Physiology of swallowing

Jenny Walton

Priyamal Silva

Abstract

The mechanism behind normal swallowing is complex and multifactorial. Due to the close proximity of the pathways of swallowing and respiration, precise coordination between these functions is vital in order to avoid entry of material into the airway and to ensure optimal health and nutrition in general. Swallowing can be divided into three stages: oral, pharyngeal and oesophageal and although initiation of the swallow is often under voluntary control, swallowing is also triggered frequently throughout the day as a reflex action due to the presence of saliva in the oropharynx. Dysphagia is a symptom frequently encountered by clinicians and its causes are vast and varied. A thorough understanding of the physiology of swallowing remains necessary to conduct a full assessment and instigate appropriate treatment for these patients in whom dysphagia is often debilitating and may significantly affect their quality of life. We present an account of the physiology of swallowing, using clinical examples to illustrate certain aspects.

Keywords Anatomy; Deglutition; Dysphagia; Physiology; Swallowing

Introduction

The pharynx assists in the shared functions of respiration and swallowing (deglutition); coordination between these functions is of great importance. This article reviews the phases of the normal swallow and describes relevant applied anatomy and physiology to assist in the understanding of what is a complex and multifactorial process. Examples of relevant pathology are used where they illustrate the phases.

Phases of swallowing

Swallowing can be subdivided into three main phases: oral, pharyngeal and oesophageal. The oral phase can be subdivided into the preparatory and transit phases. The oral phase is under voluntary control whereas the pharyngeal and oesophageal phases are involuntary. It is estimated that humans normally produce around 500 ml of saliva per day and although swallowing is thought of as an active function related to eating and drinking, it should be noted that much of this activity is occurring without active stimulation or awareness.

The oral phase

Anatomy

The oral cavity extends from the soft tissues of the lips and cheeks anteriorly to the anterior tonsillar pillars. Its functions include mastication and formation of a bolus, phonation, articulation and ventilation. The oral cavity is in direct communication and continuity with the oropharynx, the boundaries of which are the soft palate superiorly and the tip of the epiglottis inferiorly.

The nasopharynx lies between the skull base superiorly and the soft palate inferiorly. Its anterior boundary is the posterior choana. Its function is concerned with respiration; in normal swallowing, the nasopharynx is closed off by the elevation of the soft palate and uvula (Table 1).

The oral preparatory phase

This phase is concerned with the formation of a bolus from material placed into the oral cavity. This does not apply to liquids, as these need no oral preparation. The key features of this stage are coordinated, purposeful movements of the tongue, mandible and lip/buccal musculature and the simultaneous closure of the upper oesophageal sphincter (UOS) to prevent premature passage of food; these movements are coordinated in the cerebellum (Table 2).[1,2]

The oral transit phase

Tongue movement is the most important feature of this stage, as in the preparatory phase. The shape and movement of the tongue acts to seal the food bolus against the palate; the lateral aspects of the tongue sit along the alveolar ridges each side, stabilising the tongue and thereby enabling the central part to propel the bolus posteriorly. This phase lasts approximately 1 second and is prolonged with increasing viscosity of the bolus and with increasing age.[2] The transit and preparatory phases may be bypassed by syringing liquid into the back of the mouth to initiate the pharyngeal phase.

The oral phase is controlled by 3 cranial nerves: the trigeminal nerve (CN V), which controls chewing, the facial nerve (CN VII), which controls the buccal and lip musculature to assist in the positioning of food within the mouth, and the hypoglossal nerve (CN XII), which controls tongue movement.[3]

The swallowing reflex

Swallowing is a complex action; voluntary initiation of swallowing is mediated in the cortex, but swallowing may also be triggered as a reflex response to food/liquid in contact with particular areas in the oral cavity or oropharynx, or simply by the accumulation of saliva.[1] This is mediated in the medulla, which receives afferent impulses from the nucleus tractus solitarius and the spinal trigeminal nucleus. Efferent impulses from the medulla pass through the nucleus ambiguus, the hypoglossal nucleus and the motor nuclei of the trigeminal and facial nerves, leading to the actions involved in the pharyngeal phase.

The gag reflex

The gag reflex is mediated by the same nerves as the swallowing reflex, the difference being the initial stimulus. The gag reflex is triggered by the presence of a stimulus in the oropharynx outside of normal voluntary swallowing and subsequent muscle contraction leads to gagging, retching or even vomiting (Figure 1).

