

Esophageal motility & pathophysiology of reflux disease

GNT Physiology

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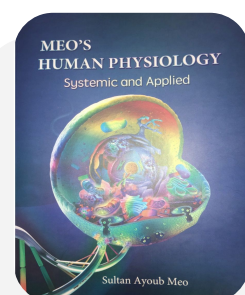
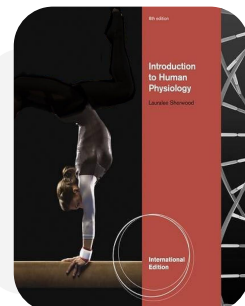
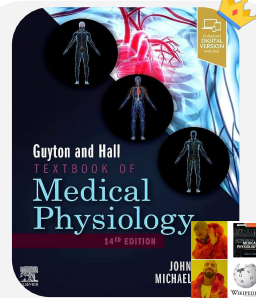
Objectives

- 💡 Discuss the role of the mouth in digestion.
- 💡 Define mastication and explain how it is brought about.
- 💡 Discuss the components of the mastication "chewing" reflex.
- 💡 Define swallowing and discuss its stages.
- 💡 Explain the changes that occur in each stage of swallowing as well as the nervous input and output of each stage.
- 💡 Discuss the types of movement that occur in the esophagus.
- 💡 Discuss the role of the lower esophageal sphincter and how it is controlled.
- 💡 Define gastroesophageal reflux disease (GERD) and achalasia and the pathophysiologic mechanisms underlying their occurrence.



Resources

Only GI chapters included



This is prof sultan meo!



[Click here](#) for a helpful channel by the team!



[Summary](#) of the Lecture!



The mouth

Female slides

• What is the role of the mouth in digestion?

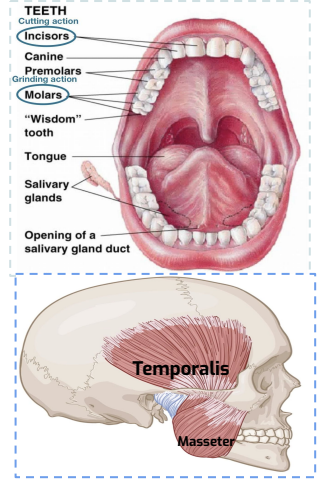
- 1- Mechanical digestion **By teeth**
- 2- Chemical digestion **By saliva**

• What is the process of cutting and grinding food in the mouth called? Mastication "chewing"

• What are the muscles involved in chewing and what is their innervation?

Chewing muscles are innervated by CN-V (5th cranial nerve). and 1st pharyngeal arch

- **Masseter**
- **Temporalis**
- **Lateral Pterygoid**
- **Medial Pterygoid**



How Teeth organization helps in digestion

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

Digestion in the mouth

1. Minimal
2. Mechanical breakdown of food.
3. **Carbohydrate digestion starts due to salivary amylase.**

Secretion in the mouth

Receives secretions from salivary glands.

Absorption in the mouth

Not much



Mastication "Chewing"

Male slides

Function of the Mastication:

To breakdown the bolus to small particles

To lubricate the bolus with salivary secretion

To begin digestion of carbohydrate (α -amylase)

1

Taste centers in the brainstem and Hypothalamus responsible for rhythmical chewing movements

2

Much of the chewing process is caused by a chewing reflex & stretch reflex.

3

Why is it important to chew food?

Food enters the body in a large size, if it is not digested, it will damage the esophagus during its passage

