I. Developmental Stages of the Esophagus
   A. Gestation week 4—primitive foregut forms as a ventral tubular structure
   B. Lateral grooves invaginate on each side of the proximal foregut, and fuse to separate the respiratory
      tube (ventral) from the esophageal tube (dorsal)
   C. The dorsal tube fills with ciliated columnar epithelium
      1. Incomplete fusion of lateral grooves causes partial or complete failure of separation of dorsal
         and ventral compartments, producing several forms of tracheoesophageal fistula (TEF)
      2. TEF or laryngopharyngeal cleft anomalies occur in 1:3,000–4,000 live births
   D. Gestation week 10—esophageal lumen re-established
   E. Gestation week 16—esophageal stratified squamous epithelium appears; swallowing can be ob-
      served
   F. Normal esophageal length
      1. 8–10 cm at birth
      2. Doubles in first year of life
      3. Final adult length ~25 cm from cricopharyngeus to lower esophageal sphincter

II. Anatomy
    A. Histology—see chapter on Normal Microanatomy
    B. Structure
       1. Anatomic limits
          a. Upper limit—upper esophageal sphincter is at the level of the cricoid cartilage
          b. Esophageal body traverses the chest in the posterior mediastinum
          c. Esophagus is divided in thirds based on the type of muscle—striated muscle in the up-
             per third, mixed striated and smooth muscle in the middle, and smooth muscle only in
             the lower third
          d. Lower esophageal sphincter (LES) is the anatomic distal end of the esophagus
          e. There is a short abdominal segment of the esophagus below the diaphragm, composed
             mainly of the lower 2–3 cm of the LES
       2. Upper esophageal sphincter (UES)
          a. Skeletal muscle
          b. Anatomically poorly defined—comprised of three structures:
             1) Musculature of the cricopharyngeus muscle
             2) Lower border of the inferior pharyngeal constrictor
             3) Upper fibers of the esophagus
       3. LES composed of:
          a. Expanded circular smooth muscle of the distal esophagus
          b. Buttressed by the right crus of the diaphragm
    C. Innervation
       1. Afferents
          a. Vagus nerve—transmits information about pain, temperature, chemical, osmotic stimuli
          b. Spinal nerve—afferents from muscle layer and serosa transmit mechanosensitive inform-
             ation and act as nociceptors
             1) Afferents from intraepithelial nerve endings mediate acid-induced pain
             2) Calcitonin gene-related peptide and substance P in these nerves mediate visceral
                pain
       2. Efferents are both parasympathetic and sympathetic
          a. Vagus nerve provides predominate motor innervation
b. Parasympathetic nerve supply
   1) Nucleus ambiguus and dorsal motor nucleus of the vagus nerve
   2) Innervation of the esophageal muscles and glands

c. Sympathetic nerve supply
   1) Cervical and thoracic sympathetic chain (spinal segments T1–T10)
   2) Regulates blood vessels, sphincter contraction, peristalsis, glandular activity
   d. Preganglionic nerves terminate on cells of Auerbach (myenteric) plexus between circular and longitudinal layers of muscle, and stimulate smooth muscle. Auerbach plexus also present in skeletal muscle, though function unclear

3. Motor Function:
   a. Upper 1/3 of esophagus (including UES) is under central control (skeletal muscle)
   b. Lower 2/3 of esophagus (including LES) has both central and peripheral control (smooth muscle)

4. Pain sensation:
   a. Noxious stimuli trigger chemoreceptors (direct irritants) or mechanoreceptors (pressure)
   b. Both vagal and sympathetic afferents carry pain signals centrally
   c. Pathways overlap with heart and respiratory system, making localization of pain difficult
   d. Significant overlap between different pain receptors (chemical, mechanical, temperature), making types of sensation difficult to separate

5. Visceral hyperalgesia
   a. Prolonged acid exposure in the esophagus causes altered sensory perception and sensitization of neurons, with heightened pain signaling even to physiologic events
   b. Visceral hyperalgesia may contribute to feeding problems

D. Vasculature
   1. Arterial
      a. Upper esophagus—branches of superior and inferior thyroid arteries
      b. Midesophagus—branches of the bronchial and right intercostal arteries and descending aorta
      c. Distal esophagus—branches of the left gastric, left inferior phrenic, and splenic arteries
   2. Venous
      a. Upper esophagus—drained by superior vena cava
      b. Midesophagus—azygos veins
      c. Distal esophagus—portal vein (via left and short gastric veins). Varices occur in this area

III. Physiology
   A. Swallowed food bolus is delivered to hypopharynx by tongue and mouth musculature
      1. UES is constantly contracted (except while sleeping)
      2. Coordinated swallow includes simultaneous elevation of soft palate, closure of the larynx, and brief relaxation of cricopharyngeus to admit swallowed bolus through UES
      3. Cricopharyngeal achalasia is characterized by failure of UES relaxation with swallowing
         a. Associated with Chiari malformation (centrally mediated dysfunction of UES)
         b. Can be associated with disorders of skeletal muscle or neurologic disorders that affect skeletal muscle
   B. Both the force applied to the bolus by voluntary swallowing and esophageal peristalsis propel the bolus through the esophageal body
      1. Average speed of esophageal peristalsis is about 1 cm/sec
      2. Average speed of bolus through the hypopharynx during swallowing is 10 cm/sec
   C. LES relaxation occurs simultaneous with swallowing
      1. LES relaxation persists until resting pressure is restored by wave of esophageal peristalsis
      2. Duration of relaxation is several seconds, sufficient to allow bolus to pass through the relaxed LES
   D. Spontaneous transient LES relaxation (TLESR) in the absence of swallowing is the most important mechanism permitting gastroesophageal reflux
      1. Spontaneous LES relaxations occur with increased frequency postprandially due to gastric distension, which stimulates subdiaphragmatic nerves
      2. Afferent sensory fibers from the stomach go to vagal nuclei, which lead to efferent vagal-mediated relaxation of LES
E. Abnormal LES pressure
   1. Resting pressure of LES is ~20–30 mm Hg. Resting pressure below 10 mm Hg is abnormally low
      a. Resting pressure is reduced by:
         1) Drugs—theophylline, nitroglycerine, botulinum toxin
         2) Inflammation
         3) Displacement of LES into thorax (hiatus hernia), which reduces pressure due to negative pressure environment
         4) Disorders of smooth muscle
   2. Increased resting LES pressure occurs with:
      a. Displacement of LES into abdominal cavity, where resting pressure is augmented by positive intraabdominal pressure
      b. External abdominal compression
      c. Cholinergic agents (bethanechol), gastrin
      d. Esophageal achalasia and diffuse esophageal spasm may have abnormally high resting LES pressure
F. Esophageal glands
   1. Release mucous important for esophageal clearance of food and neutralizing any refluxed acid

Recommended Reading


Sengupta JN. Esophageal sensory physiology. GI Motility Online. 2006. doi: 10.1038/gimo16.
1B. Normal Esophageal Histology

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I. Introduction
A. Most of the esophagus is lined by squamous epithelium, a non-keratinized, stratified epithelium
B. Distal end lined by columnar epithelium
C. The normal squamo-columnar junction is at the level of the diaphragm
D. Esophageal squamous mucosa contains three layers – epithelium, lamina propria, and muscularis mucosae

II. Squamous epithelium of the esophagus
A. Basal layer
   1. Contains several layers of cuboidal basophilic cells, which divide and differentiate as they move toward the surface and desquamate over a period of about 7 days
   2. Basal layer accounts for 10-15% of the total epithelial thickness
   3. Hyperplasia to >15% of epithelial thickness occurs in patients with GER and other inflammatory conditions, especially in the distal esophagus
B. Above the basal cell layer, glycogenated cells progressively flatten and are identified with Periodic acid-Schiff (PAS) stain
   1. As cells approach the luminal surface, polarity changes from vertical to horizontal
   2.Granular and keratinized layers are absent in esophageal mucosa
   3. Scattered endocrine cells and melanocytes may be present
   4. CD3+ lymphocytes are present in the lower and middle squamous cell layers
   5. Antigen-presenting Langerhans cells are present just above the basal layer
C. Lamina propria
   1. Projections of lamina propria (papillae) extend into the squamous epithelium at regular intervals, creating an irregular lower border to the squamous epithelium
   2. Mucosal integrity and growth are maintained in part by epidermal growth factor (EGF)

