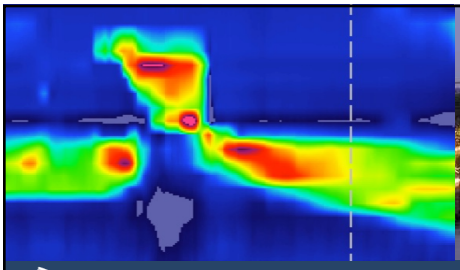

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The Charleston Pharyngoesophageal Manometry Program • April 7 – 8, 2023 • Charleston, SC

# Normal Manometric Esophageal Swallowing

**Ashli K. O'Rourke, M.S., M.D.**

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Mark & Evelyn Trammell Endowed Chair in Otolaryngology
Department of Otolaryngology – Head and Neck Surgery
Medical University of South Carolina

## OUTLINE

- Importance of Esophageal Evaluation
- Evaluation of Esophageal Function
- Esophageal Anatomy & Function
- Normal Manometric Esophageal Definitions

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# Why is our understanding of esophageal dysphagia important?

- Swallowing involves bolus transfer from the lips to the stomach.
- Swallowing mechanism is interrelated in timing and function.
- Dysfunction in one area can affect the other.
- We need to understand, evaluate, and treat the *swallowing mechanism as a whole*

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# Difficulty in Localization

**Wilcos et al Dig Dis Sci 1995**

- Accurate localization in 21.6%

**Edward DW, Dis Esophagus 1974 ; Smith DF et al, AJR 1998**

- 1/3 patients with known distal obstructive lesions localized to suprasternal notch & above

**Roeder et Al Dig Dis Sci 2004**

- 1.8% patients were accurate when localizing symptoms to proximal esophagus

**Madhavan et al Dysphagia 2015**

- The majority (71%) of explanatory "food sticking" causes were identified in the esophagus

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# Not just one location…

**Jones B et al. Gastrointest Radiol 1995**

- 40 patients with suprasternal complaints - 11/40 (28%) esophageal pathology only and 14/40 (35%) combined oropharyngeal-esophageal disorders

**Edward DW, Dis Esophagus 1974**

- 50% achalasia patients had concomitant pharyngeal abnormalities

**Gullung et al. Ann Oto Rhin Laryn; 2012**

- 82% of patients with delayed initiation of pharyngeal swallow had impaired esophageal clearance

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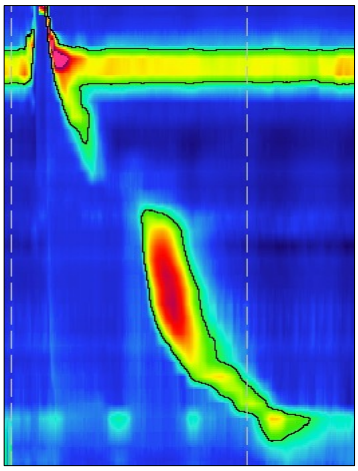
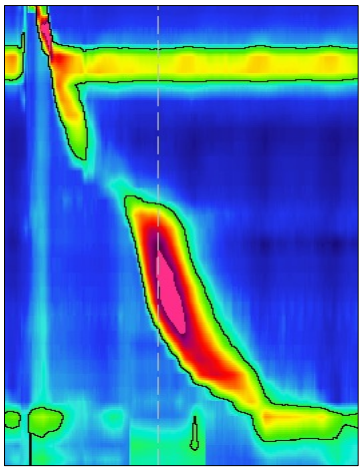
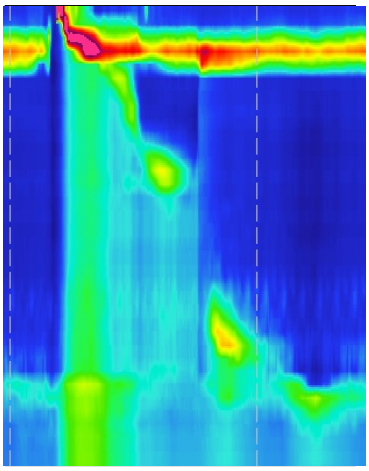
# Swallowing Phases are Interrelated in Function



Normal Swallow



Effortful Swallow



Mendelsohn Swallow

O'Rourke A, Morgan L, Coss-Adame E, Morrison M, Weinberger P, Postma G 2014

# No Man's Land

| Otolaryngologist | Gastroenterologist |
|---|---|
| • Oropharyngeal dysphagia<br>• Cricopharyngeal dysfunction<br>• Cervical esophageal abnormalities | • Distal esophageal web/ring<br>• LES dysfunction<br>• GERD (but not LPR)<br>• Gastrointestinal issues |

What about esophageal body disorders?

# Speech-Language Pathology

- Essential partner in dysphagia evaluation & management
- Lack formal education in esophageal dysphagia
- "SLP should have sufficient knowledge to make an appropriate referral and plan cooperative management." (ASHA 1992)

ASHA American Speech-Language-Hearing Association

**Guidelines for SLP Performing Videofluoroscopic Swallow Studies**

Special Interest Division 13, Swallowing and Swallowing Disorders (Dysphagia) 2003; 2007

https://www.asha.org/Practice-Portal/Clinical-Topics/Adult-Dysphagia/

- "Responsibility of appropriately trained physicians to evaluate and diagnose esophageal stage dysphagia.
- SLPs also recognize causes and signs/symptoms of esophageal dysphagia and make appropriate referrals for its diagnosis and management.
- Dysphagia is defined as problems involving the oral cavity, pharynx, esophagus, or gastroesophageal junction.
- Clinicians should be aware that oropharyngeal swallowing function is often altered in patients with esophageal motility disorders and dysphagia."

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# The Bottom line

- Patients are very often not able to accurately localize their dysphagia symptoms.
- Many SLPs and ENTs have deficits in training in the evaluation of esophageal dysphagia.
- We need to be prepared to “look farther” to diagnose the etiology of dysphagia.

