Gastrointestinal Physiology

Lecture 3

Swallowing (Deglutition)

Physiology of Esophageal Motility

(Chapter 63: 763-765)

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Learning Objectives

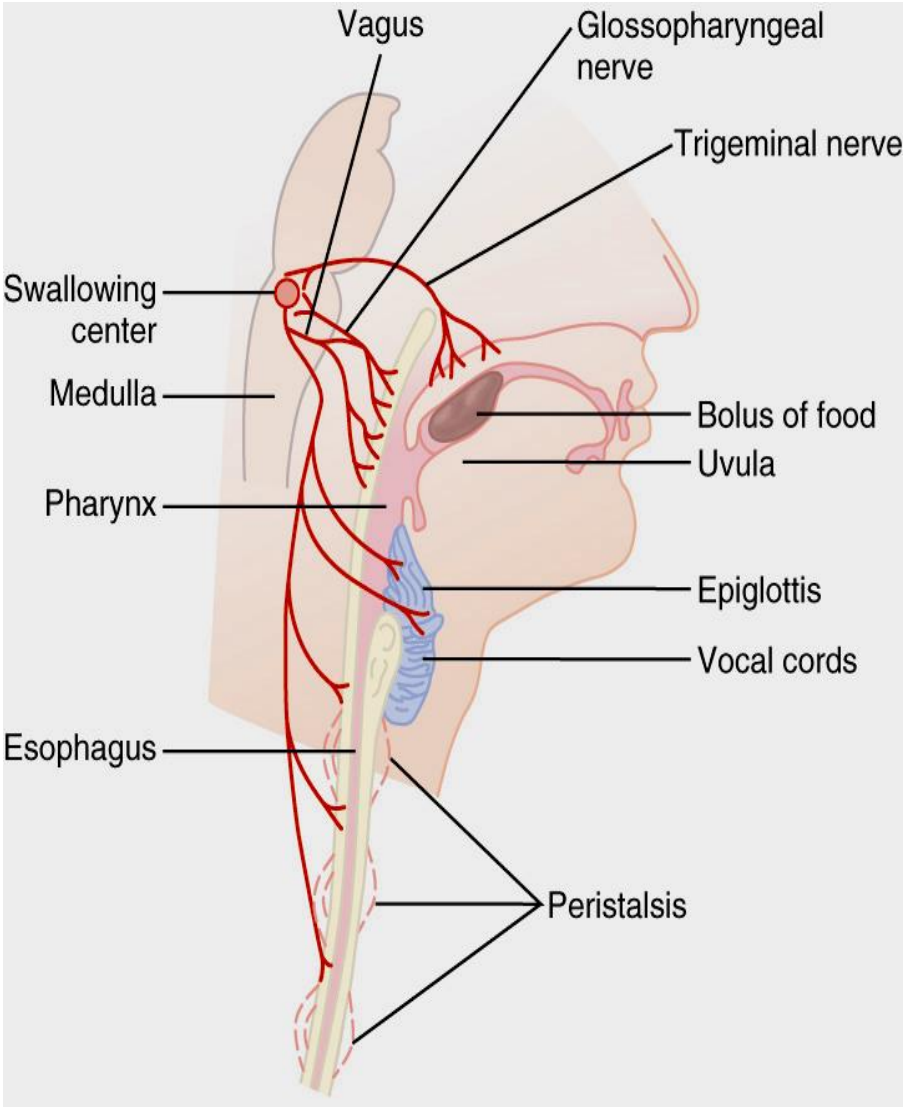
- Swallowing process and its stages
  - Oral stage
  - Pharyngeal stage
  - Esophageal stage
- Types of esophageal peristalsis
- Function of lower esophageal sphincter
- Prevention of esophageal reflux by valvelike mechanism
- Achalasia
- Incompetence of lower esophageal sphincter

Swallowing (Deglutition)

- Swallowing is the ordered sequence of events that propel food from the mouth to the stomach.
- Swallowing can be initiated voluntary, but thereafter it is almost entirely under reflex control.
- This reflex inhibits respiration and prevents the entrance of food into the airway passages.

Swallowing Center

Swallowing is initiated voluntarily in the mouth, but thereafter is under involuntary or reflex control. The reflex portion is controlled by the *swallowing center* in the medulla.



Stages of Swallowing

1. Oral Stage (voluntary)
2. Pharyngeal stage (involuntary)
3. Esophageal stage (involuntary)

I- Oral stage:

- ✓This stage involves the voluntary rolling of the bolus posteriorly into the pharynx by the upward and backward pressure applied by the tongue against the palate.

