

TITLE: Caustic Ingestion and Foreign Bodies in the Aerodigestive Tract
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Caustic Ingestion

Esophageal, pharyngeal, and laryngeal injury can occur from ingestion of bases, acids, and bleaches. Ingestion of substances containing bases produce the most significant injury. Bases include lye (NaOH, KOH), which is found in drain cleaners, ammonia, and electric dishwasher soap. Other caustics include detergent powders and hair-straightening formulas, which are especially hazardous because child-proof packaging is not standard on these. Disc batteries are also responsible for significant esophageal injury.

Toward the end of the 19th century and beginning of the 20th century, lye products became commercially available for domestic use, primarily as drain cleaners. With this increased availability came an increasing number of accidental caustic ingestions mostly in the pediatric population. Noting that no warning labels were being used on these products, Chevalier Jackson stated "that poison sold by druggists to the laity are subject to legal regulations as to labeling, and such drugs go into the medicine cupboard while the caustic alkalis sold by the grocer go into the kitchen." He began a public campaign, against some opposition, to institute proper labeling on these containers and the Federal Caustic Act of 1927 was enacted. Since then the Poison Prevention Packaging Act in 1970 and the Federal Hazardous Substances Act in 1972 have toughened regulations and now proper labeling including antidote instructions, concentration restrictions (10%), and child-resistant packaging is required.

Despite these precautions, it is still estimated that 5,000 accidental lye ingestions occur yearly by children under 5 years of age. In general, these ingestions are accidental in the pediatric population and intentional in the adult population (suicide attempts). In the pediatric

population, most of these ingestions occur at home and in the kitchen. High family stress, both parental and environmental, is said to be the most significant contributing factor.

Three types of chemicals are responsible for these injuries – alkalis (pH > 7), acids (pH < 7), and bleaches (pH = 7). The injuries caused by these substances differ in their severity and mechanism of injury. Alkalis cause the most severe injury and work through liquefaction necrosis. Since they are soluble once they form soaps with fat, there is an edematous loosening of the tissue with deep diffusion of the alkali into the tissues. Only neutralization of the substance by the tissue itself will cease the reaction. Acids work through coagulation necrosis, with formation of an eschar by the reaction. This coagulum serves to protect the tissue by limiting deeper penetration. Bleaches are considered esophageal irritants only and no significant morbidity generally occurs.

Disc batteries found in appliances and hearing aids among other places deserve special mention as they can become lodged in the esophagus with subsequent leakage around its seal. These contain very high concentrations of KOH or NaOH and can cause damage as early as one hour postingestion.

The amount, type, concentration, and time of contact of the agent all factor into the severity of the burn. The initial contact of the agent will produce immediate changes in the mucosa, which progresses during the next three days. Following the acute phase of the injury, a latent period begins, during which time stricture formation may occur. The process may proceed as rapidly as one month or during a period of years.

Assessment

Initial management depends on accurate diagnosis. This begins with a careful history detailing the brand name, type, and amount of ingestion. A parent can be sent home to obtain the container, which will help in these regards. Often these ingestions are unwitnessed which can make this portion of the workup difficult. Once the agent is known, poison control can be contacted for assistance. It is also important to know whether vomiting occurred as this can increase the length of time of esophageal exposure.

Symptoms of hoarseness, stridor, and dyspnea are noted. Odynophagia, drooling, and refusal of food suggest a more severe injury. Substernal chest pain, abdominal pain, and rigidity suggest profound injury and perforation of the esophagus or stomach. Despite this, guidance of treatment by the patient's signs and symptoms is not always reliable as some patients with moderate to severe injury can have few of these complaints.

Physical exam can reveal evidence of caustic ingestion by examination of the lips, chin, hands, chest, or clothing for signs of burn. There may be burns in the mouth and pharynx, which should be examined with proper lighting and suction. Restraint is warranted if necessary. The absence or presence of oral injuries is not predictive of esophageal injury so further evaluation should continue even if no findings are obvious.

Approximately 20% of patients without oral injury will have esophageal injury and up to 70% of patients with oral injury can be without esophageal injury. Examination of the hypopharynx and larynx can be examined with a mirror or a flexible fiberoptic scope if the airway is stable.