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# OUTLINE


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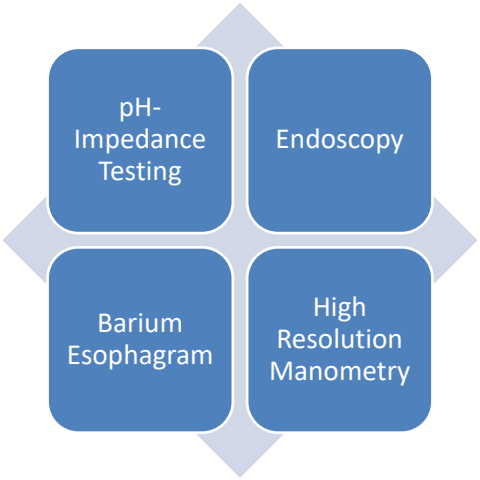
# Evaluation of Esophageal Function

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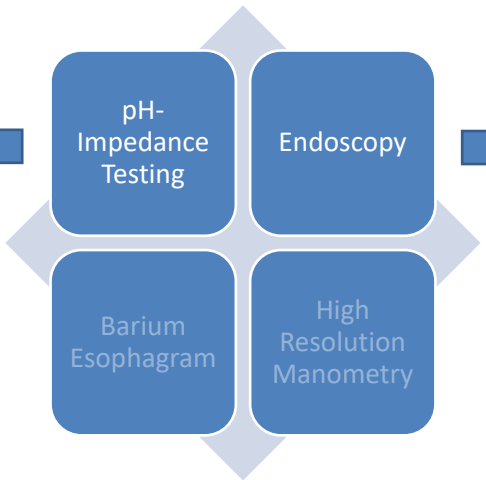
# Evaluation of Esophageal Function

Objective measurement
Symptom association




Mucosal Detail
Webs, rings, strictures
Infectious esophagitis
Intervention

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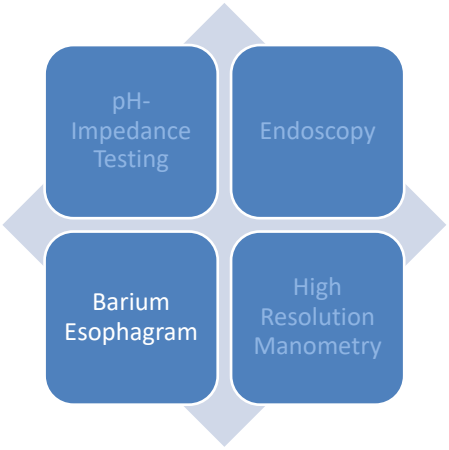
# Barium Esophagram

- Common radiographic examination available at most institutions
- Barium used medically since 1910
- Single & double contrast media
- Still Images & Fluoroscopy (be careful of frame rate!)
- Often used as initial study for patients with suspected esophageal dysphagia
- Anatomic information
  - Hiatal hernia
  - Diverticula
  - Stricture
- Radiologists will comment on presence of reflux and motility
  - Inaccurate alone for GERD diagnosis
  - What about motility?

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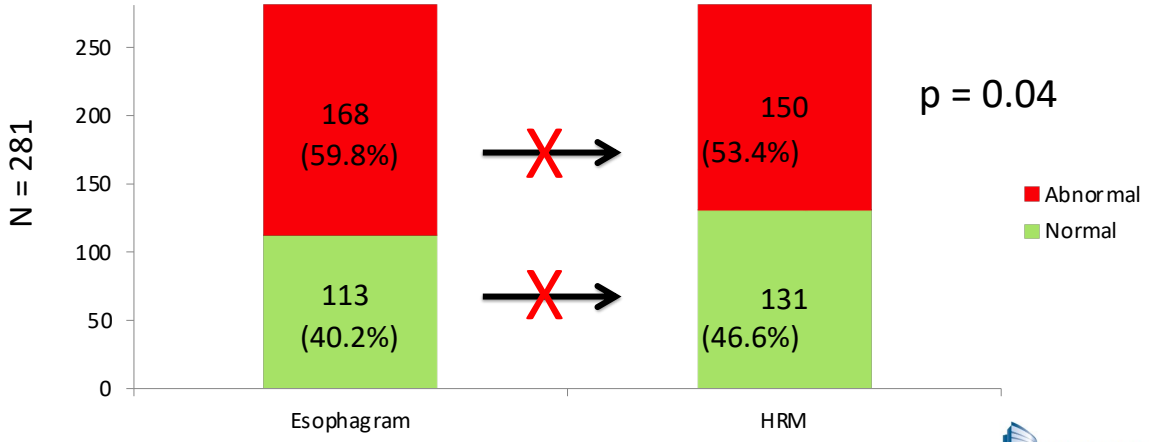
# Utility of Esophagram in Evaluating Esophageal Motility

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O'Rourke et al Otolaryngology HNS 2016

## Accuracy of Esophagram in Detection of Motility Disorders

| | |
|---|---|
| Sensitivity | 0.69 |
| Specificity | 0.50 |
| Positive Predictive Value | 0.61 |
| Negative Predictive Value | 0.58 |

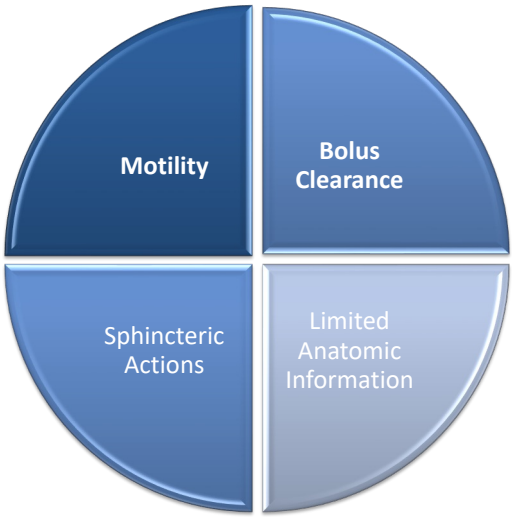
O'Rourke et al Otolaryngology HNS 2016

Zambito et al. Is barium esophagram enough? Comparison of esophageal motility found on barium esophagram to high resolution manometry. Am J Surg. 2021 Mar;221(3):575-577.

| | |
|---|---|
| Sensitivity | 0.14 |
| Specificity | 0.72 |
| Positive Predictive Value | 0.30 |
| Negative Predictive Value | 0.50 |

BE concordant with HRM 21/46 (46%) (p = 0.028).