II- Pharyngeal stage:

The bolus stimulates swallowing receptor areas around the pharynx opening and impulses pass to the swallowing center and initiate a series of autonomic pharyngeal muscle contractions as follows:

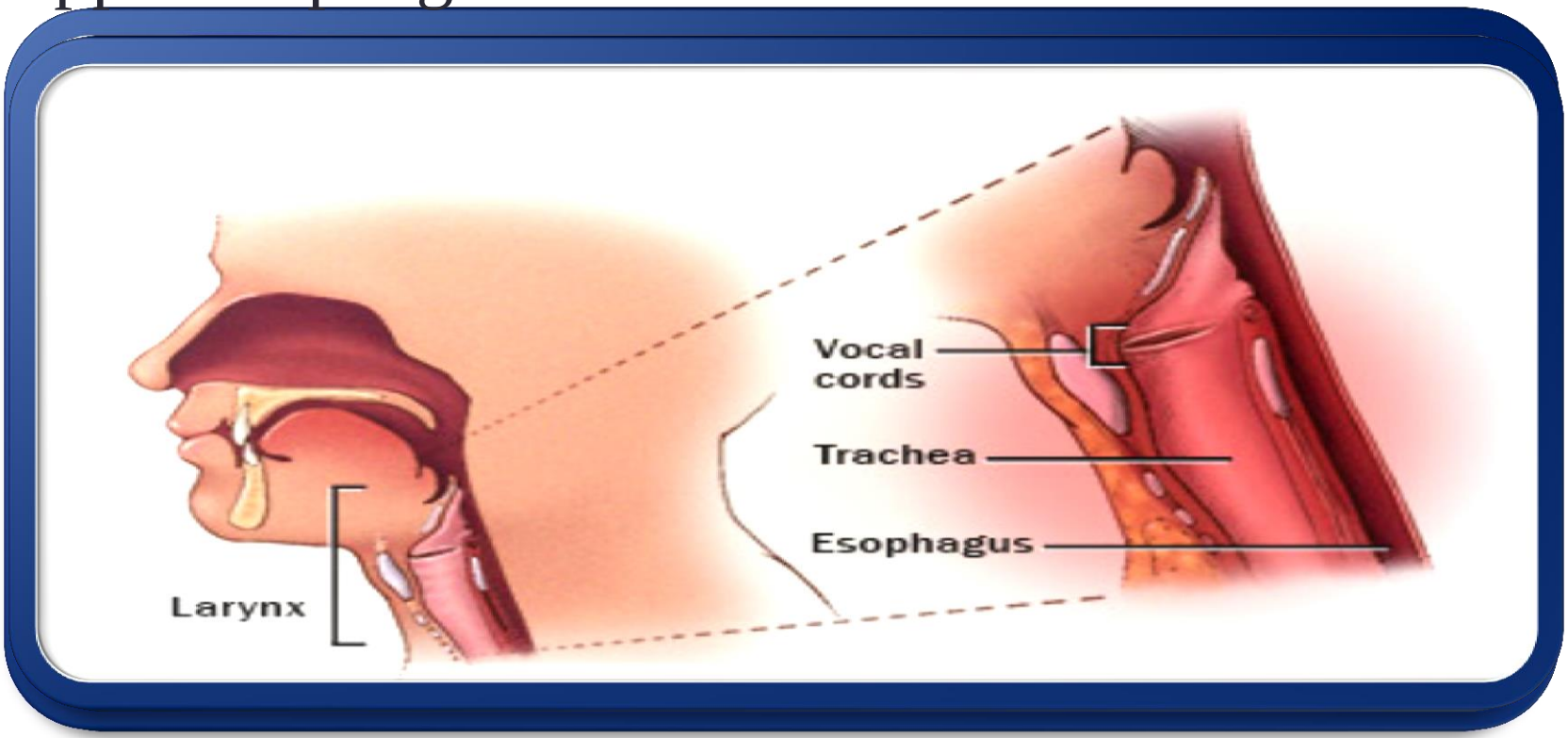
1- The soft palate is pulled upward which prevents the food from entering the nasal cavities.

2- The palatopharyngeal folds are pulled medially to approximate each other to form a sagittal slit through which food must pass into the posterior pharynx.

3- The vocal cords of the larynx 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.