Radiologic exam can include chest and neck radiographs especially if any symptom of airway distress is noted or if a concomitant foreign body is suspected. Barium swallows are of little use in the acute phase since it only delays endoscopy and will not reveal first- or second-degree injuries.

Since signs and symptoms are not accurately predictive of esophageal injury, esophagoscopy is carried out in virtually every patient who is suspected of caustic ingestion. Esophagoscopy is carried out within 24 to 48 hours (some authors say 72 hours) of ingestion. During this time period, the injury will have demarcated itself so that the degree of injury can be reliably predicted. Prior to this time period, one can underestimate the injury as only erythema may be seen in the early phases of more severe injury. Endoscopy after 48-72 hours increases the chance of iatrogenic perforation as there will be structural weakness in the esophageal wall. Rigid versus flexible esophagoscopy is debatable but most otolaryngologists feel rigid esophagoscopy is superior. Esophagoscopy is carried down to the upper limit of a severe burn. Advancing beyond this point can increase the chance of perforation. On endoscopy, grade 1 is a superficial injury, grade 2 is transmucosal, and grade 3 is transmural. Noting whether the injury is circumferential is important as well. If evaluation begins over 48 hours after ingestion, esophagoscopy is not considered safe and evaluation should begin with barium swallow. During esophagoscopy, direct laryngoscopy and any other indicated procedure should be done to evaluate concomitant injury to the larynx which could cause airway compromise and necessitate tracheotomy.

Bleach ingestion is an exception to the rule of esophagoscopy for virtually all caustic ingestions. Bleaches are approximately 5-6% sodium hypochlorite and produce an ulceration that usually does not result in stricture or permanent sequelae at these concentrations. If no oropharyngeal burn is present, a barium swallow is obtained in three weeks. If oropharyngeal burns are present, then esophagoscopy should be done and management proceeds similarly to the other caustics.

Initial Management

The goal of treatment is preventing permanent injury or stricture in the esophagus. Initial treatment should begin with rinsing of the mouth with water or milk. Drinking water or milk can lead to dilution and neutralization of the chemical but should not exceed 15 cc/kg as more can lead to emesis with further injury to the esophagus. Induced emesis and gastric lavage are contraindicated to avoid further exposure of the esophagus. Neutralization agents such as vinegar for lye ingestion and sodium bicarbonates for acid ingestion are also contraindicated as it is thought that an exothermic reaction will occur further injuring the tissue. Some feel that this is not accurate because the volume of surrounding tissue and local blood flow is sufficient to dissipate any heat produced from the reaction. Analgesics are indicated for patient comfort.

Antibiotic use is controversial. Proponents state that by decreasing bacterial counts in the burned tissue, granulation tissue formation is reduced which will lessen the chance of stricture formation. Others would argue that antibiotics promote the influx of gram negative organisms into the tissue without decreasing stricture formation and may mask the signs of more serious infection. If antibiotics are used prophylactically, ampicillin at 50-100 mg/kg/day is recommended.

Steroids must be started within the first 8 hours for maximal effectiveness. Since esophagoscopy is not carried out until 24-48 hours, many physicians treat all patients with steroids initially and discontinue them if endoscopic findings warrant it. Prednisone at 2 mg/kg/day is used for 21 days with a subsequent 21 day taper. Steroids are used with the goal of decreased stricture formation. Grade 1 burns do not usually progress to stricture so steroids are stopped if diagnosis confirms this. Steroids also are not used in the grade 3 injuries as surgery will be required and the risk of perforation is increased with steroid use. Grade 2 injuries are where steroids are felt to be most beneficial in preventing stricture formation. In numerous animal studies, steroids have been found to limit the inflammatory response, reduce the formation of granulation tissue, fibrous tissue proliferation, and stricture formation. Cardona and Daly feel that strictures are also easier to manage in steroid treated patients. Others have found a decreased incidence of permanent esophageal sequelae with steroid use but some authors have reported no benefit with steroid use. Anderson in a widely cited paper, concluded that steroids appear to confer no benefit in children who have ingested a caustic substance, but Holinger argues that their study showed a clear trend toward improved outcomes with steroid use. He thought that with larger patient numbers and higher doses of steroids, there would be statistical significance.