How is it achieved? Chewing reflex



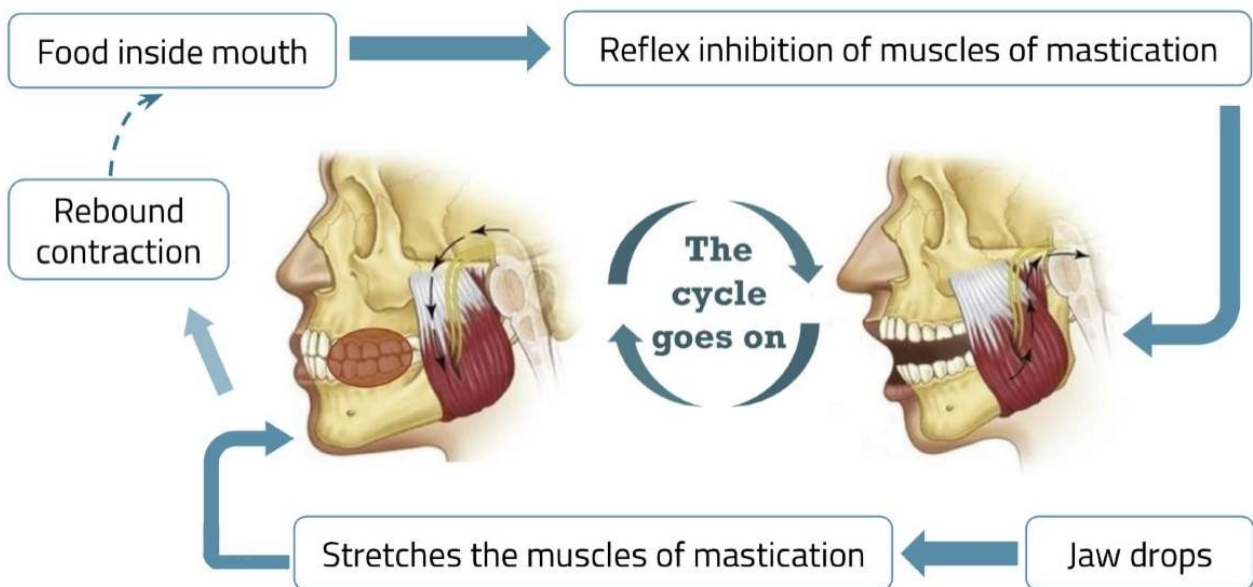
Mastication "Chewing" cont.

Male slides

The presence of a Chewing reflex & stretch reflex:

- bolus of food in the mouth at first initiates reflex inhibition of the muscles of mastication, which allows the lower jaw to drop. **Initially, chewing is voluntary**
- The drop in turn initiates a stretch reflex of the jaw muscles that leads to rebound contraction.
- This automatically raises the jaw to cause closure of the teeth, but it also compresses the bolus again against the linings of the mouth, which inhibits the jaw muscles once again, allowing the jaw to drop and rebound another time; this is repeated again and again. **biting of the tongue during chewing proves its involuntary**

Female slides



Chewing reflex: It's voluntary a reflex. However, most of it is subconscious. As food enters the mouth:

1- The pressure that the food exerts on the wall of the mouth will excite mechanoreceptors in the mouth.

2- These mechanoreceptors will send inhibitory signals to muscles of mastication.

3- Jaw will drop

4- Dropping of the jaw will lead to stretch of muscles of mastication which will initiate a stretch reflex.

5- This reflex will cause contraction of muscles and the jaw will be brought back up This cycle will go on until the food is small enough to be passed and swallowed.

#med 442



Deglutition "Swallowing"

- Swallowing is the entire process of moving food from mouth through esophagus and into the stomach.
- Swallowing is the ordered sequence of events that propel food from the mouth to the stomach
- 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

The process of swallowing can be divided into 3 stages:

Oral stage (voluntary)

moves bolus from mouth to pharynx.

Pharyngeal stage (involuntary)

-Moves food bolus from pharynx to esophagus
-The pharynx plays a role in respiration as well as swallowing.

Esophageal stage (involuntary)

transports food from esophagus to stomach.

I- Voluntary stage

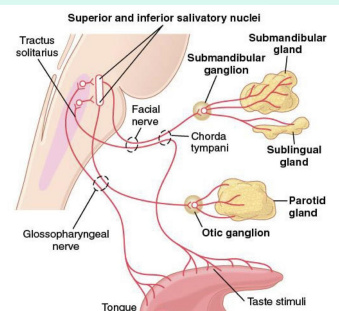
Initiates swallowing and moves bolus from mouth to pharynx.

The first stage of swallowing involves the voluntary rolling of the chewed food posteriorly into the pharynx by the upward and backward pressure applied by the tongue against the palate.

