
السلام عليكم ورحمة الله وبركاته

Gastrointestinal Physiology
Lecture 2

Esophageal Motility and Pathophysiology of Reflux Disease

(Chapter 64; Pages 807-816)

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Learning Objectives

- Mastication and chewing reflex
- Swallowing process and its stages
- Types of esophageal peristalsis
- Esophageal sphincter
- Function of lower esophageal sphincter
- Achalasia
- Incompetence of lower esophageal sphincter

Mastication (Chewing)

Functions:

1. To lubricate the bolus with salivary secretion.
2. To breakdown the bolus to small particles.
3. To begin digestion of carbohydrate

   (by amylase).

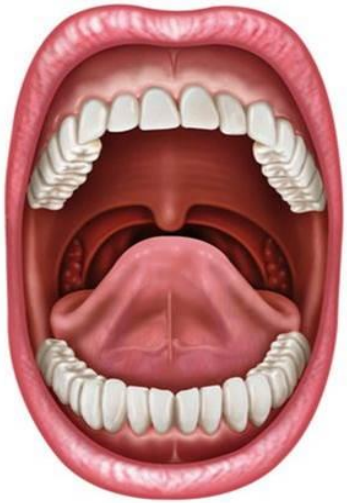
❖**Teeth organization**

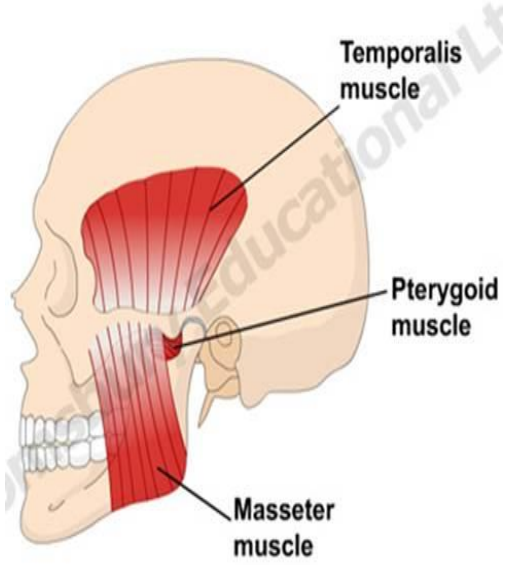
- Anterior teeth (incisors) for cutting
- Posterior teeth (molars) for grinding

❖Chewing muscles are innervated by cranial nerve V (trigeminal nerve):

- Masseter
- Temporalis
- Pterygoid

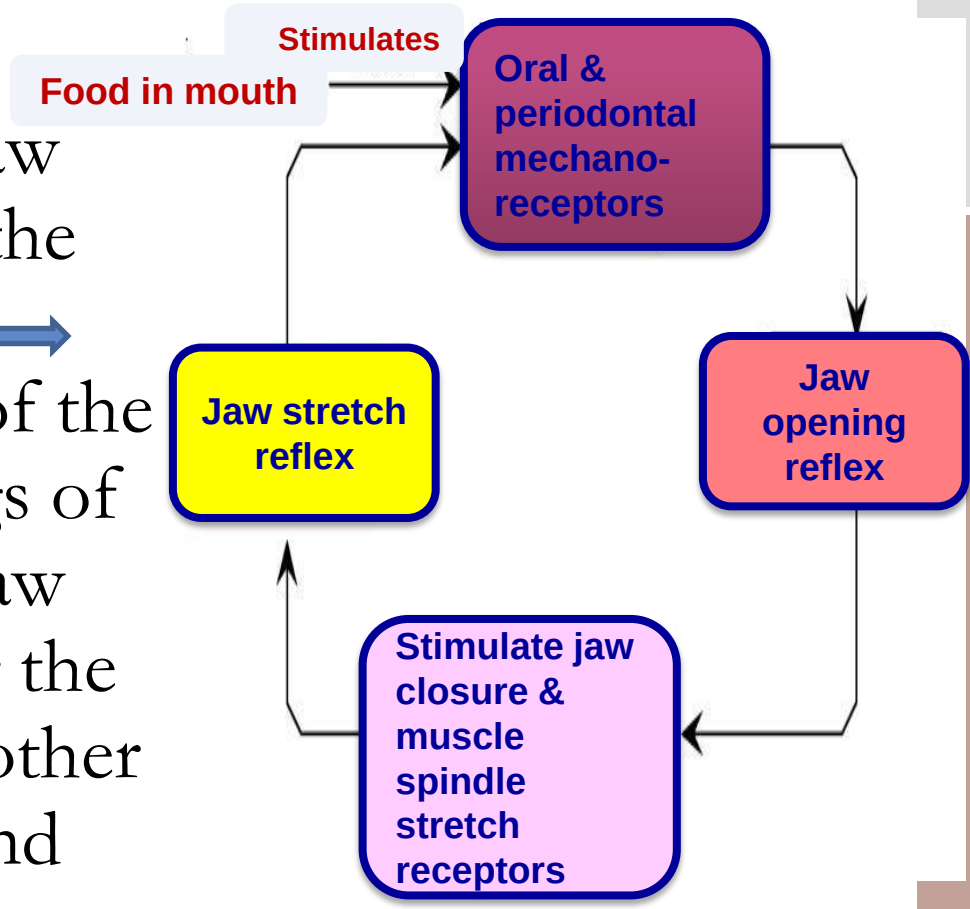
❖Taste center (Hypothalamus) → rhythmical chewing movements (Chewing reflex).





Chewing (stretch) reflex

- The presence of a bolus of food in the mouth initiates reflex inhibition of the muscles of mastication ⟹ the lower jaw drops ⟹ stretch reflex of the jaw muscles & contraction ⟹ jaw closure & compression of the bolus again against the linings of the mouth ⟹ inhibits the jaw muscles once again, allowing the jaw to drop and rebound another time; this is repeated again and again.



Swallowing (Deglutition)

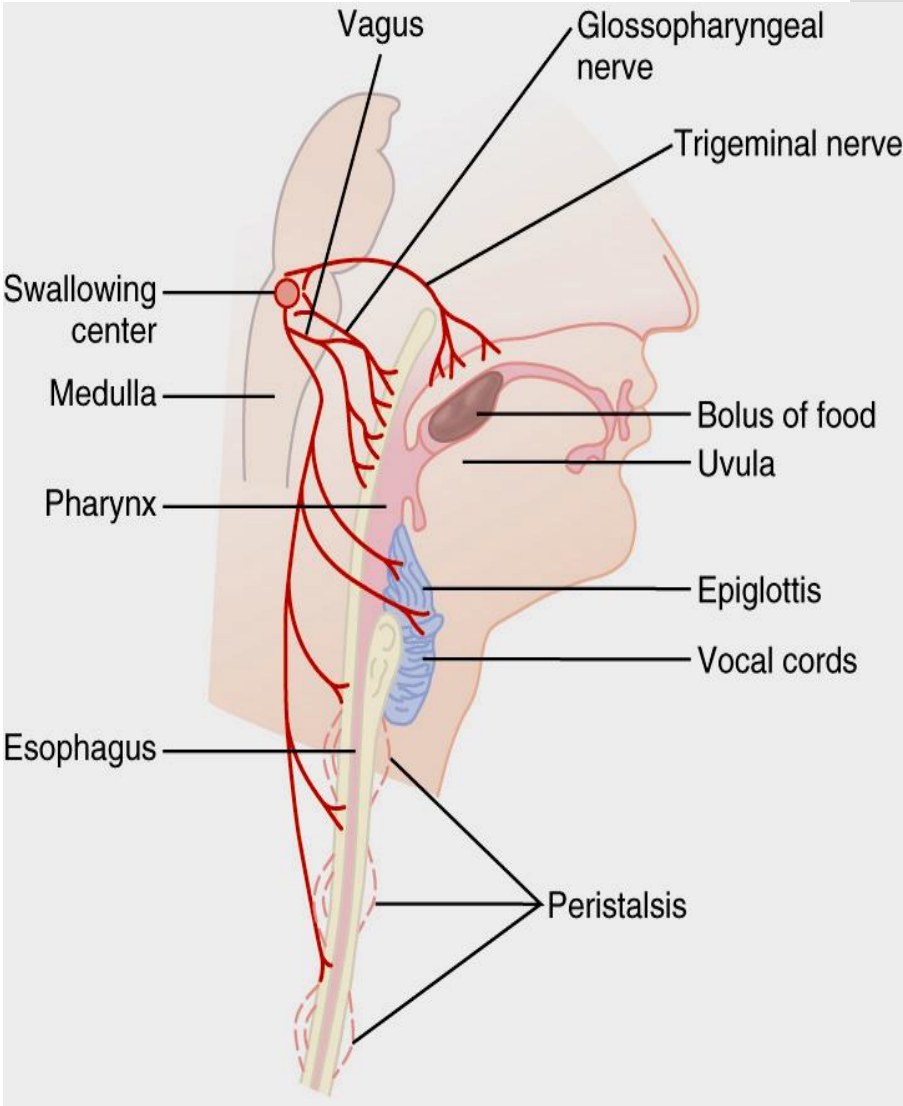
The ordered sequence of events that propel food from the mouth to the stomach.

