

# Clinical Esophagology and Transnasal Esophagoscopy



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# Contents

<i>Preface</i>	<i>vii</i>
<b>1</b> Esophageal Anatomy and Physiology	1
<b>2</b> Transnasal Esophagoscopy (TNE)	15
<b>3</b> The Videofluoroscopic Esophagram	29
<b>4</b> High-Resolution Esophageal Manometry	49
<b>5</b> Ambulatory pH and Impedance Monitoring	67
<b>6</b> Esophagitis	79
<b>7</b> Upper Esophageal Sphincter Dysfunction	91
<b>8</b> Esophageal Webs and Rings and Diverticula	125
<b>9</b> Esophageal Motility Disorders	141
<b>10</b> Esophageal Stricture	159
<b>11</b> Hiatal Hernia	177
<b>12</b> Barrett's Esophagus	189
<b>13</b> Esophageal Neoplasia	201
<i>Index</i>	<i>217</i>



# Preface

The first bite of wedding cake. A champagne toast. A lovingly prepared family meal. Just a sip of water. From Sunday brunch to Saturday dinner, one person's joyful occasion is another's nightmare.

The ability to enjoy food and drink is our common ground, our universal experience, one that is vital and cherished by all. When our swallowing is jeopardized, what was once mindless and festive becomes isolating and painful.

Nearly two-thirds of people with solid food dysphagia will have an esophageal contribution to their swallowing complaint. One-third of those with cervical dysphagia will have an esophageal etiology for their symptom. It is essential that all dysphagia clinicians have an advanced knowledge of the esophageal phase of deglutition.

This book has grown out of my passion and dedication to improve the health and wellness of every individual with swallowing difficulty. It is my hope that it will serve as a valuable resource for clinicians of *all* educational backgrounds and training levels.

This work was supported by the enduring conviction of my patients. Swallowing disability is physically and emotionally devastating. People, however, are resilient and remarkably courageous in their fight to restore dignity to a life that has been radically altered. The physician-patient relationship is an extraordinary bond, and I dedicate this work to the patients whom I have not been able to help. I would especially like to thank my mentors, my father, and my loving wife. Without your guidance, mentorship, and support, this would not have been possible.

To our young clinicians and scientists—the world needs you. Innovations in the treatment of swallowing disorders are limited. For those of us who do battle in the clinic, on the ward, in the operating room, and in the laboratory, let us redouble our efforts to innovate, raise awareness, and make a difference. Vitalize your sense of innovation and THINK BIG. The time is now. Our patients are depending on you.





# 1

## Esophageal Anatomy and Physiology

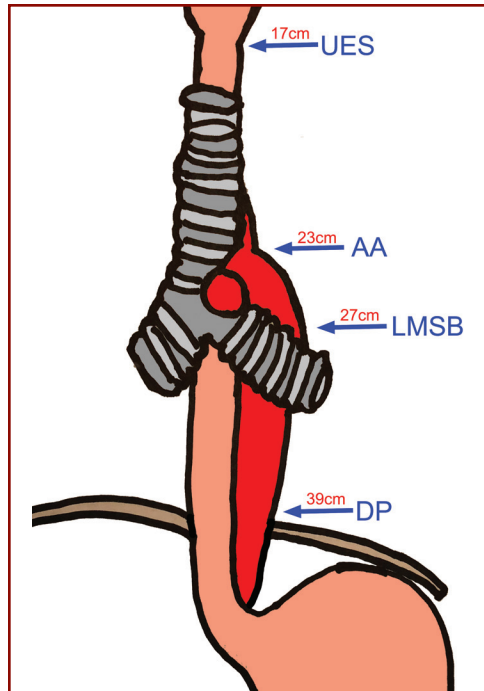
### INTRODUCTION

The esophagus is a muscular tube approximately 25 cm long. It is guarded by two sphincters and withstands four anatomic compressions. The length of the esophagus and the distance from the nasal vestibule and oral commissure to the level of each compression are important for the clinician to appreciate, as these distances serve as essential landmarks when visualization in the esophagus becomes obscured from retained food and saliva, stricture, hernia, or neoplasm. From cranial to caudal, the compressions (and their approximate distance from the nasal vestibule and oral commissure) are the cricoid cartilage and cricopharyngeus muscle (17 cm), the aortic arch (23 cm), the left mainstem bronchus (27 cm), and the diaphragmatic pinch (39 cm) (Figures 1–1 to 1–3).