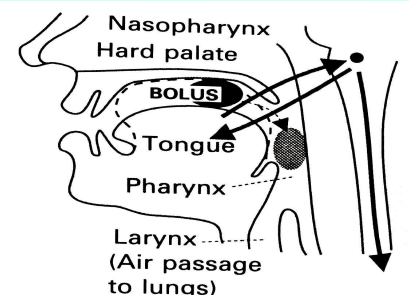
When food is ready for swallowing → voluntarily squeezed or rolled into pharynx.

Once the food bolus is ready to be swallowed, the tongue will move upward and backwards. This will roll the food bolus into the esophagus. This is controlled by the swallowing center.

Swallowing center in lower pons & medulla



Tongue moves upward & backward against palate





Stages of swallowing cont.

2- Pharyngeal stage

Important

- involuntary and moves food bolus through pharynx and into esophagus.

- At the pharynx, the bolus of food stimulates epithelial swallowing receptor areas all around the pharynx opening and impulses from this area pass to the brain stem (swallowing center) and accordingly initiate a series of autonomic pharyngeal muscle contractions as follows:

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

2- The palatopharyngeal folds on each side of the pharynx are pulled medially to approximate each other. These folds form a sagittal slit through which food must pass into the posterior pharynx. This slit performs a selective action, allowing food that has been masticated sufficiently to pass with ease. Because this stage of swallowing lasts less than 1 second, any large object is usually impeded too much to pass into the esophagus.

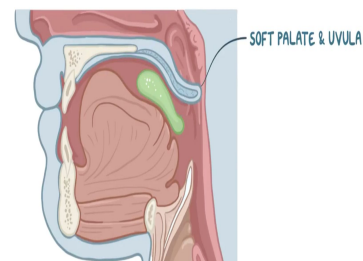
3- The vocal cords of the larynx are strongly approximated and the larynx is pulled upward and anteriorly by the neck muscles. These actions and the ligaments that prevent the epiglottis from moving upward, cause the epiglottis to swing backward over the opening of the larynx. All these effects prevent food from going into the nose and trachea. Destruction of the vocal cords or the muscle that approximate them can cause strangulation.

4- The upward movement of the larynx pulls up and enlarges the opening to the esophagus. The upper esophageal sphincter (or the pharyngoesophageal sphincter) relaxes and allows food to move freely from the posterior pharynx into the upper esophagus.

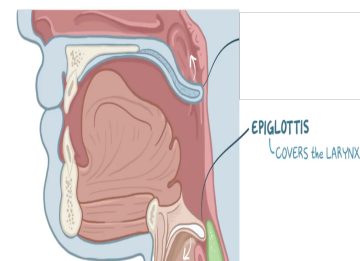
5- Once the larynx is raised and the pharyngoesophageal sphincter relaxes, the entire muscular wall of the pharynx contracts (superior, middle, then inferior parts) propelling the food by peristalsis ⁽¹⁾ into the esophagus.

⁽¹⁾ Pharyngeal peristalsis isn't exactly like the GIT peristalsis (propulsive-receiving segments) because the pharynx wall is made up of semi striated muscle, not smooth muscle.

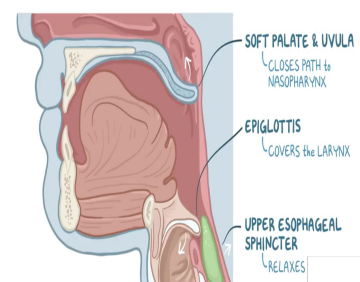
(1)(2)



(3)



(4)



Summary of pharyngeal stage of swallowing:

1. The trachea is closed
2. The esophagus is opened
3. 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).



Stages of swallowing cont.

2- Pharyngeal stage cont.

Nervous initiation of the pharyngeal stage of swallowing:

1	Sensory impulses from the mouth are received by the nucleus tractus solitarius (NTS) via the medulla oblongata through the trigeminal and glossopharyngeal nerves .
2	The most sensitive areas of the posterior mouth and pharynx for initiating the pharyngeal stage of swallowing are located in a ring around the pharyngeal opening including the tonsillar pillars .
3	The successive stages of swallowing are then automatically initiated by neuronal areas of the reticular substance of the medulla and lower portion of the pons (collectively called the deglutition or swallowing center).
4	The motor impulses to the pharynx and upper esophagus are transmitted from the swallowing center by the 5th, 9th, 10th, and 12th cranial nerves and few of the superior cervical nerves .