Initiated voluntary, thereafter it is entirely under reflex control.

Inhibits respiration and prevents the entrance of food into the airway passages.

Swallowing Center

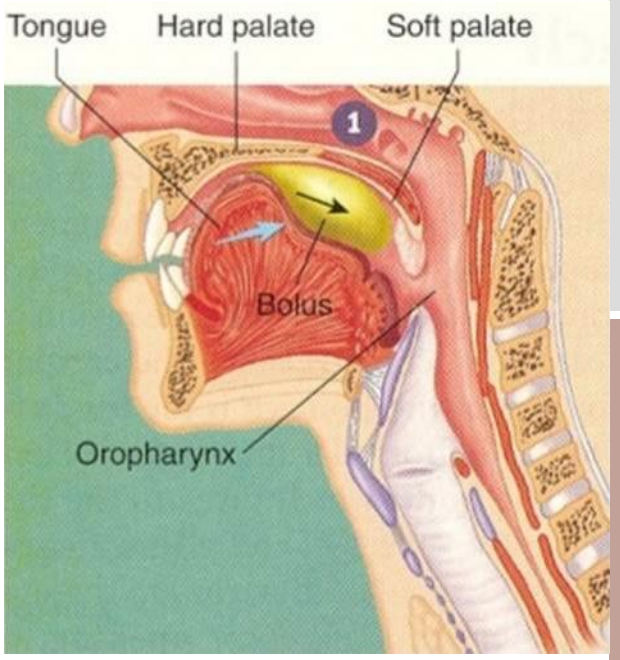
The reflex portion of wallowing is controlled by the ***swallowing center*** in the medulla.



Stages of Swallowing

I- The Oral Stage

- ✓ This stage involves the voluntary rolling of the chewed food (bolus) posteriorly into the pharynx by the upward and backward pressure applied by the tongue against the palate.
- ✓ The activation of somatosensory receptors in the pharynx initiates the involuntary swallowing reflex in the medulla. From here on, swallowing becomes entirely automatic and can not be stopped.



II- The Pharyngeal Stage

1. •At the pharynx, the bolus stimulates epithelial swallowing receptor areas all around the pharynx opening and impulses pass to swallowing center and accordingly initiate a series of autonomic pharyngeal muscle contractions as follows:

2. •The soft palate Is pulled upward to close the posterior nares which prevents the food from entering the nasal cavities.

3. •The palatopharyngeal folds pull medially to approximate and form a sagittal slit through which food must pass into the posterior pharynx.

II- The Pharyngeal Stage (Cont.)

4

- The vocal cords are strongly approximated and the larynx is pulled upward and anteriorly by the neck muscles. These actions cause the epiglottis to swing backward over the opening of the larynx.

5

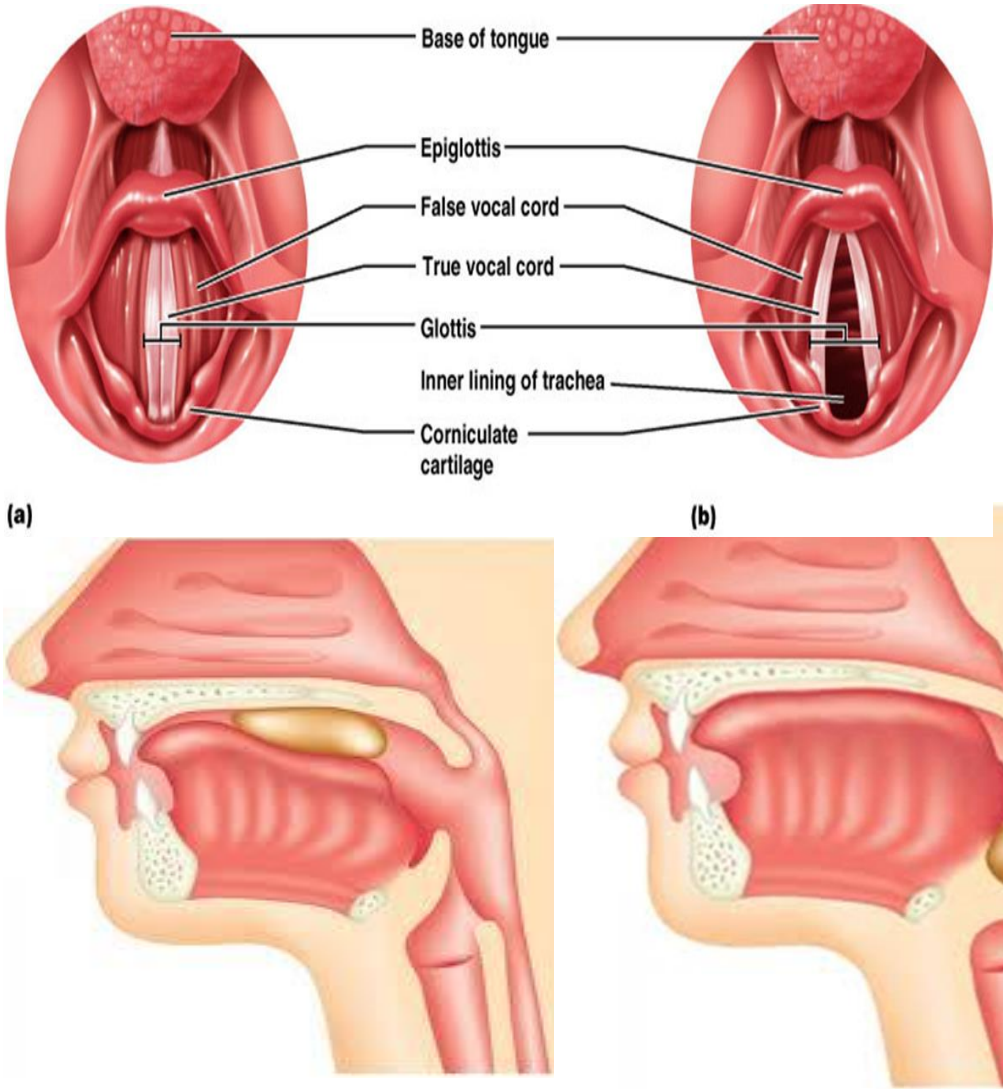
- The upward movement of the larynx pulls up and enlarges the opening to the esophagus. The upper esophageal sphincter relaxes and food move into the upper esophagus.

6

- Once the larynx is raised and the pharyngoesophageal sphincter relaxes, the entire muscular wall of the pharynx contracts propelling the food by peristalsis into the esophagus.
- Swallowing center inhibits the respiratory center.

