benign objects in asymptomatic patients and early endoscopic removal for caustic items,

Executive Summary

- The most common location for pediatric obstructions is the criocopharyngeus.
- Objects in the esophagus have spontaneous passage rates of 28% in children without pre-existing esophageal disease.
- Once objects pass into the stomach, 90% will complete their course without complications, and the majority of objects pass within 4 to 6 days.
- Objects larger than 2 cm in diameter or longer than 5 cm (or a length greater than 3 cm in infants) typically require GI consultation and endoscopic removal due to the higher potential for obstruction at the pylorus, duodenal sweep, or ileocecal valve.
- As a general rule, a button battery in the esophagus is an emergency and should be removed immediately, regardless of whether or not the child is symptomatic.

Figure 1. Radiograph of 15-month-old Child



AP and lateral views

Images courtesy of Stanford Hospital and Clinics Emergency Department

prolonged impaction, or symptomatic patients.

Pathophysiology

Foreign body ingestion is largely a problem of childhood. Younger children are more likely to ingest foreign bodies as part of normal developmental “exploratory behavior,” with 80% of cases occurring in children, commonly between the ages of 6 months and 3 years.³ The great majority of these cases result in uneventful outcomes, as the object passes spontaneously and without harm through the gastrointestinal

tract. In the pre-endoscopy era, 93-99% of blunt foreign bodies would pass spontaneously through the GI tract and only 1% of cases required surgery. Today, 10-20% of patients undergo endoscopy, with 1% undergoing surgical management.⁴ Children with developmental delays and psychiatric disorders are more likely to ingest foreign bodies, and those children with pre-existing esophageal disease such as eosinophilic esophagitis or stricture are at higher risk of subsequent complications.

Children ingest a variety of objects

from simple coins to more dangerous items such as magnets, button batteries, and needles. It is estimated that coins make up 31-46% of all ingestions, the most common of which is the penny.^{5,6} Other common objects include small toys, needles, pins, batteries, jewelry, magnets, bones, and food boluses (most commonly meat).

Button batteries are a unique subcategory of foreign body and made up 13% of all ingestions in one study.⁷ Early recognition of these objects is crucial in the appropriate management of affected children,

as they cannot be simply observed, as is the case in many other types of ingestions. Due to unique mechanisms of injury involving pressure necrosis, hydrolysis, and liquefaction necrosis, both button batteries and magnets carry greater morbidity and mortality and should prompt consideration of immediate removal. The narrow end of a button battery, known as the “anode” or negative terminal, is the location at which tissue damage occurs. Hydroxide ions build up, resulting in a chemical burn on surrounding structures. This can be remembered as “narrow-negative-necrotic.” It is also worth noting that certain button batteries carry greater risk than others. According to Litovitz et al, while the number of button battery ingestions has remained relatively constant during the past 20 years, there has been a 6.7-fold increase in the number of major and fatal outcomes associated with these ingestions. The authors identified a correlation between major outcomes and an increase in the number of 20- to 25-mm-diameter cell batteries, as well as an increase in the number of lithium battery ingestions.⁸ It is suggested that lithium is a particularly harmful substance, as it has the potential to carry a much higher current than other metals and, thus, cause greater damage.

While most gastrointestinal foreign bodies pass spontaneously, at times this natural progression can be interrupted, leading to an object lodged in the gastrointestinal tract.

Common sites of obstruction include the proximal esophagus at the level of the cricopharyngeus muscle (in line with the clavicles on X-ray, also known as the thoracic inlet), the mid-esophagus at the level of the aortic arch (at the carina on X-ray), the lower esophageal sphincter (2-4 vertebral levels above the gastric bubble on X-ray), the pylorus, and the ileocecal valve. Of these, the most common location for pediatric obstructions is the cricopharyngeus, which accounted for up to 77% of esophageal foreign body obstructions in one study.⁹

Figure 2. Common Locations for Esophageal Foreign Body Obstruction in Children

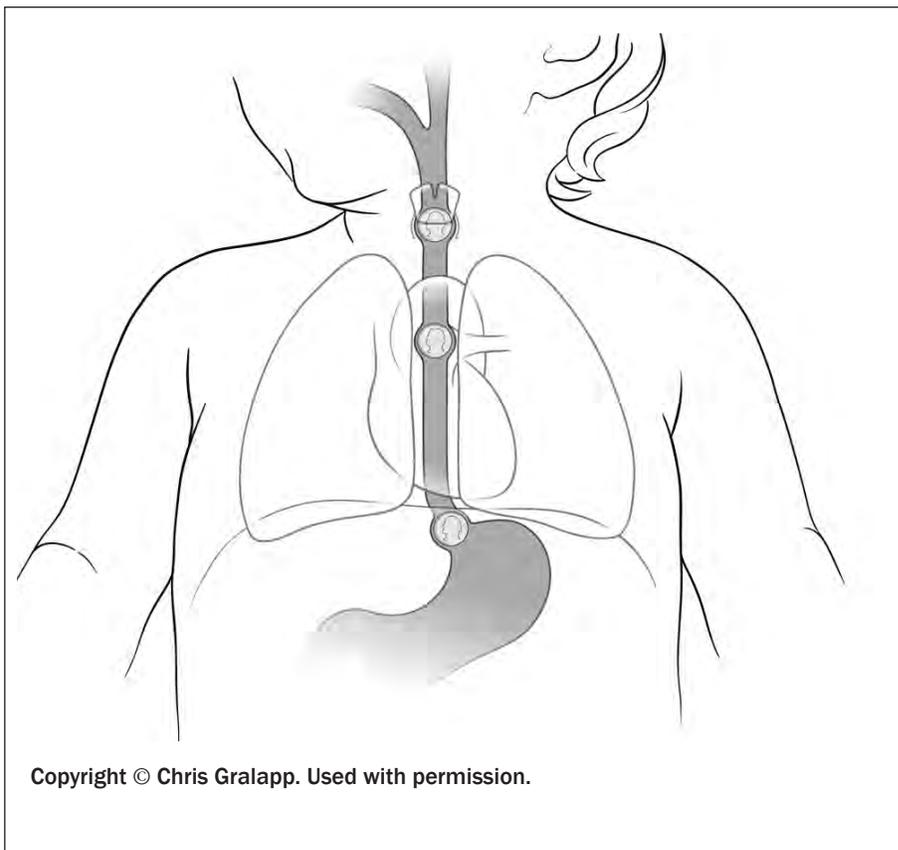


Table 1. Symptoms of Esophageal Foreign Bodies

- Drooling
- Vomiting
- Regurgitation
- Respiratory symptoms: coughing/choking/stridor/tachypnea
- Dysphagia/odynophagia
- Poor feeding/food refusal
- Fever
- Foreign body sensation
- Gagging
- Irritability
- Pain in neck, throat, or chest

Adapted from: Uyemura, M. Foreign body ingestion in children. *Am Fam Physician* 2005;72:287.

Objects in the esophagus have been noted to have spontaneous passage rates of 28% in children without preexisting esophageal disease.¹⁰

There is a greater likelihood of spontaneous passage if the object is located in the distal esophagus. Waltzman et al found that up to

Figure 3. A Game Piece in the Esophagus of a Child



A playing piece from the game Monopoly in the esophagus of a child
Image courtesy of Stanford Hospital and Clinics, Emergency Department

56% of objects in the lower third of the esophagus would pass spontaneously within 16 hours, compared to 23-30% for objects higher up. Spontaneous passage was also noted to be more likely in males and older children.¹¹ (See Figure 2.)

Once objects pass into the stomach, 90% will complete their course without complications. The majority of objects pass within 4 to 6 days, but some may take up to 4 weeks.⁴ Objects larger than 2 cm in diameter or longer than 5 cm (or a length greater than 3 cm in infants) are exceptions. They typically require GI consultation and endoscopic removal due to the higher potential for obstruction at the pylorus, duodenal sweep, or ileocecal valve.⁴

History and Physical

Because the potential complications of a retained foreign body can

be quite severe, prompt diagnosis and appropriate management are essential. However, this is made difficult by the fact that, in a substantial number of cases, patients are asymptomatic and ingestions were unwitnessed. The physician, therefore, must always consider the possibility of a foreign body ingestion in a child with “sore throat,” dysphagia, increased secretions, and drooling, especially if the child is ill-appearing. Studies have shown anywhere from 7% to 64% of patients with esophageal foreign bodies are asymptomatic at the time of presentation.^{5,12} Furthermore, anywhere from 8% to 40% of foreign body ingestions are unwitnessed.^{4,6} And while the age range of 6 months to 5 years represents both the innate curiosity of young children and the development of a pincer grasp, foreign body ingestions can occur even

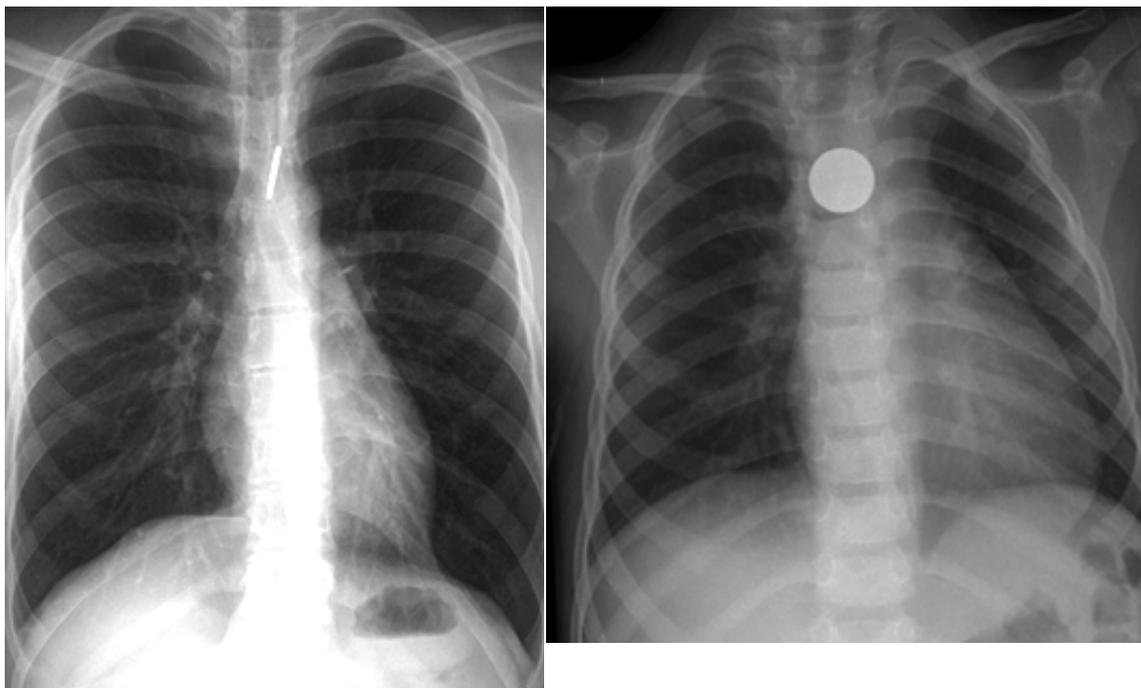
in children younger than 6 months of age. In such cases, it is often an older sibling who is responsible for “administering” the foreign body. Children with development delay and pre-existing esophageal disease are at a higher risk for foreign body ingestion and subsequent complications, and a higher index of suspicion should be maintained in these patients.