III. Histology of the gastroesophageal junction (GEJ)
A. Z line - a gross landmark representing the junction of squamous epithelium and transitional cardiac mucosa of the proximal stomach (darker red)
B. The exact GEJ is difficult to identify grossly. It is not clear whether the Z line lies precisely at, or slightly proximal to the GEJ
   1. True cardiac mucosa is a columnar epithelium, with tubular glands containing mucin producing cells, parietal cells, and rarely, chief cells
   2. Transitional cardiac mucosa, found just below the GEJ, is similar to cardiac mucosa, but contains very few parietal cells
   3. When cardiac mucosa overlies esophageal glands or squamous epithelial – lined ducts, location within the esophagus is certain
   4. Variability in extent of cardiac mucosa may be a result of metaplasia secondary to peptic disease, GERD, or H pylori

IV. Lamina Propria of the esophagus
A. Consists of the non-epithelial portion of the esophageal mucosa above the muscularis mucosae
B. Consists of loose areolar connective tissue containing blood vessels, nerves, inflammatory cells, and mucus-secreting glands
C. Lymphocytes, plasma cells, and occasional lymphoid follicles are present
D. Rests on the muscularis mucosa
V. **Muscularis Mucosae of the esophagus**
   A. First identifiable in the esophagus at the level of the cricoid cartilage, and becomes thicker distally
   B. Proximally consists of isolated or irregular muscle bundles
   C. In middle and lower esophagus, the muscularis mucosae forms a continuum of longitudinal (exterior) and transverse (internal) fibers

VI. **Submucosa of the esophagus**
   A. Wide zone below the muscularis mucosae, consisting of loose connective tissue with blood vessels, nerves, poorly formed submucosal ganglia, lymphatics, and submucosal glands
   B. Contains an extensive lymphatic plexus
   C. There are two types of submucosal glands: superficial (neutral mucin production) and deep (acidic mucin production)

VII. **Muscularis Propria of the esophagus**
   A. Well-developed circular and longitudinal layers
   B. The upper third consists of striated muscle gradually changing to smooth muscle in the middle and lower third of the esophagus
   C. The lower esophageal sphincter is not a clearly defined anatomic structure, but consists of thickened smooth muscle fibers that extend approximately 2 cm above and 3 cm below the diaphragmatic hiatus

VIII. **Adventitia of the esophagus**
   A. The esophagus does not have a serosal layer
   B. The external layer (adventitia) consists of loose connective tissue, with longitudinally directed blood and lymph vessels and nerves
   C. Gradually merges into the connective tissue of the mediastinum
   D. Numerous elastic fibers at the GEJ anchor the esophagus to the diaphragm

**Recommended Reading:**

Gastrointestinal Pathology: An Atlas and Text (Lippincott Williams & Wilkins), Hardcover (2008) by Cecilia M Fenoglio-Preiser, Amy E Noffsinger, Grant N Stemmermann, pages 11-20

Odze and Goldblum: Surgical Pathology of the GI Tract, Liver, Biliary Tract and Pancreas, 2nd Edition (2009), pages 16-17, 40

Biopsy Interpretation of the Gastrointestinal Tract Mucosa (Biopsy Interpretation Series) (Hardcover) Elizabeth A. Montgomery, pages 1-2
I. Physiology of Esophageal Motility
A. Primary peristalsis—Initiated by swallowing
B. Secondary peristalsis—Initiated by stretch on esophageal wall
C. Upper esophageal sphincter (UES) and lower esophageal sphincter (LES) are tonically contracted between swallows
D. Sphincter relaxation induced by swallowing, vomiting, and release of gas
E. Transient relaxations of LES are not associated with swallow
   1. Transient relaxations occur normally after meals in response to gastric distension
   2. Transient relaxations are responsible for >90% of GE reflux episodes

II. Esophageal Manometric Evaluation
A. Indications
   1. Diagnosis of achalasia, nutcracker esophagus, diffuse esophageal spasm
   2. Evaluation of chest pain, dysphagia, and odynophagia
   3. Accurate placement of esophageal pH probe, especially when anatomy is abnormal (hiatus hernia, scoliosis)
   4. Evaluation of medical therapy
   5. Confirm diagnosis of systemic diseases associated with esophageal dysmotility
B. Equipment and procedure
   1. Water-perfused or solid state manometry catheter with at least three recording sites
   2. Catheter placed transnasally
   3. Standard protocol involves three maneuvers
      a. Pull through from stomach to esophagus to assess LES resting pressure and location
      b. Wet swallows with water to determine LES relaxation
      c. Assessment of peristalsis in esophageal body
      d. High resolution manometry
         1) One sensor per centimeter from pharynx to stomach
         2) Enables detailed segmental assessment of esophageal motor function
         3) Facilitates diagnosis of vigorous achalasia, LES pseudo-relaxation, and other subtle abnormalities

Figure 1. Normal esophageal manometry. There is a decrease in pressure of the LOS when the child swallows (-). There are normal amplitude peristaltic oesophageal contractions. Distance above LOS is indicated in cm.

III. Achalasia
   A. Degeneration of myenteric plexus of the lower 2/3 of esophagus (smooth muscle)
   B. Symptoms—Progressive esophageal obstruction, especially with solids; chest pain, aspiration, weight loss, and chronic pulmonary disease
   C. Manometric findings—Absent or abnormal peristalsis, incomplete LES relaxation, elevated baseline LES pressure
   D. Possible etiologies—Autoimmune, infectious, environmental
   E. Allgrove syndrome—Achalasia, ACTH insensitivity, and alacrimia. Autosomal-recessive gene on chromosome 12q13
   F. Rozycki syndrome—Achalasia, autosomal-recessive deafness, short stature, vitiligo, muscle wasting
   G. Other associations—Chagas disease, paraneoplastic syndrome, sarcoidosis, Down syndrome, pyloric stenosis, Hirschsprung disease, intestinal pseudo-obstruction
   H. Making the diagnosis
      1. Upper GI barium x-ray showing dilated esophagus and bird beak deformity at LES
      2. Fluoroscopy showing abnormal or absent esophageal peristalsis
      3. Manometry showing absence of peristalsis in esophageal body, failure of LES relaxation during swallow, and elevated resting LES pressure
   I. Treatment
      1. Balloon dilation of LES—Good results in 60%. Complications include perforation, fever, pleural effusion
      2. Heller myotomy of the LES produces symptom relief in >75%
      3. Gastroesophageal reflux occurs after both surgical and dilation therapy
      4. Botulinum toxin injection of LES inhibits acetylcholine release at neuromotor junction, with short-term symptom relief
      5. Isosorbide dinitrate—Decreases LES pressure and improves esophageal emptying
      6. Nifedipine—Calcium channel blocker reduces LES pressure and decreases amplitude of esophageal contractions

IV. Diffuse Esophageal Spasm
   A. Manometry shows simultaneous esophageal contractions after >20% of wet swallows

V. Nutcracker Esophagus
   A. Manometry shows high amplitude peristaltic contractions in patients with chest pain
   B. Associated anxiety, depression, and somatization

Figure 2. Oesophageal manometry of a child with achalasia. There is a high LOS pressure, and there is absent peristalsis and lack of LOS relaxation after wet swallows (-). Distance above LOS is indicated in CM.

VI. **Collagen vascular diseases produce secondary esophageal dysmotility, pain, dysphagia, and aspiration**
   A. Scleroderma, polymyositis, dermatomyositis, and mixed connective tissue disorder
   B. 73% prevalence of esophageal dysmotility in pediatric scleroderma and mixed connective tissue disorder
   C. Manometric findings
      1. Low or absent LES pressure
      2. Decreased or absent distal (smooth muscle) esophageal peristalsis
      3. Normal UES and upper esophageal peristalsis (striated muscle)

VII. **Neurologic disorders producing esophageal dysmotility**
   A. Disorders of striated muscle produce UES dysfunction—CP, muscular dystrophies, cranial nerve abnormalities, and Arnold Chiari malformation
   B. Muscular dystrophy reported to be associated with reduced esophageal peristaltic amplitude

**Recommended Reading**


Deglutition is a complex process encompassing three phases (oral, pharyngeal and esophageal), requiring coordination and normal anatomic structures.