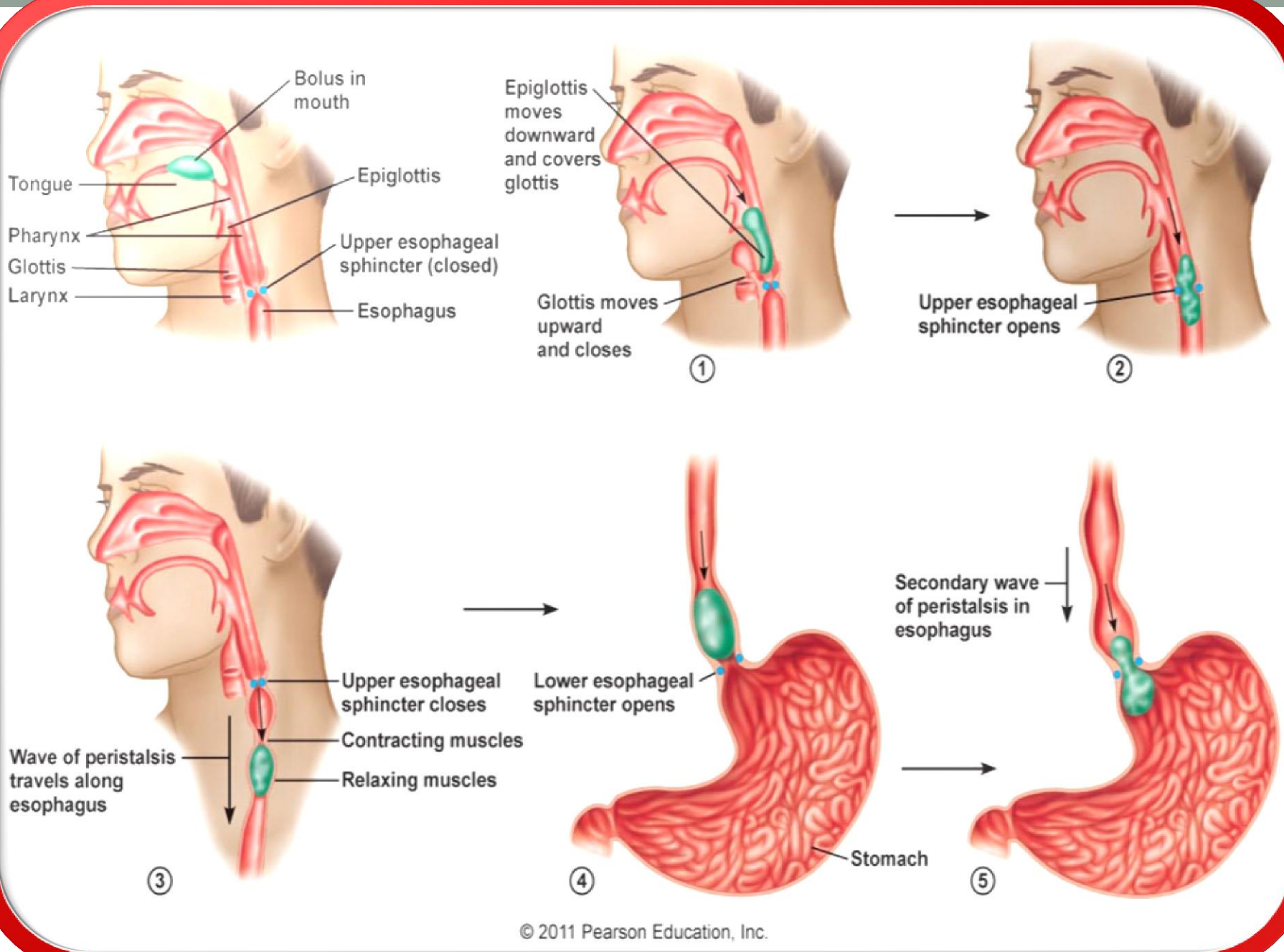
4- The upward movement of the larynx pulls up and enlarges the opening to the esophagus.

5- The upper esophageal sphincter (the pharyngoesophageal sphincter) relaxes and allows food to move freely from the posterior larynx into the upper esophagus.



6- Once the larynx is raised and the pharyngoesophageal sphincter relaxes, the entire muscular wall of the pharynx contracts (superior, middle, then inferior parts) propelling the food by peristalsis into the esophagus.

7- During the pharyngeal phase, the swallowing center inhibits the respiratory center of the medulla which stops respiration during swallowing.



Nervous initiation of the pharyngeal stage of swallowing.

- The most sensitive areas for initiating the pharyngeal stage of swallowing are located in a ring around the pharyngeal opening including the tonsillar pillars.
- Sensory impulses are received by the nucleus *tractus solitarius* (NTS) via the medulla oblongata through the 5^{th} & 9^{th} cranial nerves.

- The successive stages of swallowing are then automatically initiated by swallowing center in medulla and lower portion of the pons.
- The motor impulses to the pharynx and upper esophagus are transmitted from the swallowing center by the 5^{th}, 9^{th}, 10^{th}, and 12^{th} cranial nerves and few of the superior cervical nerves.

III- Esophageal stage:

The esophagus is a conduit to move food rapidly from the pharynx to the stomach.

Physiologically, esophagus is divided into three functionally distinct regions:

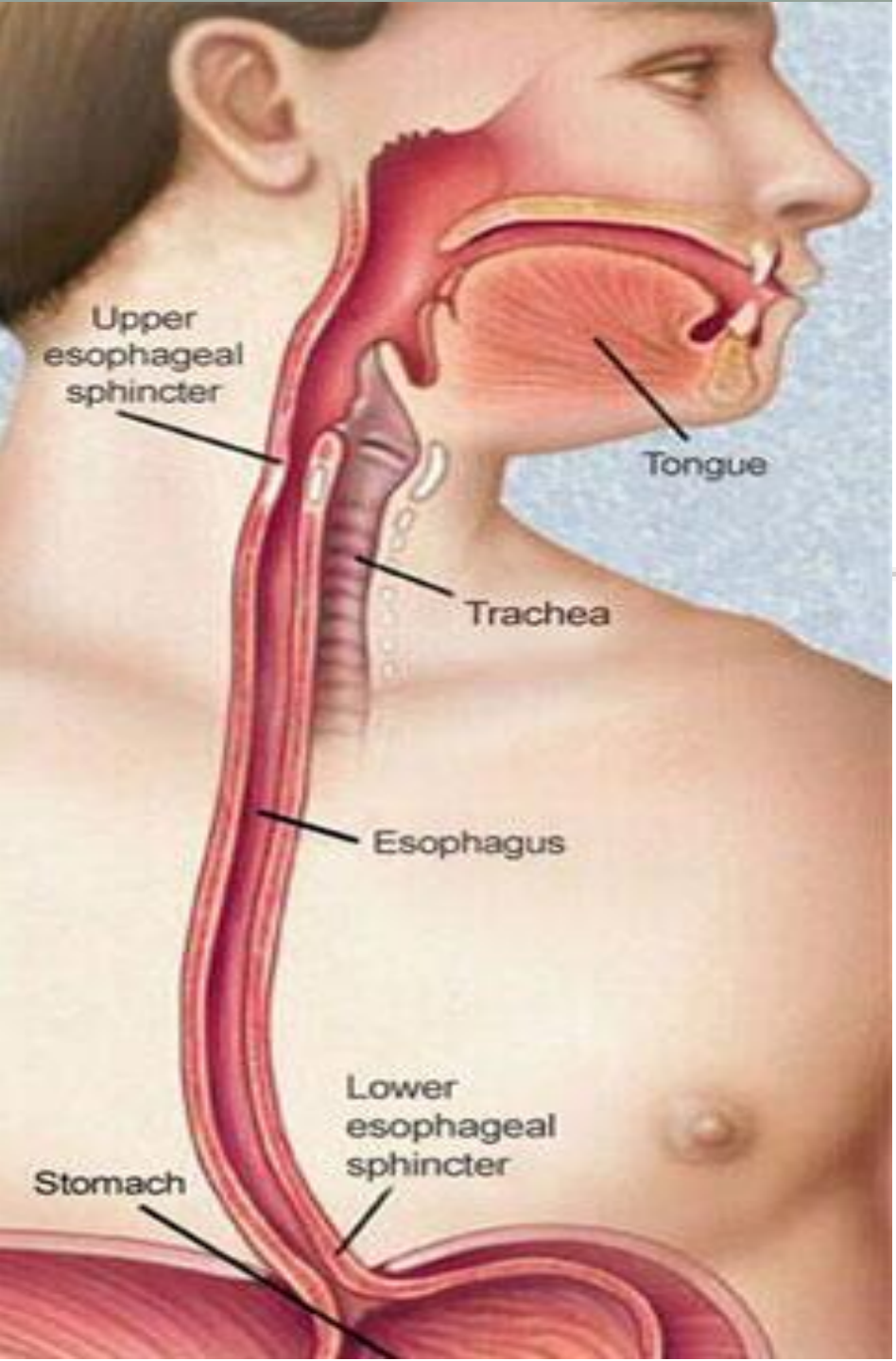
1- Upper esophageal sphincter (UES)

2- Esophageal body

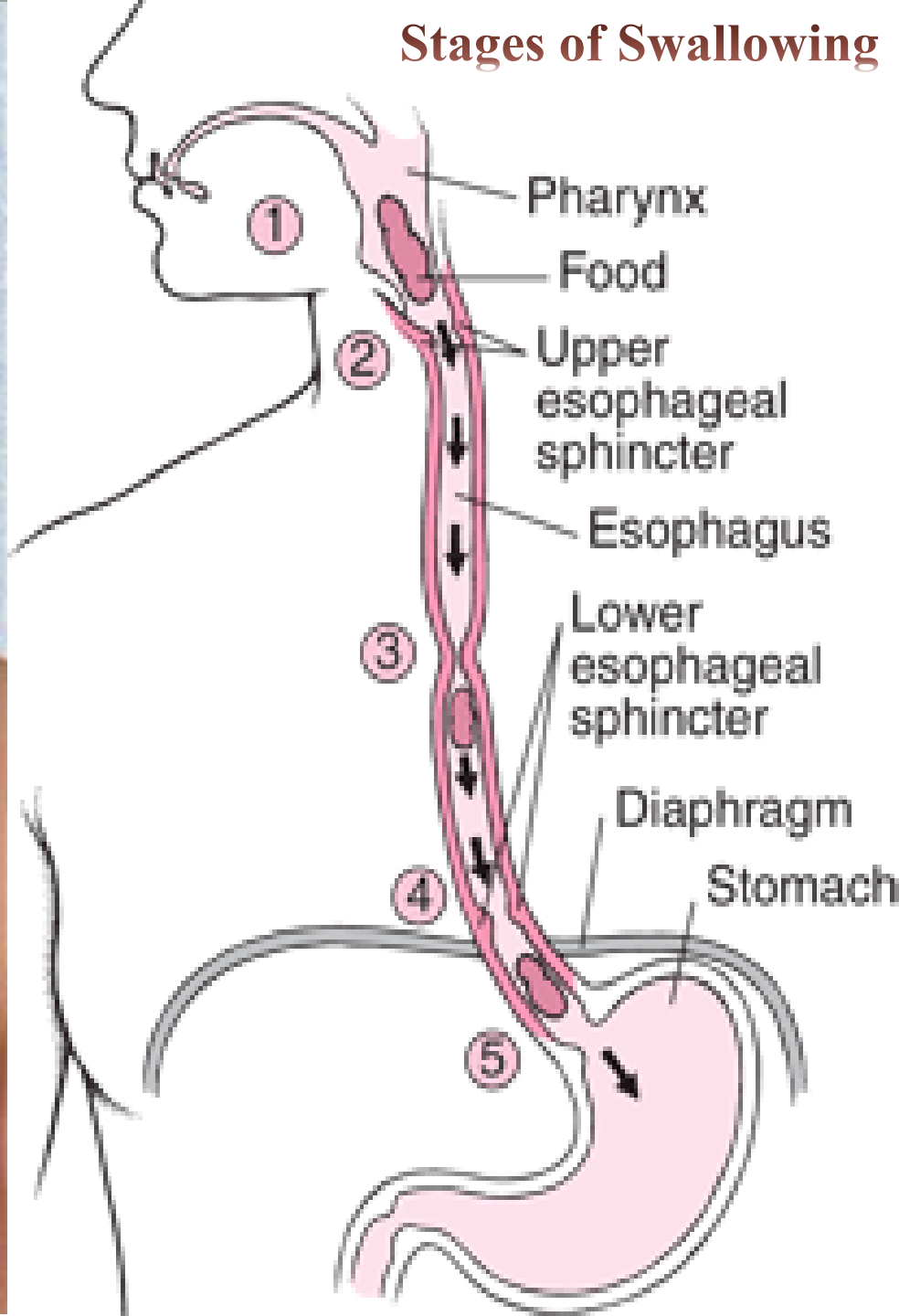
3- lower esophageal sphincter(LES)