Summary of The Pharyngeal Stage

- The trachea is closed.
- The esophagus is opened
- A fast peristaltic wave initiated by the nervous system of the pharynx forces the bolus of food into the upper esophagus
- Time of process is < 2 seconds.



Nervous Initiation of the Pharyngeal Stage of Swallowing

Most sensitive areas for its initiating:-

Are located in a ring around the pharyngeal opening including the tonsillar pillars.

Sensory impulses:-

Are received by the nucleus tractus solitarius via the medulla oblongata through the 5th & 9th cranial nerves.

Swallowing center initiates:-

Automatic successive stages of swallowing

Motor impulses to pharynx:-

Are transmitted from the swallowing center by the 5th, 9th, 10th, and 12th cranial nerves and few of the superior cervical nerves.

III- The Esophageal Stage

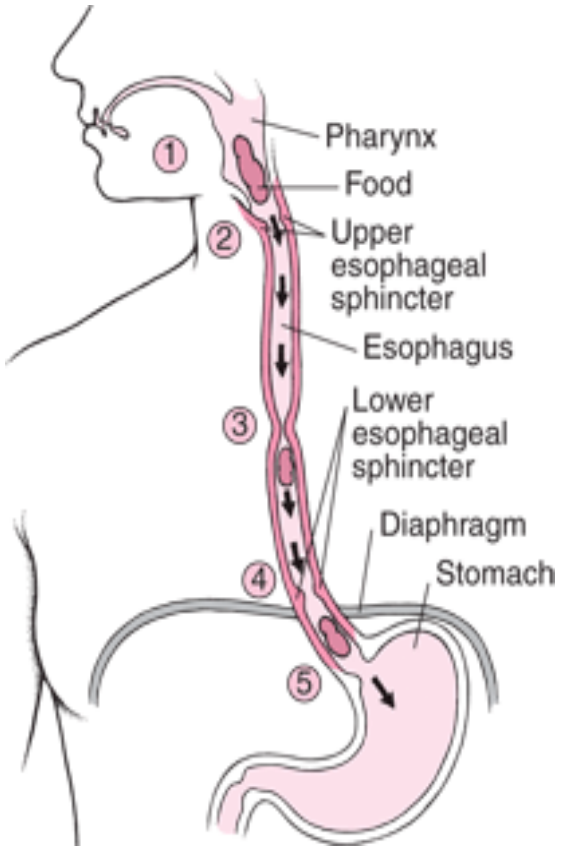
- The esophagus is a conduit to move food rapidly from the pharynx to the stomach.
- The esophageal stage is controlled partly by the swallowing reflex and partly by the enteric nervous system (ENS). In case of vagotomy enteric nervous system takes over.
- Physiologically, esophagus is divided into three functionally distinct regions:

Upper esophageal sphincter (UES)

Esophageal Body

Lower esophageal sphincter (UES)

III- Esophageal Stage (Cont.)



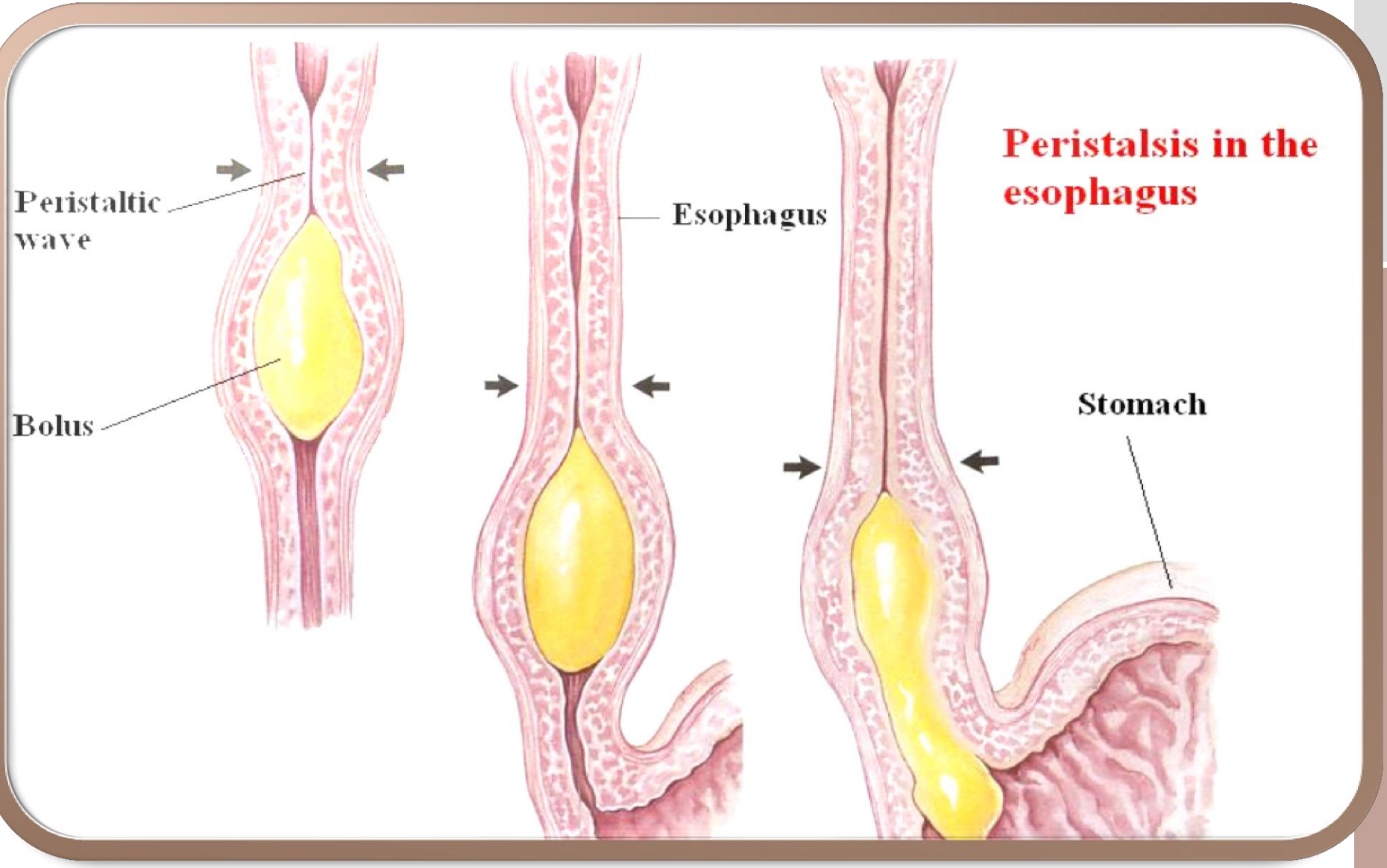
The upper 1/3 of the esophagus:- Striated muscle (peristaltic waves are controlled by impulses from IX and X nerves)

The lower 2/3 of the esophagus:- Smooth muscle (controlled by the X nerve through connections with esophageal myenteric nervous system).