For those patients who are symptomatic, the most common presenting symptoms are vomiting and regurgitation.⁹ Other symptoms include dysphagia, odynophagia, drooling, respiratory symptoms, pain in the throat, neck, or chest, or foreign body sensation. (See Table I.) Patients with unwitnessed ingestions and no initial symptoms, or those who were not appropriately diagnosed and treated at the time of initial presentation, may go on to develop “chronic” foreign body, defined as an object retained for greater than 7 days. These children are more likely to have respiratory symptoms at the time of presentation due to trachea compression or esophageal erosion. A study by Miller et al looked at 41 cases of chronic foreign body and found that 76% of patients presented with respiratory symptoms, including respiratory distress, asthma-like symptoms, and cough.¹³ Respiratory symptoms typically stem from the compression on the trachea from a neighboring foreign body against the posterior wall of the airway (which is not protected by tracheal rings). This can often confuse the picture when it is unclear whether a child aspirated or ingested the object in question.

Differential Diagnosis

Although the differential for an ill-appearing child is broad, in the appropriate clinical setting, foreign body ingestion should always be on the differential diagnosis for any ill-appearing or septic child without an obvious source. Perhaps the greatest diagnostic error is failing to have foreign body on the differential in the septic child who presents

Figure 4. Sagittally Oriented Coin



A rare view of sagittally oriented coin in the esophagus (left), a more classic radiograph of an esophageal coin seen en face (right).

Reprinted with permission from the *American Journal of Roentgenology*. Schlesinger A, Crowe JE. Sagittal orientation of ingested coins in the esophagus in children. *AJR* 2011;196:670-672.

without a clear source of infection. In a study of button battery ingestions, 27% of the major outcome cases and 54% of the fatal cases were misdiagnosed, usually because of the non-specificity of presenting symptoms and no history of a foreign body ingestion.⁸

Diagnosics

In any child in whom a foreign body is suspected, a diagnostic evaluation, including radiographs, should be conducted. Both PA and lateral views of the chest and neck should be obtained. Even in cases where caregivers are certain a child ingested a particular, seemingly benign object, the physician may be surprised to find either multiple objects or an object the parents never suspected the child of ingesting. In one case, parents were convinced a child had ingested a small plastic house from the game of Monopoly. The

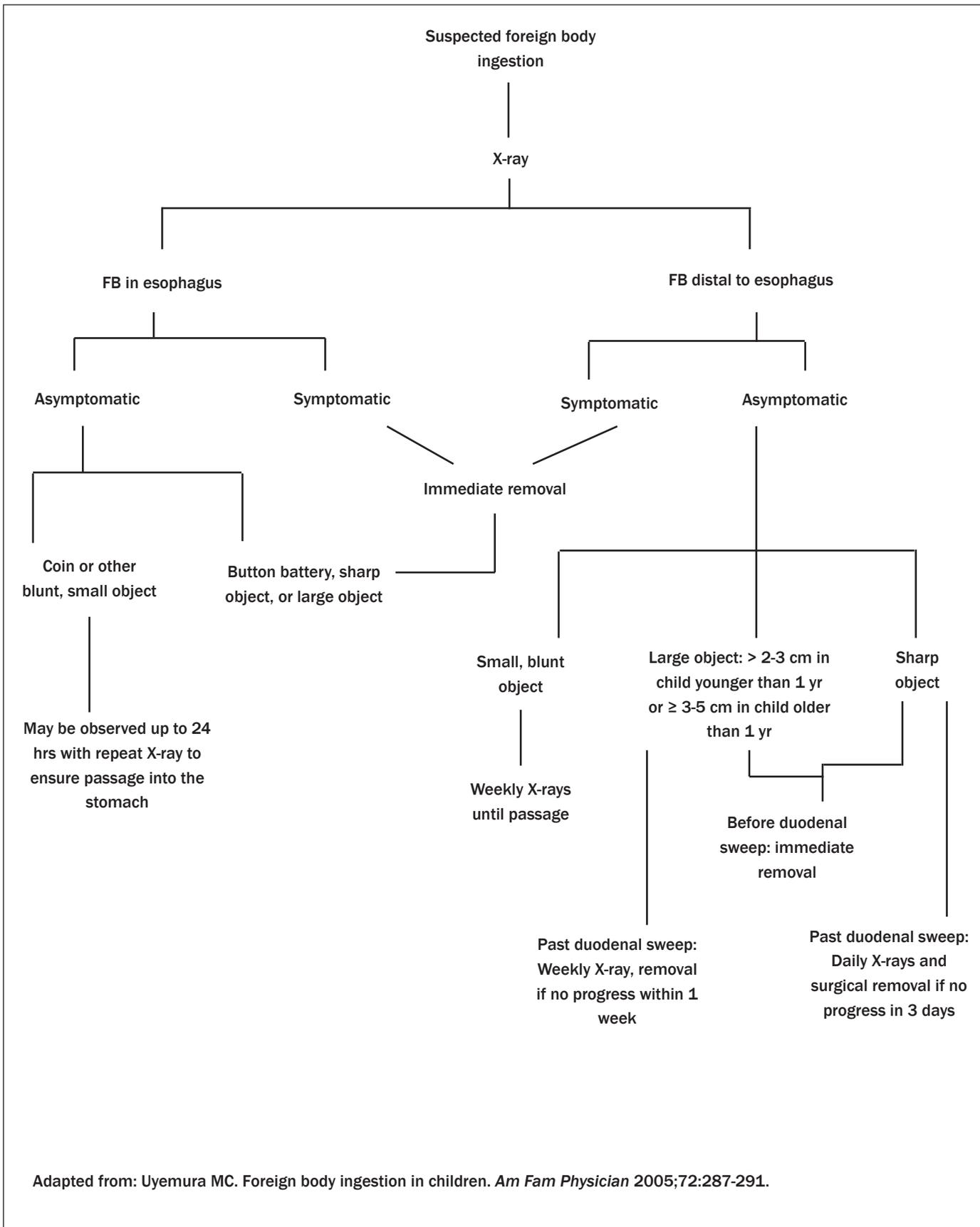
radiograph instead showed the image in Figure 3.

As a general rule, coins that appear “en face” on the PA view are lodged in the esophagus, and coins with the edge alone showing are lodged in the trachea. This is considered to be due to the anatomy of the trachea, wherein the cartilaginous rings are not fully circumferential, forcing the coin into a perpendicular orientation. At times, this rule is not met, and esophageal coins may appear as though they are in the trachea on a PA view.⁸ (See *Figure 4*.) This is commonly seen when a coin is at the level of the aortic arch. To avoid misdiagnosis, a lateral view should also be obtained, as an esophageal foreign body will be seen posterior to the airway in this projection.

The value of X-ray in foreign body ingestions cannot be overstated. Many times, an X-ray will

show a foreign body in a completely asymptomatic child. Radiographs have the advantage of localizing an object and giving some characterizations of its size and shape. Button batteries have a unique appearance on X-ray, as is highlighted. (See *Figure 1*.) While coins will appear as a singular rectangular opacity on the lateral view, a button battery will have a subtle step-off, with the negative terminal diameter being somewhat smaller than the positive terminal’s diameter. On the PA view, a “double ring” can sometimes be seen representing this same step-off. Plain films of the entire GI tract, from the neck to the abdomen, should be done at the time of initial presentation. Follow-up studies are often done at various intervals (depending on the object and the initial location), in addition to caregiver monitoring of the stool for passage. Of note,

Figure 5. Treatment Algorithm for Foreign Body Ingestions in Children



Adapted from: Uyemura MC. Foreign body ingestion in children. *Am Fam Physician* 2005;72:287-291.

only 64% of foreign bodies are radiopaque and, thus, identifiable on X-ray. Therefore, if suspicion is high, further studies should be pursued.⁷ It is important for providers to remember that not all metals are radiopaque and common objects such as can pull-tabs and small toys may not show up on X-ray.

Hand-held metal detectors (HHMDs) have shown promise as a cost-effective, safe way of identifying and locating an ingested metallic foreign body. Unlike X-rays, they are able to identify aluminum objects, thus increasing their sensitivity.¹⁴ In one study of 172 patients, HHMDs were 100% sensitive and 92% specific for foreign body. They have the added advantage of being a tool that can be used by inexperienced operators (for example, in a triage situation). In the same study, HHMDs were 96% sensitive and 81% specific in the hands of inexperienced operators.¹⁵

Computed tomography can be used in patients with negative X-rays in whom suspicion remains high, as many items are not radiopaque. In addition, they provide more information in regard to the condition of surrounding structures in hospitals where endoscopy is not readily available.¹²

Endoscopy is the diagnostic and therapeutic modality of choice in patients who have ingested a dangerous object such as a button battery or sharp item, in whom both removal and local inspection of surrounding tissues is desired. In addition, in patients who have had resolution of foreign body but continue to be symptomatic, endoscopy is warranted for inspection of local structures. Two types of endoscopy are available, both flexible and rigid. Both methods are safe and effective; however, rigid endoscopy is generally considered to be better at visualizing the upper cervical esophagus.¹⁶ It does, however, have the disadvantage of requiring general anesthesia and having a greater risk of perforation. Flexible endoscopy has the advantage of visualizing as far distal as the duodenum, can be done under simple

sedation, and has a lower complication rate.

In addition to imaging, laboratory evaluation including a CBC and septic work-up in an unwell-appearing child should be pursued. Pediatric ENT or GI consultation should be obtained early and, if the child presents to a hospital where urgent endoscopy is unavailable, transfer to a higher level of care should be arranged.

Management

Given that a certain percentage of gastrointestinal foreign bodies will pass spontaneously, the physician first must decide whether a foreign body warrants intervention. Endoscopic removal, while generally considered to be a safe procedure, does carry with it risks such as bleeding, infection, perforation, and complications associated with sedation or anesthesia and, therefore, should be avoided unless absolutely necessary.