I. Three phases of deglutition
   A. Oral: voluntary activity
      1. Mouth functions as both sensory and motor organ
      2. Physical changes in food bolus produced by oral cavity include changes in size, shape, volume, pH, temperature, and consistency
   B. Pharyngeal: reflexive and complex
      1. Lasts for about 1 second in healthy individuals
      2. Steps include:
         a. Tongue loading and transport of bolus posterior in solid feedings
         b. Elevation of the pharyngeal tube simultaneous with bolus delivery
         c. Velopharyngeal closure
         d. Relaxation of the upper esophageal sphincter (UES)
         e. Closure of the laryngeal vestibule, followed by a peristaltic wave in the posterior pharyngeal constrictors, propels the bolus past the UES
   C. Esophageal:
      1. UES is a manometrically defined high-pressure zone measuring ~3 cm in length, which is composed of striated muscle located just caudad to the hypopharynx. The UES is tonically closed at rest, and opens during swallowing. Resting pressure is variable, ranging from 30–80 mm Hg
      2. Distention of the esophagus produces reflex ↑ in UES resting pressure (protective response)
      3. In some studies, acidification of the esophagus causes ↑ UES resting pressure
      4. The main UES muscle is the cricopharyngeal muscle, which is enervated by vagal branches of the pharyngeal plexus

II. Changes in components of oral and pharyngeal cavities during development
   A. In infants the tongue lies entirely within the oral cavity. The larynx is positioned high in the neck. The oropharynx is small in volume
   B. During childhood, the base of the tongue descends. The larynx descends to the level of the seventh vertebra by adulthood

III. Neurology of deglutition
   A. All phases of deglutition can be modified by sensory feedback (touch and pressure receptors), which may have implications in management of swallowing-impaired individuals
   B. Swallowing may be evoked by stimulating the oropharyngeal regions innervated by cranial nerve IX and the superior laryngeal and recurrent laryngeal nerves of vagus
   C. Cerebral cortex is not essential for the pharyngeal and esophageal phases of swallowing
      1. The neurons important to these phases are located in the pons and medulla
      2. Deglutition can occur in infants with no nervous tissue rostral to the midbrain (anencephaly)

IV. Non-nutritive sucking bursts are faster in frequency and shorter in duration than nutritive sucking bursts
   A. In preterm infants, non-nutritive sucking during gavage feeding is associated with improved weight gain due to either:
      1. More efficient nutrient absorption
      2. Decrease in energy requirements secondary to a lessening of infant activity or restlessness
V. Causes of disordered deglutition in pediatric patients:
   A. Prematurity
   B. Nasopharyngeal disorders—choanal atresia, nasal and sinus infection, tumor, septal deflection
   C. Oral and oropharyngeal disorders—cleft lip/cleft palate, craniofacial syndromes
   D. Laryngeal disorders—stenosis, webs, clefts, paralysis and laryngomalacia
   E. Congenital defects—laryngotracheopharyngeal cleft, tracheoesophageal fistula and/or esophageal atresia, esophageal web and stricture, vascular anomalies such as double aortic arch or right aortic arch
   F. Trauma to upper airway, oropharynx
   G. Neurologic defects—hypoxia, microcephaly, cortical atrophy, CNS infection, Arnold-Chiari malformation, dysautonomia, sensory integration or processing disorders, and CNS injury
   H. Neuromuscular diseases—myotonic muscular dystrophy, myasthenia gravis, poliomyelitis
   I. Muscular disorders—achalasia

VI. Historical features in evaluation of dysphagia
   A. Drooling or open-mouth posture suggests oral phase abnormalities
   B. Dysphagia while swallowing suggests pharyngeal phase abnormalities:
      1. Anatomical abnormality
      2. Oropharyngeal incoordination
      3. Neurologic disorder
   C. Dysphagia after swallowing suggests esophageal abnormalities
   D. Dysphagia with solids suggests only anatomical/mucosal lesions
   E. Dysphagia with solids and liquids suggests motility disorder

VII. Physical examination
   A. Structure of the face, oral cavity, and oropharynx
   B. Is there an intact hard and soft palate?
   C. Is the tongue midline and of normal size and motility?
   D. Is the size of the mandible normal (rule out Robin sequence)?
   E. Is the control of head, neck, and body position normal?
   F. Gag reflex - if present, and if weak or hyperactive
   G. Observational feeding trial
      1. Primitive reflexes or movements
      2. Positions of the head, neck and body during swallowing
      3. Abnormal feeding behaviors (such as tongue thrust and averting the mouth)
      4. A change in voice quality after feeding

Recommended Reading

Dysphagia is the sensation of difficulty swallowing or of food sticking as it passes from mouth to stomach. There are three phases of deglutition, including oral, pharyngeal, and esophageal. The symptoms associated with the oral phase include drooling, constantly open mouth, poor sucking, refusal to swallow, cough, gagging, choking, respiratory distress, and aspiration. The symptoms of the pharyngeal phase include dysphagia while swallowing. Finally, dysphagia of the esophageal phase presents as dysphagia after swallowing. Odynophagia—painful swallowing—often accompanies dysphagia.

I. Differential Diagnosis

A. Oral phase
1. Nasopharyngeal disorders
   a. Choanal atresia or stenosis
   b. Sinus and nasal infections
2. Oral cavity abnormalities
   a. Cleft lip/palate
   b. Hypopharyngeal web/stenosis
   c. Craniofacial syndromes with micrognathia—Robin sequence
   d. Trauma, infection, and mucositis
   e. Tonsillar or adenoid hypertrophy
   f. Pharyngitis
3. Profound developmental delay may be associated with uncoordinated chewing and swallowing behavior
4. Skeletal muscle hypotonia; cranial nerve abnormalities with spasticity, dystonia, or paresis

B. Pharyngeal phase
1. Anatomic defects of the pharynx
   a. Pharyngeal webs cause obstruction and dysphagia
2. Anatomic defects of the larynx
   a. Laryngeal stenosis
   b. Laryngopharyngeal cleft
   c. Laryngeal web
3. Cricopharyngeal dysfunction
   a. Cricopharyngeal achalasia
   b. Muscular hyperplasia
   c. Cricopharyngeal incoordination
   d. Dysphagia occurs due to failure to relax the upper esophageal sphincter, due to central or cranial nerve damage
4. Neurologic defects: Physiologic feature is poor motor oral-pharyngeal coordination
   a. CNS: head trauma, brain injury (infection, hypoxia), microcephaly, anencephaly, myelomeningocele, Chiari malformation, dysautonomia
   b. Neuromuscular disorders: myotonic dystrophy, myasthenia gravis, Guillain-Barré syndrome, poliomyelitis, spinal muscular atrophy

C. Esophageal phase
1. Stricture—caustic ingestion, peptic esophagitis, eosinophilic esophagitis, epidermolysis bullosa, trauma, gastric rest, pill esophagitis
2. Anatomic abnormalities—diverticulae, TE fistula, aberrant cervical thymus, webs
3. Disorders of esophageal motility
   a. Achalasia:
      1) Abnormal or absent peristalsis
2) Failed lower esophageal sphincter relaxation
3) Hypertensive lower esophageal sphincter
4) Mechanism for dysphagia is that bolus transit is impaired. Stretching of the esophageal wall stimulates nociceptors that cause dysphagia

b. Diffuse or distal esophageal spasm
   1) Simultaneous esophageal contractions after 20% more swallows
   2) Lower esophageal sphincter relaxation is normal
   3) Dysphagia caused by esophageal dilation proximal to the transient muscular obstruction
   4) Treatment with calcium channel blockers or anticholinergics

c. Nutcracker esophagus
   1) Very strong simultaneous esophageal body contractions
   2) Esophageal contractions are so strong that odynophagia is the more prominent symptom

d. Systemic neuromuscular disorders causing dysphagia
   1) Systemic lupus, scleroderma
   2) Diabetes
   3) Thyroid disorders
   4) Amyloidosis
   5) Chagas disease
   6) Graft vs host disease
   7) Mitochondrial disorders
   8) Paraneoplastic syndromes

e. Vascular anomalies
   1) Double aortic arch and right aortic arch with left ligamentum arteriosum compresses the esophagus
   2) Aberrant right subclavian artery is a common variant. Although the filling defect on the esophagus may be dramatic, this lesion rarely causes esophageal obstruction
   3) The best test for diagnosis of vascular abnormalities is MRA

f. Dermatologic
   1) Dermatologic disorders affecting the squamous epithelium of the esophagus
   2) Usually associated with oral and pharyngeal disease
   3) Epidermolysis bullosa causes esophageal inflammation and stricture

g. Inflammation and injury
   1) All forms of esophagitis may cause dysphagia
   2) Caustic burns
   3) Radiation injury affects both epidermal and muscle layers

II. Testing for Dysphagia
   A. Videofluoroscopy (modified barium swallow) to detect abnormalities in swallowing, aspiration, and esophageal obstruction (oral and pharyngeal phase)
   B. Barium swallow to detect anatomic abnormalities, including obstruction (esophageal phase)
   C. Upper endoscopy to assess for mucosal disease (esophageal phase)
   D. Esophageal manometry to diagnose motility disorders

Recommended Reading


Congenital anomalies of the esophagus occur approximately once in every 3,000–5,000 live births. Esophageal atresia and tracheoesophageal fistula (TEF) are the most common anomalies.