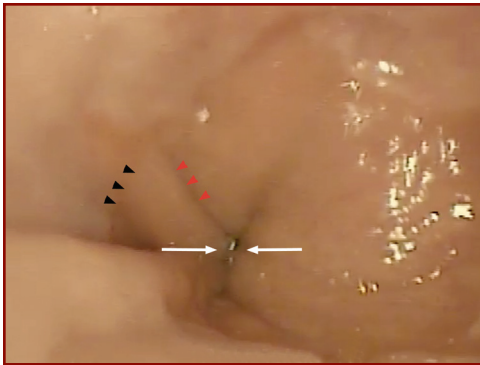
### THE UPPER ESOPHAGEAL HIGH-PRESSURE ZONE

The upper esophageal high-pressure zone (UEHPZ) is a 3-cm region of elevated pressure that unites the hypopharynx with the

cervical esophagus. There are many names used to refer to the UEHPZ (Table 1–1). The term *upper esophageal sphincter* (UES) is typically used to refer to the anatomic



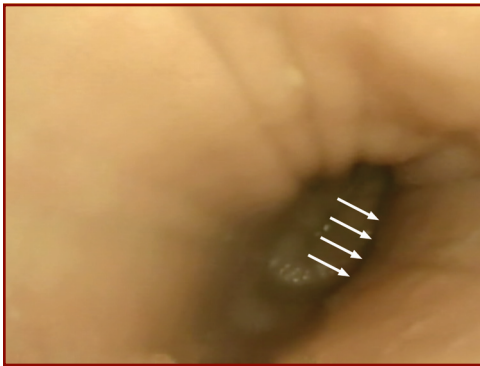
**FIGURE 1-1.** External compressions of the esophagus and the distances from the nasal vestibule.