Any child who is symptomatic at the time of presentation warrants consideration of urgent endoscopic removal. Indications for emergent removal are airway compromise, sepsis, and complete esophageal obstruction, which manifests as a child's inability to manage his or her secretions. In addition, button batteries in the esophagus, long or sharp objects, and multiple magnets should all be removed urgently. Damage from a button battery can occur in as few as 2 hours, and prompt removal is paramount. For those children who are asymptomatic, more conservative treatment options are available. (See Figure 5.) In children without any pre-existing esophageal disease who are asymptomatic at the time of presentation, an observation period up to 24 hours is appropriate, with a repeat radiograph in 12-24 hours.² Patients with reliable caregivers may be discharged home with follow-up and strict, time-specific return precautions. Caregivers should be instructed to return to the emergency department immediately if the child develops a

fever, is unable to tolerate food or liquids, or becomes symptomatic in any way. They should be instructed to monitor the child's stool for passage of the object. Furthermore, they should be told that if the coin does not pass in 24 hours from the time of ingestion, they should return to the primary care physician or emergency department for repeat radiographs.

Once the object has passed into the stomach, the asymptomatic child may be safely discharged, with repeat radiographs every week. There are two exceptions to this, namely considerably large or sharp objects located before the duodenal sweep. Objects greater than 2-3 cm in diameter in children younger than 1 year and objects greater than 3-5 cm in older children should be removed immediately, as should any sharp object. If these dangerous items are located distal to the duodenal sweep, serial radiographs may be done until passage is confirmed. For large objects, serial X-rays are done every 3-4 days and objects are removed if no progress is made within one week. For sharp objects, daily X-rays are done and the object is removed if no progress is made in 3 days.⁴

Button batteries are managed somewhat differently due to their higher potential for morbidity and mortality. The provider should first make an attempt to determine the type and size of the battery either by determining which device the battery came from or by having caregivers bring in the original packaging or matching battery. The code printed on the battery gives an idea as to the size and composition of the battery in question. The first letter indicates the composition of the anode, or negative terminal (with "C" referring to lithium, "L" indicates alkaline, and "S" indicates silver), and the second letter indicates the shape of the battery (with "R" standing for round). The trailing numbers refer to size, with the first one or two numbers indicating the battery diameter rounded up to millimeters, and the second

two numbers indicating the battery thickness or height. A CR2030 battery, for example, refers to a lithium battery that is 20 mm in diameter and 3.0 mm in height. This information helps guide management and predict prognosis.

As a general rule, a button battery in the esophagus is an emergency and should be removed immediately regardless of whether or not the child is symptomatic. An exception to this is a child older than 12 years who has ingested a battery known to be less than 12 mm in diameter. Provided these children are asymptomatic, have no pre-existing esophageal disease, and have reliable caregivers, they may be observed as outpatients. Caregivers should be instructed to inspect the stools for passage and, if no battery is seen in 10-14 days or if the child develops symptoms, a repeat X-ray should be done.⁸

Removal

Button Batteries. For batteries in the stomach, asymptomatic children may be observed, provided there was no magnet co-ingestion. For most situations, a repeat radiograph should be done in 10-14 days, or earlier if the child becomes symptomatic. However, in a child younger than 6 years of age who ingested a battery greater than 15 mm, a repeat X-ray should be obtained in 3 days. If the battery is still in the stomach, it should then be removed.⁸ If the true diameter of the battery is not known, the more conservative observation plan should be chosen. It is estimated that in 40% of battery ingestions, a definitive determination of battery diameter cannot be made.⁸

Options for Foreign Body Removal. Once the decision is made to remove the object in question, multiple treatment options are available. By and large, endoscopy is the mainstay of therapy and is readily available in many clinical settings. Other options include the use of Magill forceps, Foley balloon extraction, and esophageal bougienage. As mentioned previously, 1% of

cases will ultimately require surgical removal.

For objects located in the proximal esophagus, some authors have described a technique involving removal of the object using Magill forceps under direct visualization. Cetinkursun et al describe placing 164 children under general anesthesia (with mask ventilation), examining the upper esophagus using direct laryngoscopy, and removing coins. They reported a 96.4% success rate using this technique, with an average time to removal of 33 seconds. No complications were reported.¹⁷ Some authors have criticized this technique, given the potential for vomiting and laryngospasm with an unprotected airway. This risk can be mitigated by first endotracheally intubating the patient. Advantages of this technique are its high reported success rates and relative simplicity without the need for advanced equipment. Disadvantages are that it is only useful for objects in the upper esophagus and the potential for complications related to an unprotected airway.

Another technique described in the literature is esophageal bougienage. This technique involves passing a semi-rigid Hurst bougie dilator into the esophagus through the mouth and pushing the object into the stomach. This technique is reserved for small, smooth objects such as coins and is contraindicated in patients with pre-existing esophageal disease. A single pass alone is attempted. Traditionally, this procedure was described as safe when performed by surgeons. However, Emslander et al conducted a prospective study in which emergency medicine physicians performed the bougienage technique and concluded it was as safe and effective in the hands of non-surgeons with no observed complications.¹⁸ The advantages of this technique are its relative simplicity and cost-effectiveness. One study compared bougienage to traditional endoscopy and found that the average treatment time and cost of bougienage were

2 hours and \$1210, respectively. In comparison, endoscopy length of stay was estimated at 8 hours, with an average cost of \$3100.¹⁹

Foley balloon removal has also been described in the literature. It involves placing the patient in Trendelenberg position and passing a catheter past the foreign body under fluoroscopic guidance. The balloon is then inflated and the catheter is pulled back, dragging the object out of the esophagus. The advantage of this technique is it is also cost-effective, fast, and only requires simple equipment that is readily available in most emergency departments. However, once the object is pulled out of the esophagus, the proceduralist has little control over the object and it has the potential to then move into the airway. There has been at least one reported case of complete airway obstruction leading to death resulting from this technique.²

A newer method utilizes endoscopic forceps known as "penny pincers." Under fluoroscopic guidance, the device is advanced to the coin, grasps it, and then withdraws, maintaining control of the coin the entire time. This procedure can be performed without sedation and has been shown to be highly effective and efficient in multiple small studies, with an average treatment time of 41 seconds.^{2,20} The disadvantage is it requires a fairly specialized tool that may not be readily available in all clinical settings.

Finally, endoscopy is the mainstay of therapy used in 20-30% of patients. It has the distinct advantage of visualizing the surrounding structures and is, therefore, both diagnostic and therapeutic. The procedure requires general anesthesia or sedation and carries with it both the risks associated with sedation, as well as procedural risks of bleeding, bronchospasm, esophageal perforation, and mediastinal infection. It is also more expensive than the aforementioned techniques, requires greater resources, and is associated with longer lengths of stay.

Endoscopy can be done with

either a rigid or a flexible device, as mentioned previously. The most feared complication of the rigid approach is esophageal perforation, which has been noted in as much as 3.2% of cases.²¹ Many studies have shown similar success rates of both approaches for removing foreign bodies, with many authors suggesting flexible endoscopy should be the initial management choice. Advocates of flexible endoscopy report better visualization of esophageal mucosa, greater ease at biopsying, shorter treatment times, and faster recovery.²¹

Some pharmacologic agents have been described in the literature. Glucagon is the most common of these agents and has traditionally been used to relax the lower esophageal sphincter, thus allowing for passage of the item into the stomach. While there has been some evidence that this may be effective in adults (who typically have food bolus obstruction at the lower esophageal sphincter), similar results have not been found in children. In a placebo-controlled trial, the patients who received glucagon were shown to have a lower rate of spontaneous passage into the stomach than those who had received placebo, perhaps due to the fact that the majority of pediatric foreign bodies become obstructed at the level of the cricopharynx.²²

Corticosteroids, usually given intravenously, have been used, advocated, and studied to prevent permanent damage in patients with caustic esophageal injuries after alkali ingestions.²³ There is no evidence that steroids reduce damage or prevent complications from button batteries lodged in the esophagus.²⁴

In summary, there are multiple options available for the treatment of esophageal foreign bodies. The physician must consider the patient, the type of foreign body, the time of ingestion, and the resources available when deciding which technique is most appropriate. For any child who is ill-appearing or in whom esophageal damage or perforation is suspected, the only treatment options

that should be considered are endoscopy or surgery.

Complications

There is significant morbidity and mortality associated with foreign bodies retained in the esophagus. Complications can result from pressure necrosis, a sharp object perforating the mucosal wall, chemical irritation, and the extremely noxious tissue hydrolysis from a battery terminal. This can result in local tissue necrosis, perforation, mediastinitis, vocal cord paralysis (from damage to the recurrent laryngeal nerve), stricture, esophago-aortic fistula, and tracheoesophageal fistula. Ultimately, these can lead to sepsis, airway compromise, exsanguination, and death. The chance of complication is, in part, dependent upon the type of object ingested, with especially sharp, large, or noxious objects such as high-powered magnets and button batteries causing greater damage.

Button battery ingestions are unique in that they can cause local tissue damage in as little as two hours and, therefore, should prompt urgent removal. The mechanism of injury is a combination three factors, the primary of which is the generation of an electrical current at the battery's negative terminal, which hydrolyzes tissue. Liquefaction necrosis through leakage of alkaline material and local tissue pressure also contribute.¹ Multiple magnet ingestions have also been shown to be particularly problematic and have the potential for adhering two loops of bowel together and causing obstruction and pressure necrosis/perforation of local tissue.

Disposition

Many children who have a foreign body removed can be discharged home on the same day, provided there are no complications and the child is without any major symptoms. The parents should be instructed to follow-up with the child's primary care physician in two to three days to ensure that

the child has not developed symptoms that may portend an evolving complication. Parents should be given strict instructions to return to the emergency department if the child develops difficulty breathing, fever, dysphagia, speech changes, inability to tolerate secretions, or hemoptysis.

Case Conclusion

Upon identification of a button battery on radiographs, the ENT took the child to the operating room, and the button battery was retrieved. An injury was noted on the posterior esophagus with aortic pulsations. A femoral line was placed and the child was started on antibiotics and steroids. A CT angiogram was done, which showed no evidence of great vessel injury. The child was discharged home one week later and recovered well.