I. Esophageal Duplication
   A. Foregut duplications account for one-third of all GI duplications
      1. Amongst foregut duplications, esophageal are the most common
   B. Duplications appear as cysts, diverticulae, and tubular malformations
   C. Gastric mucosa is frequently observed in duplications, irrespective of site of origin
   D. Diagnosis
      1. Identified on upper GI and/or CT of chest
      2. May be difficult to distinguish from bronchogenic cysts
      3. Vertebral anomalies occur in up to 50% of patients with esophageal duplication
   E. Most common presenting symptoms are respiratory distress in neonates and dysphagia in older children
   F. Small cysts may be asymptomatic
   G. Older children may have gastrointestinal/bronchial hemorrhage and spinal meningitis if the wall of duplication erodes from acid production
   H. Management is surgical excision

II. Esophageal Stenosis
   A. Stenosis due to tracheobronchial rest (TBR) is most common
      1. Due to abnormal separation of foregut into trachea and esophagus
      2. Found within 3 cm of gastric cardia
      3. Often results in significant obstruction
   B. Intrinsic congenital esophageal stenosis caused by congenital malformation of the esophageal wall
      1. May not be present at birth
      2. Incidence is 1/25,000–50,000 live births
   C. Fibromuscular stenosis and membranous webs occur in middle third
      1. Fibromuscular stenosis has smooth wall and is 1–4 cm in length, with partial obstruction of esophageal lumen
      2. Membranous diaphragm is least common
   D. One-third of reported cases of TBR and fibromuscular stenosis are associated with esophageal atresia and TEF
   E. Symptoms and signs
      1. High lesions present with respiratory symptoms
      2. Lower lesions present with vomiting
      3. Majority present as dysphagia after solid foods are introduced
   F. Diagnosis by upper GI (UGI) and endoscopy
   G. Treatment is via excision with end-to-end anastomosis
      1. Fibromuscular stenosis can be treated by dilation
      2. Esophageal webs are amenable to dilation

III. Esophageal Atresia/Tracheoesophageal Fistula (TEF)
   A. Incidence is 1/3,000–4,000 live births, highest amongst Caucasians
   B. 0.5%–2% risk of recurrence among siblings of affected child
   C. Anatomy
      1. In esophageal atresia, proximal and distal portions of esophagus do not communicate
         a. Upper segment is a dilated blind-ended pouch with hypertrophied muscle
         b. Distal end is atretic, with thin walls
         c. Gastroesophageal sphincter is typically incompetent, with defective vagus nerve
2. In TEF, there is an abnormal communication between trachea and esophagus
   a. 84% of patients demonstrate a blind-ending upper esophageal pouch, with fistula
      from trachea to distal esophagus (see Figure 1)
   b. 50%–70% have other anomalies, including genitourinary, cardiac (35%), gastrointesti-
      nal (25%), and musculoskeletal (20%), as well as VACTERL association (10%)
   c. Right-sided aortic arch occurs in <2% of cases

D. Signs and symptoms of esophageal atresia/TEF
   1. Prenatal history of polyhydramnios
   2. Smaller than normal gastric air bubble
   3. NG tube that meets resistance prior to entering stomach may also lead to diagnosis
   4. Cough, emesis, and cyanosis during feeding
   5. Distal fistulae may produce progressive abdominal distension with air
   6. H-type TEF often diagnosed late
      a. Newborns may have choking or respiratory distress with eating
      b. Recurrent pneumonia or wheezing
      c. Diagnosis depends on visualizing the fistula, either during endoscopy, or during a
         barium esophagram with contrast injected via slowly withdrawn NG tube

E. Treatment is surgical
   1. Cardiac evaluation is mandatory prior to surgical repair
   2. Postoperatively, there is a 10%–17% risk of anastamotic leak, leading to formation of salivary
      fistula, mediastinitis, and/or pneumonitis
   3. 25%–40% of patients have gastroesophageal reflux postoperatively due to impaired mid-
      esophageal peristalsis
   4. Tracheomalacia occurs in up to 75% of cases
   5. Barrett's esophagus is a long-term complication of TEF
   6. Recurrent infections postoperatively raise the possibility of recurrent or missed fistula in older
      children

IV. Esophageal Web
   A. Mucosal membrane occludes esophageal lumen, usually found in proximal esophagus
   B. Associated with TEF
   C. More common in females
   D. Plummer-Vinson syndrome: webs associated with glossitis, iron deficiency anemia, and
      koilonychias (spoon nail)
   E. Webs occur as an inflammatory complication of epidermolysis bullosa, cicatrical pemphigoid,
      Stevens-Johnson syndrome, psoriasis, idiopathic eosinophilic gastroenteritis, and GVHD

V. Esophageal Ring
   A. A-ring: asymptomatic, caused by hypertrophied circular muscle 1.5–2.0 cm above squamocolumnar
      junction
   B. B-ring: also called Schatzki ring, contains only mucosa
   C. C-ring: indentation of esophagus caused by diaphragmatic crura
   D. Symptoms are similar to esophageal atresia, with complete membrane/web
   E. Diagnosis by endoscopy or UGI series
   F. Therapy: dilation or surgical resection
Figure 1. Types of esophageal atresia and tracheoesophageal fistula.
From: Esophageal Atresia/Tracheoesophageal Fistula overview
www.ncbi.nlm.nih.gov/books/NBK5192/

Recommended Reading


Gastroesophageal reflux (GER) is the retrograde movement of gastric contents into the esophagus. This is a normal physiologic process that occurs throughout the day in healthy infants, children, and adults. Most episodes last <3 minutes, occur postprandially, and have few or no symptoms. Gastroesophageal reflux disease (GERD) is the pathologic sequelae that can occur with GER. GERD is the most common esophageal disorder.

I. Pathophysiology
   A. 90% of GER episodes in infants and children occur during transient lower esophageal sphincter relaxation (TLESR)
      1. TLESR are not associated with swallowing or esophageal peristalsis
      2. TLESR occur up to 6 times per hour in normal adults, especially after meals
      3. TLESR are rare during sleep
      4. Gastric distension increases the frequency of TLESR
   B. Lower esophageal sphincter (LES) pressure, usually between 8–30 mm Hg
   C. Relaxation of LES is vagally mediated via brainstem and precipitated by swallowing
   D. Nocturnal reflux is uncommon in healthy children, and is characteristic of GERD

II. Natural History
   A. During infancy, GER manifests as effortless regurgitation
      1. 50% of infants have GER in the first 3–6 months
      2. Less than 20% of infants still have GER at 12–15 months
   B. GERD with onset after 2 years of age is less likely to resolve spontaneously

III. Differential Diagnosis
   A. Other forms of esophagitis: infection, eosinophilic esophagitis, chemical esophagitis
   B. Gastric disorders: peptic ulcer disease, gastritis
   C. Motor abnormalities: esophageal spasm, achalasia
   D. Other disorders associated with vomiting: urinary tract infection, increased intracranial pressure, food allergy, child neglect or abuse, eating disorder