Jenny Walton *MBChB MSc(dist) MRCS DOHNS is a Specialist Registrar on the Oxford Rotation, UK. Conflicts of interest: none declared.*

Priyamal Silva *FRCS ORL-HNS is a Consultant in Otolaryngology at the John Radcliffe and Churchill Hospitals, Oxford, UK. Conflicts of interest: none declared.*

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Muscles of the soft palate

Muscle	Actions	Innervation	Vascular supply
Levator veli palatini	Elevate and pull back the posterior part of the palate to close off nasopharynx during swallowing	Cranial accessory nerve via pharyngeal plexus	Ascending palatine branch of facial Greater palatine branch of maxillary
Tensor veli palatini	Tightens and depresses soft palate to open the Eustachian tube	Mandibular nerve via nerve to medial pterygoid	Ascending palatine branch of facial Greater palatine branch of maxillary
Palatoglossus	Elevates root of tongue and medialises palatoglossal arches to separate oral cavity from oropharynx	Cranial accessory nerve via pharyngeal plexus	Ascending palatine branch of facial Ascending pharyngeal
Palatopharyngeus	Pull pharynx up and forwards to shorten it during swallowing	Cranial accessory nerve via pharyngeal plexus	Ascending palatine branch of facial Greater palatine branch of maxillary Ascending pharyngeal
Musculus Uvulae	Retracts and thickens middle part of palate to help close off nasopharynx	Cranial accessory nerve via pharyngeal plexus	Ascending palatine branch of facial Descending palatine branch of maxillary

Table 1

Components of the oral preparatory phase

Component of phase	Muscles	Function
Lip closure	Orbicularis oris	Keep food in the mouth
Contraction of buccal musculature	Buccinator	Prevent food entering the lateral sulci
Rotary motion of jaw	Temporalis, masseter, medial pterygoid	Chewing
Lateral rolling motion of tongue	Intrinsic muscles, genioglossus	Direct food towards teeth
Bulging of the soft palate anteriorly	Palatoglossus, levator veli palatini	Close off oropharynx and widen nasal airway

Table 2

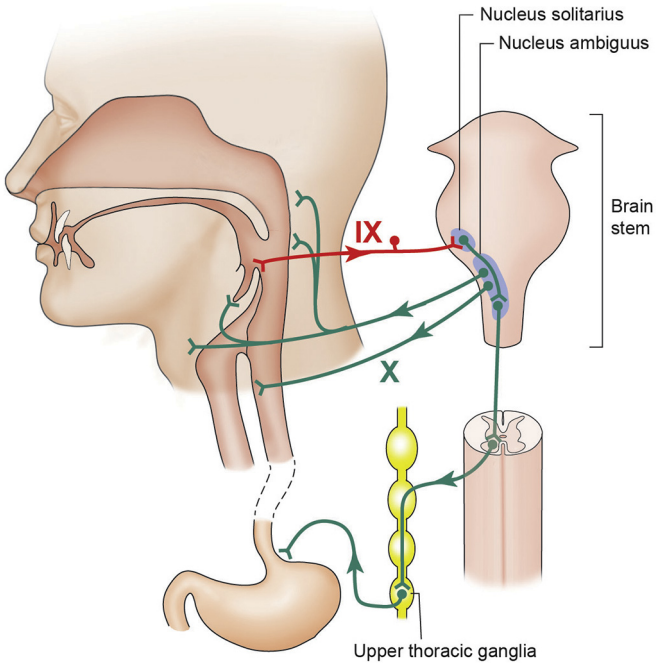

Figure 1 Nerves of the swallowing and gag reflexes. Image modified from Standring S, ed. Gray's Anatomy: the anatomical basis of clinical practice. 40th edn. Elsevier. 2008. Fig 19.12 Swallowing and gag reflexes. p283.

The pharyngeal phase

Anatomy

The pharynx continues inferiorly as a tube surrounded by muscular layers. The outermost layer consists of the three pharyngeal constrictor muscles: muscle sheets situated posteriorly with their fibres running obliquely. The inferior constrictor consists of thyropharyngeus and cricopharyngeus, the latter of these forming the primary component of the Upper Oesophageal Sphincter (UOS). A deficiency occurs between these two parts: see CAB 3. The inner layer consists of longitudinal muscles: palatopharyngeus, stylopharyngeus and salpingopharyngeus. Contraction of these muscles during swallowing acts to shorten and widen the pharynx, facilitating passage of the bolus into the oesophagus.

The suprahyoid muscles: digastric, mylohyoid, stylohyoid and geniohyoid, act to elevate the hyoid bone and larynx during swallowing in order to protect the airway. This function is aided by the epiglottis: a sheet of fibrocartilage sitting anterior to the laryngeal inlet (Figure 2). The epiglottis is not essential clinically and it is possible for a functional, safe swallow to be adopted if the epiglottis is removed.

Physiology

This phase is triggered by stimulation of the glossopharyngeal (cranial nerve (CN) IX) and vagus (CN X) nerves by the presence of the bolus, and is mediated in the medulla. Coordination

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