

Movements of Gastrointestinal Tract Mastication

Kaylan Chapalamadugu¹, Sravani Pragna K¹, Muralinath E¹, Manjari P¹, Sri Hari Reddy K¹, Guru Prasad M², Sridevi V³

¹College of veterinary science, Proddatur, Andhrapradesh, India.

²Vaishavi microbial pvt. Ltd, Telangana, India.

³Department of Biosciences, Mohan Babu University, Tirupati, India

Introduction: Mastication or chewing is treated as the first mechanical process in the gastric intestinal (GI) tract, by which the food substances are cut or torn into very small particles and the crushing of food substances takes place into a soft bolus.

Importance of mastication:

- 1.Appreciation of taste of food.
- 2.Breakdown of foodstuffs into smaller particles.
- 3.Lubrication and moistening of dry food particles by saliva, so that easy swallowing of bolus takes place.
- 4.Through mixing of saliva with food substances.

Muscles and the movements of mastication:

Muscles of mastication:

- 1.Buccinator muscle
- 2.Masseter muscle
- 3.Pterygoid muscle
- 4.Temporal muscle.

Movements of mastication:

- 1.Opening and closure of mouth
- 2.Rotational movement of jaw
- 3.Protraction and retraction of jaw.

Control of mastication:

Action of mastication is related to a reflex process. It is performed voluntarily also. The center for mastication is located in medulla and cerebral cortex. Muscles of mastication are provided by mandibular division of 5 th cranial(trigeminal nerve).

Deglutition:

Definition:

Deglutition or swallowing is the process by which the movement of food occurs from mouth into stomach.

Stages of deglutition:

Deglutition takes places in three stages.

Oral stage: The movement of food occurs from mouth to pharynx.

Tharyngeal stage: The movement of food takes places from pharynx to oesophagus.

Esophageal stage: The movement of food happens from esophagus to stomach.

Oral stage or first stage:

Oral stage of deglutition is under voluntary control. In this stage, the movement of bolus takes place from mouth unto pharynx with the help of series of actions.

Sequence of events during oral stage:

Bolus is kept over postero dorsal surface of the tongue. It is termed as the preparatory position.

Retraction and depression of the anterior part of tounge takes place.

An elevation and retraction of posterior part of occurs against hard palate. This condition leads to the pushing of the bolus backwards into the pharynx.

Forceful contraction of tounge against the palate provides a positive pressure in the posterior part of oral cavity. This situation results in the pushing of the food into pharynx.

Pharyngeal stage or second stage:

Pharyngeal stage is under involuntary control. In this stage, the bolus is pushed from pharynx into the esophagus. Pharynx acts a common passage for food as well as air. It is classified into larynx and esophagus. Larynx lies anteriorly and continues as respitaory passage. Esophagus lies behind the larynx and proceed as GI tract. Since pharynx communicates with mouth, nose, larynx and esophagus, during this stage of deglutition, bolus from pharynx gains entry into four paths.

1. Back into mouth
2. Upward into nasopharynx
3. Forward into larynx
4. Downward into esophagus.

Whatever it may be, because of different coordinated movements, bolus is made to gain entry into esophagus. Entrance of bolus through other paths is hampered as follows:

1. Back into mouth:

Return of bolus back into the mouth is obstructed by

- a. Position of tongue against the soft palate (roof of the mouth)
- b. More intra oral pressure created by the movements of tongue.

2. Upward to nasopharynx:

Movement of bolus into the nasopharynx from pharynx is hampered by elevation of soft palate along with its extension termed as uvula.

3. Forward into larynx:

Movement of bolus into the larynx is hampered by the following steps:

- a. Approximation of the vocal cords.
- b. Forward and upward movement of larynx.
- c. Backward movement of epiglottis to seal the opening of the larynx(glottis).
- d. All these movements stop respiration for a few seconds. It is termed as deglutition apnea.