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Physician CME Questions

1. The peak incidence of foreign body ingestions occurs at which age?
 - A. 1-6 months
 - B. 6 months to 3 years
 - C. 2-5 years
 - D. 5-7 years
2. What percentage of pediatric foreign bodies ultimately require endoscopic removal?
 - A. less than 1%
 - B. 5-10%
 - C. 10-20%
 - D. 50-60%
3. What is the most common anatomical location at which a foreign body will become obstructed in the pediatric patient?
 - A. the tracheal bifurcation
 - B. the thoracic inlet
 - C. the level of the diaphragm
 - D. the ileocecal valve
4. Which of the following is *not* an indication for immediate endoscopic removal of a foreign body in the stomach?
 - A. sharp object
 - B. patient younger than 6 years of age, battery > 15 mm, and no movement in 3 days
 - C. magnet co-ingestion
 - D. an object greater than 12 mm
5. Glucagon is an effective medication for the passage of an esophageal foreign body in children.
 - A. true
 - B. false
6. Which terminal of a button battery causes local tissue necrosis?
 - A. negative
 - B. positive
7. Which battery size is associated with greatest morbidity and mortality?
 - A. 12 mm
 - B. 13 mm
 - C. 20 mm
 - D. 10 mm
8. Most gastrointestinal foreign bodies will pass spontaneously.
 - A. true
 - B. false
9. What is the appropriate management for a 2-year-old child who has a 6 cm long object distal to the duodenal sweep?
 - A. discharge home with follow-up as needed
 - B. discharge with a repeat radiograph in 3-4 days
 - C. urgent endoscopic removal
 - D. discharge with repeat radiograph in 1 day

Emergency Medicine Reports

CME Objectives

Upon completion of this educational activity, participants should be able to:

- recognize specific conditions in patients presenting to the emergency department;
- apply state-of-the-art diagnostic and therapeutic techniques to patients with the particular medical problems discussed in the publication;
- discuss the differential diagnosis of the particular medical problems discussed in the publication;
- explain both the likely and rare complications that may be associated with the particular medical problems discussed in the publication.

CME Instructions

HERE ARE THE STEPS YOU NEED TO TAKE TO EARN CREDIT FOR THIS ACTIVITY:

1. Read and study the activity, using the provided references for further research.
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3. Pass the online tests with a score of 100%; you will be allowed to answer the questions as many times as needed to achieve a score of 100%.
4. After successfully completing the last test of the semester, your browser will be automatically directed to the activity evaluation form, which you will submit online.
5. **Once the completed evaluation is received, a credit letter will be e-mailed to you instantly.** You will no longer have to wait to receive your credit letter.

10. What is the appropriate management of an asymptomatic, developmentally delayed 13-year-old boy who has ingested a single hearing aid battery (less than 12 mm), which is located in the stomach, and he has reliable caregivers?
- urgent ENT consultation for endoscopy
 - discharge home with repeat X-ray the following day
 - discharge home with repeat X-ray in 7 days
 - discharge home with repeat X-ray in 10 days

The New 2013 and 2014 TJC Patient Flow Standards for the ED and More

Tuesday, January 8, 2012
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- Explain the four hour rule on getting patients to their room when admitted.

Patient flow is a hospital issue that has a major impact on the emergency department and other temporary locations and is a critical component of TJC surveys. Register today to make sure you and your staff are ready when TJC comes calling.

Presenter: Sue Dill Calloway, R.N., M.S.N, J.D., is a nurse attorney and President of Patient Safety and Healthcare Consulting and Education

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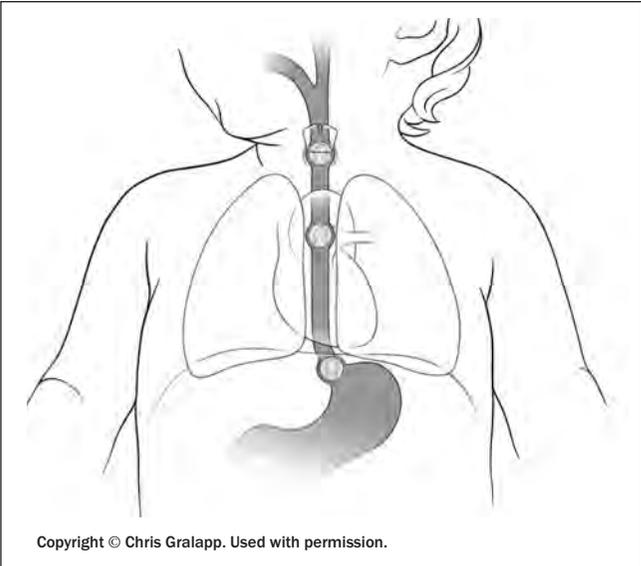
Pediatric Foreign Body Ingestions

Radiograph of 15-month-old Child



AP and lateral views
Images courtesy of Stanford Hospital and Clinics Emergency Department

Common Locations for Esophageal Foreign Body Obstruction in Children



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Symptoms of Esophageal Foreign Bodies

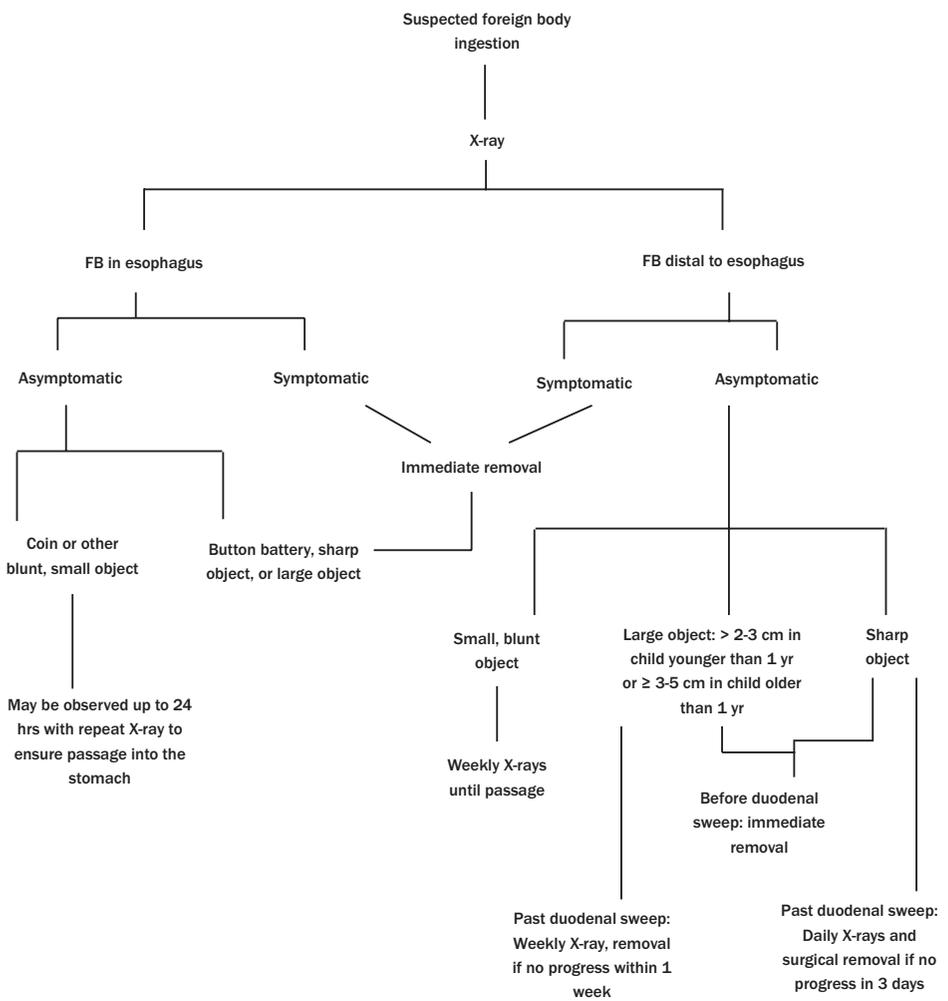
- Drooling
 - Vomiting
 - Regurgitation
 - Respiratory symptoms: coughing/choking/stridor/tachypnea
 - Dysphagia/odynophagia
 - Poor feeding/food refusal
 - Fever
 - Foreign body sensation
 - Gagging
 - Irritability
 - Pain in neck, throat, or chest
- Adapted from: Uyemura, M. Foreign body ingestion in children. *Am Fam Physician* 2005;72:287.

A Game Piece in the Esophagus of a Child



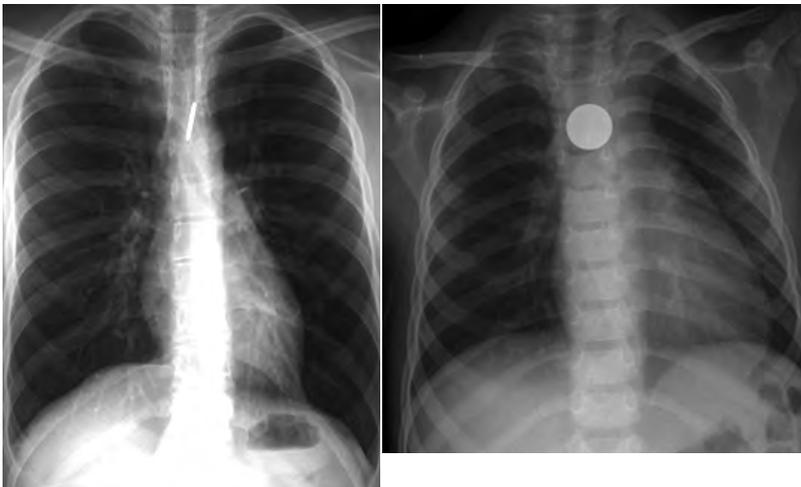
A playing piece from the game Monopoly in the esophagus of a child
Image courtesy of Stanford Hospital and Clinics, Emergency Department

Treatment Algorithm for Foreign Body Ingestions in Children



Adapted from: Uyemura MC. Foreign body ingestion in children. *Am Fam Physician* 2005;72:287-291.

Sagittally Oriented Coin



A rare view of sagittally oriented coin in the esophagus (left), a more classic radiograph of an esophageal coin seen en face (right).

Reprinted with permission from the *American Journal of Roentgenology*. Schlesinger A, Crowe JE. Sagittal orientation of ingested coins in the esophagus in children. *AJR* 2011;196:670-672.

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An Update on Spinal Cord Injury: Epidemiology, Diagnosis, and Treatment for the Emergency Physician

A spinal cord injury can be devastating. The National Spinal Cord Injury Statistical Center (NSCISC) has been collecting epidemiologic data on spinal cord injury (SCI) for nearly 40 years and has been able to provide the public and medical community with information on the evolution of SCI, including demographics, injury patterns, long-term prognosis, and socioeconomic impacts. There have been some interesting trends and significant changes to the data as time, technology, and culture have progressed. According to the NSCISC website, as of 2011, there are approximately 12,000 new cases of SCI annually. This figure does not include those who die from their injuries at the scene. It is believed that there are as many as 316,000 people currently living with SCI in the United States.¹ This article will provide an update of the recent literature and standard of care in the diagnosis and treatment of acute SCI.

