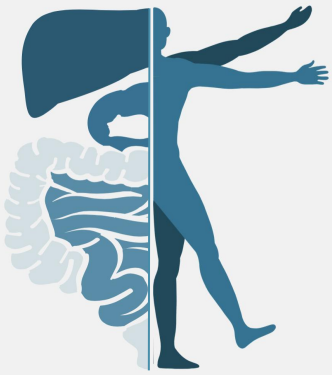
Physiology Team 439

MED439
KING SAUD UNIVERSITY

Revised & Approved
Bassam Alasmari
Rania Almutiri



Esophageal motility

Objectives:

- Discuss the role of the mouth in digestion.
- Define mastication and explain how is it 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 is it
- controlled.
- Define gastroesophageal reflux disease (GERD) and achalasia and the pathophysiologic mechanisms underlying their occurrence.
- Mastication and chewing reflex
- Swallowing process
- Stages of Swallowing
- Nervous initiation of pharyngeal stage of swallowing
- Effect of pharyngeal stage on respiration
- Function of lower esophageal sphincter
- Prevention of esophageal reflux by valve like mechanism

Useful video

Color index:

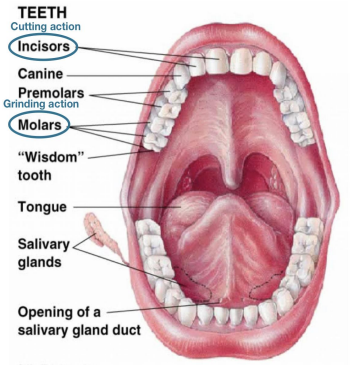
- Important.
- Girls slide only.
- Boys slide only.
- Dr's note.
- Extra information.

Editing File

The mouth

- **What is the role of the mouth in digestion?**

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

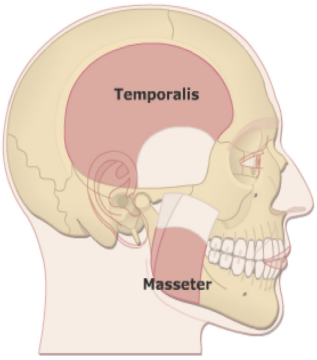


- **What is the process of cutting and grinding food in the mouth called?**

  Mastication "chewing"

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

  Chewing muscles are innervated by CN-V (5th cranial nerve).
  - Masseter
  - Temporalis
  - Lateral Pterygoid
  - Medial Pterygoid



Teeth organization

Only In boys slides

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

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 "

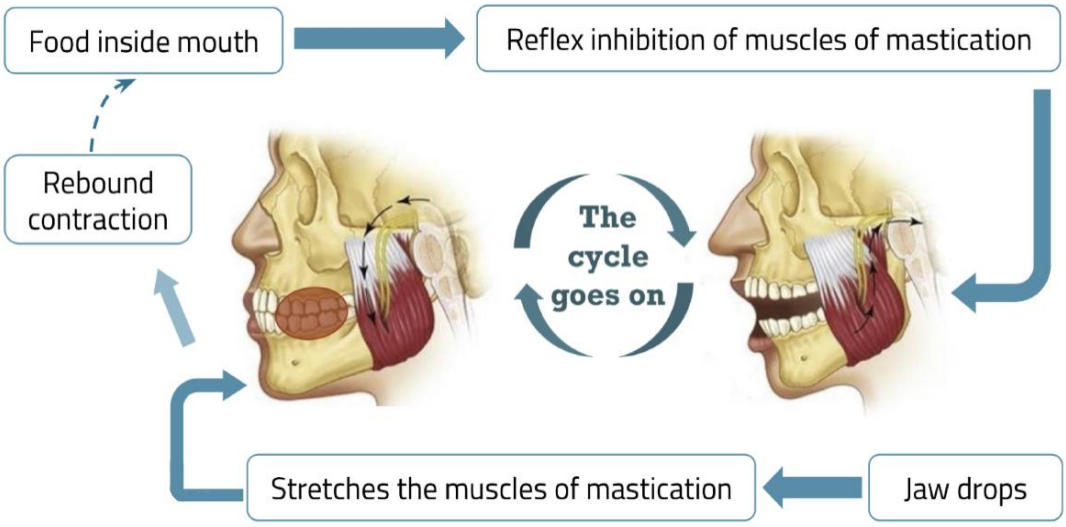
Functions Only In boys slides

- To lubricate the bolus with salivary secretion
- To breakdown the bolus to small particles
- To begin digestion of carbohydrate (α-amylase)