**A**



**B**

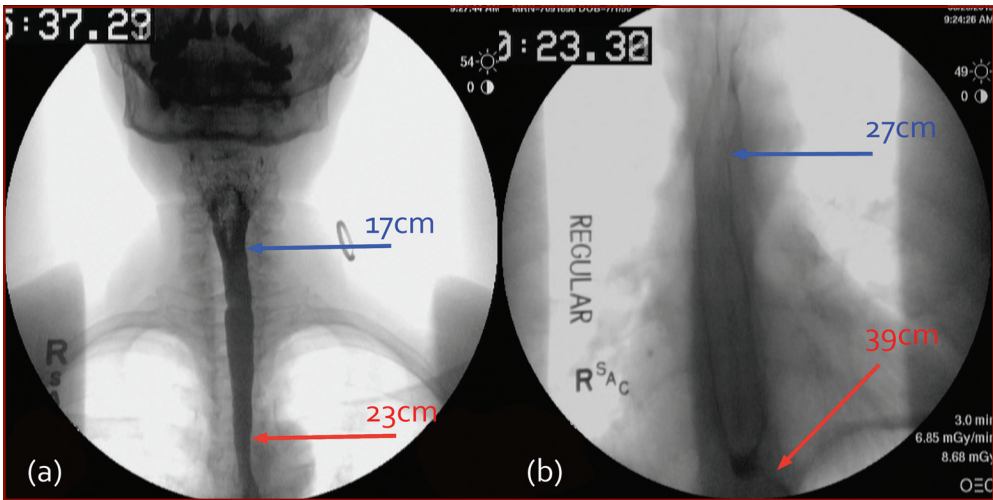


**C**



**D**

**FIGURE 1-2.** **A.** Endoscopic view of the esophageal compression caused by the diaphragm (diaphragmatic pinch, *white arrows*). Also seen is the squamocolumnar junction (*black arrowheads*) and gastric rugae (*red arrowheads*). The top of the gastric fold is at the level of the squamocolumnar junction and demarcates the esophago-gastric junction. The rugae extend approximately 1.5 cm above the diaphragm and do not meet endoscopic criteria for diagnosis of hiatal hernia (>2 cm). **B.** Endoscopic view of the esophageal compression from the left main stem bronchus (*white arrows*). The compression is in a left anterior location. **C.** Endoscopic view of the esophageal compression from the aortic arch (*white arrows*). The aortic compression is in the left anterolateral location. **D.** Endoscopic view of the esophageal compression at the pharyngoesophageal inlet (*white arrows*). The compression is primarily caused by the elastic recoil of the laryngeal framework and cricoid cartilage against the cervical spine.



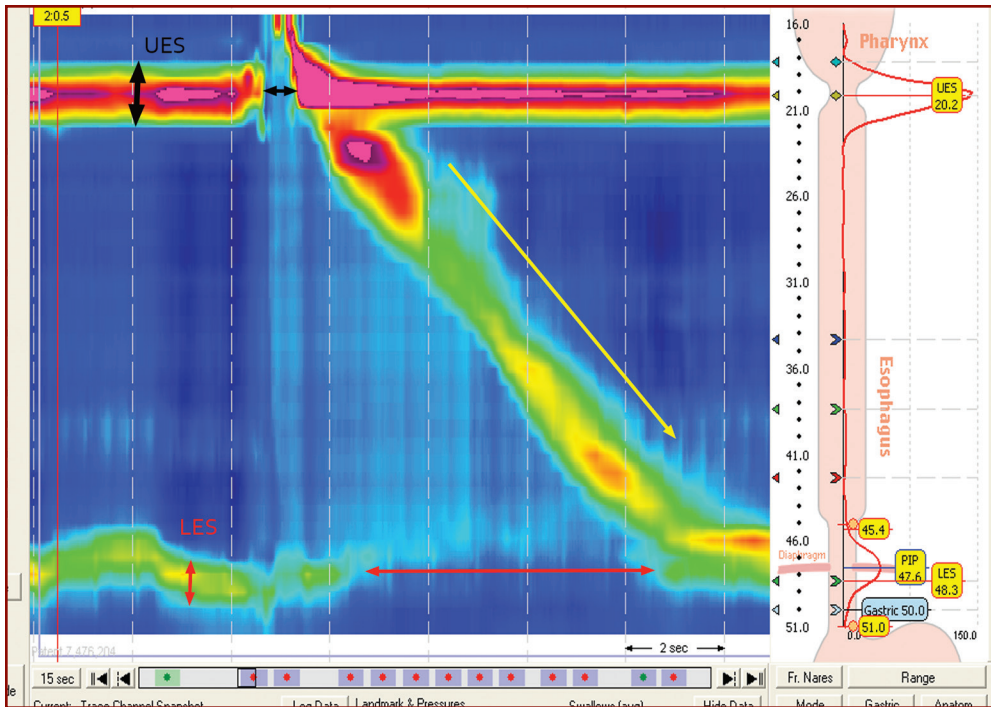
**FIGURE 1-3.** Anterior-posterior fluoroscopic view displaying the 4 external compressions of the esophagus. **A.** Pharyngoesophageal compression at the level of the cricoid cartilage (*blue arrow*) and aortic compression (*red arrow*). **B.** Esophageal compression from the left main stem bronchus (*blue arrow*) and diaphragm (*red arrow*).