— Ann M. Dietrich, MD, Editor

Epidemiology

When data collected from the early 1970s are compared to current information, general trends are noted in age at time of injury and racial/ethnic distribution of SCI. In the early 1970s, SCI was a disease of young, Caucasian males with an average age in the late 20s, and close to 70% of those affected by SCI were Caucasian, with 14% and 0.9% affecting African Americans and Asians, respectively. Since 2005, the trends demonstrate an older population being affected, with the average age at time of injury approximately 40.7 years old, likely a reflection of the increasing age of society. An appreciable increase in the incidence of SCI in the African-American and Hispanic populations has also been observed, with African Americans now accounting for close to 27% and Hispanics for 8.3% of all SCI reported annually. These changes are likely a result of the general changes in the country's population, as well as improved referral, documentation, and reporting methods throughout the country.

Motor vehicle collisions (MVC) are persistently the most common cause of SCI and represent approximately 40.4% of all reported injuries. Falls (27.9%) are second to MVC, followed by violence (15.0%) and sporting injuries (8.0%). Interestingly, falls as an etiology of SCI appear to be increasing in prevalence, whereas sporting injuries are declining. As an etiology, violence peaked between 1990 and 1999 at a rate of 24.8%, but decreased in the following decade.

From a social perspective, approximately half of patients are married at the time of their injury. Compared to national averages, these marriages are only slightly more likely to end in divorce or separation. Those individuals who are not married at the time of injury are slightly less likely, overall, to get married. Close to 58% of people are employed at the time of their injury. Not surprisingly, at the end of their first year following injury, only approximately 11.6%

Executive Summary

- Since the injury to the cord is bilateral for anterior cord syndrome, the pattern of symptoms that accompanies this injury includes bilateral motor paralysis and loss of pinprick, temperature, and pain sensation below the level of injury. Since the posterior aspect of the cord is preserved, so is proprioception and vibratory sensation.
- Classic Brown-Séquard syndrome, in its purest form, is described as a loss of ipsilateral motor function, proprioception, vibratory and pressure sensation, and contralateral loss of temperature and pain sensation below the level of injury.
- Of all cord syndromes, Brown-Séquard syndrome has the best overall prognosis, with more than 80-90% of people recovering bowel and bladder function and more than 75% regaining their ambulatory status.
- The most common of all partial cord syndromes is central cord syndrome, which is distinguished from the other cord syndromes by the fact that the upper extremities are significantly more affected from the motor perspective than the lower extremities.

remain employed. Optimistically, this number increases to 35.2% after 20 years and holds steady for data collected after 30 years post-injury.

Spinal Cord Injury Model System Program

In the 1970s, the National Institute on Disability and Rehabilitation created the Spinal Cord Injury Model System Program through federally funded grants. The model systems are composed of 14 major medical institutions and three subcontracted facilities, which focus on the treatment of spinal cord injury, traumatic brain injury (TBI), and burn injury. The purpose is the collection of information and to conduct research surrounding the rehabilitation, long-term outcomes, and complications of SCI, TBI, and burn injuries, in addition to social aspects including health, wellness, and service delivery. Over the years, the model systems have provided a great deal of information about spinal cord injury, rehabilitation, and outcomes.²

Based on the 2011 National Spinal Cord Injury Database figures, the lifetime costs associated with SCI depend upon the severity/level of injury and the age at which the injury is sustained. The first year following the injury is always associated with a greater cost than subsequent years. It is estimated that a high quadriplegic (C1-C4) will expend approximately \$985,000 in the first year alone, followed by

approximately \$171,000 annually. Injuries occurring earlier in life at higher spinal cord levels require the most financial expense. High quadriplegia sustained at age 25 results in an estimated \$4.3 million lifetime expense, whereas the same injury sustained at age 50 is estimated to cost approximately \$2.4 million. Lower cervical SCI and SCI resulting in paraplegia, on average, cost less for both the first year of treatment as well as for lifetime associated cost. (See Table 1.)

Grading Scales

There are two well-known scales used to grade and prognosticate SCI. The Frankel scale was developed during World War I, but is less commonly used today. It is a basic scale that grades the SCI based on level and is used to evaluate functional recovery. There are five grades used in the Frankel scale, which essentially divide complete versus incomplete spinal injuries as follows:

- A — complete paralysis (no motor/sensory below level of injury);
- B — sensory present below level of injury;
- C — incomplete injury with motor and sensory function below level of injury;
- D — fair to good motor function below level of injury; and
- E — normal function (no motor or sensory deficit).³

The American Spinal Injury

Association (ASIA) Impairment Scale (AIS) is a more widely used and more refined scale. Based on the Frankel scale's five grading levels, the AIS was originally developed in 1982 and has undergone six revisions, with the most recent occurring in 2002. The AIS differs from the Frankel scale in that it more clearly defines complete and incomplete injury by determining sacral sparing (presence of rectal motor function or sensory function at S4-S5 dermatome), determining the presence of neurologic level of injury using sensory and motor evaluation in bilateral extremities, and by determining, in incomplete injuries, where partial zones of sensory or motor preservation exist.

Practically, the ASIA is a scale that scores motor and sensory function on different scales. There is also a letter that is assigned based on degree of motor, sensory, and/or presence of sacral function. Although for completeness sake the motor and sensory scales are important in the evaluation of an acute SCI, from a functional perspective, the letter grade is most often used and conveys substantial information.

The motor scale is a 100-point scale that uses 10 muscle groups (five groups in the upper extremities and five in the lower) that are tested bilaterally. It is important to recognize that the muscle strength is not what is tested, but rather the range of motion. Range of motion is

Table 1. Economic Impact of SCI

Severity of Injury	Average Yearly Expenses (in 2010 dollars)		Estimated Lifetime Costs by Age at Injury (discounted at 2%)	
	First Year	Each Subsequent Year	25 years old	50 years old
High Tetraplegia (C1-C4)	\$985,774	\$171,183	\$4,373,912	\$2,403,828
Low Tetraplegia (C5-C8)	\$712,308	\$105,013	\$3,195,853	\$1,965,735
Paraplegia	\$480,431	\$63,643	\$2,138,824	\$1,403,646
Incomplete Motor Functional at Any Level	\$321,720	\$39,077	\$1,461,255	\$1,031,394

Data Source: Economic impact of SCI , *Topics in Spinal Cord Injury Rehabilitation 2011*;16(4).

scored using the standard 0-5 point scale, with 0 indicating no movement and 5 indicating movement against full resistance. Assessment of strength in each motor group instead of range of motion across the joint can lead to inappropriately high scores that will inevitably overestimate the final motor score and, therefore, final ASIA score. A motor index score of 100 is evidence of no motor deficit, or a normal exam. The motor level is defined as the lowest level at which there is 3/5 movement.

The sensory grading system is a 112-point scale that tests 28 dermatomes bilaterally for both light touch and pinprick sensation. The sensory level is defined as the most caudal level with normal light touch and pinprick sensation. Again, a sensory index score of 112 demonstrates a normal sensory examination. (See Table 2.)

Complete injuries are those in which there is no motor or sensory function below the level of injury. Specifically, AIS A injuries are those in which there is no sacral motor function or sensation. Incomplete injuries are grades B, C, or D, and the specific letter assignment depends on the presence of motor, sensory, or grade of muscle strength. AIS E is a normal neurologic exam with no deficits appreciated. Zone of partial preservation is a term only

applied in complete SCI (those in which there is no sacral motor or sensory function) and describes areas of preserved segments below the neurologic level of injury.

The AIS may suggest the potential for minimal to some neurologic recovery, but has not been validated as a true prognostic scale. It does, however, provide the medical community with a common language to communicate the severity and level of SCI and, for this reason, in addition to the thoroughness of the AIS, it has been adopted by the majority of major medical intuitions both nationally and internationally.⁴

Pathophysiology

The normal structure, neuroprotective mechanism, and metabolism of the spinal cord are interrupted as a result of injury. There are many theories on the pathophysiology of the spinal cord following injury, but most theories include the belief that there are two main phases of evolution, primary and secondary injury, and it is likely that the actual process encompasses components of all theories. The progression of injury is believed to occur over the course of the first week, but successive histologic changes can be seen as far out as one month following injury.

Normally, the gray matter of the spinal cord has a much higher rate of metabolism and contains the

neuronal bodies directly within the tissue itself, as opposed to the white matter that has a slower metabolic rate and contains its neuronal bodies at distant sites. This difference makes the gray matter more susceptible to injury than the white matter.

Primary injury occurs at the time of the initial insult and can be either penetrating or blunt. Primary injury to the spinal cord is commonly due to trauma and affects the cord level at which the trauma occurs. Primary injury also occurs to neighboring levels adjacent to the primary site secondary to edema, hemorrhage, concussive, stretching, or shearing forces and ischemia.

In the minutes, hours, and first several days following SCI, metabolic changes take place in the spinal cord that are believed to lead to secondary injury. It is at this point that the many theories on SCI diverge. After direct injury to the cord, there is a period of inflammation that occurs within the gray and white matter, which leads to the metabolic and biochemical changes that can be toxic to the spinal cord tissue, leading to further damage. Following spinal cord injury, clinically it is not uncommon to have hypotension and bradycardia as a result of autonomic dysfunction, which can contribute to decreased cord perfusion and, ultimately, continued cord damage. Although there are many theories that describe

Table 2. ASIA Scale/Grading

AIS Impairment Scale	
A	Complete — Absence of motor and sensory function in sacral segments (S4-S5)
B	Incomplete — Preserved sensory function, but absent motor function below neurologic level of injury. Sacral sensation intact (S4-S5)
C	Incomplete — Preserved motor function below neurologic level of injury. More than half of muscle groups below injury have muscle grade of 3 or less.
D	Incomplete — Preserved motor function below neurologic level of injury. More than half of muscle groups below injury have muscle grade of 3 or greater
E	Normal Examination — No motor or sensory deficits

different biochemical complications as a result of injury, they all conclude that ultimately a cascade of toxic mediators (excitatory amino acids, free radicals, or calcium ions, for example) results in neuronal cell damage and death propagating secondary spinal cord injury.⁵

Spinal Cord Syndromes

The anatomy of the spinal cord must be appreciated to identify the patient's specific spinal cord syndrome. Patterns of symptoms can give the examiner an idea of the injury sustained, prognosis, and outcome even prior to imaging.