## Esophageal High Resolution Manometry with Impedance

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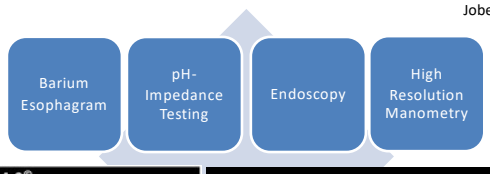
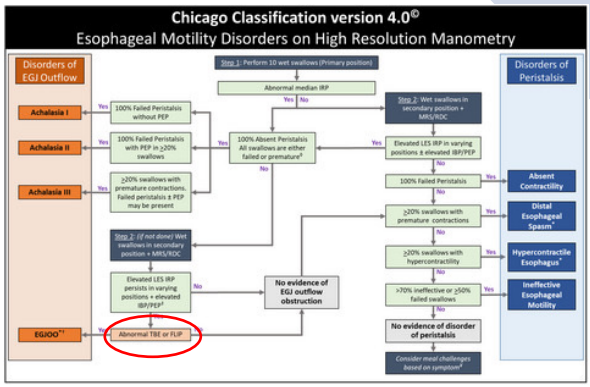
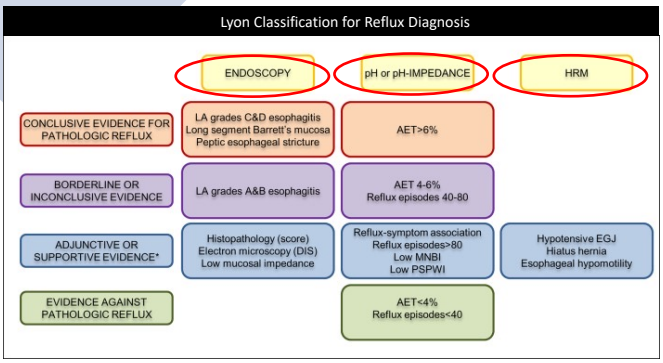
All four tests is the standard pre-operative evaluation for patients being evaluated for anti-reflux surgery.

Jobe, et al. American College of Surgeons, 2013;217: 586-597.




Yadlapati. Neurogastro & Motil 2021; 33: e14058.




Gyawali *et al* *Gut* 2018;67:1351-1362.

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# OUTLINE

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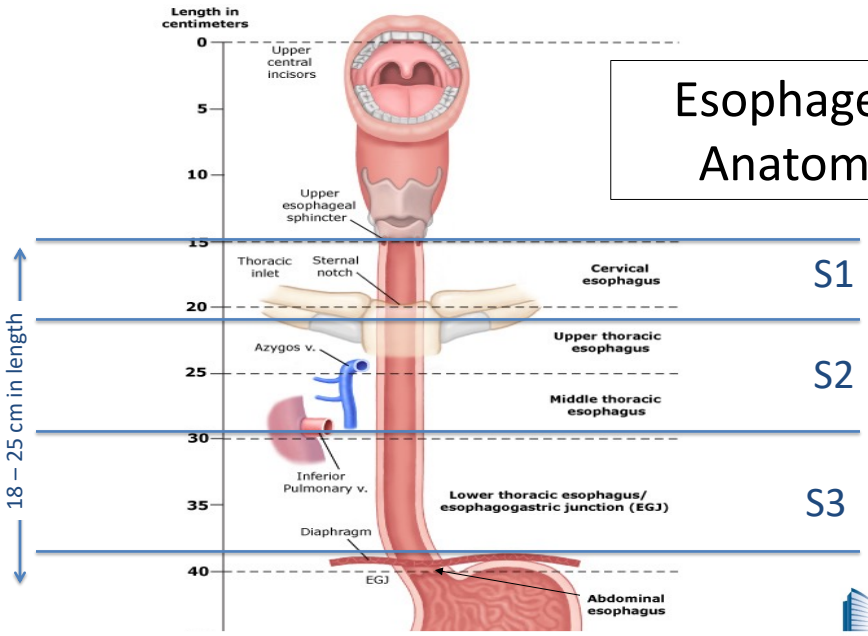
# Esophageal Anatomy

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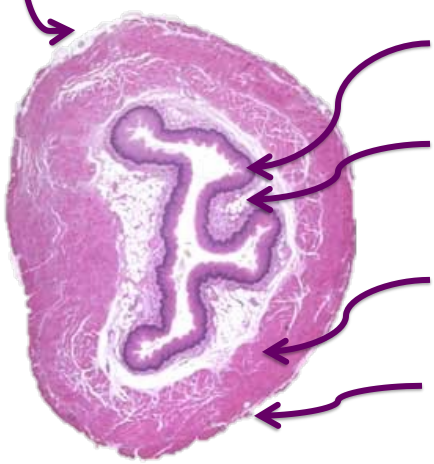
# Histology

No serosa



Mucosa: Non-keratinizing squamous epithelium

Submucosa: Connective tissue, Meissner's Plexus, vascular plexus, mucous glands

Muscularis: Outer longitudinal, inner circular; Auerbach's plexus lies between the muscle layers

Adventitia: Fibrous connective tissue

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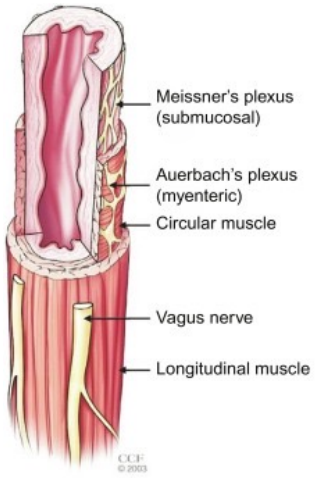
# Extrinsic Innervation

- T1 – T10 Sympathetic Chain
  - Relax muscle wall
  - Blood vessel constriction
  - Pain transmission
- Vagus (cranial nerve X)
  - Sensory → "general" but includes mechanoreceptors for distention
  - Parasympathetic → glandular secretions
  - Motor
    - Nucleus ambiguous (IX, X, XI)
      - Upper esophageal sphincter
      - Upper striated muscle
    - Dorsal motor nucleus
      - Smooth muscle
      - Lower esophageal sphincter




Su A; Parker C, Conklin J. Esophageal anatomy and physiology. In Clinical and Basic Neurogastroenterology and Motility, p. 79-88 2020 Elsevier Inc.