- The musculature of the upper third of the esophagus is skeletal muscle (peristaltic waves are controlled by impulses from glossopharyngeal and vagus nerves) while the musculature of the lower two thirds of the esophagus is smooth muscle (controlled by the vagus through connections with the esophageal myenteric nervous system).

- When bolus of food passes through UES, the swallowing reflex closes the sphincter so food cannot reflux into the pharynx.



Stages of Swallowing



Types of Esophageal Peristalsis:

Primary peristalsis
- Continuation of pharyngeal peristalsis
- Coordinated by swallowing center
- Cannot occur after vagotomy (striated muscle)

Secondary peristalsis
- Occurs in response to distention
- ENS and swallowing center are both involved
- Can occur after vagotomy (smooth muscle)

- **Receptive Relaxation of the Stomach.**

When peristaltic waves reaches the stomach, it relaxes to receive the food.

Esophageal sphincters

1. The upper esophageal sphincter (UES)
   - It prevents entry of air into esophagus.
   - It relaxes during swallowing for about 1 second allowing the bolus to be forced through the relaxed UES.

2. The lower esophageal sphincter (LES)

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

* With initiation of esophageal peristalsis, The LES opens mediated by impulses in vagus nerve.

* In absence of esoph. peristalsis, the sphincter remains tightly closed to prevent reflux of gastric contents into esophagus.

Functions of LES

- The principle function of the LES is to prevent reflux of stomach contents into the esophagus.
- It normally remains tonically constricted.
- When a peristaltic wave of swallowing passes down the esophagus, it relaxes the LES (for 7-10 sec.) and allows easy propulsion of the swallowed food into the stomach.

It is necessary to have a barrier at the gastroesophageal junction (why?)

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

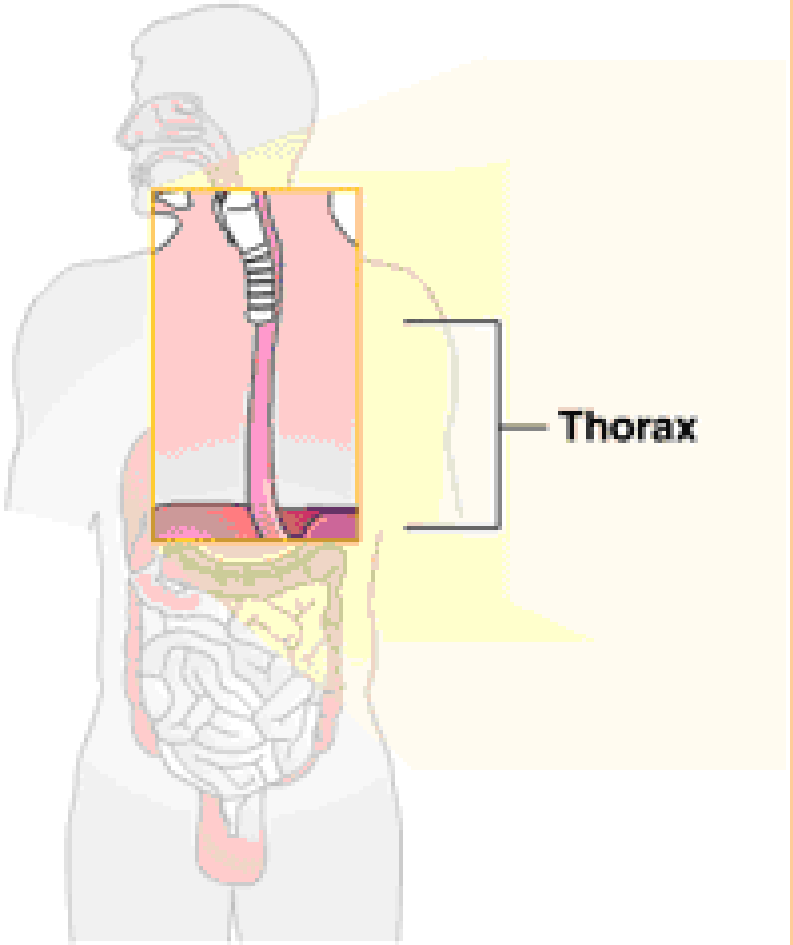
Competence and the antireflux functions of the LES is due to:-