The spinal cord is divided into tracts. These tracts contain bundles of nerve fibers that run together in either an ascending or descending fashion, cross over the spinal cord in varying locations, and have clinically and characteristically significant findings when damaged. There are three particular tracts of the spinal column that are critically important. The dorsal column is an ascending, ipsilateral tract that is located in the posterior aspect of the cord and contains information on proprioception and vibration. The corticospinal tract is a descending, ipsilateral motor tract. Lastly, the spinothalamic tract is an ascending, contralateral tract that contains pain, temperature, and light touch nerve fibers.

Anterior Cord Syndrome

Anterior cord syndrome is usually sustained due to a hyperflexion injury to the cervical cord, but can occur anywhere in the spinal column. Hyperflexion of the cord causes direct contusion to the cord or can result in the protrusion of disc contents, bony fragments that have fractured, or, rarely, can cause direct laceration or thrombosis to the anterior spinal artery. Since the injury to the cord is bilateral, the pattern of symptoms that accompany this injury includes bilateral motor paralysis and loss of pinprick, temperature, and pain sensation below the level of injury. Since the posterior aspect of the cord is preserved, so is proprioception and vibratory sensation.

The overall prognosis for anterior cord syndrome is poor. Improvement in motor function can be seen within the first 24 hours following injury, but usually does not occur after the first day. After 30 days following injury, there is little to no additional recovery of function.⁶

Brown-Séquard Syndrome

Brown-Séquard syndrome is an anatomic or functional hemisection of the cord, which has several potential causes. From a trauma perspective, Brown-Séquard is commonly the result of penetrating

trauma to the spinal cord. However, more commonly it is due to inherent spinal or compressive lesions such as tumors or epidural hematomas. Classic Brown-Séquard syndrome, in its purest form, is described as a loss of ipsilateral motor function, proprioception, vibratory and pressure sensation, and contralateral loss of temperature and pain sensation below the level of injury. Although the pure form of Brown-Séquard syndrome is rarely seen, a partial form of Brown-Séquard is more common. Interestingly, because the fibers of the lateral spinothalamic tract decussate one or two levels above or below where the injury may occur, it is possible to see ipsilateral pain and temperature sensory loss above the level of injury.

Of all cord syndromes, Brown-Séquard syndrome has the best overall prognosis, with more than 80-90% of people recovering bowel and bladder function, and more than 75% regaining their ambulatory status.⁷

Central Cord Syndrome

The most common of all partial cord syndromes is central cord syndrome, which is distinguished from the other cord syndromes by the fact that the upper extremities are significantly more affected from the motor perspective than the lower extremities are. The most common mechanism of injury is a hyperextension injury, and it is usually seen after a fall in an older population with preexisting spinal stenosis or arthritis. The injury to the spinal cord affects the central portions of the corticospinal and spinothalamic tracts, resulting in the disproportionate pattern of symptoms between the upper and lower extremities. Patients typically have greater weakness in the proximal muscles than in the distal ones. Sensory symptoms are also appreciable, with some patients presenting with dysesthesias of their upper extremities as their predominant symptom.

The prognosis of central cord syndrome is dependent upon the severity of the cord contusion after injury

and the age at the time of injury. Patients younger than 50 years old at the time of injury tend to have more significant bladder continence recovery (80%) and achieve ambulatory recovery (90%) as compared to their older counterparts. Those older than 50 years at the time of injury have approximately a 50% chance of regaining ambulatory function, and only 30% regain bladder continence.⁸

Acute Management of SCI

The acute management of spinal cord injury occurs in several settings. In the prehospital setting, providers must maintain a high index of suspicion for spinal injury when presenting on the scene of any motor vehicle collision, fall, assault, or various other mechanisms in which injury to the spinal cord, occult or obvious, may have occurred. As with any trauma, airway, breathing, and circulation (the ABCs) always come first in the stabilization of a patient. In the event of high cervical spine injuries, severe trauma, or head injuries in which the patient's respiratory effort, mental status, or ability to maintain his/her own airway may be compromised, it may be indicated to bring the patient to the closest local facility for airway protection. Inline cervical spine stabilization should be utilized in every trauma patient for intubation, regardless of a high or low suspicion for SCI. A single person should be dedicated to maintaining the integrity of spinal stabilization, while another is cautiously securing the airway. If a high suspicion for cervical spine injury exists, fiberoptic intubation, when available, should be considered as the safest means of intubation.

Proper prehospital precautions include cervical spinal immobilization with a rigid cervical collar, full spinal precautions, log-rolling, and transporting patients on a backboard. Minimizing movement of the patient while still maintaining the ability to provide care should be balanced.

Upon arrival in the hospital setting, ABCs should be reevaluated and intervention at any step should

be taken to stabilize the trauma patient. The airway should be secured, while maintaining cervical spine precautions, in any patient with significant facial trauma, head injury, or GCS less than 8. In those patients who are believed to have a significant or isolated spinal injury requiring urgent rather than emergent intubation, consideration of fiberoptic or other advanced method of intubation is warranted. Patients with high cervical spine injuries (C5 and above) are at high likelihood of requiring mechanical ventilation and should be closely monitored and considered for early intubation and airway control.⁹

A primary survey as part of a trauma evaluation should be rapidly but thoroughly preformed. Part of the primary survey should include examination of the spine. With the patient's cervical spine being properly immobilized, the patient should be log-rolled and the emergency physician should palpate the spine for bony tenderness, obvious step-offs, or crepitus that would heighten the suspicion for spinal injury. The presence of any of these findings should prompt the physician to perform further diagnostic evaluation. If none of these exist and there are no concerning neurologic findings, the backboard can be removed.

Hemodynamic Status

In evaluation of a patient's hemodynamic status, sufficient vascular access should be obtained while keeping in mind additional injuries, which may limit optimal locations for access placement. What is considered sufficient may vary based on injuries sustained and presenting hemodynamics and should be determined based on the physician's clinical judgment. It is important to remain vigilant to the fact that many spinal cord-injured individuals develop a significant amount of hemodynamic lability in the first few hours, days, and even weeks following their injuries, and what seems sufficient may quickly become otherwise. The hemodynamic lability will often require vasoactive support

and, therefore, placement of central venous access and an arterial line are reasonable even if a patient is initially stable. Frequent reevaluation of vital signs in a patient with SCI is warranted.

Spinal Shock vs. Neurogenic Shock

Initial vital signs can vary depending on an isolated spinal fracture or spinal cord injury or multi-system trauma. In a hemodynamically unstable patient with what appears to be isolated spinal trauma, the medical provider should still be concerned about and exclude additional internal injuries, particularly abdominal injuries. Hypovolemic shock can present similarly to spinal and neurogenic shock; however, the management varies considerably. Once other injuries have been excluded as the cause of shock (i.e., intra-abdominal bleeding, thoracic trauma, etc.), it is safe to attribute hemodynamic instability to acute spinal cord injury. In SCI, vital signs can vary dramatically as well and can reflect two well-known but different entities: spinal shock and neurogenic shock.

Spinal Shock. Spinal shock is a presentation of acute SCI that occurs within the first 24 hours following injury and describes a transient constellation of symptoms that include total loss of reflexes below the level of injury, flaccid paralysis including loss of rectal tone, and complete loss of sensation. These findings are often accompanied by autonomic dysfunction, but spinal shock is not a hemodynamic phenomenon.¹⁰ The presence of priapism in a patient with acute SCI is suggestive of spinal shock. There are several theories that attempt to explain both the pathophysiology as well as define the duration of spinal shock. No clear consensus exists, but many theories suggest that the end of spinal shock occurs when the first reflexes return. Often, the first reflex to return is the bulbocavernosus reflex. Despite the lack of consensus on the pathophysiology and termination of spinal shock, all theories agree that spinal shock begins within 24 hours, and

usually within minutes to hours of the acute injury. Most theories suggest that spinal shock begins to resolve within 72 hours of onset, but there are several schools of thought that suggest termination based on the return of deep tendon reflexes several weeks after injury or the return of detrusor function, which can take several months to recover.¹¹

Neurogenic Shock. Neurogenic shock is a hemodynamic phenomenon that is also associated with acute SCI. A classic triad of symptoms including hypotension, bradycardia, and peripheral vasodilation, secondary to a profound loss of systemic vascular resistance, is seen. Neurogenic shock is often referred to as “warm shock” because of the vasodilation, but as a result of the spinal injury, it is not uncommon for these patients to be hypothermic. Onset is usually within 30 minutes of injury and can last several days to weeks following injury.¹² Neurogenic shock is most commonly seen in association with spinal cord injury above the level of T6, but can occur at any level. A recent study suggests that neurogenic shock is seen in approximately 19% of cervical spinal injuries, 7% of thoracic spinal injuries, and in only 3% of lumbar spine injuries.¹³ As previously stated, any trauma patient with hypotension should be quickly assessed to ensure there is no alternative cause. Neurogenic shock should, therefore, essentially be a diagnosis of exclusion once hemorrhage and thoracic trauma have been effectively excluded.

Treatment of shock in SCI is dependent upon identification of spinal shock or neurogenic shock. It is important to make the distinction between the two in each individual, but to also keep in mind that a single patient can have both conditions concomitantly. Treatment of spinal shock is primarily supportive. In contrast, the treatment of neurogenic shock requires volume resuscitation to help compensate for the massive vasodilation that occurs, in addition to pharmacologic support. Early use of vasopressors is

recommended to avoid fluid overload, although no specific goal of mean arterial or systolic blood pressures has been identified as optimal. Pharmacologic support in the form of vasopressors should be initiated once fluid resuscitation has failed to improve the patient’s hemodynamics. Norepinephrine should be used as a first-line agent, followed by medications like dopamine and dobutamine. Medications like phenylephrine, with unopposed alpha activity, should be avoided, given the pathophysiology of neurogenic shock and the potential for reflexive bradycardia, which may further worsen the spinal cord injury. Atropine is used to treat bradycardia.¹⁴

Overall, the goal of treating neurogenic shock is the same as treatment for any form of shock: adequate tissue perfusion. Most importantly, however, treatment of neurogenic shock should be aimed at maintaining perfusion of the injured region of the spinal cord in hopes of minimizing any additional secondary injury.