IV. Clinical Diagnosis
   A. Diagnosis is often clinical, based upon typical symptoms and the lack of signs and symptoms of other disorders
   B. No unique symptom complex is diagnostic of GERD
   C. Adolescents are more likely to have typical heartburn than young children and infants
   D. Upper airway symptoms: limited data link reflux to hoarseness, chronic cough, sinusitis, otitis media, and erythema/cobblestoning of the larynx
   E. Reflux is not a common cause of irritability, unexplained crying, or distress in otherwise healthy infants
   F. Most apparent life-threatening events (ALTE) are not related to GERD

V. Testing for GERD
   A. Barium upper GI (UGI) is useful to rule out anatomic abnormality
   B. Esophageal pH monitoring is useful to evaluate efficacy of antisecretory therapy
   C. Impedance and/or pH monitoring is useful to correlate symptoms with reflux episodes, and also useful to differentiate eosinophilic esophagitis from GERD in patients with peptic esophagitis
      1. If GERD is suspected as a cause of apnea or ALTE, impedance testing/pH monitoring with polysomnography may provide data confirming the association of symptoms with reflux events
2. Impedance: detects acid, weakly acidic, and non-acid reflux. Superior to pH monitoring alone for relation between symptoms, GER, and postprandial reflux

D. Motility studies are useful to confirm achalasia or other disorders of the esophagus that mimic GERD

E. Endoscopy and biopsy
   1. Visible breaks in mucosa of the distal esophagus is reliable evidence of reflux esophagitis
   2. Visible esophageal erythema, pallor, and lack of vascular markings are very subjective
   3. Biopsy is important to rule out other causes of esophagitis and monitor/diagnose Barrett’s esophagitis

F. Nuclear scintigraphy is not recommended to diagnose GERD

G. Gastric emptying studies do not diagnose GERD, and are only useful in patients with a history suggesting gastric retention

H. Esophageal/gastric ultrasound is not recommended to diagnose GERD

VI. Treatment

A. Lifestyle change in infants
   1. Formula-fed infants may benefit from a 2–4-week trial of extensively hydrolyzed formula
   2. Thickened formula may reduce regurgitation, but does not reduce reflux episodes
   3. Prone positioning decreases acid exposure, but may increase SIDS. Left-sided positioning also decreases reflux compared to right-sided positioning

B. Lifestyle changes in children/adolescents
   1. No evidence for elimination of any specific food
   2. Obesity, late night eating, and large meals all contribute to GERD
   3. Prone sleeping or elevation of the head of the bed may be helpful

C. Pharmacologic therapy
   1. Histamine-2 receptor antagonists have rapid onset of action, but tachyphylaxis or tolerance may develop
   2. Proton pump inhibitors are superior to histamine-2 receptor antagonists for treating erosive esophagitis or GERD symptoms
      a. Twice-daily dosing is not routinely indicated
      b. Pediatric patients with endoscopically diagnosed reflux esophagitis or nonerosive reflux disease are treated with PPIs for three months
      c. No controlled studies support the empiric use of acid suppression to treat infant irritability
   3. Prokinetic agents
      a. Insufficient evidence to support routine use of metoclopramide, erythromycin, domperidone, bethanecol, or cisapride for GERD
   4. Buffering agents, alginate, or sucralfate may be useful for on-demand symptom suppression, but are not recommended for long-term use

D. Surgical therapy: Nissen fundoplication
   1. May be beneficial in children with relapsing severe GERD
   2. Indications: failure of medical therapy, dependence on long-term medical therapy, nonadherence to medical therapy, intractable pain, neurological impairment, recurrent bleeding, and aspiration

E. Three groups of patients with asthma and positive tests for GERD may benefit from anti-reflux therapy
   1. Asthmatics with heartburn
   2. Asthmatics with nocturnal respiratory symptoms
   3. Asthmatics who are steroid dependent or have difficult-to-control asthma
Recommended Reading


Eosinophilic esophagitis is characterized by significant eosinophilic infiltrate localized to the esophagus. The etiology appears to be an increased immunologic response to allergen exposures. There is a strong link to atopy.

I. Definition
Eosinophilic esophagitis (EoE) is a clinicopathologic diagnosis requiring the following criteria:
A. Symptoms of esophageal inflammation - pain, heartburn, and recurrent emesis. Older children and adolescents may present with food impaction and dysphagia
B. Esophageal mucosal biopsy shows an eosinophilic infiltration with >15 eosinophils/high-power field (40X)
C. Exclusion of other disorders associated with similar clinical, histological, or endoscopic features

II. Etiology
A. Inflammatory condition of the esophagus caused by a mixed IgE and non-IgE mediated allergic response
B. The precipitating allergens cannot always be identified. Food antigens and aeroallergens are suspected
C. Non-IgE response involves T helper 2 (Th2) signaling via cytokines IL-5, IL-13, eotaxin-1, -2, and -3 (pro-inflammatory and chemo-attractant)
D. Chronic EoE associated with tissue remodeling and collagen deposition in the lamina propria

III. Epidemiology
A. Incidence in children in the United States is 1.23 per 10,000
B. Prevalence in children in the United States is 4.3 per 10,000 (0.043%)
C. Prevalence is increasing due to chronic and non-fatal nature of EoE, but incidence was shown to be stable between the years of 1982-1999

IV. Clinical Symptoms
A. EoE may present with GERD that is unresponsive to acid suppressing therapy
B. Two thirds of children with EoE have a history of asthma, eczema, food allergies, environmental allergies, chronic rhinitis, or family history
C. In infants and toddlers, food refusal, vomiting, and pain with eating may be prominent
D. Preschool and school-aged children may have chronic abdominal pain and vomiting
E. Adolescents may have symptoms of gastroesophageal reflux, dysphagia, and recurrent food impaction are common
F. 55% of adult food impactions are related to EoE

V. Endoscopic Findings
A. Longitudinal furrowing of the esophageal body
B. White exudates, often in 1-3 mm plaques
C. Edema
D. Friability
E. Small-caliber esophagus or stricture at any location of active disease
F. “Trachealization” of the esophagus (circumferential ridges)

VI. Histologic Findings Consistent with EoE
A. Hyperplasia of the basal zone of the esophageal mucosa beyond 1/3rd the total mucosal thickness
B. Increased height of papillae beyond 1/3rd the total mucosal thickness
C. Superficial eosinophilic microabscesses
D. Eosinophilic inflammatory infiltrate with eosinophils count >15/hpf
VII. Differential Diagnosis
A. GERD
B. IBD
C. Celiac Disease
D. Viral Esophagitis
E. Parasitic Infection
F. Drug Allergy
G. Hypereosinophilic Syndrome
H. Churg-Strauss Syndrome

VIII. Treatment
A. Topical steroids (fluticasone or budesonide)
   1. 50% histological remission and 67% resolution of vomiting compared to placebo in one study
   2. Dose used in this study 880 mcg/day
   3. Upon discontinuation of steroids, 90% of patients had recurrence of symptoms
B. Elimination Diet, dictated by food allergy testing with skin prick or allergy patch test
   1. One study demonstrated symptomatic and histological improvement in 75% of patients
C. Six Food Elimination Diet: (Milk, Soy, Egg, Wheat, Peanut, and Fish/Shellfish)
   2. One study demonstrated symptomatic and histological improvement in 74% of patients
D. Elemental Diet
   3. One study demonstrated symptomatic and histological improvement in 98% of patients
E. Anti-IL-5 and anti-IL-13 monoclonal antibody therapy is still experimental

IX. Endoscopy
A. Follow-up EGD with biopsies should be performed after intervention, to evaluate endoscopic and histological improvement if symptoms persist
B. The incidence of stricture and risk factors for development of strictures is unknown
C. Strictures can be treated with dilation, but have an increased risk of perforation
D. Controversy remains surrounding the benefit of complete histological remission, defined as < 1 eos/hpf on four or more random endoscopic biopsies of the esophagus, to prevent stricture formation

Recommended Reading


1H-2. Infectious Esophagitis

Kelly Fair Thomsen, MD

Esophageal infections are rare in children. Herpes simplex virus is the most common in an immunocompetent host. Candida infections are rare and most often associated with prolonged antibiotic or PPI exposure or abnormal anatomy or motility.