Deglutition of apnea:

Apnea is related to temporary arrest of breathing. Deglutition apnea or swallowing apnea is the arrest of breathing during pharyngeal stage of deglutition.

Entrance of Bolus into esophagus:

Because of the closure of other three paths, the bolus must pass through the oesophagus. This happens by the combined effects of various factors:

- a. Upward movement of larynx is capable of stretching the opening of oesophagus.
- b. Simultaneously, upper 3 to 4 cm of esophagus relaxes. The formation of this part of esophagus occurs by the cricopharyngeal muscle and its is termed as upper esophageal sphincter or pharyngo esophageal sphincter.
- c. At the same time, the beginning of peristaltic contractions takes place in the pharynx because of the contraction of pharyngeal muscles.
- d. Elevation of larynx also lifts the glottis away from the food passage. All these factors mentioned above perform together so that, the movement of bolus occurs easily into the oesophagus. The whole process is completed within 1 to 2 seconds and this process is purely under involuntary control.

Esophageal stage or third stage:

Esophageal stage is under an involuntary control. In this stage the food enters the stomach from esophagus. Esophagus is capable of forming the passage pharynx into the stomach. Movements of esophagus are meant for this function and the movements are termed as peristaltic waves. Peristalsis is nothing but a wave of contraction, followed by the wave of relaxation of muscle fibers of GI tract, which travel particularly in an aboral direction (away from mouth). By this type of movement, the propulsion of the contents happens downwards along GI tract. If the bolus reaches the esophagus, an initiation of peristaltic waves occurs. Generally, two types of peristaltic contractions are observed in esophagus.

- a. Primary peristaltic contractions.
- b. Secondary peristaltic contractions.

a. Primary peristaltic contractions:

If bolus arrives the upper part of esophagus, the peristalsis begins. This is termed as primary peristalsis. After origin, the peristaltic contractions go down through the rest of esophagus, propelling the bolus towards stomach. Pressure developed during the primary peristaltic contractions is essential for propelling the bolus. In the beginning, the pressure shows negativity in the upper part of esophagus. This is because of the stretching of the closed esophagus due to the elevation of larynx. But immediately, the pressure shows positivity and enhances upto 10 to 15 cm of water.

2. Secondary peristaltic contractions:

If the primary peristaltic contractions do not show the activity of propelling the bolus into the stomach, the secondary peristaltic contractions lay a role in pushing the bolus into stomach. Secondary peristaltic contractions are caused by the distention of upper esophagus by the bolus. After origin, these contractions go down just like the primary contractions and provide a positive pressure.

Role of lower esophageal sphincter:

Distal 2 to 5 cm of esophagus behaves as sphincter and it known as lower esophageal sphincter. The contraction of this sphincter occur always. If bolus arrives this part of the esophagus, the relaxation of this sphincter happens, so that the contents arrive the stomach easily. After the entry of bolus into the stomach the constriction of sphincter occurs and closes the lower end Of esophagus. The relaxation and constriction of sphincter take place in sequence with the arrival of peristaltic contractions of esophagus.

Deglutition reflex:

Even though the beginning of swallowing is a voluntary act, later it is changed into involuntary and is performed by a reflex action termed as deglutition reflex. It happens particularly during the pharyngeal and esophageal stages.

Stimulus:

If the bolus arrives the oropharyngeal region, the receptors present in this region are activated.

Afferent fibers:

Afferent impulses from the oropharyngeal receptors via the glossopharyngeal nerve fibers to the deglutition center.

Center:

Deglutition center is located at the floor of the fourth ventricle in medulla oblongata of brain.

Efferent fibers:

Impulses from deglutition center pass through glossopharyngeal and vagus nerves and arrive soft palate, pharynx and esophagus. The glossopharyngeal nerve is related to pharyngeal stage of swallowing. The vagus nerve is related to esophageal stage.