Neurologic Evaluation

In the patient with an acute spinal cord injury, it is imperative to obtain a thorough neurologic evaluation as soon as possible. After initial stabilization, it is important to perform the neurologic examination as completely as possible, fully assessing both motor and sensory deficits. Rectal sensation and tone are imperative in the neurologic evaluation of an acute SCI. All reflexes should be evaluated, as they can provide important clues to diagnosing spinal shock. As previously described, the ASIA scale is the most commonly used and most widely accepted scale for determining the extent of neurologic injury in patients with SCI and should be performed at 72 hours. The ASIA can be performed earlier, but in patients with spinal shock it may not be accurate and should be redone once reflexes return. Specifically, the diagnosis of complete versus incomplete injury (AIS A versus B, C, or D) cannot be made until spinal shock has resolved, and this diagnosis carries significant

implications for the patient’s prognosis.

Polytrauma

In patients with spinal cord injury in the setting of additional injuries or hemodynamic instability, it is reasonable to defer definitive treatment of the spinal cord injury until other life-threatening injuries are addressed (i.e., abdominal trauma/hemorrhage, or thoracic or cardiac injury), assuming the cervical spine is properly immobilized using a hard collar and log-roll precautions are used when moving the patient.

Imaging of the Spine

Imaging of the spine in a trauma patient can be accomplished using plain films, computed tomography (CT), or magnetic resonance imaging (MRI). The type of imaging chosen by the emergency physician should be based on the physician’s clinical suspicion, level of risk stratification, or pretest probability for SCI.

In the past several decades, many studies have evaluated close to 40,000 patients with an asymptomatic cervical spine examination. From these studies, class I evidence exists that states that in an asymptomatic patient, there is no benefit in obtaining cervical spine imaging. In addition to the fact that imaging provides no benefit in the asymptomatic population, it also exposes patients to unnecessary radiation, is costly to the medical system, and utilizes unnecessary resources. In 2001, the Congress of Neurological Surgeons and the American Association of Neurologic Surgeons published the Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injuries, which define an asymptomatic patient by the following criteria:

- Neurologically normal (GCS 15, no focal motor or sensory deficits, appropriate response to external stimuli, and appropriate orientation);
- Free of intoxication or substances, which can alter a patient’s level of alertness;
- Absence of midline neck tenderness from the nuchal ridge to the first thoracic vertebrae;

- Absence of associated, distracting injury (including, but not limited to a long bone fracture, large lacerations or degloving injuries, burns, or injuries that require surgical consultation).¹⁵

In emergency medicine, there are two clinical rules commonly used to evaluate the cervical spine in patients with blunt trauma. The National Emergency X-Radiography Utilization Study (NEXUS) used the same criteria mentioned above to evaluate patients with blunt trauma and demonstrated 100% sensitivity in excluding cervical spine trauma. If all of the criteria are met, the authors recommend that imaging not be performed.¹⁶ The Canadian C-Spine (CCR) rule includes additional criteria, which more clearly risk stratify patients based on the mechanism of injury, previous spinal disease or injury, as well as clinical examination findings. Although a lengthier rule, the CCR may allow for clearance of cervical immobilization devices in patients who may have otherwise kept the collar based on NEXUS.¹⁷

Alternatively, the symptomatic patient is the patient with pain on examination of the midline cervical spine, an altered level of consciousness due to trauma or intoxication, or patients with neurologic deficit. These are the patients who should undergo radiologic evaluation prior to clearance of the immobilization device. Plain radiographs are sufficient when three views are completed and the radiograph quality is optimal.¹⁸ Injuries may be missed in those who have suboptimal films that do not adequately show the region of injury. These missed injuries secondary to suboptimal imaging most commonly occur at high cervical levels (C2) as well as at the cervical-thoracic junction (C7-T1). The emergency physician knows that in the acutely injured patient wearing a hard cervical collar, optimal plain films are often hard to obtain. For this reason, CT has been studied as an adjunct mode of imaging to plain radiographs and has been found to be a cost-effective means of evaluating for cervical spine injury.¹⁹

Computed tomography of the spinal column has been shown to be an efficient and sensitive modality to assess for bony injury. However, in 2005 Holmes suggested that only in patients with a depressed mental status and high likelihood of cervical spine injury should CT be the initial mode of imaging. In populations with less significant injuries and a lesser likelihood of cervical spine injury, plain films still should be used as the initial screening method.²⁰

In the past several years, there has been a movement to make CT the standard of care in the evaluation of the cervical spine in the trauma patient. The Eastern Association for the Surgery of Trauma (EAST) has started to recommend CT as the standard way to evaluate the cervical spine in those patients who do not meet NEXUS criteria and are suspected of having a cervical spine injury. In patients with neurologic deficit, EAST recommends the addition of an MRI in the evaluation of a cervical spine injury.²¹

In 2011 Duane et al studied trauma patients to evaluate the accuracy of NEXUS criteria using CT scan as the gold standard and found NEXUS to miss a number of significant injuries. They looked at approximately 2600 patients and found 26 with missed injury based on the NEXUS criteria. Of the 26 missed, 19 patients required additional intervention in the treatment of their injuries, including several who required operative repair and one who required placement of a halo.²²

In symptomatic patients, ligamentous spinal injuries should also be a consideration. Once radiographs and/or CT have evaluated and are negative for bony injury, flexion/extension films can be performed in the awake patient to assess for subluxation, reflecting the presence of ligamentous injury. Three cervical views and a negative flexion/extension film have been cited as having a negative predictive value of 99%.²³ In neurologically impaired individuals, those who cannot flex or extend their neck secondary to pain or

muscle spasm, or those who cannot undergo flexion/extension films for any other reason but in whom a concern for cervical spine injury exists, flexion/extension films with fluoroscopic guidance or MRI evaluation should be performed.²⁴

MRI evaluation of patients is costly and time consuming. MRI should not be performed in unstable patients. In the evaluation of the obtunded trauma patient, the cervical spine can be cleared using MRI. The current data support the use of MRI within 48 hours of the trauma event to evaluate specifically for ligamentous injury. Benzel et al studied 174 patients with suspected cervical spine injuries who underwent MRI evaluation. Thirty-six percent of patients were found to have MRI evidence of injury, but, more importantly, none of the patients with a negative MRI had later spinal instability and were all cleared of their immobilization device.²⁵

Despite the evidence that supports the use of plain radiography in evaluation and clearance of the cervical spine, it is quite common and acceptable for the emergency physician to order a CT in trauma patients, especially in the trauma patient who is going to require other CT imaging. Simultaneous imaging of the cervical, thoracic, and/or lumbar spine is more efficient and reliable at assessing for injury.²⁶ It is also important to remember that any patient with a single spinal injury is at risk for an additional spinal injury, and the presence of a single spinal injury should prompt radiographic evaluation of the remainder of the spinal column. Plain radiographs (AP and lateral images of the thoracic and lumbar spine) are sufficient if the patient is asymptomatic.

As with many conditions evaluated by the emergency physician, follow-up within a reasonable period of time is essential for the trauma patient. Patients with symptoms but negative films and/or CT scan should continue the use of their rigid neck immobilizer until neurosurgery can evaluate the patient.

Surgical Consultation

In the patient with spinal injury, appropriate neurosurgical or orthopedic consultation is essential and should be obtained in a timely matter. Every hospital has specific guidelines as to which surgical services should be consulted based on the level or severity of the injury or specific deficits associated with the injury. The goal of surgical intervention is spinal stabilization and decompression of the spinal cord to prevent additional or ongoing injury. Early decompression, if indicated, within 4-6 hours of injury may improve outcomes.

Steroids

The use of high-dose steroids in the presence of spinal injury used to be the standard of care and was included as part of many SCI guidelines. In the past several years, this practice has been called into question and many studies have addressed this controversy. Although currently controversy still exists surrounding the use of steroids, the practice has been removed from guidelines and is no longer considered the standard of care.

The purpose of steroids in spinal cord injury was originally thought to be of benefit in three distinct ways. Steroids were thought to improve blood flow to the injured area of the spinal cord, assist in limiting the inflammatory response to injury, and reduce vasogenic shock and edema.

The National Acute Spinal Cord Injury Study (NASCIS) I, II, and III are the three largest prospective, double-blinded, randomized studies on the use of steroids in spinal cord injury. NASCIS I studied 330 patients with acute spinal cord injury with two groups: a high-dose methylprednisolone group against a standard-dose methylprednisolone regimen. The patients were evaluated at 6 weeks and 6 months following injury. NASCIS I found no difference in outcome (recovery of sensory or motor function between the two groups, but although not statistically significant, both a higher rate of wound infection and early case

fatality were found in the high-dose methylprednisolone group).²⁷

NASCIS II studied three treatment groups with a total of 487 patients: a high-dose methylprednisolone group (different dose than used in NASCIS I), a naloxone group, and a placebo group. In the high-dose methylprednisolone group, statistically significant improvements were found with respect to pinprick and light touch sensation at 6 weeks and 6 months following injury. Unfortunately, this finding was lost at one year post-injury. Post-hoc analysis revealed improved neurologic outcomes in groups receiving steroids within 8 hours of their acute injury. Interestingly, patients receiving steroids more than 8 hours following injury were found to have worse neurologic outcomes than the comparison groups, despite this finding not reaching statistical significance. Similarly to NASCIS I, there were more wound infections, pulmonary complications (including an increase in pulmonary embolism), and adverse events noted in the steroid group.²⁸

NASCIS III compared methylprednisolone given for 24 hours, methylprednisolone given for 48 hours, and tirilazad mesylate given for 48 hours in patients with acute spinal cord injury. Patients were assessed at 6 weeks and 6 months for motor function change, in addition to being scored on the Functional Independence Measure (FIM). The group receiving 48 hours of methylprednisolone and whose therapy was started within 3-8 hours of injury was found to have a statistically significant improvement in motor score at 6 weeks and 6 months (one full motor grade) and were more likely to show improvement in the FIM scores. However, analysis of the groups reveals a disproportionate number of patients in the group receiving 48 hours of steroids who had minor motor deficits on initial examination as compared to the other two treatment groups. This discrepancy alone could account for the statistical findings in the 48-hour treatment group and, in fact, once

this discrepancy was controlled for, the statistical significance disappeared. The group receiving tirilazad had similar outcomes in motor recovery rates to the treatment group receiving methylprednisolone for 24 hours. Like NASCIS I and II, there were higher complication rates noted in the groups receiving high-dose steroids. The 48-hour treatment group had higher rates of pneumonia and severe sepsis as compared to the 24-hour methylprednisolone and tirilazad groups. The conclusion drawn by the authors of NASCIS III was that patients who are started on a high-dose steroid regimen within 3 hours of injury should receive only a 24-hour course of steroids, but those receiving steroids within 3-8 hours of injury should be maintained on steroids for 48 hours.²⁹

Ultimately, the use of steroids in acute SCI is controversial and should be the decision of the institution and treating physician. It is not currently clear if there is a significant benefit in neurologic outcome with steroid use, and more studies need to be done, but it is clear that patients who receive steroids have higher complication rates, including severe sepsis, pneumonia, pulmonary embolism, gastrointestinal bleeding, and wound infections, than their counterparts. For these reasons, as mentioned above, high-dose steroids are not currently a part of treatment guidelines for acute SCI. The Congress of Neurological Surgeons states that treatment of acute SCI with steroids "should only be undertaken with the knowledge that the evidence suggesting harmful side effects is more consistent than any suggestion of clinical benefit."³⁰

Blood Pressure Management

Blood pressure management in acute spinal cord injury is another area in which class I evidence is lacking. It is clearly understood that hypotension can directly contribute to hypoperfusion and result in further injury to the spinal cord. Many studies over the previous two

decades have attempted to determine the optimal blood pressure, or mean arterial pressure (MAP), in acute spinal cord injury and the duration of treatment to maintain the proposed blood pressure. The theory is similar to that for steroids, in that the goal is to reduce secondary injury to the spinal cord from hypoperfusion.