**Fungal Infections**

I. *Candida albicans* causes 95% of fungal infections of the esophagus. *C tropicalis*, *C krusei* and *C stellatoidea* are also implicated

A. Background:
   1. Symptoms not diagnostic: dysphagia, odynophagia, substernal chest pain, and emesis
   2. Occurs with/without oral candidiasis in healthy persons
      a. In oncology patients, oral thrush and esophageal candidiasis usually coexist
   3. Definitive diagnosis requires esophageal biopsy and culture

B. Predisposing factors
   1. Mucositis – secondary to chemotherapy or radiation
   2. Leukopenia
   3. Steroid use (including inhaled steroids)
   4. Acquired or congenital immunocompromise
   5. Stasis, abnormal motility: scleroderma, achalasia
   6. Severe malnutrition (immunocompromise most likely mechanism)
   7. Broad-spectrum antibiotic therapy (especially in malnourished or immunocompromised patients)
   8. Underlying esophageal disease (EoE, GERD)

C. Diagnostic findings
   1. Endoscopic findings: Adherent white plaques on the esophageal wall
   2. Histology: Tangled hyphae and unicellular forms invading surface epithelium
   3. Culture is of limited use, as *Candida* is frequently present in the mouth and GI tract without esophagitis
   4. Radiologic findings: Air contrast barium esophagram may show ulcerations and exudates

D. Therapy
   1. In healthy individuals, may be self-limited
   2. *Candida* esophagitis treated first-line with oral or IV fluconazole or oral itraconazole solutions for 14–21 days after clinical improvement. Duration of treatment depends on severity of illness, and patient factors such as age and degree of immunocompromise
   3. If esophageal biopsy is not possible, empirical therapy for *Candida* may be indicated
   4. Rare complications are stricture and fungal balls

II. Other, much less common causes of fungal esophagitis

A. Cryptococcosis: clinically similar to *Candida*; described in AIDS; can be seen on culture or biopsy
B. Histoplasmosis: associated with disseminated *Histoplasma* infection in immunocompromised patients. Severe systemic disease with fever, bone marrow failure, and hepato-splenomegaly. Treated with amphotericin B followed by itraconazole
C. Blastomycosis: very rare
D. Aspergillosis: very rare
Viral Infections

I. Herpes simplex affects stratified epithelium. HSV1 is most common, but HSV2 is also seen

A. Occurrence
   1. Occurs in children with normal immunity
   2. Occurs as superinfection after physical or chemical esophageal injury
   3. Most often occurs in immunocompromised children
   4. Occurs with or without oral herpetic lesions

B. Symptoms
   1. Odynophagia and/or dysphagia
   2. Often associated with fever and malaise
   3. Retrosternal, squeezing chest pain with swallowing, very similar to pill esophagitis
   4. Dehydration, ketosis, and weight loss secondary to voluntary limitation of oral intake.
      Drooling may be prominent

C. Endoscopic and histological findings
   1. Herpetic vesicles occur in the first 1–2 days of infection
   2. Volcano ulcers: distinct round lesions with yellow borders characteristic of infection occur after several days
   3. Histological findings best seen at the edge of ulcers
      a. Nuclear inclusions
      b. Multinucleate giant cells
      c. Prominent mononuclear cell infiltrate

D. Diagnostic testing
   1. Viral culture
   2. Immunohistochemical stains
   3. Previously well patients should be screened for unsuspected immunodeficiency – HIV testing

E. Therapy
   1. In immunocompetent individuals, this is usually self-limited, resolving in 1–2 weeks
   2. Acyclovir in immunocompromised host or severe cases
   3. Foscarnet in cases of acyclovir resistance

II. CMV

A. Occurrence
   1. CMV esophagitis is rare in immunocompetent patients
   2. Usual host: AIDS or organ transplant patients
   3. Patients with previous mucosal damage

B. Endoscopic and histological findings
   1. Ulcerations similar to HSV, but usually more linear and deeper
   2. Basophilic nuclear inclusions in biopsies from edge of ulcer

C. Treatment: ganciclovir or foscarnet
   1. Duration guided by clinical/endoscopic response
   2. High recurrence risk

III. Less common viral infections

A. Varicella zoster in immunocompromised patients
B. HIV—Idiopathic esophageal ulceration (IEU)
   1. Giant ulcers can be seen in primary HIV infection, as well as in chronic AIDS with CD4 <100
   2. Clinically indistinguishable from CMV
   3. Chronic IEU has been described in up to 40% of adults with AIDS
**Bacterial Infections**

I. *Mycobacterium tuberculosum*
   A. Occurs as part of systemic infection, or advanced pulmonary or mediastinal infection
   B. Upper GI series may reveal extensive lymphadenopathy displacing the esophagus

**Differential Diagnosis**

I. Peptic esophagitis, eosinophilic esophagitis, pill esophagitis, foreign body
   A. These conditions occur without systemic signs of illness
   B. Odynophagia and retrosternal pain may be severe in eosinophilic esophagitis and pill esophagitis, but is less severe in peptic esophagitis
I. Causes of Esophagitis
   A. There are two main disease entities associated with esophagitis in children: gastroesophageal reflux disease (GERD) and eosinophilic esophagitis (EoE)
   B. There is clinical and histologic overlap between these conditions, so definitive diagnosis usually requires clinicopathologic correlation
   C. Other conditions causing esophagitis include inflammatory bowel disease (IBD) [especially Crohn’s Disease], pill-induced or radiation-induced esophagitis, graft vs host disease, and infectious esophagitis
   D. Viral infections with CMV and HSV in immune competent patients are rare. (See Infectious Esophagitis)
   E. Candidal esophagitis is also rare in immune competent hosts. (See Infectious Esophagitis)
   F. Bacterial causes of esophagitis are rare in immune competent hosts
   G. HIV-infected children may experience esophagitis from tuberculosis, HSV, or CMV

II. Tips for Best Biopsy Yield
   A. The site of biopsy should be above the distal 15% of the esophagus to avoid confusion with normal variance associated with Z-line
   B. Biopsies should include epithelium, lamina propria, and muscularis mucosae
   C. Biopsies should be oriented in a perpendicular plane to maximize diagnostic yield
   D. Three main features in the histological diagnosis of esophagitis: increased thickness of the basal zone, elongation of stromal papillae with vascular ingrowth, and inflammation (eosinophils, lymphocytes and neutrophils)
   E. For definitive diagnosis of esophagitis, the presence of 2 of 3 of these features is preferable

III. Grading of Esophagitis
   A. Different histologic grading systems for esophagitis exist, but are not often used
   B. Correlation between macroscopic and histologic features is generally poor; partly because the esophagitis may be patchy, but also because histologic esophagitis may exist when the esophagus is macroscopically normal

IV. GERD
   A. Minimal histologic criteria include simultaneous occurrence of elongated papillae, and basal zone hyperplasia and inflammation, in particular, the presence of eosinophils. Moderate esophagitis is diagnosed if there is ingrowth of vessels in the papillae, and at least one eosinophil present. There are no eosinophils in a normal esophageal biopsy
   B. Classically, four biopsies are recommended for GERD, with two biopsies taken near the Z line, and two taken 2 cm above the Z line

V. EoE
   A. Unlike the rest of the GI tract, normal esophageal mucosa harbors no eosinophils, and infiltration of the epithelium by eosinophils represents a sign of esophagitis
   B. In the AGA consensus recommendations, a peak eosinophil count of more than 15 per HPF (x40) is required for the diagnosis of EoE
   C. Preferential eosinophilic localization is in the superficial portions of the esophageal epithelium and formation of eosinophilic microabscesses, defined as clusters of 4 or more eosinophils
   D. Multiple level biopsies are needed for diagnosing EoE
   E. Other causes of esophagitis (especially GERD) should be excluded either by a PPI trial or Ph probe study
VI. Other Causes of Esophagitis
- Presence of esophageal intraepithelial lymphocytes may indicate Crohn’s disease
- Nonspecific esophagitis has also been found in a lesser degree in patients with ulcerative colitis
- When indicated, use of special stains and cytopathologic examination of biopsies reveals special features, such as intracytoplasmic inclusion in viral esophagitis

Recommended Reading


11. Upper GI Bleeding

Tiffany Patton, MD
Ruba Azzam, MD

Upper gastrointestinal (UGI) bleeding refers to bleeding from a site proximal to the ligament of Treitz. Presentation of UGI bleeding includes hematemesis, coffee ground emesis, and melena. The cause of bleeding varies with age.

I. Epidemiology
A. Upper GI bleeding is the indication for 5% of all childhood upper endoscopies. The incidence increases to 6%–25% in critically ill children, with only 0.4% caused by life-threatening bleeds.