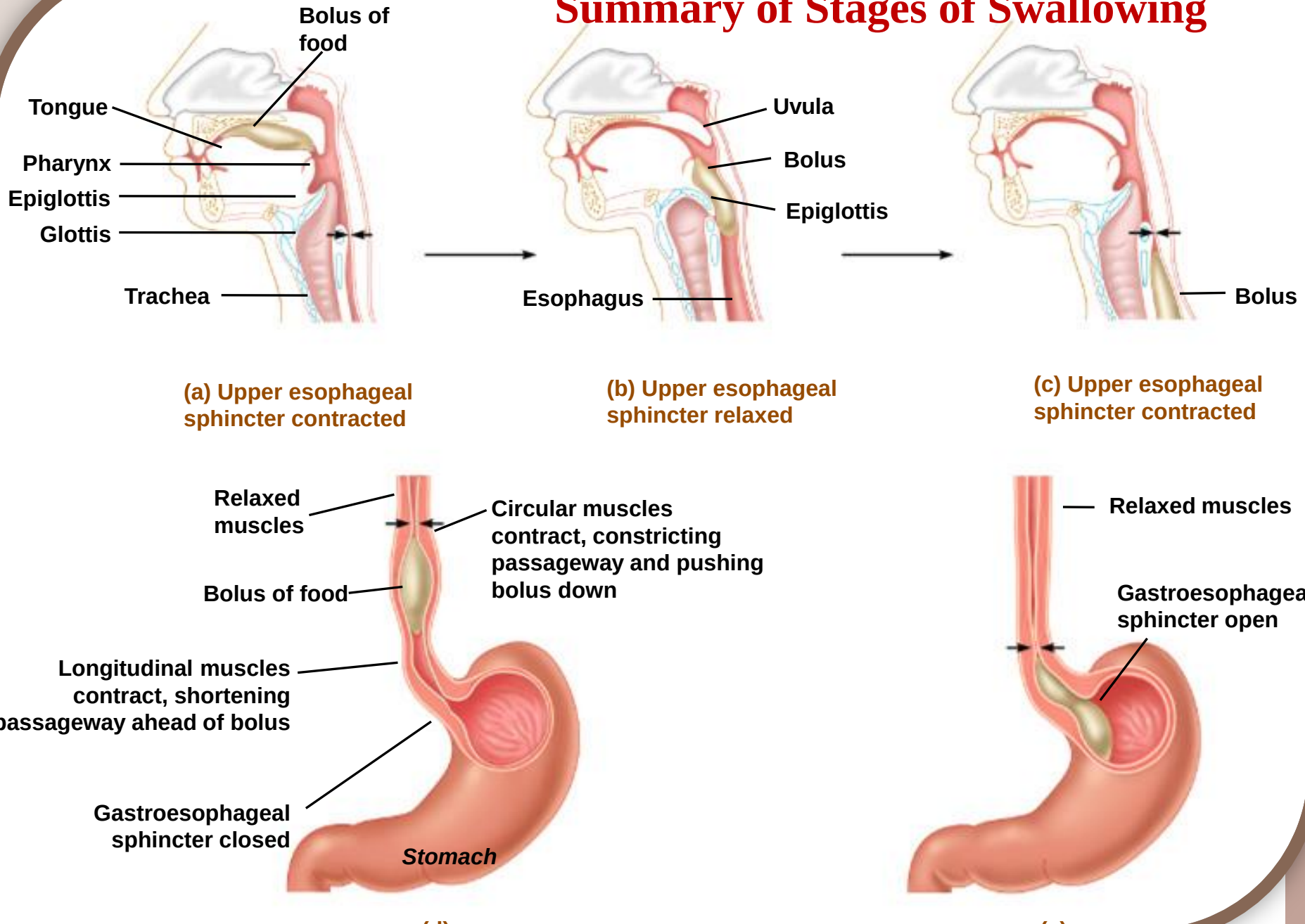
The swallowing reflex closes UES:- A peristaltic wave begins just below UES when bolus pass through it and traverse the entire esophagus.

The lower esophageal sphincter:- Relaxes and the bolus enters the stomach.

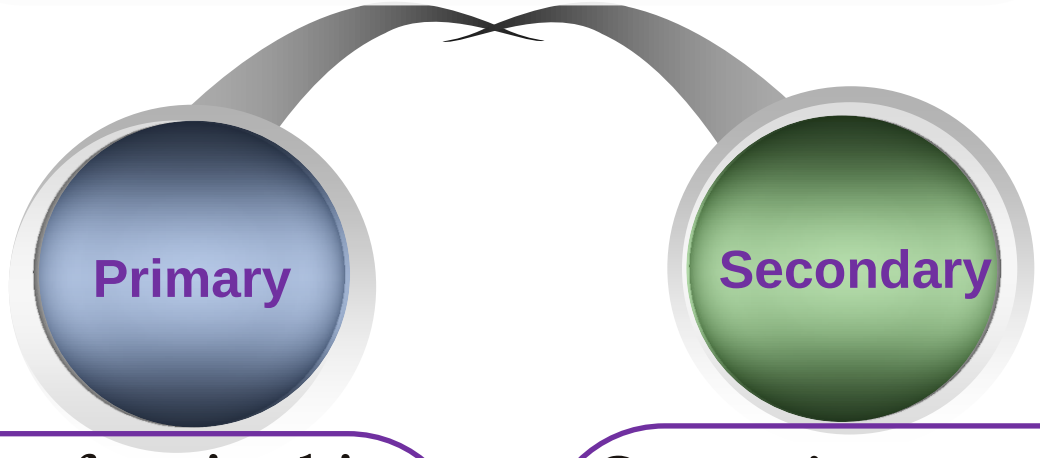
Esophageal Preistalsis



Summary of Stages of Swallowing

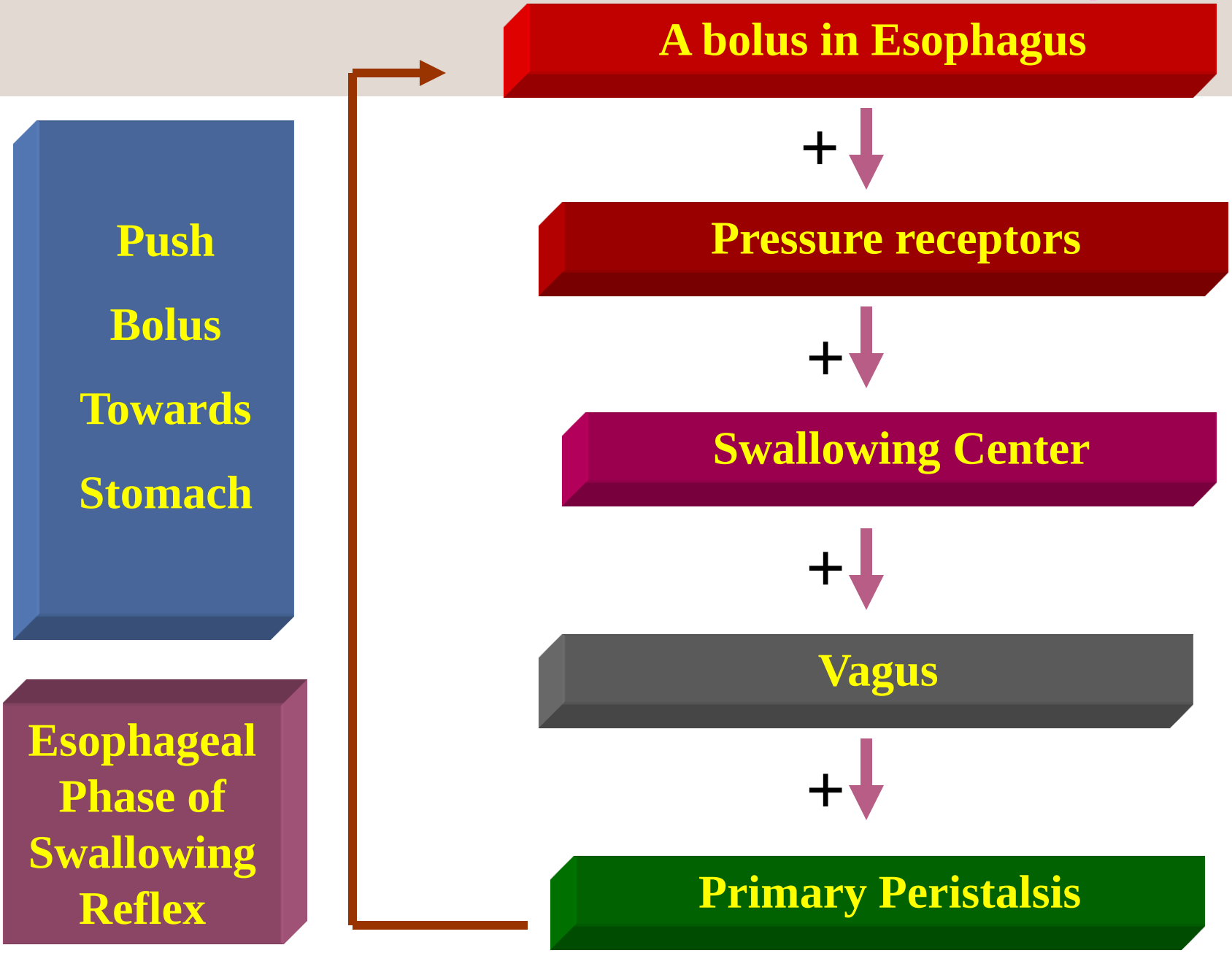


Types of Esophageal Peristalsis:

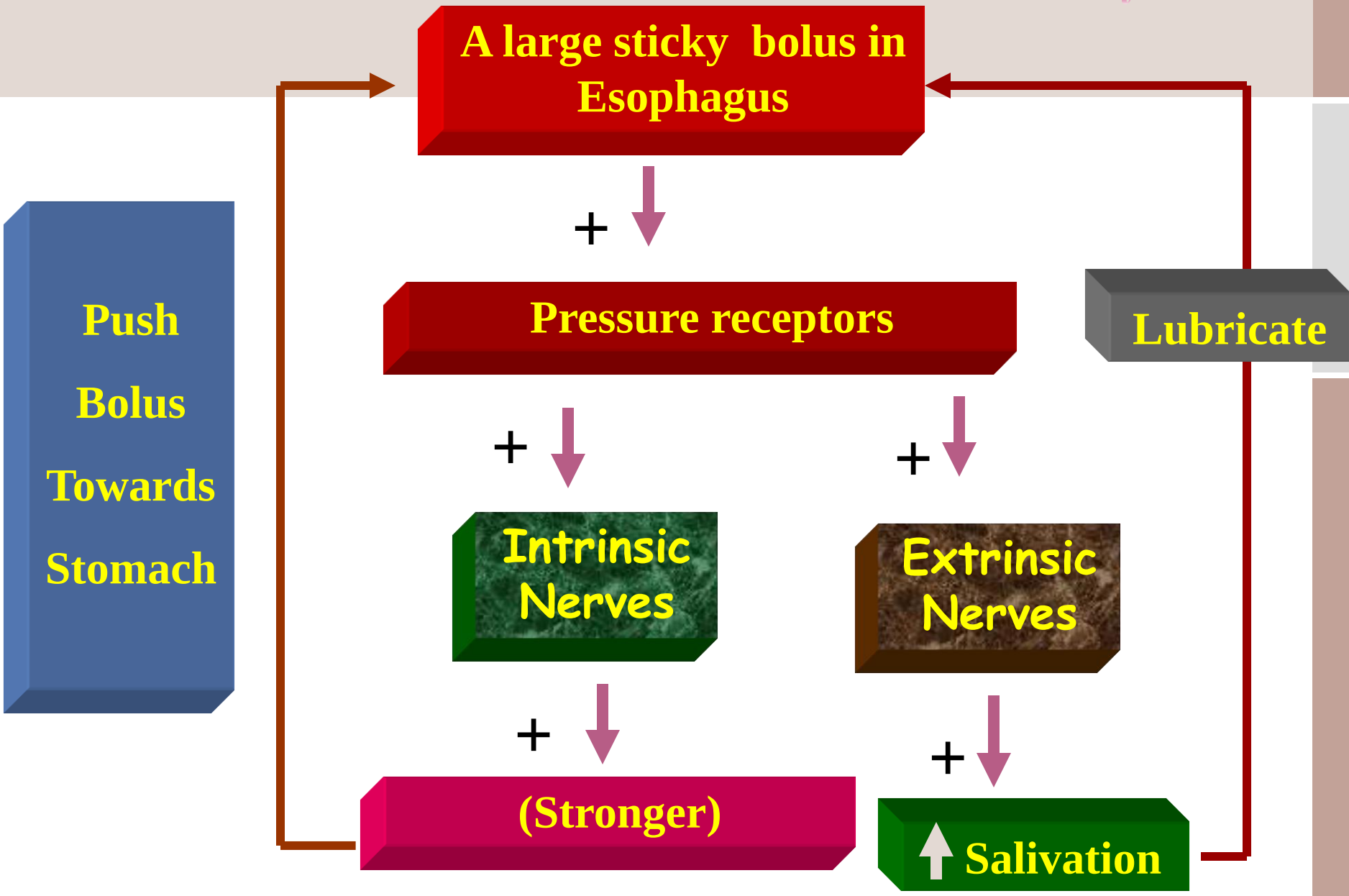


- A continuation of peristaltic wave that begins in pharynx and spreads into esophagus during the pharyngeal stage of swallowing.
- This wave passes from the pharynx to the stomach in 8-10 sec.
- Coordinated by swallowing center

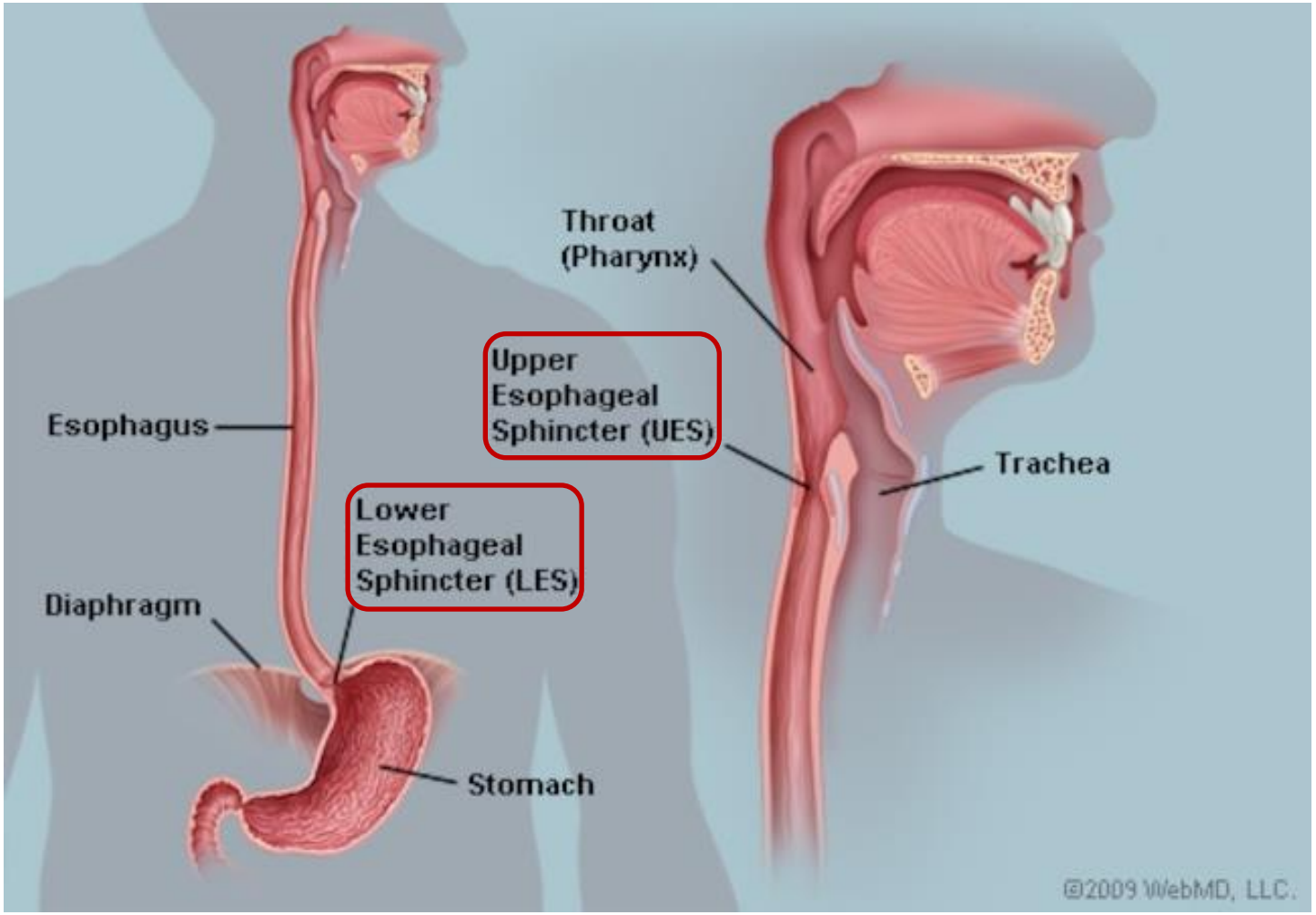
- Occurs in response to distention and continue until all the food is emptied into the stomach.
- ENS and swallowing center are both involved