1. Taste centers in the brain stem and Hypothalamus responsible for rhythmical chewing movements.*
2. Much of the chewing process is caused by a chewing reflex & stretch reflex.*
3. **The presence of a Chewing reflex & stretch reflex:** *
4. - 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
5. - The drop in turn initiates a stretch reflex of the jaw muscles that leads to rebound contraction. *
6. - 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
7. Why is it important to chew food?
   How is it achieved? **Chewing reflex** *

Chewing reflux

Only In girls 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.

Deglutition "Swallowing"

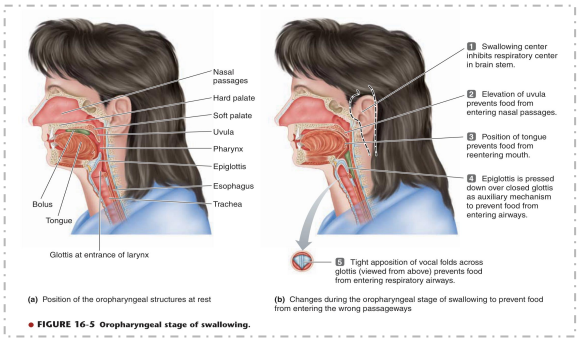
- Swallowing is the entire process of moving food from mouth through esophagus and into the stomach.
- Swallowing is the ordered sequence of events that propel food from the mouth to the stomach
- Swallowing is initiated voluntarily in the mouth, but thereafter is under involuntary or reflex control.
- The reflex portion is controlled by the swallowing center in the medulla.

The process of swallowing can be divided into 3 stages:

1- Voluntary stage. (oral stage)
2- pharyngeal stage (involuntary)
3- Esophageal stage (involuntary)

The pharynx plays a role in respiration as well as swallowing.
Generally swallowing can be divided into:

- Oral stage (voluntary)
- Pharyngeal stage (involuntary)
- Esophageal stage (involuntary) that transports food from the pharynx to the stomach.

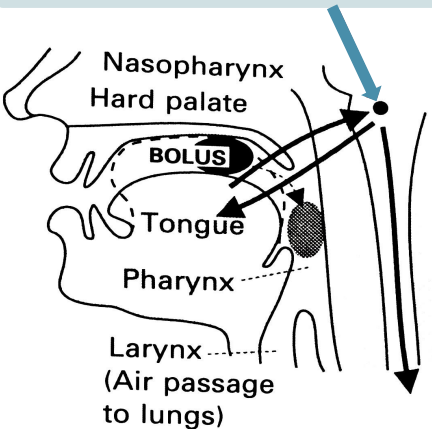


Extra from Sherwood

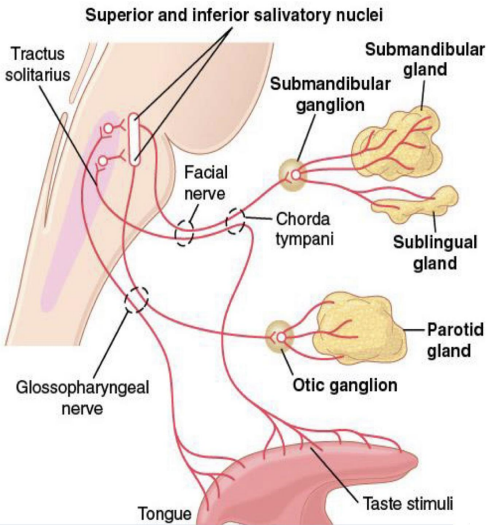
1- Voluntary stage

- 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.

Swallowing center Lower pons & medulla



Tongue moves upward & backward against palate



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

2- Pharyngeal stage (M)

Details only In boys slides

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.