B. Presentation:
1. Hematemesis—vomiting of bright red blood (usually an indication of a large-volume or rapidly bleeding lesion)
2. Coffee-ground emesis—refers to the appearance of blood denatured by contact with gastric acid
3. Melena—black, tarry stools caused by bacterial oxidation of blood from anywhere in the GI tract proximal to the colon (may occur with as little as 50–100 mL of UGI bleeding)

II. Pathogenesis
C. The cause of UGI bleed varies with age:
1. **Neonates**—swallowed maternal blood, hemorrhagic disease of the newborn, stress gastritis, peptic ulcer disease, vascular anomaly, coagulopathy, and milk protein sensitivity
2. **Infants**—stress gastritis, peptic ulcer disease, Mallory-Weiss tear, vascular anomaly, gastrointestinal duplications, esophageal/gastric varices, foreign body, and hereditary telangiectasia
3. **Child/Adolescent**—Mallory-Weiss tear, esophagitis/gastritis, peptic ulcer disease, varices, caustic ingestion, vasculitis (HSP), Crohn disease, hemobilia, foreign body, tumor and telangiectasia

III. Diagnosis
A. History and physical examination are critical to determining the etiology of UGI bleeding. Clinical signs may be associated with specific diseases:
1. Hyperactive bowel sounds, borborygmi (UGI bleed)
2. Petechiae, purpura (coagulopathy, thrombocytopenia, intense vomiting, Henoch-Schönlein purpura)
3. Hemangioma, telangiectasia (vascular anomalies)
4. Caput medusae, spider angioma, jaundice (chronic liver disease)
5. Epistaxis (nose bleed)
6. Blood in hypopharynx (adenoid and tonsillar disorders)
7. Hyperpigmented lesions on gums and lips (Peutz-Jeghers syndrome)

B. Evaluation
1. First assess vital signs, cardiovascular stability, and level of consciousness. Assess physical signs and symptoms of pallor, diaphoresis, restlessness, lethargy, and abdominal pain. Orthostatic changes (increase in pulse by 20 beats/min or decrease in systolic blood pressure >10 mmHg when moving from supine to sitting) can be more ominous signs of rapid blood loss
2. Laboratory evaluations required in any undiagnosed, clinically significant upper GI bleed: complete blood count with platelets and differential, reticulocyte count, coagulation panel (PT, PTT, INR), chemistry panel, liver function tests, blood type and crossmatch
3. Nasogastric tube placement and irrigation. Aspiration of bright red blood or coffee grounds confirms that the bleeding point is proximal to the pylorus

C. Imaging modalities should be chosen after consideration of the differential diagnostic list
1. Plain films of the neck and chest may show the presence of foreign bodies or free air, suggesting a perforation
2. Upper GI contrast study can detect ulceration, radiolucent foreign bodies, and duplication cysts
3. Abdominal ultrasound can assess portal blood flow when portal hypertension is suspected
4. Nuclear medicine (radiolabeled RBC scan) can detect actively bleeding sources with flow as low as 0.1 mL/min
5. Angiography can detect active bleeding at a rate of 0.5 mL/min or higher (therapeutic coil- ing/embolization of a bleeding vessel can be done simultaneously)

D. Endoscopy
1. Is the currently preferred diagnostic and therapeutic modality, but is not required in hemody- namically stable patients without anemia
2. Identifies mucosal lesions and determines source of bleeding in ~90% of cases
3. Contraindicated if patient is unstable or has profound anemia

IV. Treatment/Management
A. Fluid and blood resuscitation as needed to correct shock, fluid loss, and anemia
B. Correct any coagulopathy or metabolic/electrolyte abnormality
C. Pharmacologic therapy:
   1. Acid suppression with IV/PO proton pump inhibitors is helpful in acid peptic disease (most common cause of UGI bleeding in children)
   2. Sulcrafate (40–80 mg/kg/day divided in 2–4 doses) binds directly to ulcer bases, facilitating healing in peptic ulcer disease
   3. Octreotide
      a. A synthetic octapeptide analogue octapeptide that reduces splanchic and portal blood flow. May be used in variceal and nonvariceal bleeds
      b. Vasopressin causes peripheral vasoconstriction and may aggravate or produce renal failure
      c. 1–2 mcg/kg IV bolus octreotide, followed by 1–4 mcg/kg/hour continuous infusion
      d. Dose of octreotide may be reduced by 50% over 12 hours when bleeding is con- trolled, and discontinued completely when reduced to 25% of original starting dose
D. Endoscopic intervention (see Therapeutic Endoscopy)
   a. Injection therapy (usually with 1:10,000 epinephrine in normal saline) can be injected into and near an oozing lesion
   b. Contact thermal methods with heater probe; monopolar and bipolar probes provide hemostasis by local tamponade, coagulation, and blood vessel wall fusion
   c. Endoscopic clip placement provides compression of bleeding vessel
E. Esophageal/gastric variceal management (see Therapeutic Endoscopy)
   a. Injection sclerotherapy
   b. Band ligation
   c. Sclerosing glue (N-butyl-2-cyanoacrylate) injected into varix solidifies on contact with blood, plugs the variceal lumen, and sloughs in 6 weeks to 6 months
   d. Intraesophageal balloon tamponade (Sengstaken-Blakemore tube or Linton tube)

Recommended Reading


Caustic ingestions are most commonly seen between 1 and 3 years of age. Most of these ingestions are accidental and small in amount. According to National Poison Data System (NPDS), most pediatric toxic ingestions involve cosmetic or personal care agents, analgesics, and cleaning agents. Ingestion of alkaline agents is more common than acidic agents in the U.S.

A. Esophageal burns account for most of the severe and chronic complications of caustic ingestion
   1. Liquid caustics are most likely to cause esophageal injury
   2. Crystalline or powder caustics adhere quickly to mucosal surfaces and cause most damage in the oropharynx and upper esophagus. These agents may cause lung injury if inhaled

B. Esophageal burns occur in 18%–46% of pediatric caustic ingestion cases

C. Cleaning agents are the most common causes of esophageal burns
   1. Strong alkaline agents: dishwasher detergent, oven and drain cleaners
   2. Strong acidic agents: toilet bowl cleaner, swimming pool and coffeemaker cleaners, soldering flux, antirust compounds, and battery liquids
   3. Industrial strength versions of cleaners, often found on farms, can cause more severe injury than the same compound purchased for household use
   4. Ammonia may cause caustic injury to the esophagus, as well as chemical pneumonitis
   5. Hair relaxer (ammonia compound) rarely causes severe injury. Burns are usually superficial
   6. Household bleach rarely causes injury because its pH is near neutral. Industrial strength bleaches with a higher concentration of sodium hypochlorite may cause more severe injury

D. Mechanism of esophageal injury
   1. Acidic agents induce coagulative necrosis that limits acid penetration, and damage is generally restricted to the surface mucosa
   2. Alkaline agents induce liquefaction necrosis, with very rapid transmural inflammation, and edema with risk for perforation
   3. Rapidity of injury depends on the concentration of the agent
      - As little as 1 mL of 30% NaOH can cause transmural necrosis of the esophagus within seconds
   4. Following initial necrosis, additional damage results from inflammation, infection, and vascular thrombosis
   5. Perforation is a risk for about three weeks after ingestion, until scar formation is established

E. Signs and symptoms of caustic or acid ingestion
   1. May be asymptomatic at presentation
   2. Dysphagia is the most common symptom
   3. Other symptoms: vomiting, drooling, hematemesis, chest or abdominal pain, respiratory distress
   4. The absence of burns to the perioral area or mouth does not exclude esophageal injury

F. Evaluation and treatment
   1. Document the ingested agent
      a. Physical characteristics – solid, liquid, powder
      b. Chemical characteristics – concentration, pH
      c. Volume ingested
   2. If caustic ingestion is suspected, vomiting should NOT be induced
   3. Use water to wash away residual agent in mouth or on face
   4. Endoscopy is indicated if ingestion is strongly suspected, to document presence and extent of esophageal injury
      a. Endoscopy should be performed between 6 hours and four days following ingestion
      b. Endoscopy prior to 6 hours may not reveal the full extent of injury. Endoscopy after four days increases the risk of perforation
c. Patients with a questionable history of ingestion, who are asymptomatic and without perioral or oral burns, may be observed over several hours to determine PO tolerance and to monitor for development of symptoms

5. Injuries are graded visually during endoscopy (see Table 1)

Table 1.