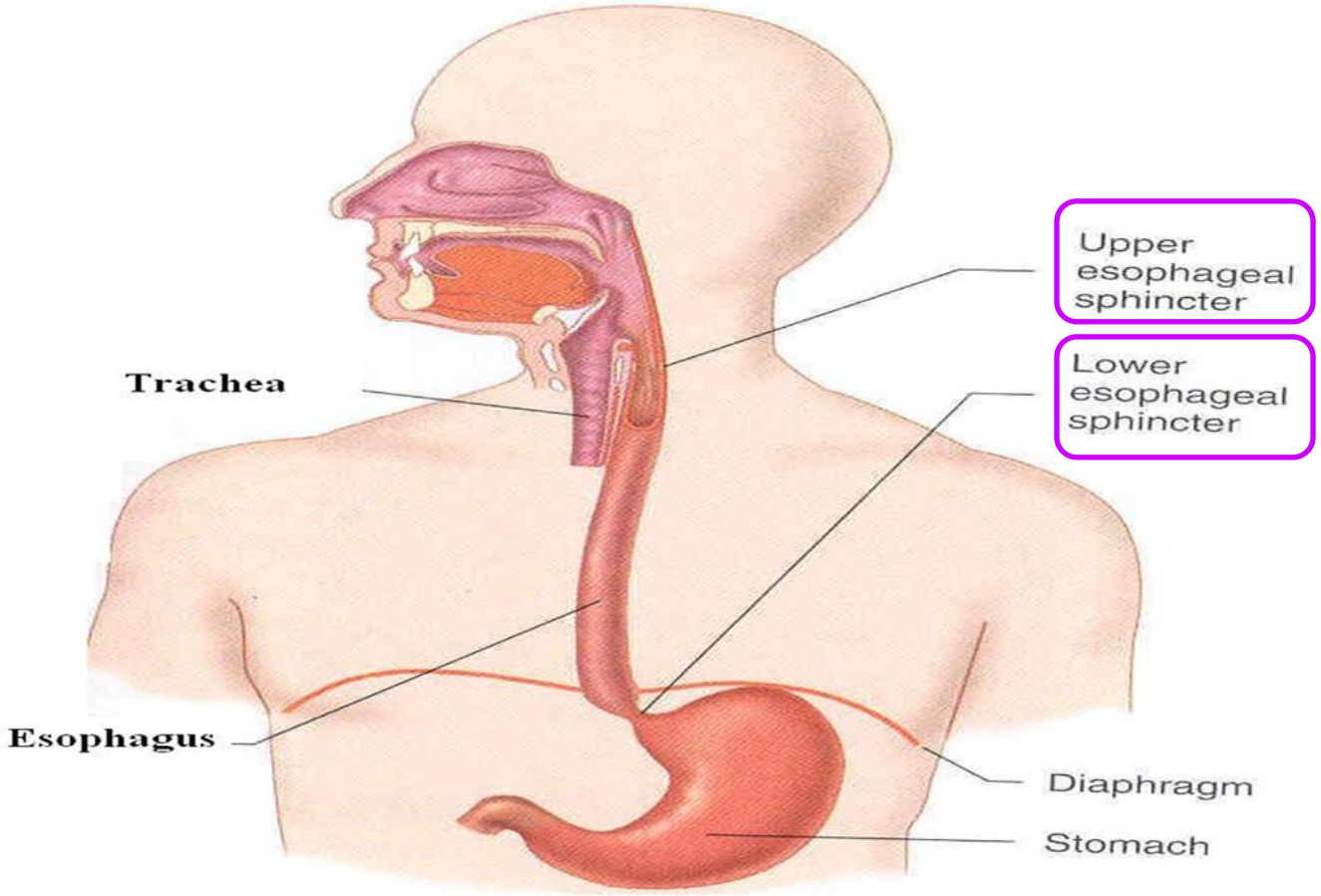

A bolus in Esophagus
+
Pressure receptors
+
Swallowing Center
+
Vagus
+
Primary Peristalsis
Push
Bolus
Towards
Stomach
Esophageal Phase of Swallowing Reflex

Secondary Peristalsis



Esophageal Sphincters





Location of upper and lower esophageal sphincters

The Upper Esophageal Sphincter (UES)

Where

- It is formed of striated muscle but is not under voluntary control, located at the lower end of pharynx and guards the entrance into the esophagus.

Function

- It prevents esophageal air insufflation during negative intrathoracic pressure events, as during inspiration.
- It prevent esophagopharyngeal/laryngeal reflux during esophageal peristalsis.

When relax

- It relaxes during swallowing for about 1 second allowing the bolus to be forced through the relaxed UES.

The Lower Esophageal Sphincter (LES)

Where

- It is formed by circular smooth muscle located in an area of ~ 3 cm upward of the junction with the stomach.

Function

- In between swallowing, it normally remains tonically constricted to prevent reflux of gastric contents into esophagus.
- During swallowing, the peristaltic wave passes down the esophagus and causes a "receptive relaxation" of LES for 7-10 sec. (mediated by vagal impulses) to allow easy propulsion of the swallowed food into the stomach.