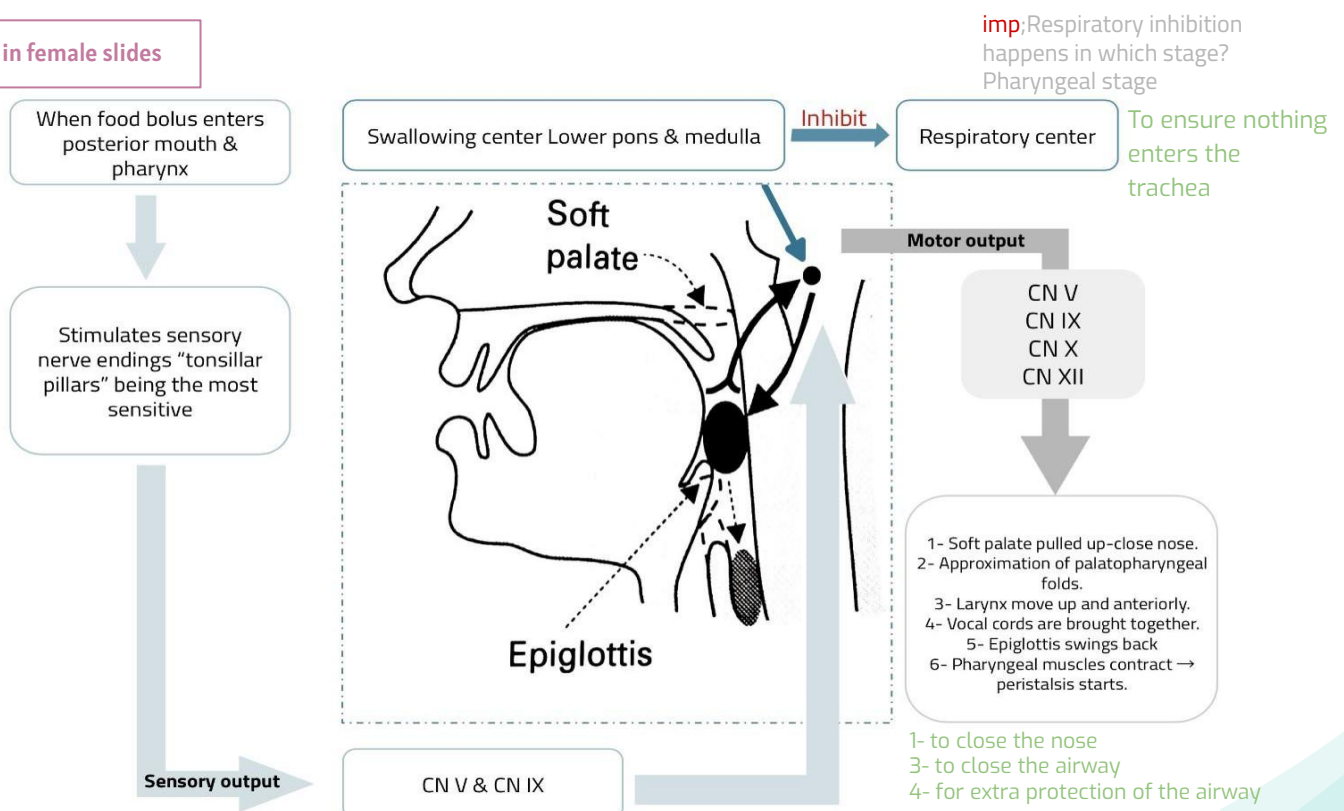
Effect of the Pharyngeal Stage of Swallowing on Respiration:

- The entire pharyngeal stage of swallowing occurs in < 6 sec, during which time the swallowing center inhibits the respiratory center in the medulla which stops respiration during the swallowing cycle, **no respiration during these 2-6 seconds**.

In summary:

- the pharyngeal stage of swallowing is a reflex act initiated by the voluntary movement of food into the back of the mouth which stimulates involuntary pharyngeal sensory receptors to elicit the swallowing reflex.

Diagram in female slides





Stages of swallowing cont.