<table>
<thead>
<tr>
<th>Grade 0</th>
<th>Normal</th>
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</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>Erythema and edema</td>
</tr>
<tr>
<td>Grade II-A</td>
<td>Noncircumferential, superficial ulceration &lt;1/3 length of esophagus</td>
</tr>
<tr>
<td>Grade II-B</td>
<td>Circumferential, deep ulceration &gt;1/3 length of esophagus</td>
</tr>
<tr>
<td>Grade III-A</td>
<td>Circumferential ulceration, areas of necrosis &lt;1/3 length of esophagus</td>
</tr>
<tr>
<td>Grade III-B</td>
<td>Extensive necrosis &gt;1/3 length of esophagus</td>
</tr>
</tbody>
</table>

G. Stricture management
   A. Circumferential burns are most likely to be complicated by stricture
   B. In patients with circumferential burns (grade II-B or III)
      1. Place NG tube under direct visualization during endoscopy (not blindly, as perforation may result) for nutrition and maintenance of lumen
   C. In patients with circumferential burns, gastrostomy may be needed
      1. Allows for placement of string to facilitate later retrograde dilation
      2. String enters via nares and exits via gastrostomy and the ends are tied
      3. In the Tucker string method of dilation, the dilator is attached to the string at the gastrostomy and pulled retrograde up the esophagus
      4. Retrograde traction dilation has lower risk of perforation than antegrade dilation with balloon or bougie
   D. There is no evidence that steroids reduce incidence of stricture
   E. Acid suppression indicated acutely and later for patients who develop esophageal dysmotility
   F. Patients with grade II-B or grade III lesions should undergo UGI or repeat endoscopy three weeks post-ingestion to monitor for stricture development
   G. Repeated dilatations of strictures are often needed
      1. 33%–48% of patients with caustic strictures have long-term success with serial dilatations
      2. Long segment strictures are often resistant to dilation therapy, and require esophagectomy with colonic interposition or gastric tube formation
   H. Long-term outcome
      A. Caustic injury increases the risk of esophageal squamous cell carcinoma
      B. Suspect esophageal carcinoma in patients with late development of dysphagia
      C. Periodic endoscopy for cancer surveillance recommended for patients starting at 20 years after caustic injury to the esophagus

Recommended Reading


There are more than 100,000 cases of pediatric foreign body ingestion every year in the United States. Most cases occur in young children 6 months to 5 years of age. Coins are the most commonly ingested foreign body. Fortunately, most ingested foreign bodies pass without complication.

I. Impacted foreign bodies
   A. Most frequent site of impaction is the esophagus
      1. Cervical esophagus (cricopharyngeus) is most common
      2. Other sites of physiologic narrowing
         a. Aortic arch
         b. Lower esophageal sphincter
   B. Common sites of impaction distal to the esophagus
      1. Pylorus
      2. At the junction of descending and transverse duodenum
      3. Ileocelecal valve
   C. Patients with past GI tract surgery or congenital GI malformation (e.g., TE fistula) are at increased risk of foreign body impaction and complications (obstruction, perforation)

II. Signs and symptoms of impacted foreign body
   A. Esophageal impaction: choking, hoarseness, refusal to eat, vomiting, drooling, bloodstained saliva, wheezing/respiratory distress, chest pain
   B. Older children may localize symptoms to neck or lower chest, reflecting an esophageal impaction in the upper or lower esophagus, respectively
   C. Longstanding esophageal impaction: neck mass, chronic cough/stridor, aspiration pneumonia, dysphagia
   D. Oropharyngeal/proximal esophageal perforation: neck swelling and/or erythema, tenderness, crepitus
   E. Intestinal impaction/obstruction: vomiting, abdominal distention

III. Diagnosis and localization
   A. Examine chest for signs of respiratory distress that may indicate tracheal compression or aspiration
   B. Inspect the neck for signs of complicated esophageal impaction or perforation
   C. Examine the abdomen for signs of obstruction or perforation
   D. Radiographs of the neck, chest, and abdomen in PA and lateral planes assist in localizing radiopaque foreign bodies and identifying multiple ingestions
      1. Metal objects and steak bones may be identified on plain films
      2. Fish or chicken bones, wood, plastic, most glass, and thin metal objects are not easily seen on plain radiographs
      3. Radiologic examination with a small amount of contrast may clarify the location of a foreign body. Contrast studies should not be done routinely, as they carry a risk of aspiration and may obscure the foreign body at subsequent endoscopy
      4. CT with 3-dimensional reconstruction can be used to clarify the location of radiolucent objects
      5. If radiographic assessment shows no foreign body, persistent symptoms related to the esophagus require endoscopic evaluation
IV. Management

A. Urgent endoscopic intervention is required for sharp objects or disk battery in the esophagus, or when esophageal impaction creates high-grade obstruction, causing inability to handle oral secretions.

B. Endoscopy for objects in the esophagus may be delayed up to 24 hours from time of ingestion, to allow time for spontaneous passage:
   1. In patients without high-grade obstruction
   2. In patients not in acute distress

C. All foreign bodies should be removed from the esophagus within 24 hours, or if duration of impaction in the esophagus is unknown.

D. Blunt objects such as coins located beyond the esophagus can be observed for spontaneous passage. Blunt objects that fail to pass from the stomach should be removed endoscopically, but there are no definitive guidelines as to duration of observation. Recommendations vary from 4 days to 4 weeks.

E. Objects longer than 5 cm may not pass the duodenal sweep or may lodge at the ileocecal valve. Removal from stomach is recommended.

F. Endoscopic evaluation and removal should be attempted for sharp objects that cannot be visualized by x-ray, as they may be in the esophagus, where perforation is a significant risk.

G. Sharp, pointed objects localized in the stomach or proximal duodenum will most likely pass safely, but endoscopic removal is recommended, if possible, to prevent complications.

H. Sharp, pointed objects distal to the duodenum should be carefully monitored for progress and for symptoms. Consider removal if object does not progress for three consecutive days.

I. Remove multiple magnets immediately, as they may attract across layers of bowel, causing pressure necrosis, obstruction, and perforation.

V. Food impaction

A. More likely in children with underlying esophageal pathology (e.g., stricture, achalasia, esophageal dysmotility, and eosinophilic esophagitis).

B. Food may be removed en bloc, piecemeal, or pushed into the stomach after direct visualization of the esophagus distal to the impaction to exclude stricture.

VI. Disk batteries

A. Immediate removal of esophageal disk batteries is recommended.
   1. Mucosal injury can occur in <2 hours, even from an intact battery.
   2. Mechanisms of injury include electrical discharge with tissue hydrolysis and corrosive injury, as well as pressure necrosis and/or leakage of contents, and can lead to fatal complications.

B. Disk batteries >20 mm in diameter are more likely than smaller batteries to impact and/or cause complications.

C. Lithium batteries generally contain higher voltage and capacitance than other button batteries, and are associated with major complications.

D. Ingestion of even dead batteries is a matter of concern, as these batteries retain enough charge to cause tissue injury.

E. The National Battery Ingestion Hotline (NBIH) recommends:
   1. No immediate attempt to remove a disk battery that has passed distal to the esophagus unless there are significant gastrointestinal signs or symptoms—severe pain, bleeding, obstruction.
   2. Immediate attempt to remove if the patient has coingested a magnet.
   3. Follow-up radiographs to document passage if battery not seen in stool within 1–2 weeks.
   4. Endoscopic removal from stomach if retained for >48 hours and if battery is >15 mm in child <6 year old (batteries >15 mm less likely to pass the pylorus).

F. Fatalities from ingested batteries reported by NIBH database:
   1. 13 fatalities in USA related to ingested batteries between 1977 and 2009.
   2. All fatalities were in children <3 years of age.
   3. All fatalities involved esophageal impaction from 10 hours to 2 weeks duration.
   4. 9 of 13 fatalities involved exsanguination from esophageal fistulas into major arteries.
   5. Delayed, unanticipated, and uncontrollable bleeding occurred up to 18 days after battery removal.

G. Cylindrical batteries pose little threat for caustic injury.
Recommended Reading