**TABLE 1-1.** Names Used to Describe the Upper Esophageal High-Pressure Zone

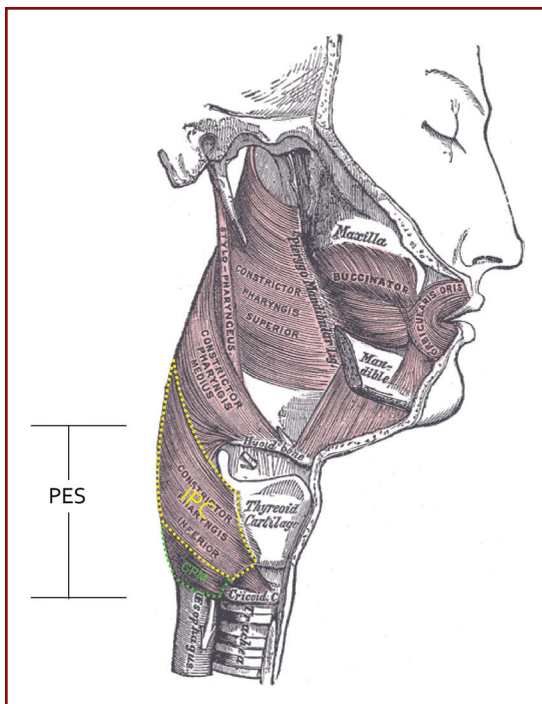
Name	Description
Upper esophageal high-pressure zone (UEHPZ)	3-cm region of high pressure connecting the hypopharynx to the cervical esophagus
Upper esophageal sphincter (UES)	Manometric high-pressure zone connecting the hypopharynx to the cervical esophagus
Pharyngoesophageal segment (PES)	The anatomic components that contribute to the upper esophageal high-pressure zone
Cricopharyngeus muscle (CPM)	Striated muscle with tonic activity at rest that contributes to the distal one-third of the upper esophageal high-pressure zone

high-pressure zone appreciated with pharyngoesophageal manometry (Figure 1–4). Although the UES is used interchangeably with the UEHPZ, a sphincter is technically an “annular muscle capable of modulating a body opening.”<sup>1</sup> The numerous structures that contribute to the UES do not meet the definition of a sphincteric muscle, and the term *UEHPZ* is more appropriate. The term

*pharyngoesophageal segment* (PES) is also synonymous with the UES and UEHPZ and is used to refer to the anatomic components that contribute to the high-pressure zone (Figure 1–5). The PES is made up of the inferior pharyngeal constrictor (IPC), the cricopharyngeus muscle (CPM), and the most proximal cervical esophagus (see Figure 1–5). Also contributing to the pressure



**FIGURE 1-4.** Normal high-resolution manometry pressure topography plot. UES, upper esophageal sphincter (larger black double arrow); UES relaxation (small black double arrow); LES, lower esophageal sphincter (small red double arrow); LES relaxation (large red double arrow); esophageal body peristalsis (yellow arrow).



**FIGURE 1-5.** The pharyngoesophageal segment (PES). (CPM, cricopharyngeus muscle; IPC, inferior pharyngeal constrictor.) Source: Gray, H., *Anatomy of the Human Body*. Philadelphia, PA: Lea & Febiger, 1918; Bartleby.com, 2000.

of the UEHPZ is the elastic recoil of the laryngeal framework against the cervical spine. The elastic recoil of the thyroid and cricoid cartilages against the anterior spine makes up the majority of UEHPZ pressure. The CPM only makes up the distal one-third of the high-pressure zone and is *not* synonymous with the UEHPZ, UES, or PES.

The two functions of the UEHPZ are to protect the proximal airway from regurgitated gastric and esophageal contents and to prevent the swallowing of air (aerophagia) during respiration and phonation. The UEHPZ maintains a consistent baseline pressure at rest. Baseline UEHPZ resting pressure is variable and approximates 60–120 mm Hg. The valve reflexively opens during deglutition, eructation (burping), and emesis. Esophageal distention and acid exposure, emotional stress, and pharyngeal stimulation all reflexively tighten the UEHPZ.<sup>2</sup> The CPM is the only aspect of the UEHPZ that contracts and relaxes during all reflex tasks. Thus, the CPM is the only true sphincteric muscle.