Protection of injured esophageal mucosa from gastric acid reflux is generally considered important although not proven in human studies. H2 blockers and liquid carafate slurries to prevent further esophageal damage is recommended.

Lathyrogens are chemicals that prevent covalent cross-linking of collagen. It is theoretically possible to prevent dense scarring or soften established scarring with their use. Authors have shown improvement in dog and rat models but no human studies are available as of yet. Penicillamine and N-acetylcysteine have been used in humans for other indications and may prove useful in caustic ingestions.

Placement of a nasogastric tube or esophageal stent can be used in severe esophageal injuries to decrease the likelihood of stricture formation by preventing adherence of the anterior and posterior walls of the esophagus. These can be placed in the first 24 hours under fluoroscopic guidance or at the time of endoscopy. In their usage in 32 patients with severe circumferential burns, Wijburg had stricture development in only 2 patients.

Later Management

Despite these measures stricture formation still develops in 10-15% of esophageal burns and must be managed expeditiously. Attempts are first made at dilation of the stricture. Prograde dilation has been used for the greatest length of time. Jackson silk-woven bougies

passed under direct vision under general anesthesia was initially used. Hurst and Maloney dilators are also used in prograde fashion. Initially they are inserted under a general anesthetic but subsequent dilations can be done in the outpatient clinic if the patient will tolerate it. Larger dilators are used until one will not pass. These are repeated every few weeks until satisfactory caliber is achieved and the patient is swallowing appropriately. Dilation can then proceed on a prn basis and followed with barium esophagograms.

Retrograde dilation is felt to be safer by some and was originally described by Tucker. In this method, a continuous loop of string is kept in the esophageal lumen and brought out of the nose superiorly and a gastrostomy inferiorly. A Tucker dilator is tied to the lower end of string and pushed and pulled out of the patient's mouth using progressively larger dilators. This can be done daily and in an awake patient until it is safe to proceed with prograde dilation.

Dilation can also be done with the use of a Gruntzig balloon dilation catheter under radiographic control. Similar to angioplasty, the balloon is passed to the area of stricture and then inflated. The advantage lies in that a radial direction of stricture dilation is performed with this method, which is thought to be less likely to result in a tear of the esophagus than the other methods, which work through a longitudinal direction of dilation.

When these methods fail, esophageal replacement is necessary. Colonic interpositions, jejunal interpositions, and gastric pull-ups are options.

The final consideration relates to the 1,000 fold increased risk of esophageal carcinoma in patients with histories of caustic ingestion. This can occur from 13 to 71 years post-ingestion and must be considered when a patient presents with worsening dysphagia years after injury. Fortunately, the prognosis is better than with the usual esophageal carcinoma patient as there is less of a tendency towards distant metastasis.

Foreign Bodies

Aerodigestive tract foreign bodies are seen in two forms – foreign body ingestion and foreign body aspiration. Toddlers are most commonly affected due to the use of their mouths to explore the environment, lack of posterior dentition to properly chew food, lack of cognitive ability to distinguish edible from inedible objects, and easy distractibility while eating. In 1984, the National Safety Council cited foreign body aspiration or ingestion as the fourth leading cause of accidental death in children aged 1 to 3 years and the third leading cause of accidental death in infants below one year. Accidental aspiration or ingestion of objects is twice as common in boys for unknown reasons. Recent advancements in equipment such as rod-lens telescopes and modern extraction devices have improved management and decreased complications, but they still prevent a significant challenge.

Foreign body ingestion

By far, the most common esophageal foreign bodies are coins (75% of cases). Meat and vegetable matter impactions are less common in children. The duration of impaction is less than

24 hours in most cases. Patients who have recurrent esophageal foreign bodies are often found to have esophageal anomalies on further workup.

Assessment

Parental suspicion that a child has swallowed an inedible object is the most constant historical finding. Symptoms include a choking spell or cough which may raise suspicion of aspiration rather than ingestion. Older children may report dysphagia or odynophagia.

Physical exam may reveal a fussy child refusing to eat or drink but otherwise normal. Drooling may signify complete obstruction of the esophageal lumen. Large or impacted foreign bodies can cause compression of the neighboring trachea with associated symptoms of respiratory compromise in 10% of cases.