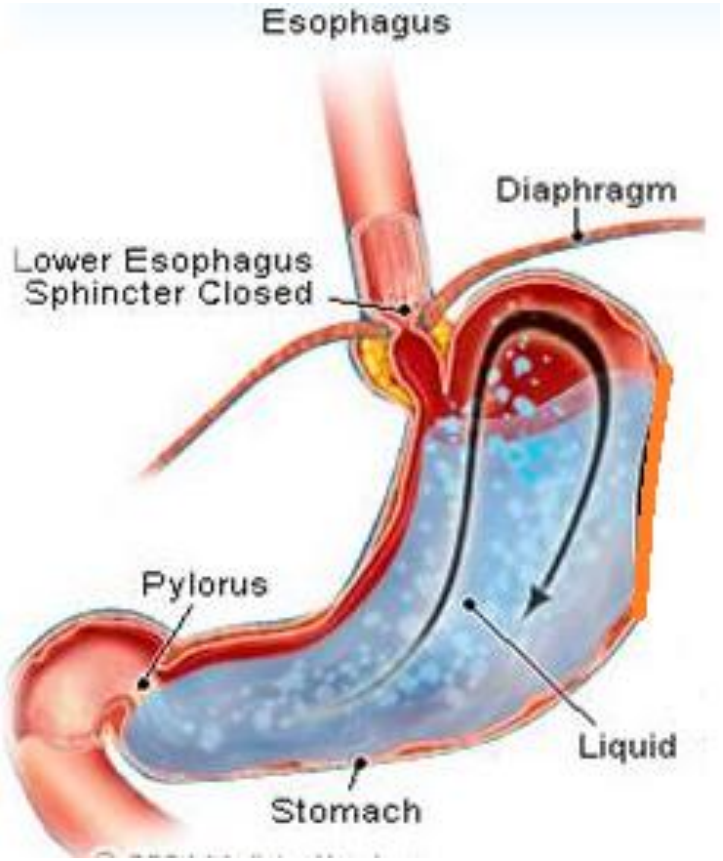
Why

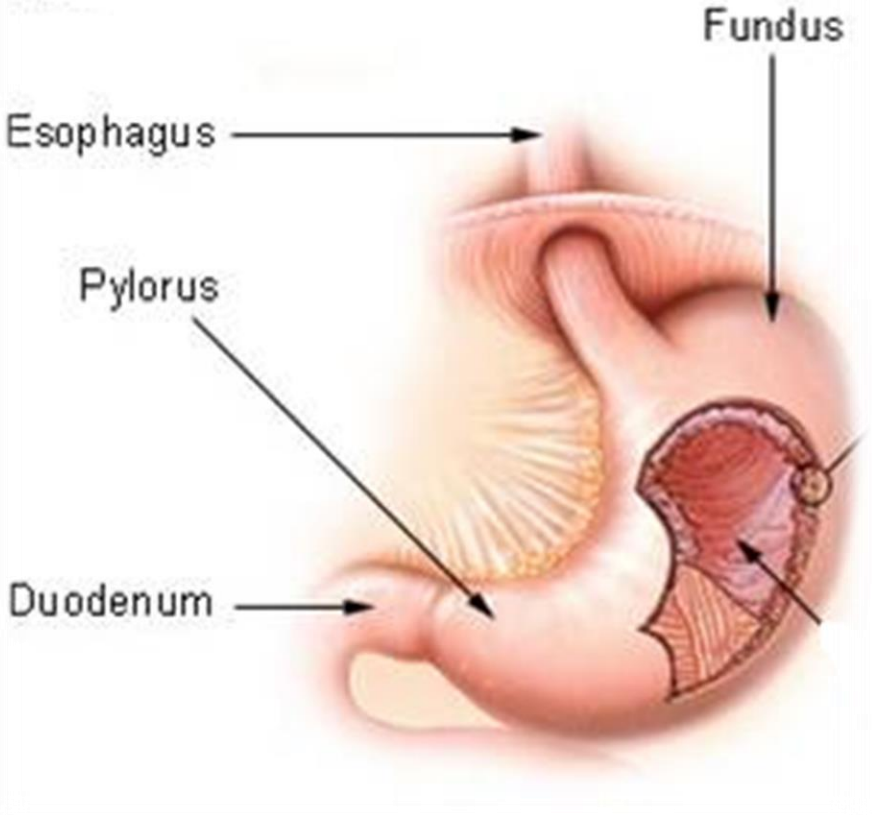
- Pressure in the esophagus is mostly –ve (except for a short intra-abdominal segment).
- So that pressure in the stomach is always higher than the esophagus.

Causes of Competence and the antireflux functions of the LES

1. Its resting pressure (15-30 mmHg).
2. The diaphragm wraps around the esophagus at the level of LES. Contraction of the diaphragm during inspiration helps to increase the pressure at the LES.
3. The flutter-valve closure of the lower esophagus by the increased intra-abdominal pressure prevents the high pressure in the stomach from forcing its contents into the esophagus.
4. Valve-like closure of the distal end of the esophagus. This involves a short portion of the esophagus that extends slightly into the stomach and caves the esophagus inward in response to increased intra-abdominal P.

Competence and the Antireflux Functions of the LES





Control of LES Function

Circular musculature of LES is regulated by nerves, (extrinsic & intrinsic), hormones and neuromodulators.

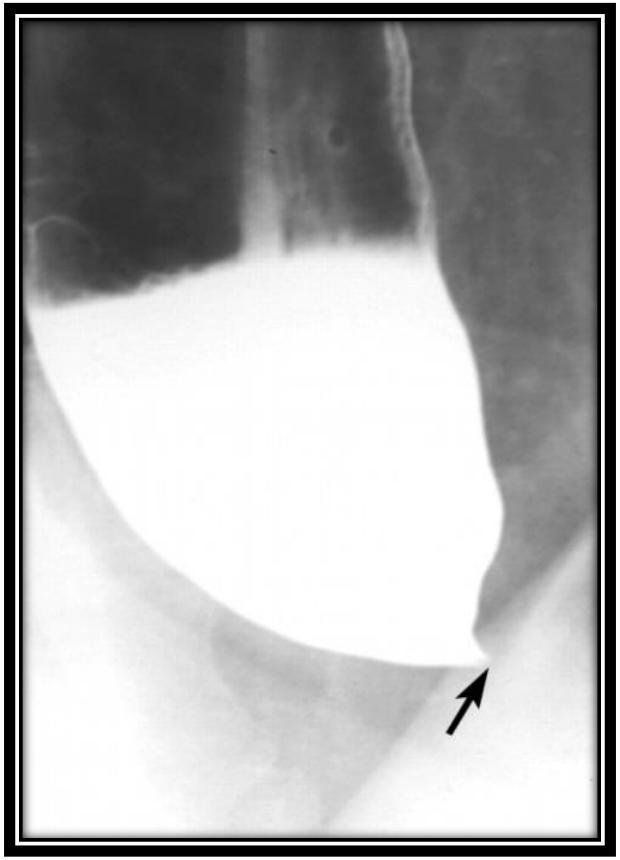
Contraction of LES

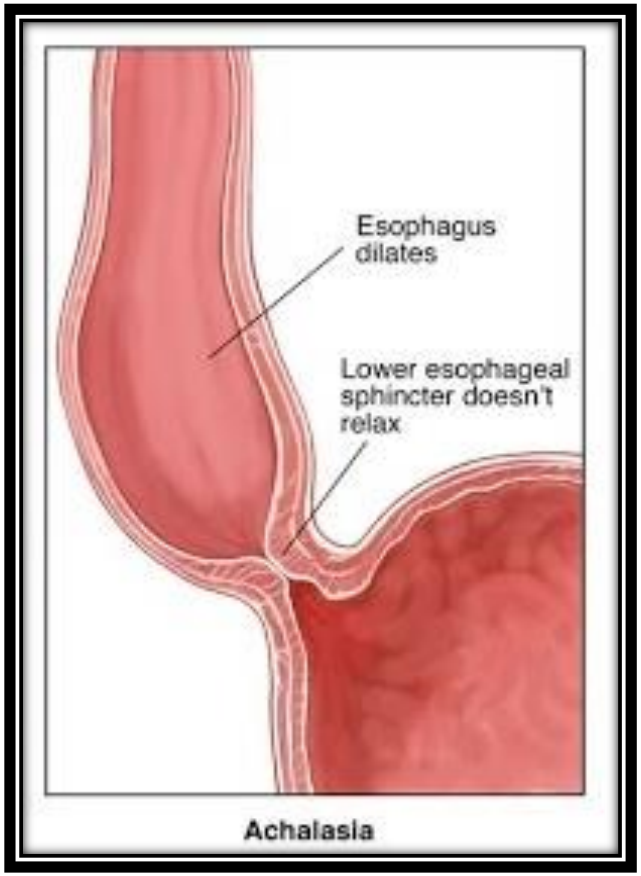
- Between swallows (tonic vagal cholinergic impulses)
- Stimulation of sympathetic nerves.
- Gastrin hormone.

Relaxation of LES

- During swallowing (efferent vagal impulses).
- The transmitter is NO or VIP.
- Secretin and cholecystokinin (CCK)

Achalasia




Esophagus dilates
Lower esophageal sphincter doesn't relax
Achalasia

Achalasia

It is due to pathology of or absence of the myenteric plexus containing VIP & NO in the lower third of esophagus (may be due to autoimmune destruction of the nerves in esophageal wall).

The musculature of the lower esophagus instead remains contracted and the myenteric plexus has lost the ability to transmit a signal to cause relaxation of the LES (high resting pressure).

Food transmission from the esophagus into the stomach is impeded or prevented. As achalasia gets worse, the esophagus gradually enlarged as food collects within it.

Food becomes putridly infected during the long periods of esophageal stasis causing ulceration of the esophageal mucosa, severe substernal pain or even rupture & death.

Achalasia (cont.)

