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# Physiology of Swallowing – A review

Kumaresan A*[1], Manoj Abraham M[1], Prathap Suganthirababu[2]

[1]Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India
[2]College of Health Sciences, Gulf Medical University, Ajman, United Arab Emirates

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ABSTRACT

Swallowing is the process which consists of 3 Phases, i.e. Oral, Pharyngeal and oesophagal phase. In these 3 phases, many cranial Nerves and around 56 muscles are involved. Swallowing process is a multi-complex task which involves volitional and Reflexive behaviour. Any abnormal Neuro muscular Physiological component can produce dysphagia. The goal of dysphagia rehabilitation is to identify and treat abnormalities in swallowing. The purpose of this review is to know the central and peripheral mechanism of the physiology involved in swallowing which is the manipulation of food including oral and voluntary stages that take place in pharynx and larynx.

* Corresponding Author

Name: Kumaresan A
Phone: +91-7299934070
Email: kresh49@gmail.com

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## INTRODUCTION

Inability to swallow will result in malnutrition and dehydration. Dysphagia is defined as the inability to swallow. The process of swallowing involves three major components, i.e. Sensory, Neuromuscular and cognitive. (American Occupational Therapy Association, 2003). Swallowing which has a neuromuscular system as one of the important components involves the coordination of central and peripheral mechanism. The central mechanism is supported by the brain stem, cortex and 6 cranial nerves. The peripheral mechanism is supported by the first 3 cervical segments and 48 pairs of muscles which aid swallowing. (Bass N, Hislop *et al.,* 1995 and Miller A *et al.,* 1997) . Swallowing consists of three phases 1. Oral phase, 2. Pharyngeal phase, 3. Oesophagal phase. (American Occupational Therapy Association, 2003, Logemann J, 1998)

### Central Mechanism of Swallowing

### Role of the brain stem in swallowing

Phases of swallowing controlled by the central pattern generator and peripheral reflexes both controlled by the timing of these three phases. The central mechanism of swallowing is a complex motor sequence involved in coordinated contraction of several muscles in mouth, pharynx, larynx and oesophagus. The motor sequence of swallowing, which can be performed without afferent feedback by a neuronal network. This network is divided into three levels: (i) an afferent level act as a Solitary tract it is input arm (ii) an efferent level corresponding to the output network, that is the different pools of motor neurons involved in swallowing and localized within the trigeminal and hypoglossal nuclei and the nucleus ambiguous; (iii) an organizing level corresponding to the interneuronal network which programs the swallowing motor sequence. The "swallowing inter neurons" of the organizing level are localized in two medullary regions: (i) a dorsal region including the nucleus of the solitary tract (NST) and the adjacent reticular formation, and (ii) a central region corresponding to the lateral reticular formation above the nucleus ambiguous (Andre Jean, 1984).

**Swallowing reflex:** The swallowing reflex starts from glossopharyngeal nerve. Impulses from this nerve pass to reticular formation in the brainstem. This is otherwise known as the swallowing centre. Swallowing centre is immediately adjacent to the respiratory centre, so there is always close coordination between these two structures. Within a second once swallow reflex started respiration is halted. Pharyngeal phase is started when swallowing reflexes is initiated

**Peripheral Mechanism of Swallowing**

**Oral Phase**

When the food is ingested through the mouth, tongue carries the food to the postcanine region[1]. For this movement jaw opens which involves protrusion of the lower jaw that moves laterally then the jaw closes and depresses. The muscles which favour this type of jaw movement is Pterygoideusmedialis and Lateralis, Massater, Digastricus, Mylohyoideus, Geniohyoideus. During swallowing, the Lips get compressed and protrudes by raising the lateral angle of mouth which moves upwards and outwards and lower lip moves downwards drawing the angle of the mouth down. The muscle that favour these movements is Orbicularis Oris, Zygomaticus minor and major, Levatorangulioris and Risorius. The tongue is shortened and broadened, the narrow tip of the tongue rises and moves downwards. Muscles which are responsible for these movements are Superior longitudinal transverse and vertical longitudinal, inferior longitudinal muscles. (Bass N, Davis P, 1985, Hislop H *et al.,* 1995, Liebman M, 1986, Netter *et al.,* 1998)

The food particles immediately get processed, i.e. they get reduced in size by mastication with salivation, chewing takes place continuously till the food is prepared for swallowing in this phase with the coordination of jaw, tongue, hyoid bone, soft palate and cheeks. (Koichiro Matsuo *et al.,* 2008, Hiiemae K, et al. 1999, Dua KS, *et al.,* 1997, and Palmer JB et al. 1997). The tongue then elevates and pulls itself posteriorly and narrows the fauces and then elevates the hyoid bone, the muscle which assists these movements are styloglossus, palatoglossus, genioglossus, hyoglossus. The tongue moves in all dimensions anterior, posterior, vertical, mediolateral to push the food backwards. The soft palate is tensed and elevates by shortening muscles attached to it. These muscles are tensor velipalatini, levatorvelipalatini and uvula (Bass N, Davis P, 1985, Hislop H *et al.,* 1995, Liebman M, 1986, Netter *et al.,* 1998).