Most foreign bodies lodge high in the esophagus just below the cricopharyngeus at C-6. A smaller percentage can become lodged in the mid-esophagus at areas of compression from the aortic arch and left mainstem bronchus.

The vast majority of esophageal foreign bodies are radiopaque and readily identified with radiography. Coins are most commonly seen and large improperly chewed pieces of meat, chicken, or fish with spicules of bone or cartilage are also seen on radiography. Undigested hot dogs are the most common esophageal objects causing fatality because they can impact the airway and cause complete airway obstruction. In the rare instance where further evidence is needed, barium swallow may outline impaction by a radiolucent object.

Management

Unlike foreign body aspiration, foreign body ingestion does not always mandate early surgical intervention. If ingestion is recent, if the object is blunt and noncaustic, and if no respiratory distress is evident, the child may be observed up to 24 hours for spontaneous passage of the object. CXR is then repeated and if advancement past the cricopharyngeus is seen, expectant management is appropriate. Once an object enters the stomach, the risk of impaction is extremely low. Even most sharp objects can be followed expectantly by serial radiographs once they are past the gastroesophageal junction. One exception to this is needles, which can lead to silent perforation, and are removed once diagnosed. There are instances when observation is not appropriate. Complete obstructions with inability to handle secretions can lead to aspiration. Any sign of airway distress demands more immediate removal. Sharp objects or disc batteries have risks of perforation when lodged in the esophagus and are not observed. Children with known esophageal anomalies or strictures are unlikely to spontaneously pass the object.

Esophageal foreign bodies are removed under general anesthesia after control of the airway with intubation. Some objects impacted at the cricopharyngeus can be removed during direct laryngoscopy. A rigid esophagoscope is inserted to the level of the object and removed with forceps. Esophagoscopy is then repeated to evaluate the esophageal wall for signs of edema, ulceration, or frank perforation. Multiple foreign bodies are seen in 5% of children.

If upon attempted removal of the object, the foreign body is inadvertently pushed into the stomach, further attempts at removal cease to avoid increased trauma to the esophagus on attempted extraction. Two exceptions to this are safety pins, which can be pushed into the stomach and then inverted to withdraw the spring end first, and the previously mentioned needles.

Disc batteries deserve special mention at this point. Esophageal lodgement of disc batteries is one of the true urgent foreign body emergencies. They contain NaOH, KOH, and/or mercury. These materials leak around the grommet seal of the battery to produce mucosal damage within one hour and involvement of muscular layers within 2 to 4 hours. Perforation may occur within 8 to 12 hours. Tracheoesophageal fistula, mediastinitis, esophageal stricture, and death are all potential complications. They are removed via esophagoscopy once a radiograph is taken to determine location. If it has passed into the stomach, the patient can be sent home with instructions for the parents to check the stool for passage of the battery. If it has not passed in 4-7 days, a repeat radiograph is taken with planned endoscopic removal if still in the stomach. Operative intervention via laparotomy is undertaken at any point if signs or symptoms of bowel perforation exist.

Postoperative management consists of keeping the child NPO for 4-12 hours. The diet is then advanced and they are monitored for signs of perforation – tachycardia, tachypnea, and fever.

Controversy exists in one final method of esophageal foreign body removal – balloon catheter extraction. This method has some advocates who claim effectiveness in up to 90% of cases. A foley catheter is inserted past the obstruction, the balloon is inflated, and the object is pulled out with the child in the head-down position. Failures are then sent for endoscopic removal. The complications include emesis, epistaxis, inadvertent balloon placement with inflation in the trachea, laryngospasm, and hypoxia. There is also a risk of converting a stable esophageal foreign body into one with airway compromise since the airway is not controlled during the procedure. Most otolaryngologists prefer management of esophageal foreign bodies under direct endoscopic visualization because of these risks.