3- Esophageal stage

1- 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.

2- **When bolus of food passes through the upper esophageal sphincter, the swallowing reflex closes the sphincter so food cannot reflux into the pharynx, and prevent air to pass in , because of the -ve pressure in the thoracic cavity**

3- The musculature of the pharyngeal wall and **upper 1/3 of esophagus (striated muscles)** are innervated by **vagus (10th cranial) & glossopharyngeal nerves (9th cranial)**, while the musculature of the **lower two thirds** of the esophagus is **smooth muscle (controlled by the vagus only, through connections with the esophageal myenteric nervous system)**.

4- It exhibits two types of peristaltic movements, **primary and secondary peristalsis**. The **primary peristalsis** is simply a continuation of the peristaltic wave that begins in the pharynx and spreads into the esophagus during the pharyngeal stage of swallowing. This wave passes from the pharynx to the stomach in 8-10 sec. **wave takes 2 seconds in the pharynx**

5- **If this primary peristaltic wave fails to move the food to the stomach, then the distention in the esophagus caused by the food will initiate secondary peristaltic wave (by ENS) which will continue until all the food is emptied into the stomach.**

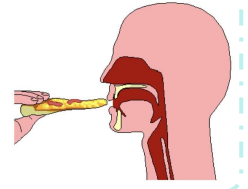
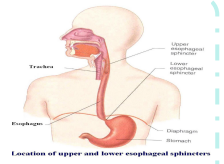


Stages of swallowing cont.

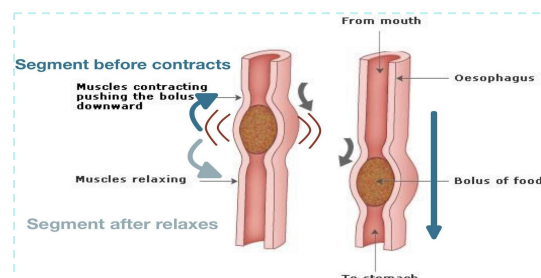
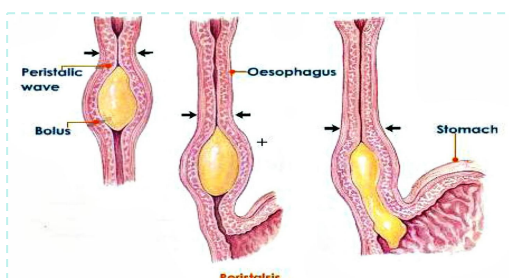
3- Esophageal stage cont.

Female slides

- ❖ involuntary and moves bolus from esophagus and into the stomach.
- ❖ Conducts food to stomach.
- ❖ Achieved by peristalsis.
- ❖ Two types of peristaltic movement in the esophagus:
1. Primary peristalsis. 2. Secondary peristalsis.



Primary peristalsis	Important	Secondary peristalsis
Continuation of the peristaltic wave that began in the pharynx.		food bolus gets stuck in the esophagus → secondary peristalsis
It takes 8-10 sec.		Initiated at the site of distention of the esophagus by the food bolus. It starts at the site where the food bolus got stuck at
If food bolus reaches stomach → job is done!		
When peristalsis approaches the stomach it is preceded by a wave of relaxation → receptive relaxation of LES		Continue until food bolus is delivered into stomach. Secondary peristalsis is usually stronger.
If it fails to deliver the food bolus to stomach → secondary peristalsis		
<p>1. The circular muscle that's before the bolus of food will contract whereas the longitudinal muscle will relax. -> food bolus will be pushed forward.</p> <p>2. When peristaltic wave becomes close to LES and stomach, it will be preceded by a relaxation wave that causes the LES to relax in preparation for bolus to enter stomach. It will also cause relaxation of fundus of the stomach and the proximal portions in preparation to receive the bolus.</p> <p>After primary peristalsis. What happens if peristaltic waves passed, but the bolus of food did not reach stomach and got stuck in the esophagus? The esophagus will initiate a secondary peristalsis.</p> <p>#med442</p>		<p>Muscles of the GI are activated by stretch. Any food bolus that got stuck in the esophagus will stretch its the wall. This will send signals to the segment before the site of where the bolus got stuck at asking the circular muscles to contract and longitudinal muscles to relax. It will also send a signal to the segment after asking the circular muscles to relax and longitudinal muscles to contract = food will move.</p> <p>Therefore, the peristaltic wave will push food bolus until it reaches stomach. If it doesn't achieve its purpose, it will be re-initiated at the site of distention until it reaches the stomach.</p> <p>#med442</p>





Esophageal secretions:

Female slides

- It is entirely mucus
 - **what is the importance of it?**
- 1- Lubrication
 - 2- Protection against acidic juices of the stomach.
- Not much absorption occurs in the esophagus.