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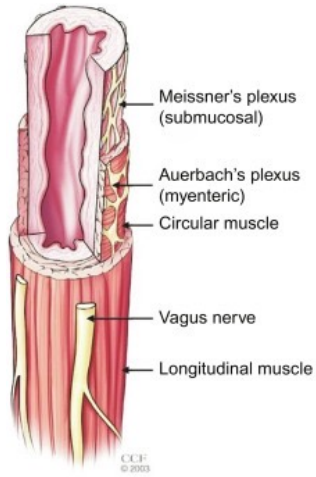
Urma, D & Kuo B. GI Motility online (2006)

# Intrinsic Innervation

- Auerbach's plexus – Myenteric Plexus
  - Ganglia lie between the longitudinal and the circular muscle layers
  - Regulates contraction of the outer longitudinal muscle layer
- Meissner's plexus – Submucosal Plexus
  - Ganglia lie in the submucosa
  - Regulate glandular secretion
  - Peristaltic contractions of the circular layer




Su A; Parker C, Conklin J. Esophageal anatomy and physiology. In Clinical and Basic Neurogastroenterology and Motility, p. 79-88 2020 Elsevier Inc.

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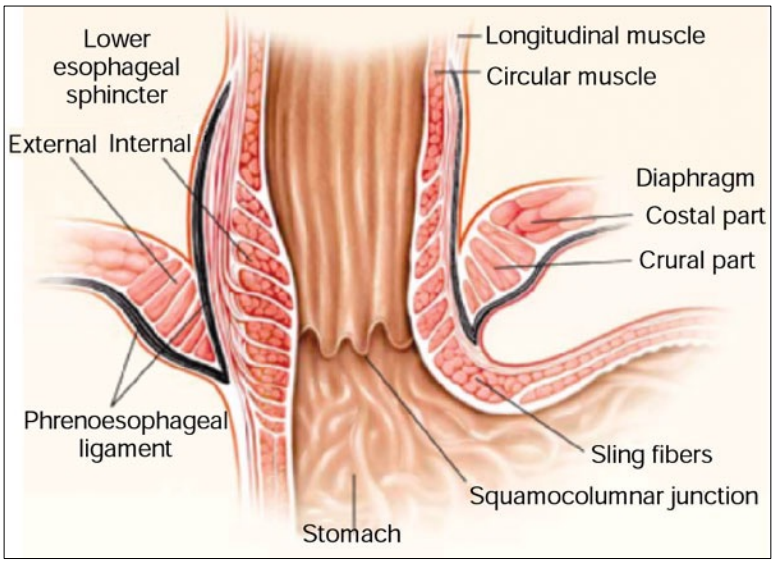
Urma, D & Kuo B. GI Motility online (2006)

## Anatomy of the Esophagogastric Junction

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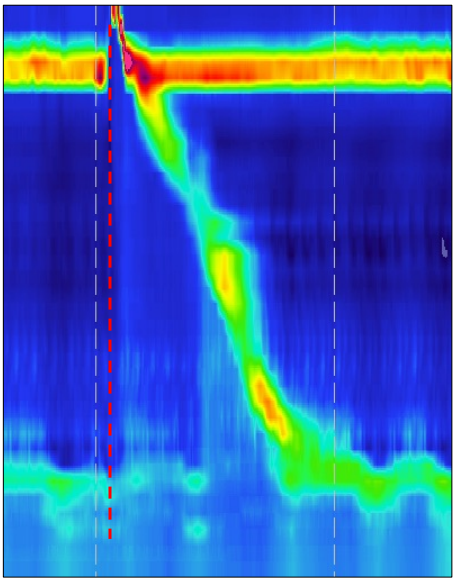
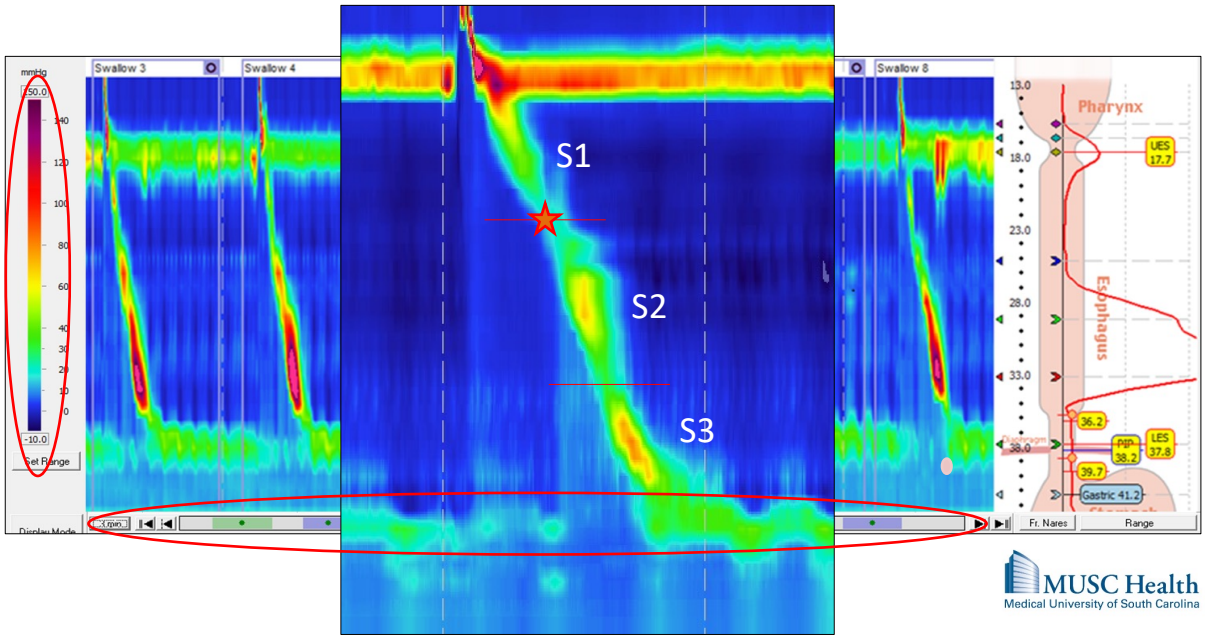
*GI Motility online* (May 2006) | doi:10.1038/gimo14