Foreign body aspiration

Before the 20th century, airway foreign bodies often resulted in death either during the initial obstructive event, the attempt at removal, or from complications afterwards. Gross described emetics, sternutatories, expectorants, purgatives, and bloodletting as early methods of removal but recommended “bronchotomy in all cases, the minute it is known that there is a foreign substance in the windpipe.” Killian is credited with the first bronchoscopic removal of a foreign body of the airway in 1897 when he removed a bone from the trachea of a man with a 9 mm rigid tube. Distal illumination during endoscopy was not available until the early 1900s. Chevalier Jackson worked with the Pilling company in the early 20th century and is credited with revolutionizing the field of bronchoesophagology. By 1936, he reported that the mortality rate from airway foreign bodies had decreased from 24 to 2 percent and that bronchoscopic removal

was successful in 98% of cases. Little change in technique occurred until the 1970s when rod-lens telescopes became available, vastly improving illumination and visualization.

Types/Location

Vegetable matter is the most common foreign body found in the pediatric airway (70-80%) with peanuts and other nuts accounting for 35% of cases. Carrot pieces, beans, sunflower seeds, and watermelon seeds are also frequently found. Metal foreign bodies have decreased in incidence since diaper safety pin use has fallen with the availability of disposable diapers. Plastic foreign bodies have risen to comprise 5-15% due to widespread use in the toy industry. These may remain in the airway for extended periods of time since they tend to be nonirritating and radiolucent.

Most airway foreign bodies (80-90%) become lodged peripherally in the bronchi because their size and configuration allow them to pass through the larynx and trachea. Large objects, those with irregular edges, and conforming objects (balloons) may impact at the larynx with potential for complete airway obstruction. The right mainstem bronchus is the more common resting place for objects primarily due to the position of the carina to the left of midline. Other factors for right mainstem proclivity could include its greater diameter, lesser angle of divergence from the tracheal axis, and greater airflow to the right lung.

Assessment

The history is the most important aspect of diagnosis as physical exam and radiography can be normal after occurrence of the acute event. Initially there is a brief period of choking, gagging, or wheezing. This may be associated with hoarseness, aphonia, or dysphonia. Coughing and choking are highly suggestive of foreign body aspiration whereas respiratory distress is a relatively rare finding. One dictum states, “a positive history must never be ignored, while a negative history may be misleading.” In many cases these episodes are unwitnessed or the symptoms minimized by parents with a resulting delay in diagnosis. Symptoms of foreign body aspiration may mimic conditions such as asthma, croup, and pneumonia. Onset of wheezing in a healthy child or “recurrence” of asthma after discontinuation of therapy should heighten suspicion of a foreign body.

The mucosa of the larynx, trachea, and bronchi rapidly adapts to the presence of foreign bodies so signs and symptoms may not be present. Foreign body aspiration has three stages. Initially, there is a choking episode followed by coughing, gagging, and occasionally complete airway obstruction. An asymptomatic interval then results when the reflexes become fatigued and irritation subsides. This stage accounts for the large number of cases with delayed diagnoses. 20 to 50% of foreign bodies are not detected for more than one week. The third stage is characterized by symptoms of complications. Cough, hemoptysis, pneumonia, lung abscess, fever, and malaise may develop at this point.

Foreign bodies in the larynx or cervical trachea can produce inspiratory or biphasic stridor. A prolonged wheeze in the expiratory phase is suggestive of intrathoracic tracheal obstruction although it can be absent with smaller objects. Discrepancy in breath sounds

between sides of the chest and unilateral wheezing are significant since most objects will impact in the one of the mainstem bronchi. Signs can be subtle and physical exam can be normal, 5-40% of patients fall into this group. The classic diagnostic triad of unilateral wheeze, cough, and ipsilaterally diminished breath sounds is observed in less than 50% of cases. Flexible fiberoptic laryngoscopy can add valuable information as laryngomalacia or other nontraumatic etiologies can be identified.

Radiographic examination with PA and lateral radiographs of the neck and chest are the most efficacious studies in patients with airway foreign bodies. Radiopaque foreign bodies are easily diagnosed with these modalities. Direct comparison of chest radiographs on inspiration and expiration is important. Inspiratory hypoinflation and expiratory hyperinflation is a hallmark of a bronchial foreign body. Radiolucent objects, which comprise a majority of airway foreign bodies, may reveal an obliterated bronchial air column, atelectasis, air-trapping in the affected lung, or a mediastinal shift. In younger children who cannot cooperate with timing of the respiratory cycle, lateral decubitus films can help. The dependent lung should collapse normally but will remain inflated with bronchial obstruction. Real-time airway fluoroscopy can improve diagnosis where available. Despite this, 25% of patients with airway foreign bodies may have normal radiographic studies.