Esophageal Sphincters

Male slides

Upper Esophageal Sphincter (UES)

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

- Its **functions** :

1) It **prevents** esophageal air insufflation during negative intrathoracic pressure events, for example: inspiration. , **so no air will enter the esophagus.**

2) It **prevents** esophagopharyngeal /laryngeal reflux during esophageal peristalsis., **so no food will go out from the esophagus.**

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

Lower Esophageal Sphincter (LES)

- The lower esophageal sphincter is formed by the esophageal **circular muscle** located in an area of 3cm upward of the junction with the stomach.

- This sphincter remains **tonically constricted** (protects the esophagus from the stomach acidic juices) until the peristaltic swallowing wave passes down the esophagus and causes a **"receptive relaxation"** of the sphincter and emptying of the Propelled food into the stomach.

- Its **function** : to prevent gastric juices reflex.

- **Failure of the sphincter to relax will result in Achalasia.**

- **Close the LES** : tonic signals -> Ach by vagus , diaphragm, Gastrin hormone, valvular-like mechanism

- **Open the LES** : +ve vagus N —> NO & VIP, secretin and CCK hormones

- **Team439 :**

- **Lower esophageal distension** → Vagus (sensory) → brainstem → Vagus (motor) → activation of **inhibitory motor neuron** → VIP (vasoactive intestinal peptide) and NO release → relaxation of LES.
- **Receptive relaxation** is considered a vasovagal reflex since both motor and sensory compartments are from the vagus nerve.
- **LES**: controls movement of food from esophagus to stomach. LES always contracts tonically, but the tone will decrease when food has to enter the stomach. This is the goal of the relaxation wave that precedes the peristaltic wave. Relaxation wave moves ahead of the peristaltic wave, so that when it reaches the LEs it relaxes and allows food bolus to enter the stomach.
- The stomach secretes HCL which is highly acidic. The esophagus can not deal with this acidic secretion since its corrosive. The LES protects the esophagus from the acidic contents of the stomach and prevent it from regurgitation. It also controls the movement of food when it enters the stomach.



The Control of LES Function

LES


Female slides

- 3 cm above the junction of esophagus with stomach, circular muscle fibers function as a sphincter.
- The LES is normally kept tonically constricted.

Why is it important?

Contraction of the circular musculature of the sphincter is regulated by:

- Nerves (extrinsic & intrinsic).
- Hormones.
- Neurotransmitter.

During swallowing	Between swallows:
Efferent inhibitory impulses from vagus nerve (Parasympathetic) cause the sphincter to relax . The transmitter probably being nitric oxide (NO) or vasoactive intestinal peptide (VIP) .	Tonic vagal cholinergic impulses maintain contraction to keep the sphincter closed . Still confused?  Osmosis, Start at 4:40
Influence of hormones:	
The gastrin hormone, released from the stomach by food → contracts LES . Secretin and cholecystokinin (CCK), are released from the upper small intestine → relax the LES .	



Causes of competence and antireflux functions of the LES

Important

1

Prevention of Esophageal reflux by **valve-like closure of distal end of the esophagus** that lies beneath the diaphragm and is exposed to +ve intra-abdominal pressure, This 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.

- This is a protective mechanism (safety factor) that Prevents reflux of gastric secretions into the lower portion of the esophagus.
- This mechanism involves a short portion of the esophagus that extends slightly into the stomach and that caves the esophagus inward **in response to increased intra-abdominal pressure**. And prevents the high pressure in the stomach from forcing its contents into the esophagus.