## Normal Esophageal Swallowing

- Relaxation of UES
  - ? Pharyngeal phase
  - "Pharyngoesophageal segment"
- Peristalsis of the Esophageal Body
  - Not too weak
  - Not too strong
  - Anterograde pattern
    - Not simultaneous
    - Not retrograde (vomiting)
- Relaxation of LES



## High Resolution Manometry

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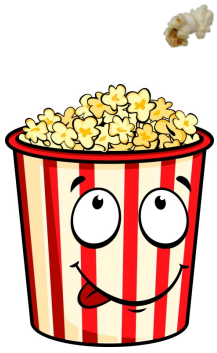

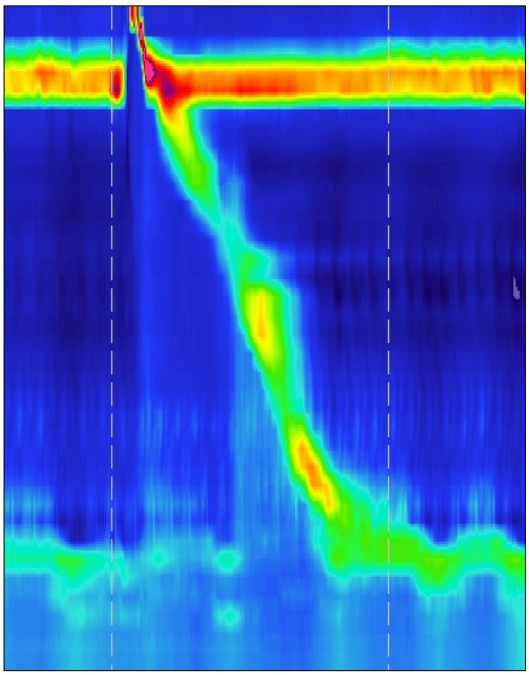

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# High Resolution Manometry with Impedance

**Manometry**

- Measures intraluminal pressure changes caused by muscular contraction and relaxation
- Measured in mmHg

**Impedance**

- Measures the resistance to electrical current flow in the GI tract
- Impedance changes due to the electric conductivity of digestive contents
- Measured in ohms

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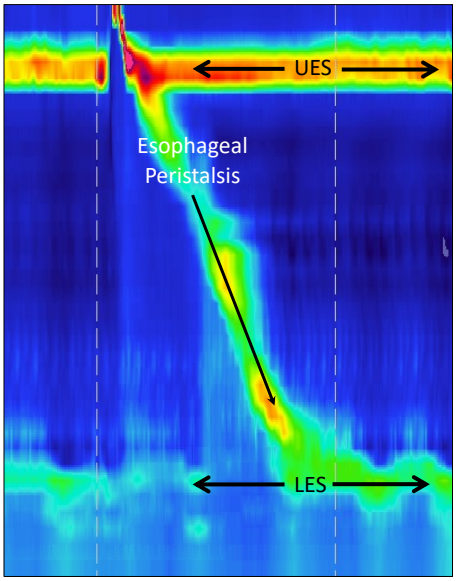


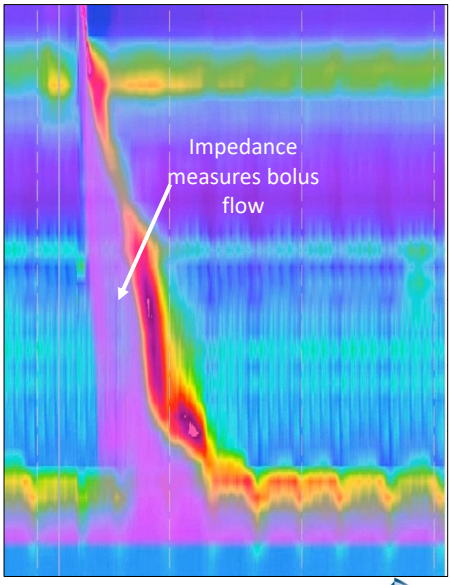


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# Esophageal Peristalsis

① PRIMARY

② SECONDARY

③ TERTIARY

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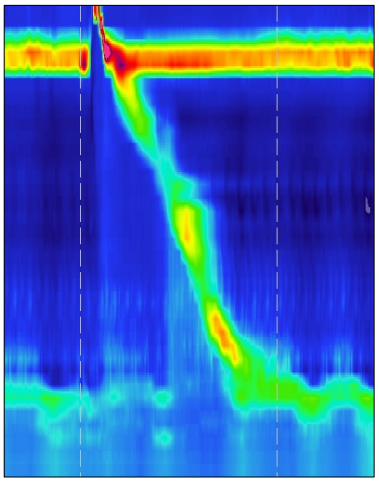
# Primary Peristaltic Wave

- Only one primary wave propagates at a time
- Disrupted by ”double swallow”



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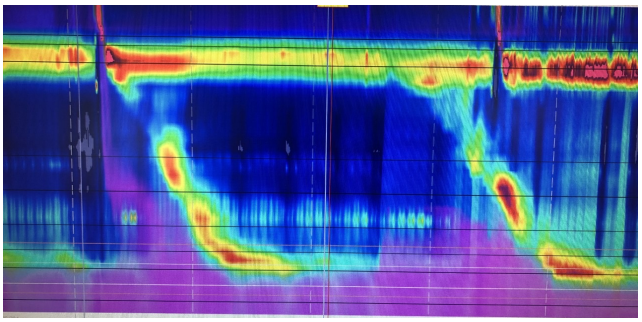
# Secondary Peristaltic Wave

- Considered a clearance wave
- Induced by esophageal distention (bolus, reflux, or air)