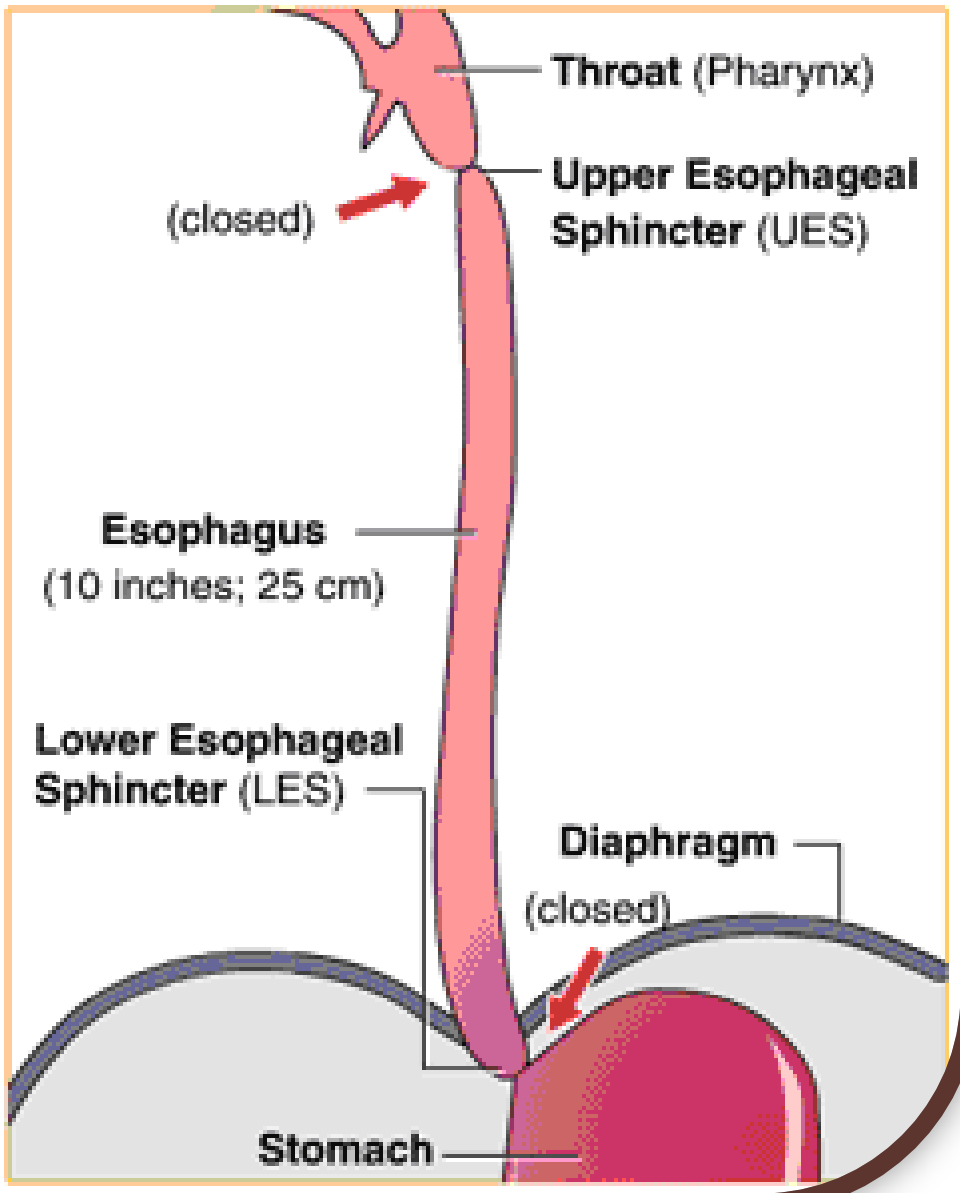
1- Its resting pressure (15-30 mmHg).

2- Flutter-valve closure of the distal end of the esophagus is exposed to +ve intra-abdominal pressure. This prevents the high pressure in the stomach from forcing its contents into the esophagus.

3- Contraction of the crura of the diaphragm that wrap around the esoph. at the level of LES helps to increase the pressure in the LES with each inspiration.

LES


Thorax


Throat (Pharynx)
Upper Esophageal Sphincter (UES)
(closed)
Esophagus
(10 inches; 25 cm)
Lower Esophageal Sphincter (LES)
Diaphragm
(closed)
Stomach

Control of LES function

* Contraction of the circular musculature of the sphincter is regulated by nerves, (extrinsic & intrinsic), hormones and neuromodulators.

* Between swallows, tonic vagal cholinergic impulses maintain contraction to keep the sphincter closed.

* Stimulation of sympathetic nerves to the sphincter also causes the LES to contract.