The hyoid bone which has a mechanical connection with the cranial base, sternum, thyroid cartilage, mandible, infrahyoid and suprahyoid muscles helps food to accumulate on the pharyngeal cavity of the tongue and the valleculae and this transport does not require gravity. (Hodgson M *et al.,* 2003, Palmer JB *et al.,* 2003).

**Pharyngeal Stage**: this is a rapid sequential phase of activity where two crucial biological features are seen. a. Food passage in the form of food bolus propels through the pharynx and UES to the oesophagus. b. Airway protection during the food passage to prevent the food from entering the airway. The soft palate elevates and contacts the lateral and posterior walls of the pharynx to allow the food bolus to enter the pharynx. Soft palates elevation prevents bolus regurgitation into the nasal cavity. Safe bolus passage in the pharyngeal stage protecting airway mechanisms without aspiration of the foreign materials to the trachea before or during the swallow. The vocal folds close to sealing the glottis. (Shaker R *et al.,* 1990, Ohmae *et al.,* 1995). The hyoid bone and larynx are pulled upwards and forward by contraction of the suprahyoid muscles and thyrohyoid muscle. (Koichiro Matsuo DDS 2008)

Upper UES opens and the bolus enters the oesophagus with 3 main factors contributing to the UES opening 1. Relaxation of cricopharyngeus muscles, 2. Contraction of suprahyoid muscles and thyrohyoid muscles, 3. The pressure of descending bonus. (Shaw DW *et al.,* 1995) Hyoid bone during the swallow, elevates anteriorly and then moves posteriorly and depresses thyroid cartilage along with hyoid itself, the muscles suprahyoideus, thyrohyoideus, mylohyoideus are responsible for these movements and at last the pharynx and larynx elevation forces the food to the oesophagus, muscles responsible are salpingopharyngeus, palatopharyngeus, stylopharyngeus. (Bass N, Davis P, 1985, Hislop H *et al.,* 1995, Liebman M, 1986, Netter *et al.,* 1998)

**Oesophagal stage**

The oesophagus is a tubular structure in which the lower oesophagal structure is tensioned at rest to prevent regurgitation back from the stomach. The bolus transport in the thoracic oesophagus is entirely different from the pharynx as the ANS regulates this peristalsis. Peristaltic wave is of two different types. The initial wave of relaxation that accommodates the bolus, followed by a wave of contraction that propels. Gravity assists peristalsis in an upright position. Pharynx sequentially constricts the nasopharynx, Oropharynx and laryngopharynx in which constrictor pharyngeus superior, medium and inferior play their role, cricopharyngeus muscle relaxes during swallow and prevents air from entering the oesophagus. (Bass N, Davis P, 1985, Hislop H *et al.,* 1995, Liebman M, 1986, Netter *et al.,* 1998)

The inlet of larynx closes along with the glottis, shortening the vocal cords and adduction and rotation of the arytenoid cartilages take place. Tension at the vocal cords is controlled followed by widening of glottis and elevation of the cricoid arch. Muscles which produce these movements are aryepiglotticus, thyroarytenoideus, arytenoid-oblique, traverse and Lateral cricoarytenoid, vocalis, cricothyroideus muscles.

**Coordination between Breathing/ Eating/ Swallowing**

Physical closure of the airway by elevation of soft palate and tilting of the epiglottis along with neural suppression of respiration in brain stem helps cease breathing. (Nishino T, *et al.,* 1985, 1991, Mc Farland DH *et al.,* 1995) When drinking water/liquids, swallowing initiates during the expiration phase. The respiratory pause of 0.5s to 1.5s continues during swallow and then breathing resumes with expiration. (Selley WG *et al.,* 1989, Klahn MS et al. 1999, Martin *Et al.,* 2005) The alteration of respiratory rhythm during solid food ingestion starts during mastication and follows exhale- swallow - exhale temporal relationship during swallowing. (Smith J *et al.,* 1989, Matsuo K *et al.,* 2007)

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