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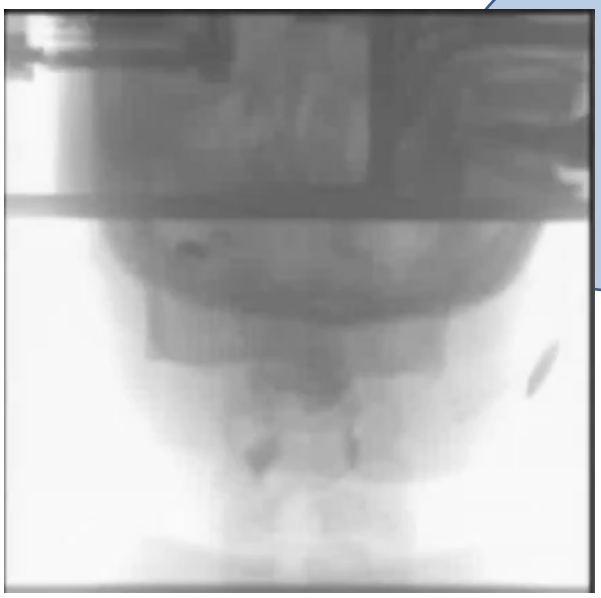
## Tertiary Contractions

Non-functional contractions

No known physiologic role

Increased in elderly
"presbyesophagus"



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# OUTLINE

Importance of Esophageal Evaluation → Evaluation of Esophageal Function → Esophageal Anatomy & Function → Normal Manometric Esophageal Definitions

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## Chicago Classification of Esophageal Motility Disorders

- Categorizes esophageal motility disorders using HRM and pressure topography plots
- Four reiterations
  - 2009 version 1
  - 2012 version 2
  - 2015 version 3
  - 2021 version 4

**Disorders of EGJ Outflow**

- Achalasia (Types I, II, III)
- EGJ outflow obstruction

**Disorders of Peristalsis**

- Absent contractility
- Distal esophageal spasm
- Hypercontractile esophagus
- Ineffective esophageal motility

Yadlapati R, et al. Esophageal motility disorders on high-resolution manometry: Chicago classification version 4.0©. Neurogastroenterol Motil. 2021 Jan;33(1):e14058.

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# Important Definitions

Integrated Relaxation Pressure

Distal Contractile Integral

Contractile Deceleration Point

Distal Latency

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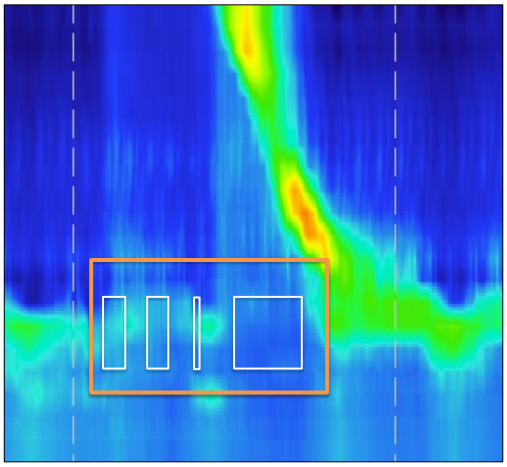
# LES Integrated Relaxation Pressure

- Mean pressure of the 4 seconds of maximal relaxation in the 10 second window following UES relaxation
- Can be non-contiguous (interrupted by diaphragmatic contraction)
- Relative to gastric pressure
- Normal is dependent on manufacturer & position
  - Supine median IRP <15 mmHg (Medtronic)
  - Supine median IRP <22 mmHg (Laborie & Diversatek)
  - Upright median IRP <12 mmHg (Medtronic)
  - Upright median IRP <15 mmHg (Laborie & Diversatek)



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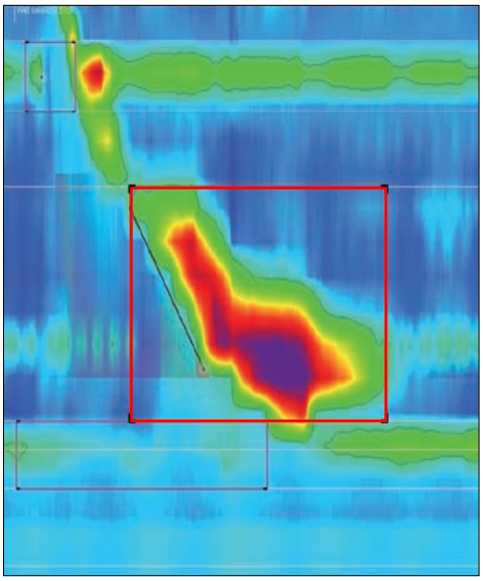
# Distal Contractile Integral

- Magnitude of the distal esophageal (smooth muscle) contraction (S2 & S3 segments)
- Products of the amplitude, duration, and length of the contraction (mmHg·s·cm)
  - Assessment of contractile "vigor"
  - Pressures > 20 mmHg are included
  - Length is from transition zone to proximal aspect of the LES
- Used to define both hyper and hypo-contractile states
  - Normal DCI 450–8,000 mmHg·s·cm
  - Weak DCI >100 and <450 mmHg·s·cm
  - Failed DCI <100 mmHg·s·cm
  - Hypercontractile DCI >8,000 mmHg·s·cm



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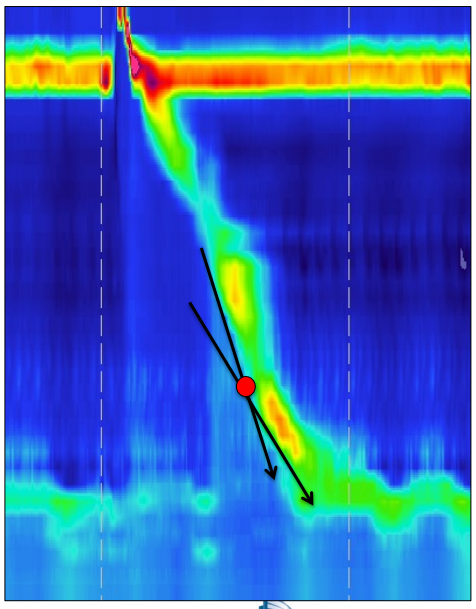
# Contractile Deceleration Point