Response:

The reflex is responsible for the upward movement of soft palate to close nasopharynx and upward movement of larynx to close respiratory passage, so that bolus arrives the esophagus. Now the peristalsis occurs in esophagus and pushes the bolus into stomach.

Applied physiology:

Dysphagia:

Dysphagia is related to difficulty in swallowing.

Cause of dysphagia:

- a. Decreased movement of esophagus due to neurological disorders namely parkinsonism.
- b. Mechanical obstruction of esophagus due to tumor, strictures, diverticular hernia (out pouching of the wall).
- c. Muscular disorders leading to difficulty in swallowing during oral stage or esophageal stage.

Esophageal achalasia or Achalasia cardia:

Esophageal achalasia or Achalasia cardia is a neuromuscular disease manifested by accumulation of food compounds in the esophagus obstructing normal swallowing. It is due to failure of lower esophageal cardiac sphincter to relax particularly during swallowing. The accumulated food compounds are responsible for causing dilatation of esophagus.

Features of esophageal achalasia:

1. Chest pain
2. Cough

3. Dysphagia
4. Weight loss

Gastro esophageal reflex (GERD):

GERD is a disorder manifested in regurgitation of acidic gastric content through esophagus. The flow of regurgitated gastric contents occurs into pharynx or mouth. Regurgitation is due to the weakness or incompetence of lower esophageal sphincter.

Features of GERD:

1. Cough or change of voice
2. Dysphagia
3. Esophagitis (inflammation of esophagus)
4. Esophageal ulcers or cancer (in chronic cases)
5. Heart burn or pyrosis (pain full burning sensation in chest due regurgitation of acidic gastric content into esophagus)

Movements of stomach:

Activities of smooth muscles of stomach enhance during gastric digestion and when the stomach shows emptiness.

Types of movements in stomach:

1. Human contractions
2. Peristalsis
3. Receptive relaxation

Hunger contractions:

Hunger contractions are the movements of empty stomach. These contractions are related to the sensations of hunger. Hunger contractions acts as peristaltic waves and these waves are super imposed over the contraction of gastric smooth muscle as a whole. These type of peristaltic waves is entirely different from the digestive peristaltic contractions. The digestive peristaltic contractions normally happen in the body and pyloric parts of the stomach. But, peristaltic contractions of empty stomach involve complete stomach. Hunger contractions are classified into three types.

Type 1 Hunger contraction:

Type 1 hyper contractions in the first contractions to appear in the empty stomach, if the tone of the gastric muscles is low. Each contraction lasts for about 20 seconds. The interval between contractions is approximately 3 to 4 seconds. Tone of the muscles does not enhance between contractions. Pressure produced by these conversations is about 5 cm of water.

Type II Hunger Contractions:

Type II hunger contractions appear when the tone of stomach is stronger. Tone increases in stomach if food intake is postponed, even after the appearance of the Type I contractions. Each of the type II contractions lasts for 20 seconds like type I contractions. But the pause between the contractions is decreased. Pressure produced by these contractions is 10 to 15 cm of H₂O.

Type III contractions:

Type III contractions are similar to incomplete tetanus. These contractions are seen if the hunger becomes severe and the tone enhances to a great extent. Type III contractions are rare particularly in men as food is taken normally before the appearance of these contractions. These contractions last for approximately 1 to 5 minutes. The pressure created by these contractions enhances to 10 to 20 cm of water. If the stomach is empty, the type I contractions appear followed by type II contraction. If food intake is still postponed, then type III contractions appear and as soon as food is consumed, disappearance of hunger contractions takes place.

Receptive relaxation:

Receptive relaxation is the relaxation of the upper portion of the stomach when bolus enters the stomach from esophagus. It involves the fundus and upper part of the body of stomach. Its significance is to accommodate the food easily, without much increase in pressure inside the stomach. This process is called accommodation of stomach.