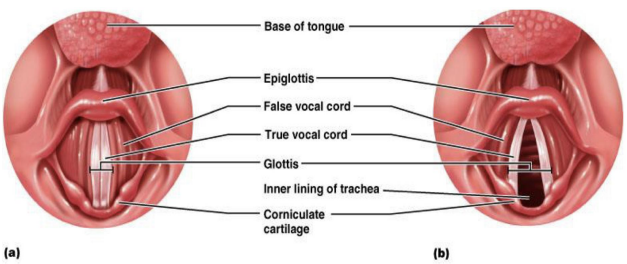
2- The palatopharyngeal folds on each side of the pharynx are pulled medially to approximate each other. These folds form a sagittal slit through which food must pass into the posterior pharynx.his slit performs a selective action, allowing food that has been masticated sufficiently to pass with ease.Because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

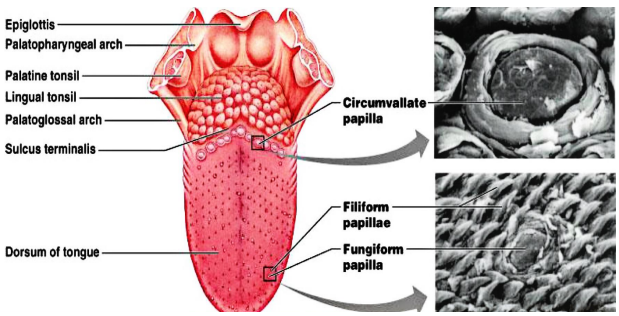
3- The vocal cords of the larynx are strongly approximated and the larynx is pulled upward and anteriorly by the neck muscles. These actions and the ligaments that prevent the epiglottis from moving upward, cause the epiglottis to swing backward over the opening of the larynx. All these effects prevent 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.





2- Pharyngeal stage cont... Only In boys slides

Summary of pharyngeal stage of swallowing:

- The trachea is closed, the esophagus is opened, and 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

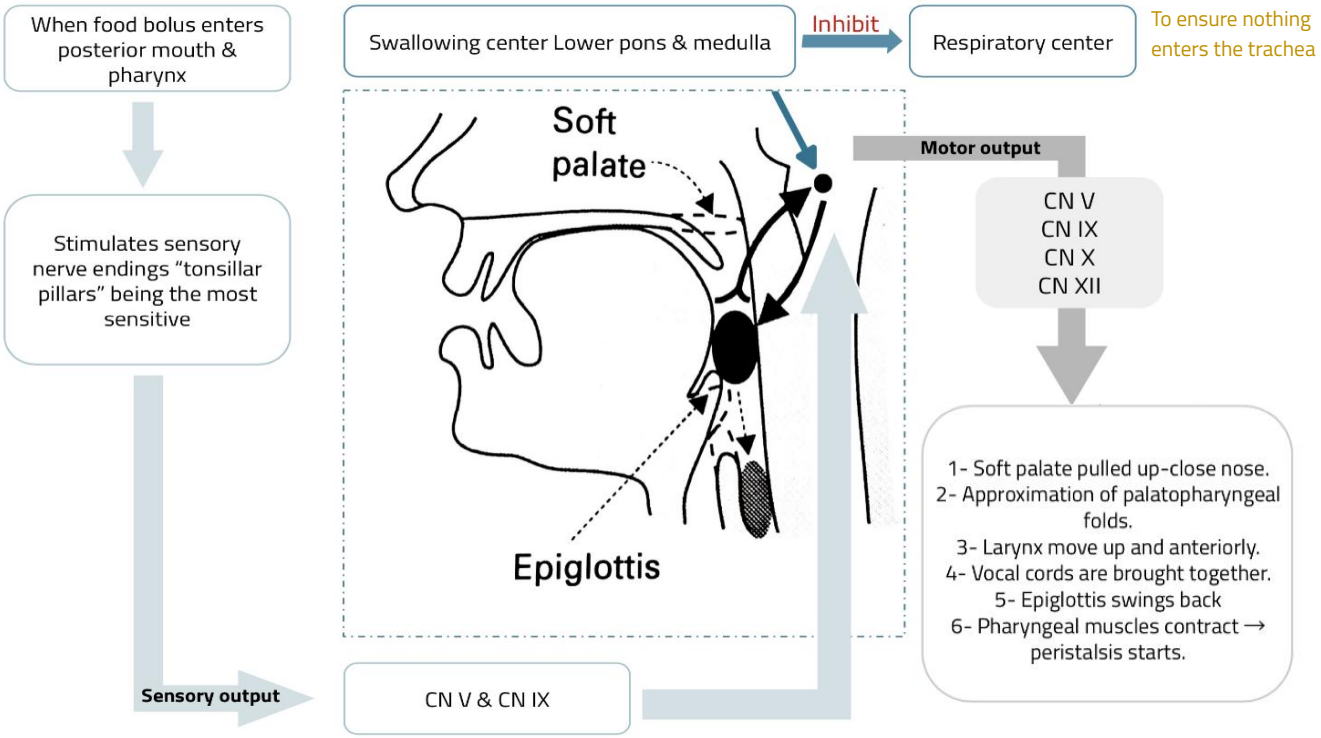
1. Sensory impulses from the mouth are received by the nucleus tractus solitarius (NTS) via the medulla oblongata through the trigeminal and glossopharyngeal nerves.