- An inflection point along the 30 mmHg isobaric contour at which the propagation wave velocity slows.
- Must be identified within 3 cm of the LES proximal margin
- This slower segment is the emptying of the ampulla of the esophagus into the stomach



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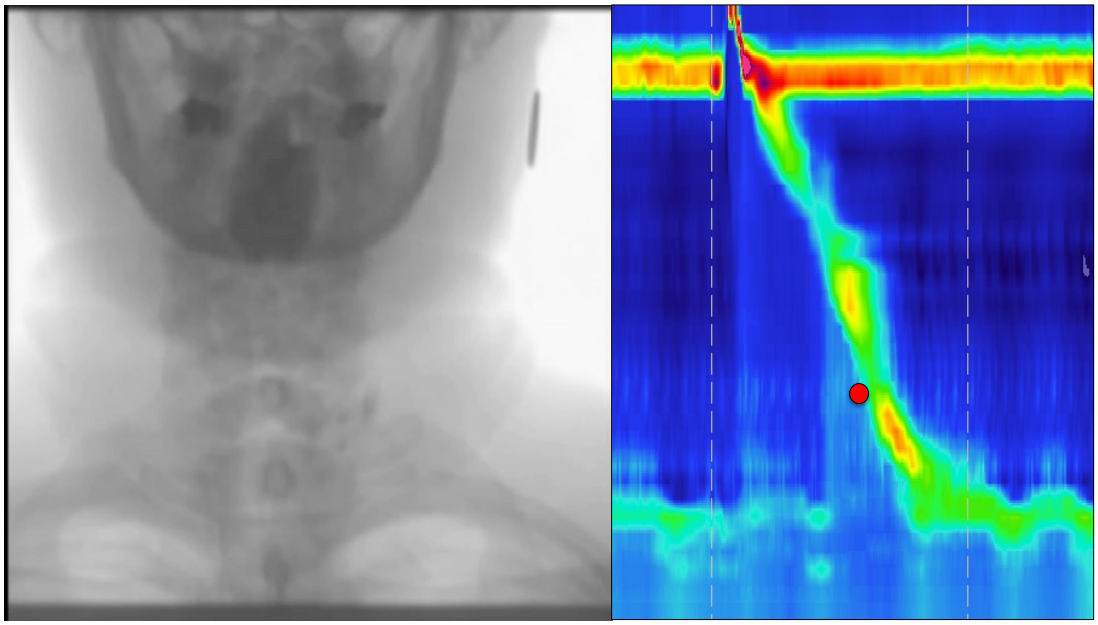
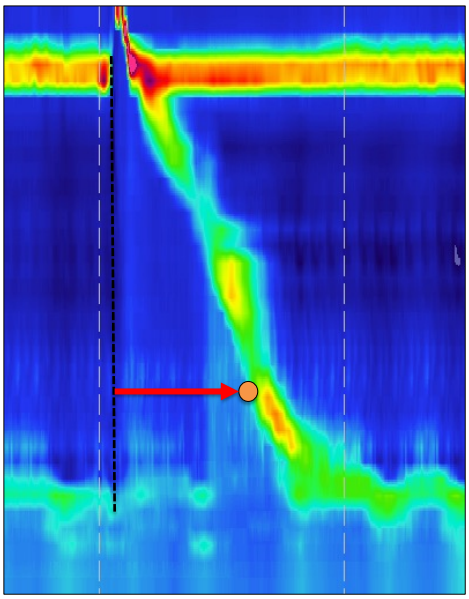


## Distal Latency

- Time interval between UES relaxation and CDP
- Normal is greater than 4.5 seconds
- Less than 4.5 seconds is a premature swallow



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# Important Normal Definitions

| | | |
|---|---|---|
| ✓ | Integrated Relaxation Pressure (IRP) | Supine < 15 (med) or 22 (lab) mmHg<br>Upright < 12 (med) or 15 (lab) mmHg |
| | Distal Contractile Integral (DCI) | 450 – 8000 mmHg·s·cm |
| | Contractile Deceleration Point | |
| | Distal Latency (DL) | > 4.5 sec |

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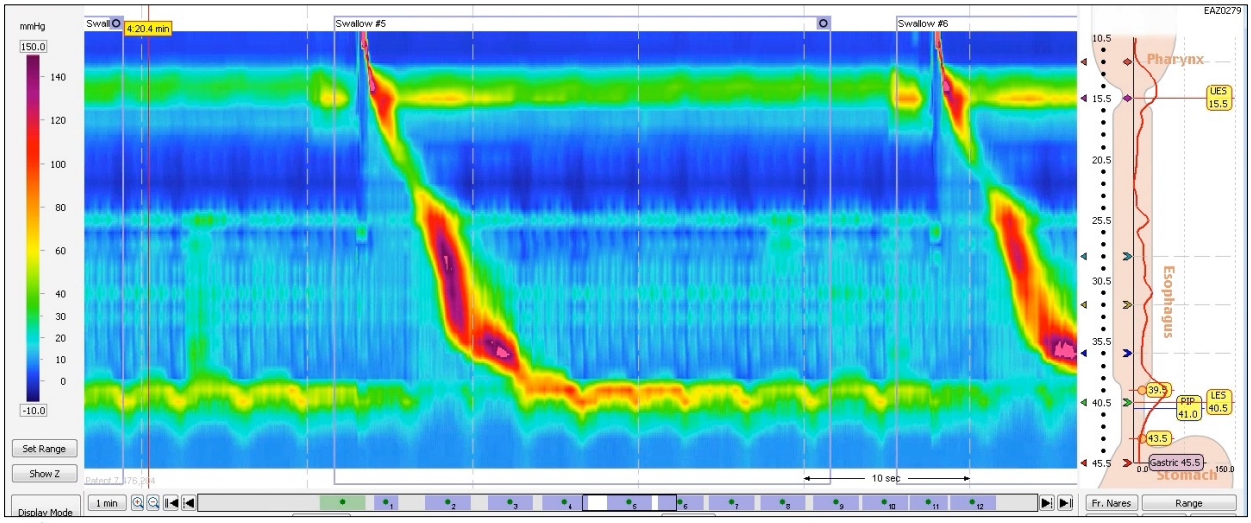
# Normal Esophageal Manometry Study