Diagnosis:-

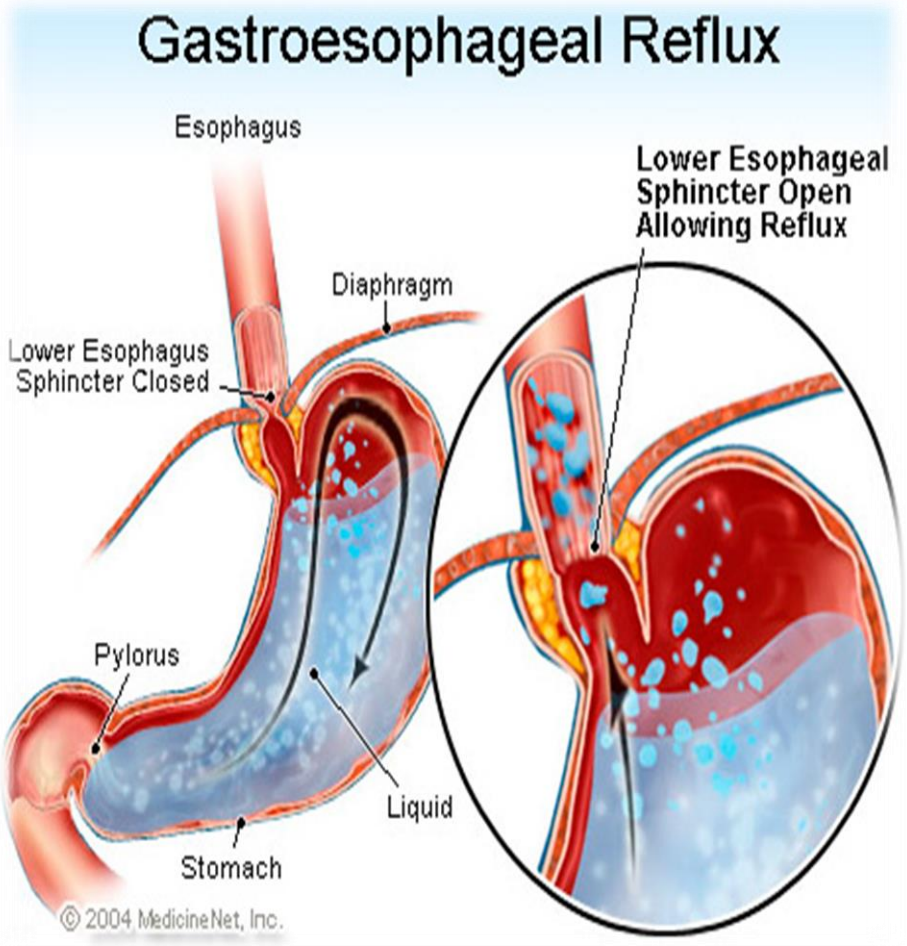
- Esophageal manometry.
- X-rays of upper digestive system (barium swallow).
- Upper endoscopy.

Nonsurgical treatment

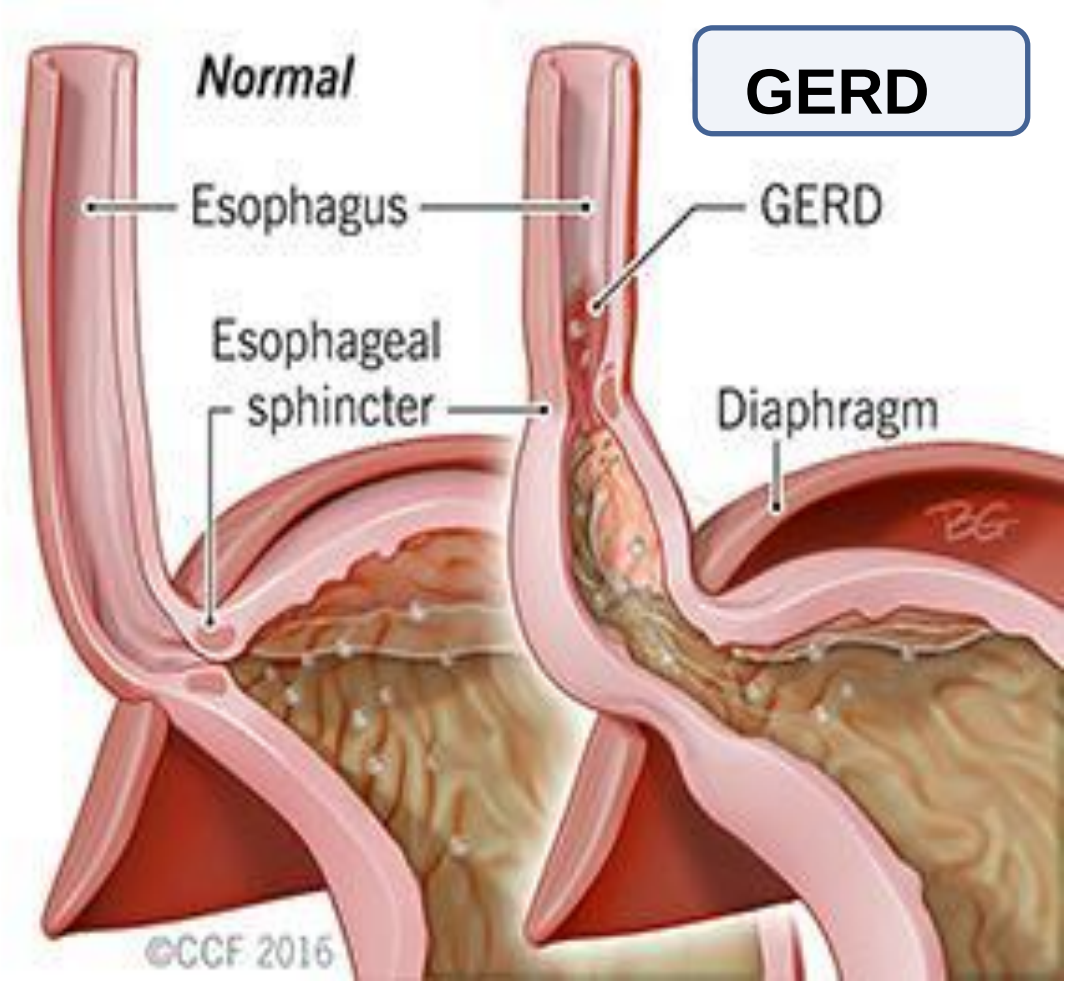
- Pneumatic dilation by balloon insertion into the esophageal sphincter.
- Injecting muscle relaxant (Botox) directly into the esophageal sphincter.
- Medication as muscle relaxants, nitroglycerin before eating.

Surgical treatment as myotomy, cutting the muscle at the lower end of the esophageal sphincter.

Gastroesophageal Reflux Disease (GERD)
Incompetence of the LES



Gastroesophageal Reflux Disease (GERD)
Incompetence of the LES



Gastroesophageal Reflux Disease (GERD)
Incompetence of the LES

What is?

Incompetence of the lower esophageal sphincter allows reflux of gastric contents into the esophagus.

Cause?

It may result from a generalized loss of intrinsic sphincter tone or from recurrent inappropriate transient relaxations triggered by gastric distention.

Contributing factors

Weight gain, fatty foods, caffeinated or carbonated beverages, alcohol, tobacco smoking and drugs (as anticholinergics, antihistamines, calcium channel blockers, progesterone and nitrates).

Gastroesophageal Reflux Disease (GERD) Incompetence of the LES (Cont.)

It can lead to

Reflux esophagitis, heart burn, esophageal stricture, ulcer, dysplastic changes (cancerous),or Barrett esophagus (normal tissue lining the esophagus resembles tissue lining of the intestine).

Diagnosis

Is clinical, sometimes with endoscopy, with or without 24-h pH testing.

Treatment

Involves lifestyle modification, acid suppression using proton pump inhibitors, and sometimes surgical repair.

THANK YOU