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.

Diagram only found In girls slides



2- Pharyngeal stage cont... Only In boys slides

- **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.

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.

3- Esophageal stage Only In boys slides

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.

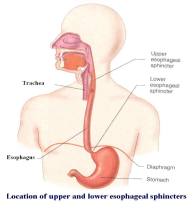
3. The musculature of the pharyngeal wall and upper 1/3 of esophagus (striated muscles) are innervated by vagus (10th cranial) & glossopharyngeal nerves (9th cranial), while the musculature of the lower two thirds of the esophagus is smooth muscle (controlled by the vagus only, through connections with 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 which will continue until all the food is emptied into the stomach.

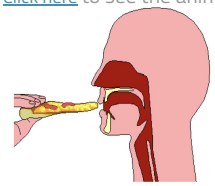
3- Esophageal stage cont...

Only In girls slides



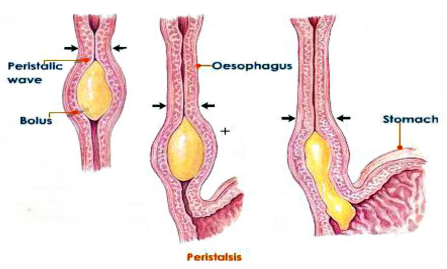
Location of upper and lower esophageal sphincters

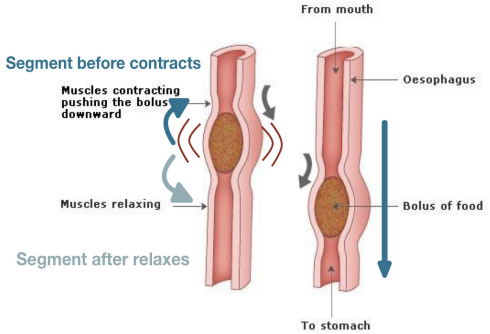
Click here to see the animation



- involuntary and moves bolus from esophagus and into the stomach
- Conducts food to stomach.
- Achieved by peristalsis. mediated mainly by myenteric plexus but its controlled by the vagus nerve
- Two types of peristaltic movement in the esophagus:
  1. Primary peristalsis. 2. Secondary peristalsis.

Primary peristalsis	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 (lower esophageal sphincter)	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	
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. 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. 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.	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. 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.





Esophageal secretions: (females 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

(Males Slides)

Upper Esophageal Sphincter (UES)

- Its formed of **skeletal muscle but is not under voluntary control**, located at the lower end of pharynx and guards the entrance into the esophagus.
- It prevents esophageal air insufflation during negative intrathoracic pressure events, for example: inspiration.
- It prevents esophagopharyngeal/laryngeal reflux during esophageal peristalsis.
- It relaxes during swallowing for about 1 second allowing the bolus to be forced through the relaxed UES.

Lower Esophageal Sphincter (LES). (M)

- 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"**[1] of the sphincter and emptying of the Propelled food into the stomach.
- Failure of the sphincter to relax will result in **Achalasia.(M)**

1. 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 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 coruusive. 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 Only In boys slides

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

- Nerves (extrinsic & intrinsic)
- Hormones
- Neurotransmitter

DR's homework
What are the factors that modify tone of LES ?
(increase tone of LES) & (Decrease tone of LES)

During swallowing, **efferent inhibitory impulses** from vagus nerve cause the sphincter to **relax**.
The transmitter probably being nitric oxide (NO) or vasoactive intestinal peptide (VIP).

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

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

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

Causes of competence and antireflex functions of the LES

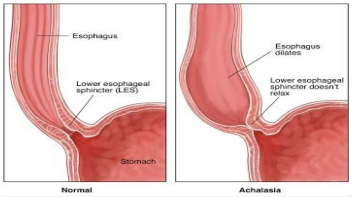
(Males Slides) Important

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 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



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.