Effective UEHPZ opening is essential for safe and efficient bolus transit from the pharynx into the esophagus. Opening depends on elevation of the larynx off of the cervical spine, intrinsic CPM relaxation, and distention of the laryngeal framework off of the spine afforded by the pressure exerted on the advancing bolus by the tongue and pharynx. Jacob et al described five phases of UEHPZ opening (Table 1–2).<sup>3</sup>

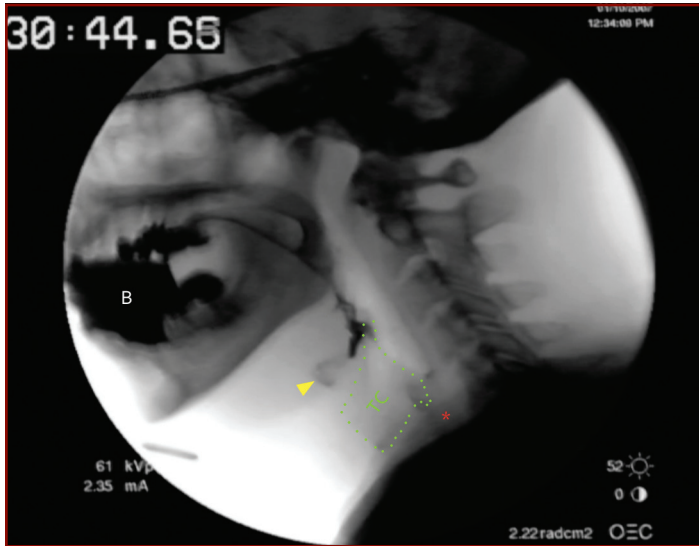
Phase I of UEHPZ opening involves muscular relaxation of the tonically active CPM (Figure 1–6). As the CPM relaxes, the hyoid and larynx elevate off of the cervical spine toward the mandible (Phase II, Figure 1–7). This brings the larynx forward underneath the base of the tongue and helps direct the bolus posteriorly toward the hypo-

**TABLE 1–2.** Stages of Upper Esophageal Sphincter High-Pressure Zone Opening and Closing

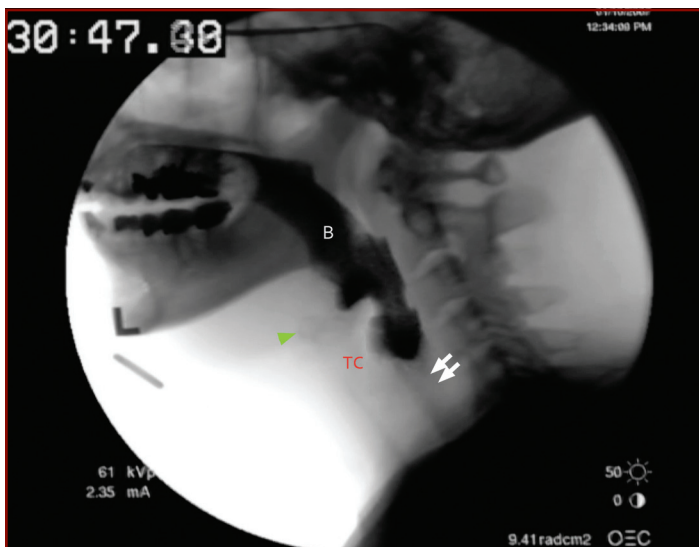
Stage	
I	Muscular relaxation of the CPM
II	Elevation of the larynx off the anterior cervical spine
III	UEHPZ distention through pressure exerted on the bolus by the tongue and pharynx
IV	Passive closure through elastic recoil of the laryngeal framework
V	Active PES closure through CPM contraction

Abbreviations: CPM, cricopharyngeus muscle; PES, pharyngoesophageal segment; UEHPZ, upper esophageal high-pressure zone.