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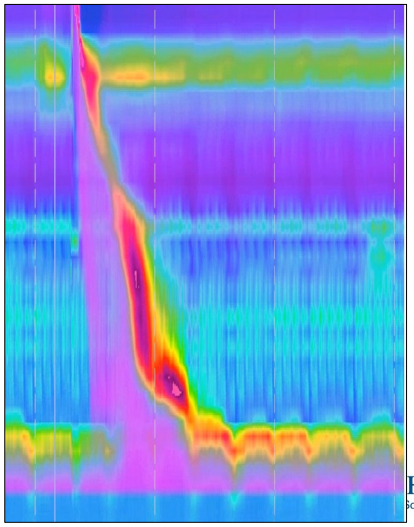
# High Resolution Manometry with Impedance

**Admittance**

- It is the inverse of impedance and thus, how easily flow is allowed
- Surrogate for distention
- Measured in milliSiemens

**Impedance**

- Measures the resistance to electrical current flow in the GI tract
- Impedance changes due to the electric conductivity of digestive contents
- Measured in ohms



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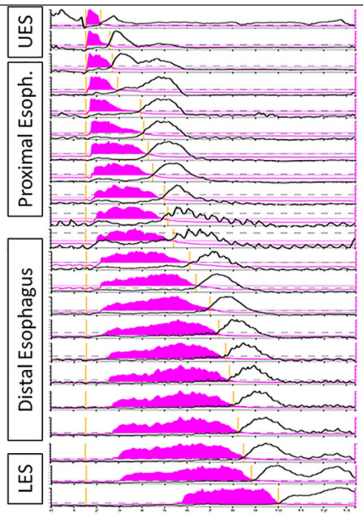
**Distension contraction plots of pharyngeal/esophageal peristalsis: next frontier in the assessment of esophageal motor function**

*Am J Physiol Gastrointest Liver Physiol* 323: G145–G156, 2022.

Taher I. Omari,[1] Ali Zifan,[2] Charles Cock,[3] and Ravinder K. Mittal[2]




*Bottom right*: esophageal high-resolution manometry (E-HRM) impedance recording showing the admittance waveform (marker of luminal cross-section area and distension) and pressure (contraction) waveform along the length of the esophagus. Note, that peak distension and peak contraction traverse the esophagus sequentially, and there is a close temporal correlation between the end of distension and onset of contraction at each location in the esophagus. *A*: baseline period; *B*: distension period; *C*: contraction period. CSA, cross-sectional area; UES, upper esophageal sphincter.

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**Distension contraction plots of pharyngeal/esophageal peristalsis: next frontier in the assessment of esophageal motor function**

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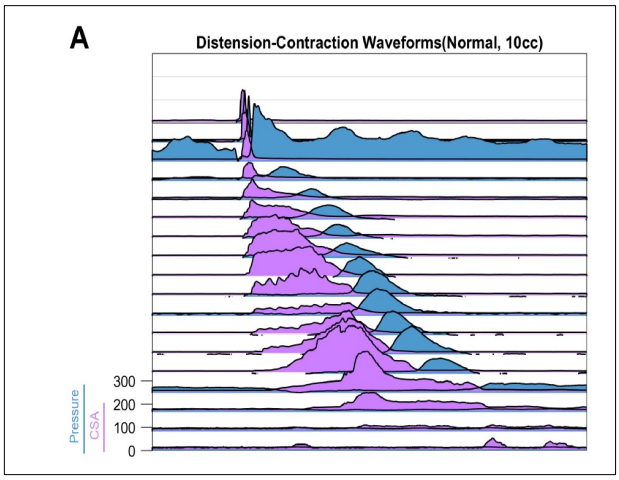
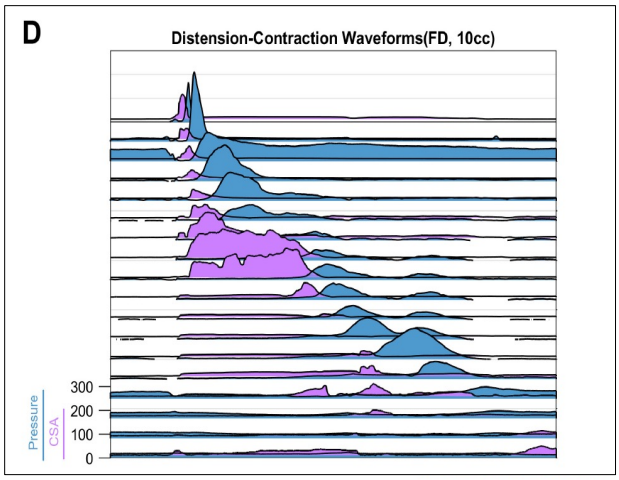
Normal Subject




Patient with "functional dysphagia"




# Important Concepts

- Peristalsis does not equal bolus transit.
- Coordination is as important as pressures.
- Most normative data for the esophagus were collected in the left decubitus position
- Limited normative data for the pharynx

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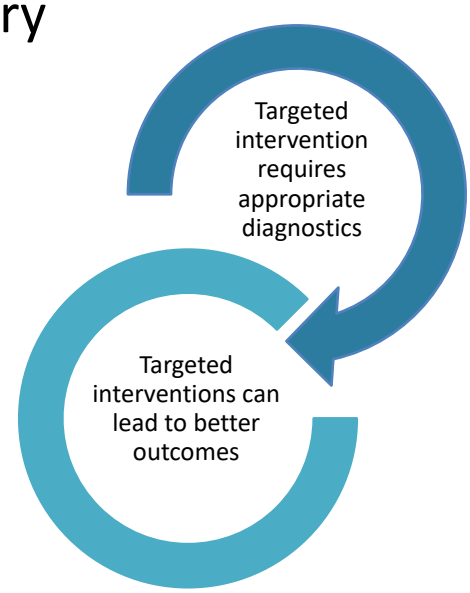
# Summary

- Understanding normal is essential to identifying the pathological mechanisms.
- There are characteristic pressure patterns in both the pharynx and the esophagus that are consistent with normal swallowing function.

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