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

2) Gastroesophageal Reflux disease (GERD) Incompetence of LES

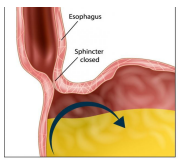
Only In boys slides

- 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.

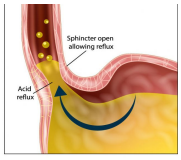
Contributing factors

1	weight gain	2	fatty foods
3	caffeinated or carbonated beverages	4	alcohol and tobacco smoking
5	drugs (as anticholinergics, antihistamines, calcium channel blockers, progesterone and nitrates).		

Female's doctor: **What do you think would happen?**
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 الاكل 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).



Healthy stomach



Gerd stomach

MCQ & SAQ:

Q1: The process of mastication is initiated by .....

A. Stretch reflex
B. Jaw drop
C. Food bolus inhibiting jaw muscles
D. Jaw muscles contraction

Q2: UES is made up of..... and is.....

A.Smooth muscles, under voluntary control.
B.Skeletal muscles, under voluntary control.
C.Smooth muscles, not under voluntary control.
D.Skeletal muscles, not under voluntary control.

Q3: In the pharyngeal stage:

A.palatopharyngeal folds pull medially to approximate and form a horizontal slit.
B. The larynx is pulled upward and anteriorly by the face muscles.
C. The soft palate is pulled downward to close the posterior nares.
D. The epiglottis swings backwards over the opening of the larynx.

Q4: Which of the following physiological process assists in clearing a large food bolus from the esophagus?

A. Migrating myoelectric complex
B. Receptive relaxation
C. Reverse peristalsis
D. Secondary peristalsis

Q5: Which causes contracts the LES

A.Scretin
B.Gastrin
C.Vasoactive intestinal peptide
D.Cholecystokinin

Q6: Failure of LES to relax causes?

A. GERD
B. Dilation of lower end of esophagus
C. Achalasia
D. B and C

answer key:
1: C
2: D
3: D
4: D
5: B
6: D

1- How does the swallowing reflex function?

2- what are the functions of mastication?

3- Mechanisms that prevent gastric reflux (causes of competent LES). male's doctor question

4- Mention four of the contributing factors to GERD.

A1: The swallowing reflex center is located in the medulla oblongata. Generator neurons are situated within a primary sensory relay, that is, the nucleus tractus solitarii. which is transmitted by the 5th, 9th, 10th, and 12th cranial nerves and few of the superior cervical nerves

A2: 1- To lubricate the bolus with salivary secretion
2- To breakdown the bolus to small particles
3- To begin digestion of carbohydrate (α-amylase)

A3: 1-Tonic contraction of LES
2-Valve like mechanism which is due to increased intra-abdominal pressure
3- diaphragmatic contraction

A4: fatty foods, caffeinated or carbonated beverages, alcohol, tobacco smoking

Leaders:

- Abdulaziz Alsuhaim.
- Yara Alasmari.

Co-leader:

- **Mayasem Alhazmi**.

Organizers:

- Rawan baqader
- Haya Alanazi
- Shaden Alobaid
- Mayasem Alhazmi.
- Leen Almadhyani

Note takers:

- **Shaden Alobaid**
- Raghad Albarrak
- **Homoud Algadheb**.

Revisers:

- **Abeer Awwad.**

MEMBERS:

- Abdulaziz Alamri
- Basel Fakeeha
- Ahmad Alkhayatt
- Aljoud Algazlan
- Almaha Alshathri
- Abdulrahman Barashid
- Nada Bin Obeid
- Tarfa Alkaltham
- Yara alzahrani
- Sarah AlQuwayz
- Abdulrhman Alsuhaibany
- Abeer Awwad
- Mohammed alkathiri
- ziyad alhosan.
- **Rand AlRefaei**
- Omar Alhalabi
- Joud Alarifi
- Ibrahim Alnamlah
- Hamad Almousa
- Abdullah Alburikan
- Leen Almadhyani
- Abdullah Alanzan
- **Bader Alrayes**
- Faisal jazzar
- Khalid Almutlaq
- Yara Alomar
- Reem Alqahtani
- Aljoharah Albnyan
- Saud Alhasani
- Muneerah Alsadhan

Physiology439@gmail.com