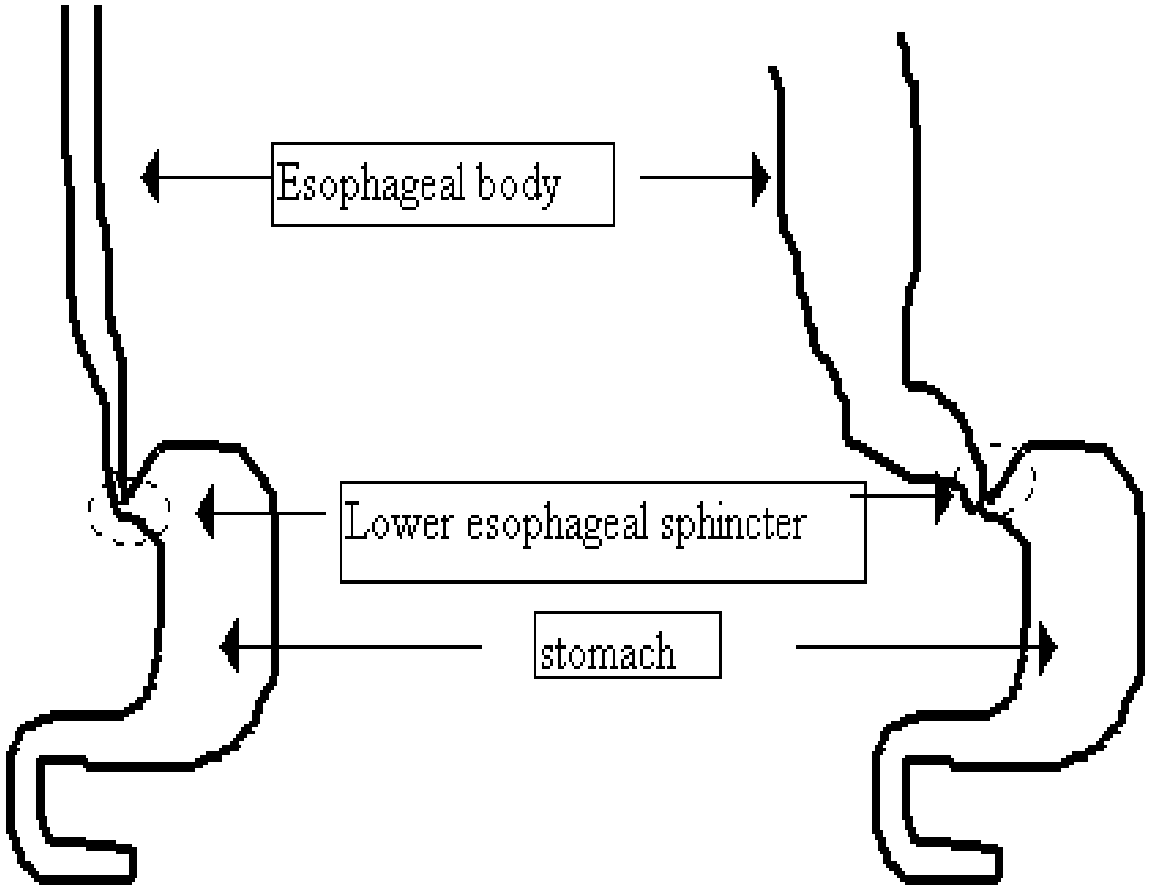
* During swallowing, efferent impulses in the vagus are inhibitory causing the sphincter to relax. The transmitter probably being nitric oxide or vasoactive intestinal peptide (VIP).

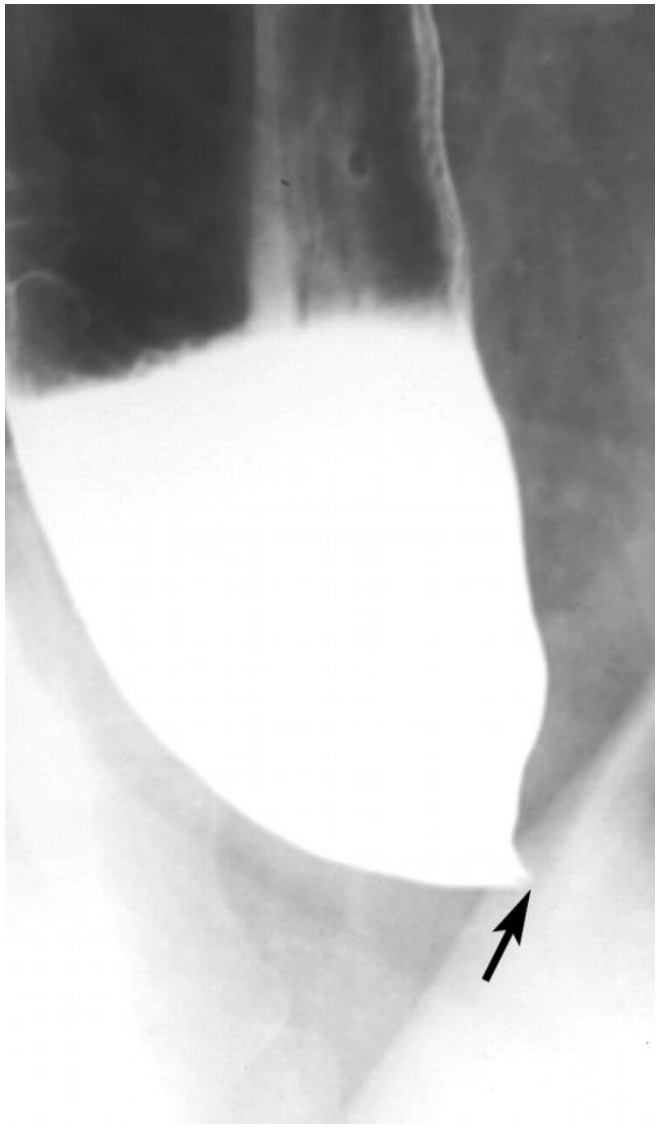
* The hormone gastrin, released from the stomach by food, contracts LES.