Peristalsis:

When food enters the stomach, the peristaltic contraction or peristaltic wave appears with a frequency of 3 per minute. It starts from the lower part of the body of stomach, passes through the pylorus till the pyloric sphincter. Initially, the contraction appears as a slight indentation on the greater and lesser curvatures and travels towards pylorus. The contraction becomes deeper while traveling. Finally, it ends with the constriction of pyloric sphincter. Some of the waves disappear before reaching the sphincter. Each peristaltic wave takes about one minute to travel from the point of origin to the point of ending. This type of peristaltic contraction is called digestive peristalsis because it is responsible for the grinding of food particles and mixing them with gastric juice for digestive activities.

Filling and emptying of stomach:

Filling of stomach:

When taking food, it organizes itself in the stomach in many layers. The first eaten food is kept against the great curvature in the fundus as well as body of the stomach. The successive layer of food particles lie nearer the lesser curvature, till the last portion of food eaten lies near the upper end of lesser curvature, adjacent to cardiac sphincter. The liquid retains near the lesser curvature and flows towards the pyloric end of stomach over a V shaped groove. This groove is created by the smooth muscle and it is termed magenstrasse. But, if a large quantity of fluid is consumed, it flows around the entire food mass and is scattered over the interior part of stomach, between well of the stomach and food mass.

Emptying of stomach:

Gastric emptying is the process by which the chyme is emptied into intestine from stomach. Food that is swallowed enters the stomach and remains there for approximately 3 hours. During this period, digestion occurs. Partially digested food in stomach is converted into the chyme.

Chyme:

Chyme is the semisolid mass of partially digested food that is formed in the stomach. It is acidic in nature. Acid chyme is emptied from stomach into the intestine slowly, with the help of peristaltic contractions. It takes about 3 to 4 hours for emptying of the chyme. This slow emptying is necessary to facilitate the final digestion and maximum (about 80%) absorption of the digested food materials from small intestine. Gastric emptying occurs due to the peristaltic waves in the body and pyloric part of the stomach and simultaneous relaxation of pyloric sphincter. Gastric emptying is influenced by various factors of the gastric content and food.

Factors affecting gastric emptying:

Chemical composition:

Chemical composition of the food is also responsible for playing a major role in the emptying of stomach. Carbohydrates are emptied in a faster manner compared to proteins. Proteins are also emptied faster compared to fats. Thus the fats are emptied in a very slow manner.

Consistency of gastric content:

Emptying of the stomach depends upon consistency (degree of density) of the contents. Liquids, particularly the inert liquids like water leave the stomach rapidly. Solids leave the stomach only after being converted into fluid or semifluid. Undigested solid particles are not easily emptied.

pH of gastric contents:

Gastric emptying is directly linked to the pH of the chyme.

Osmolar concentration of gastric contents:

Gastric content which is isotonic to blood, leaves the stomach in a rapid manner compared to the hypotonic or hypertonic content.

Volume of gastric content:

For any type of diet gastric emptying is directly linked to the volume. If the contents of stomach are more, emptying of a large amount happens into intestine in a rapid manner.

Regulation of gastric emptying:

Gastric emptying is controlled by nervous as well as hormonal factors.

Nervous factor:

Nervous factor which controls the emptying of stomach is called the enterogastric reflex.

Enterogastric reflex:

Enterogastric reflex is the reflex that prevents gastric emptying. It is elicited by the presence of chyme particularly in the duodenum, which stops further emptying of stomach.

Mechanistics of enterogastric reflex:

1. Chyme in duodenum generates nerve impulses which are transmitted to stomach by the intrinsic nerve fibers of GI tract. These nerve impulses subsequently inhibit gastric emptying.

2. Nerve impulses from duodenum also pass via. extrinsic sympathetic fibers to stomach and inhibits its' emptying.

Factors that induce enterogastric reflex includes

1. Duodenal distension
2. Irritation in duodenal mucosa
3. pH of chyme
4. Osmolality of chyme
5. Broken protein and fat products

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