2

Resting pressure(15-30 mmhg). (Tonic contraction of LES)

3

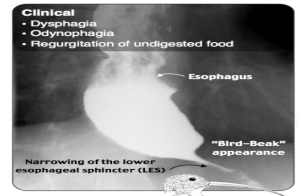
The **diaphragm** wraps around the esophagus at the level of the lower esophageal sphincter (LES), **contraction of the diaphragm** helps to increase the pressure at the LES during inspiration.



Disorders of the Esophagus

Important

Focus more on
achalasia



1) Achalasia

A condition due to high resting pressure at the LES that fails to **relax** during swallowing (**high tone**). As a result, food transmission from the esophagus into the stomach is prevented.

- **Functional obstruction.**
- Physiological basis of this condition is either 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.
- **It's caused by: degeneration of the myenteric plexus, loss of inhibitory neurons (which controls relaxation).**
- 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.

Clinical features: Dysphagia, odynophagia, regurgitation of undigested food.

Team39: Food will be stuck in the esophagus -> accumulation of food in esophagus -> dilation of esophagus "megaesophagus" which will lead to: Choking/ Irritation (due to presence of bacteria/ Inflammation/ Ulcer/ Dysphagia/ Bad smell).

2) Gastroesophageal Reflux Disease (GERD) : incompetence of LES

- Incompetence of the lower esophageal sphincter allows reflux of gastric contents into the esophagus.
- It may result from a generalized loss of intrinsic sphincter tone or from recurrent inappropriate transient relaxations triggered by gastric distention.
- LES fails to **constrict** properly OR Loss of lower esophageal sphincter tone.

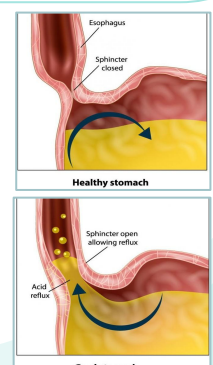
Contributing factors: **Male slides**

1. Weight gain
2. Fatty foods
3. caffeinated or carbonated beverages
4. alcohol and tobacco smoking
5. Drugs (as anticholinergics, antihistamine, calcium channel blockers, progesterone, nitrate)

Female's doctor: What do you think would happen?

Team39 : The esophagus is lined by nonkeratinized epithelium, whereas the stomach is lined by columnar epithelium. The epithelium of the esophagus enables it to tolerate احتكاك الأكل باستمرار . However, it can not tolerate acidity.

The contents of the stomach regurgitate into the esophagus and the patient will complain of heartburn. As it gets worse it will cause metaplasia (non-keratinized squamous epithelium will change into columnar epithelium) so it can tolerate the acidity. The metaplastic tissues are precancerous (barrett's esophagus).



TEST YOURSELF !

MCQ:

Q1) Which ONE of the following nerves does not transmit signals from the swallowing center to the pharynx and esophagus?

A) 6th

B) 9th

C) 10th

D) 12th

Q2) The process of mastication is initiated by:

A) inhibition of the muscles of mastication

B) Jaw drop

C) Jaw raised

D) Jaw muscles contraction

Q3) Which one of the following increases the tone of the lower esophageal sphincter?

A) Cholecystokinin

B) Gastrin

C) Nitric Oxide

D) Secretin

Q4) Respiratory inhibition occurs in which phase of swallowing?

A) voluntary

B) esophageal

C) pharyngeal

D) intestinal

Answers: Q1:A | Q2:A | Q3:B | Q4:C

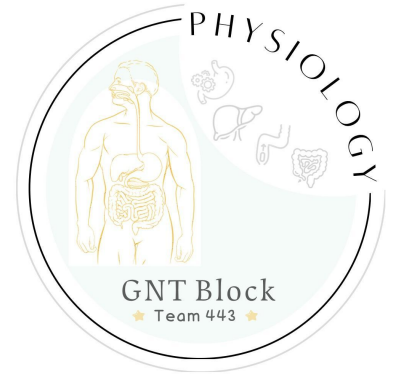
SAQ:

Q1) Explain the Achalasia briefly?

-A condition due to high resting pressure at the LES that fails to relax during swallowing. As a result, food transmission from the esophagus into the stomach is prevented.

Q2) Mention the function of the Mastication "chewing"?

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



The BEST

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