* Secretin and cholecystokinine (CCK) released from the upper intestine relax the LES.

Achalasia

- It is a condition due to high resting pressure of the LES.
- Food transmission from the esophagus into the stomach is impeded or prevented.
- It is due to pathology of or absence of the myenteric plexus containing VIP & NO in the lower third of esophagus.
- 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.





NORMAL

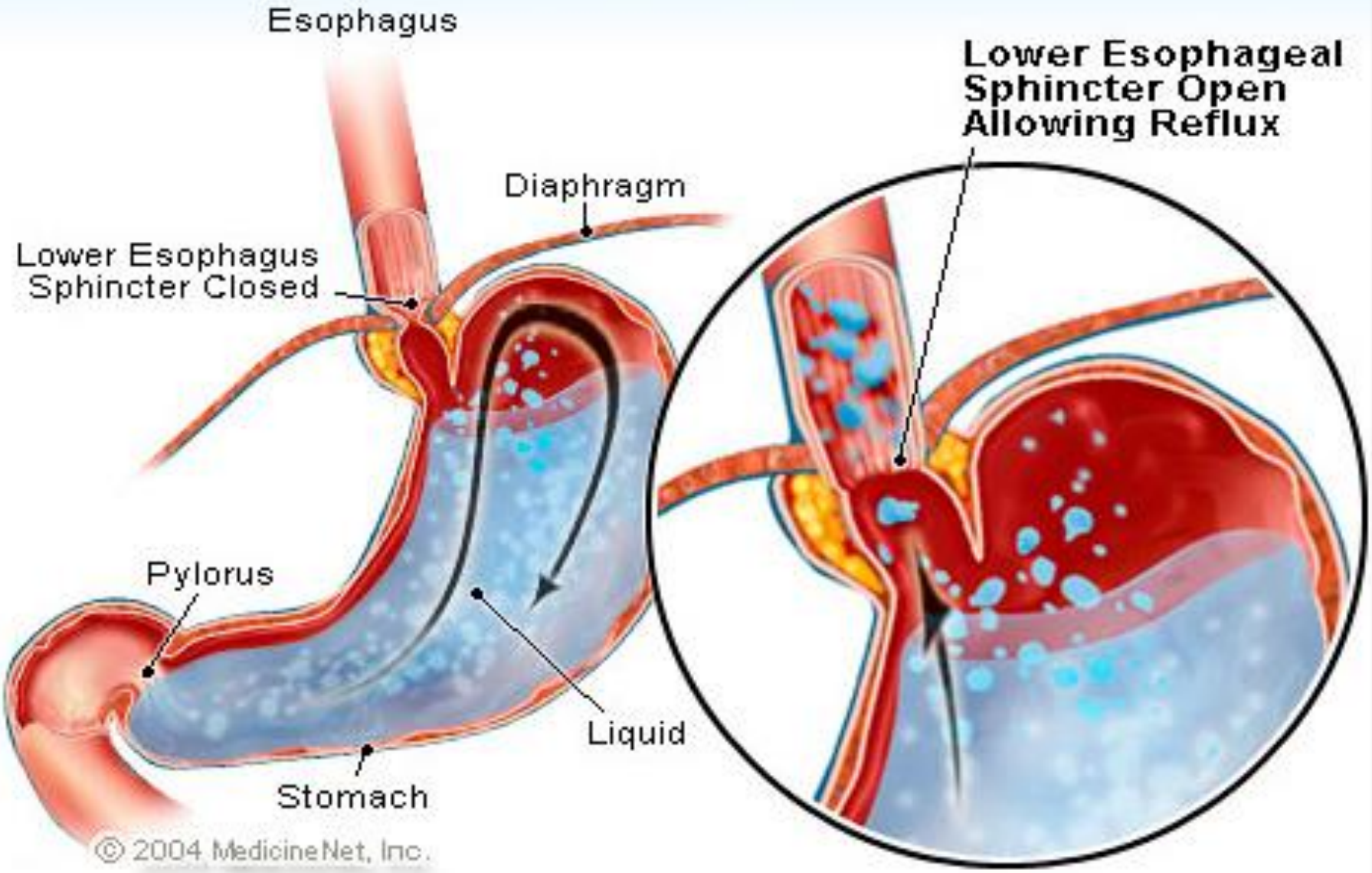
ACHALASIA

Incompetence of the LES

* Incompetence cause esophageal reflux and result in chronic exposure of esophageal mucosa to acid.
* The esophageal mucosa, except in the lower eighth of esophagus, is not capable of resisting for long the digestive actions of gastric secretions.

* It can lead to reflux esophagitis, heart burn, esophageal ulcer and dysplastic changes that may become cancerous.

Gastroesophageal Reflux



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