It is well understood and accepted that, as with traumatic brain injury, autoregulation of blood flow to the spinal cord is compromised in acute SCI. Animal models suggest that hypotension and, therefore, hypoperfusion are detrimental in acute SCI and worsen neurologic outcomes. Because the treatment of hypotension and shock is a basic tenet in medicine, class I evidence supporting or refuting the use of a goal MAP in SCI will never be obtained.

In 1993 Levi et al studied hemodynamic parameters in acute cervical SCI with 50 consecutive spinal cord-injured patients. The patients were aggressively supported using fluids and vasopressors to achieve a goal systolic blood pressure of greater than 90 mm Hg. All patients received invasive monitoring with an arterial line, central venous access, and Swan-Ganz catheters. Data for the first week following injury, including hemodynamic, neurologic, and demographic information, were analyzed. Of the 50 patients included in the study, 31 had complete (grade A) injuries, 20 had no improvement in function, 21 had appreciable improvement, and 9 died.³¹

Four years later, Vale et al studied acute cervical and thoracic SCI in 70 patients. These patients underwent similar monitoring and hemodynamic augmentation strategies as in the Levi study and were followed to one year post-injury. The goal systolic blood pressure was maintained above 85 mm Hg for 7 days following injury using fluids and vasopressors. Patients in whom decompression and spinal stabilization were indicated underwent those procedures. The authors found that after one year, 60% of patients with complete injuries had improvement by one grade on the ASIA AIS, and

20% had return of bowel function. Thirty percent of these patients had recovered the ability to walk. Of those patients who sustained incomplete cervical spine injuries, 92% recovered their ability to ambulate and 88% regained bladder control. Of the thoracic injuries, both complete and incomplete, improvements were noted and, albeit smaller percentages than their cervical counterparts, some demonstrated the ability to walk and regained bladder function. A majority of patients with thoracic injuries underwent surgical decompression or stabilization of the spine. The authors controlled for the timing of surgical intervention (early vs. late), and found no significant correlation between the timing of surgery and neurologic outcome.³²

In 2010, a literature review examined the evidence supporting the use of vasopressors to augment blood pressure in acute spinal cord injury. Unfortunately, the researchers were unable to draw any definitive conclusions about the use of vasopressors, reporting that currently there is “no gold standard on vasopressors support.” They did note, however, that cervical spine injuries require vasopressor support much more frequently than thoracic or lumbar injuries.³³ In both of the above mentioned studies, minimal morbidity associated with invasive monitoring and vasopressors administration was observed. The authors of both studies recommend the use of blood pressure augmenting medications and fluids in the acute period (the first 7 days) following spinal cord injury. The authors thought that the neurologic improvements noted in each study were the result of improved perfusion and prevention of secondary injury from hypotension.

The Congress of Neurological Surgeons states that there is “insufficient evidence” to support treatment standards or guidelines, but does affirm that hypotension in acute SCI should be avoided and/or remedied as soon as possible. Also recommended is maintenance of a MAP between 85 and 90 for the first

7 days following acute injury to help with perfusion and prevent secondary injury.¹⁵

Additional Issues in Acute SCI

Once the patient has been stabilized and admitted to the hospital and surgical consultations have been completed, there are several issues that patients face with new SCI, in addition to the emotional and physical adjustments of a new life.

Patients have significant autonomic instability, often for several weeks following their initial injury, which requires vasopressors and, frequently, long-term medications for stabilization. The general rule is, the higher the injury, the more autonomic instability can be seen and the longer the duration of instability.

Early tracheostomy in patients with cervical spine injuries has been studied and is becoming more accepted. Patients with cervical and thoracic spinal trauma often require prolonged mechanical ventilation while hospitalized, and long-term mechanical ventilation is common in patients with high cervical spine injury.⁹ In 2010 Romero et al looked at 152 consecutive patients with acute spinal injury and did a retrospective study on the timing of tracheostomy. Seventy-eight percent of patients were grade A injuries. Early tracheostomy (performed within 7 days of injury) was shown to be beneficial for reducing the number of days that mechanical ventilation was required, decreasing ICU stays, and decreasing the risk of orotracheal complications from intubation. The authors were not able to show a change in the risk of mortality associated with injury or a reduction in the risk of ventilator-associated pneumonia.³⁴ The timing of tracheostomy has also been controversial due to concerns of infection following anterior spinal stabilization. Berney et al evaluated early tracheostomy after anterior spinal stabilization and found there is a low risk of infection, further supporting the idea that early tracheostomy is beneficial.³⁵

Secondary infection risks are significant in SCI patients. As stated above, patients with spinal injuries often require prolonged mechanical ventilation and, therefore, have a significant risk of ventilator-associated pneumonia. Urinary tract infections are common among these patients, as well, given their need for prolonged catheterization. Skin breakdown and decubitus ulcers are a common complication of immobility. Aggressive mobilization and physical and occupational therapy are imperative in the prevention of ulcers as well as for the patient's general recovery.

Patients with SCI are at risk for deep vein thrombosis (DVT) and pulmonary embolism (PE). The incidence of DVT in the SCI population has been quoted between 12-64%. Consequent PE results in approximately 10% of deaths in the first year following SCI, despite the use of chemical thromboprophylaxis.³⁶ Studies have been done to evaluate the effectiveness of inferior vena cava (IVC) filter placement for prophylaxis. Whereas some studies suggest the placement of IVC filters for secondary prophylaxis in patients with a PE or a contraindication to chemical prophylaxis,³⁷ no strong evidence exists to support the routine placement, and some studies suggest that IVC filter placement may actually increase the risk of DVT development.³⁸

Conclusion

Acute spinal cord injury is a complex disease process that is often complicated by additional traumatic injury. Although physicians know a significant amount about spinal cord injury, there are many key areas still to be fully understood. As a result, over the past decade, guidelines have changed. The use of steroids and vasopressors is controversial and requires additional study. The emergency physician should be prepared to assess and treat the acute spinal cord injury regardless of level and should be aware of the differences in clinical presentation of injuries at a specific level. The emergency

medicine physician is the critical first step in the management of SCI, including airway management, imaging and clearance of the spinal cord, identification of other critical injuries, and initiation of pharmacologic management that will minimize the long-term morbidity and mortality for this devastating injury.

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4. Which of the following is true of central cord syndrome?
 - A. The lower extremities are affected more than the upper extremities.
 - B. Distal muscle groups are affected more than proximal muscle groups.
 - C. The prognosis is based on age at the time of injury and severity of cord contusion.
 - D. The majority of patients affected, regardless of age, regain bladder function.
 5. Which of the following is true of spinal shock?
 - A. It is a hemodynamic phenomenon.
 - B. It is classified by loss of reflexes, flaccid paralysis, and sensation.
 - C. It is clearly understood and defined.
 - D. It is usually completely resolved by 24 hours after injury.
 6. Which is true of neurogenic shock?
 - A. It should be treated with IV fluids and vasopressors.
 - B. It most commonly occurs with spinal injuries below T6.
 - C. It is defined by hypotension, tachycardia, and peripheral vasodilation.
 - D. It is often accompanied by hyperthermia.
 7. In which patients can cervical spine radiographs be used to clear a cervical collar?
 - A. all patients with low-risk mechanisms
 - B. symptomatic patients
 - C. patients who meet NEXUS criteria
 - D. patients who want to leave the emergency department AMA
 8. Which of the following is true about the use of steroids in spinal cord injury?
 - A. Steroid use is associated with improved neurologic outcomes.
 - B. If steroids are given for 48 hours with tirilazad, FIM scores show improvement.
 - C. Steroids should only be given if within 3-8 hours of injury.
 - D. Steroid use is highly controversial, and they should be given based on institutional and provider practices.
 9. Which is true regarding blood pressure management in patients with spinal cord injury?
 - A. BP management should be aimed at maintaining a MAP of > 90 mm Hg.
 - B. BP management should be aimed at preventing hypotension and secondary injury.
 - C. BP management is clearly associated with improved neurologic outcomes.
 - D. BP management is important, but vasoactives should not be used to augment blood pressure.
 10. Once the acute injury has been stabilized:
 - A. Autonomic instability in cervical spine injuries resolves quickly.
 - B. Patients with spinal cord injury are at increased risk of DVT, PE, and pulmonary infection.
 - C. Mechanical ventilation is uncommonly needed.
 - D. Patients integrate back into society without problems.

CME/CNE Questions

1. Which of the following is the most common cause of spinal cord injury?
 - A. penetrating injury
 - B. sporting injury
 - C. motor vehicle collision
 - D. falls
2. People with spinal cord injury are:
 - A. slightly more likely to have relationships that end in divorce than the unaffected population
 - B. likely to remain employed following their injury
 - C. will likely never get married if they are single at the time of injury
 - D. report less fulfilling lifestyles than the unaffected population
3. Which of the following is true of anterior cord syndrome?
 - A. It is usually the result of hyperextension.
 - B. Patients have a good prognosis.
 - C. It results in loss of bilateral motor function, pinprick, temperature, and pain sensation below the level of injury.

CNE/CME Objectives

Upon completing this program, the participants will be able to:

- discuss conditions that should increase suspicion for traumatic injuries;
- describe the various modalities used to identify different traumatic conditions;
- cite methods of quickly stabilizing and managing patients; and
- identify possible complications that may occur with traumatic injuries.

CNE/CME Instructions

HERE ARE THE STEPS YOU NEED TO TAKE TO EARN CREDIT FOR THIS ACTIVITY:

1. Read and study the activity, using the provided references for further research.
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