Management

The treatment of airway foreign bodies is prompt endoscopic removal under conditions of maximum safety and minimal trauma. Complete airway obstruction is an absolute emergency. Coughing, gagging, and throat clearing are protective reflexes that indicate that obstruction is not complete. The most important factor in reducing mortality is recognition of a person in acute airway distress. Blindly probing the hypopharynx with a finger may impact a loose foreign body into the larynx and worsen the situation. Back blows in the incompletely obstructed child are not recommended as a bronchial or lower tracheal foreign body can impact in the glottis from below. Complete airway obstruction is heralded by respiratory distress with the inability to speak or cough. For children under one year of age, back blows are the primary therapy. Children older than one year require gentle abdominal thrusts while supine. Older children and adults are treated using the Heimlich maneuver.

Unless actual or potential airway obstruction exists, a foreign body is not a dire emergency. The majority of patients have passed the acute phase and are no longer in distress by the time an otolaryngologist arrives for evaluation. The endoscopic removal can be scheduled when trained personnel are available, when instruments have been checked, and techniques have been tested. Direct laryngoscopy and bronchoscopy in the pediatric population are most safely carried out with a ventilating bronchoscope under general anesthesia. If respiratory distress is not apparent it is prudent to allow the stomach time to empty to decrease complications upon induction of anesthesia. A complete array of endoscopic equipment, including laryngoscopes, ventilating bronchoscopes, rod-lens telescopes, foreign body forceps, suction devices, and light cables must be selected, assembled, and tested prior to the patient entering the operating suite. A duplicate of the suspected foreign body should be used in selecting the proper type of extraction forceps. The age-matched appropriate bronchoscope and one size smaller should be available in case edema or stenosis is encountered.

During induction of anesthesia, the endoscopist should be ready to assume control of the airway should ventilation become impaired. Maintenance of spontaneous ventilation with halothane anesthetic is preferred. Laryngoscopy is initially performed to evaluate the larynx and hypopharynx, to expose the larynx for atraumatic bronchoscope insertion, and application of topical anesthetic. The ventilating bronchoscope is inserted and the anesthesia circuit is connected to the ventilating port. Once the carina is reached, the bronchus opposite the obstruction is examined and suctioned to allow for better oxygenation. The bronchoscope is then advanced to the foreign body and the appropriate extraction forceps are used to atraumatically grasp the object. Small fragments and objects can be removed through the bronchoscope with it remaining in place. Larger objects are pulled snugly against the tip of the bronchoscope and brought out as one unit. Once removed, the bronchoscope is reinserted and examination for multiple foreign bodies commences. Multiple foreign bodies are said to occur in 5-19% of cases. The obstructed bronchus is suctioned to remove secretions, which may aid in more rapid reinflation of the lung. Granulation tissue can be removed and bleeding controlled with topical vasoactive agents on cotton pledgets.

If an object is lost from the forceps grasp during removal, it should be pushed back into a bronchus – preferably the originally obstructed one. Once stabilized, another attempt at removal commences. Sharp, pointed objects are removed by advancing the bronchoscope over the object, rather than pulling it back toward the bronchoscope. In this manner the pointed end can be sheathed within the bronchoscope thus minimizing trauma upon removal.

Postoperative care consists of chest physiotherapy if retained secretions are present. Antibiotics are not required unless pneumonia is present. Routine use of corticosteroids is not necessary unless there was traumatic bronchoscope insertion or traumatic removal of the object with edema of the larynx or trachea.

Pneumonia and atelectasis are the most common complications of airway foreign bodies and are usually related to delayed removal. Pneumonia is treated with appropriate antibiotics and atelectasis is treated expectantly with chest physiotherapy. If there is persistence of symptoms beyond one week, consideration of retained foreign body must be made. Pneumothorax and pneumomediastinum are relatively rare complications.

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