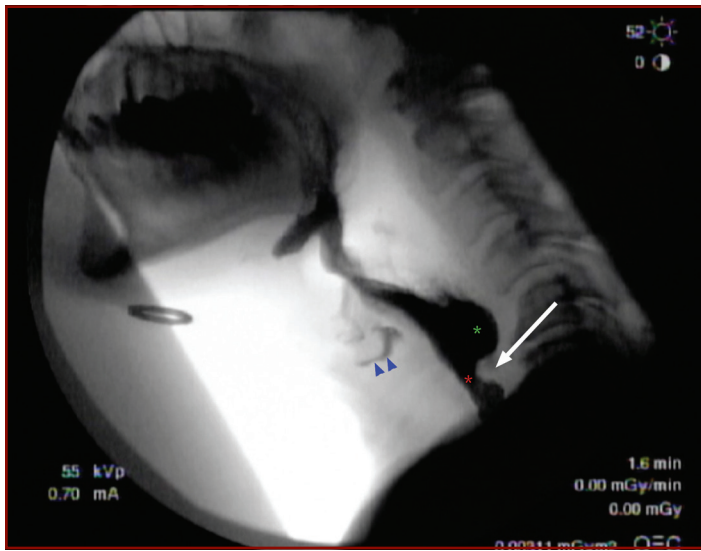
pharynx. The laryngeal framework does not actually distract off the spine to open the UEHPZ in Phase II, but the region is primed to accept the bolus in preparation for definitive opening in Phase III. The priming provided by hyolaryngeal elevation appears to be more important than muscular inhibition of the CPM.<sup>4</sup> This has significant clinical implications, as deglutition in individuals with good hyolaryngeal elevation but poor CPM relaxation is possible and frequently encountered (CPM bar, Figure 1–8). Safe and effective swallowing in individuals who can intrinsically relax their CPM but cannot elevate their larynx has not been observed as the advancing bolus will reach a closed PES and follow the path of least resistance into the airway. Phase III of UEHPZ opening involves distention of the PES through bolus size and weight (see Figure 1–8). This phase relies on pharyngeal and lingual peristalsis



**FIGURE 1-6.** Lateral fluoroscopic view depicting Phase I of upper esophageal sphincter opening. The bolus (B) is in the oral cavity. The hyoid bone (*yellow arrow*) and thyroid cartilage (TC) remain low in the neck. The cricopharyngeus muscle (*red asterisk*) exhibits intrinsic relaxation.



**FIGURE 1-7.** Lateral fluoroscopic view depicting Phase II of upper esophageal sphincter opening. The hyoid bone (*green arrowhead*) and thyroid cartilage (TC) are elevated anteriorly away from the cervical spine toward the mandible as the bolus (B) advances through the pharynx. The upper esophageal sphincter (*white arrows*) is primed but remains closed.



**FIGURE 1-8.** Lateral fluoroscopic view depicting Phase III of upper esophageal sphincter opening. The hyoid bone and thyroid cartilage remain elevated (Phase II). The intrabolus pressure created by contraction of the tongue and pharynx results in opening of the upper esophageal sphincter (*red asterisk*). There is incomplete relaxation of the cricopharyngeus muscle, which creates the fluoroscopic appearance of a CP bar (*white arrow*). The elevated pressure created by the cricopharyngeus muscle dysfunction in this patient results in pathologic dilation of the hypopharynx (*green asterisk*). There is penetration of barium to the level of the vocal folds (*blue arrowheads*).

to propel the bolus past the expansive hypopharynx, through the primed PES, behind the elevating hyolaryngeal complex, and into the cervical esophagus. The elasticity of the elevating PES allows it to be opened by the increasing pressure exerted by the passing bolus. The elastic PES opens as little as possible to accept the bolus. If there is inadequate lingual and pharyngeal contraction, the bolus will not exert enough pressure to open the PES, and the bolus will again follow the path of least resistance and threaten the airway. Phase IV of PES opening involves passive collapse of the elastic PES as the bolus passes and the larynx resumes its resting position against the

cervical spine (Figure 1–9). Phase V, the final phase of UEHPZ opening, involves PES closure through active contraction of the CPM (Figure 1–10).

### THE LOWER ESOPHAGEAL HIGH-PRESSURE ZONE

The lower esophageal high-pressure zone (LEHPZ) is a 4-cm region of the distal esophagus that functions as a valve with the primary function of preventing the regurgitation of gastric contents into the esophagus. Although the valve must prevent gastroesophageal reflux (GER), it must also