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Neurophysiology of Swallowing in the Aged

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Abstract. The neurophysiology of normal swallowing and its alterations related to age are reviewed. Clinical implications in health and disease are discussed.

Key words: Deglutition — Aging — Deglutition disorders — Oral — Pharyngeal — Esophageal.

Discussion

In analyzing the normal neurophysiology of swallowing, various neuromuscular stages must be taken into account [1]. First, the oral phase begins by closure of the lips with increase in the facial tone to maintain the food inside the mouth. Then, there are rotational and lateral jaw movements that allow mastication and tongue movements that mix the food with saliva. At the end of the oral phase, the food is formed into a bolus that is often held against the palate or less commonly on the floor of the mouth. The contact between the bolus and various sensory receptors present in the soft palate, the pharynx, and the base of the tongue triggers the oropharyngeal swallow phase. Next, the pharyngeal phase follows with closure of the velopharynx, anterior elevation of the hyoid and larynx, closure of the laryngeal opening, and relaxation of the cricopharyngeal muscle while the contractile pharyngeal wave progresses downward. The presence of residual food in the pharyngeal walls activates sensory receptors in the pharynx resulting in a second swallowing motion that clears the remaining material. Laryngo-tracheal sensory receptors also respond to food entering the airway and result in cough reflex. Finally, the esophageal phase follows.

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The neural pathways that mediate these actions involve primarily the glossopharyngeal and vagus nerves and their central connections in the medulla. Although the central anatomy remains unchanged, the effects of aging on the cytoarchitecture and physiology of swallowing centers are not precisely known in humans. Aging-related changes were extensively studied in the cerebral cortex [2]. These include decreased cortical thickness, reduced number of large neurons, and increased number of small neurons with little change in neuronal density, indicating primarily neuronal shrinkage with aging. Similar detailed studies were not conducted on other neural structures, although there is evidence that various alterations of the cytoarchitecture occur in aging in other parts of the nervous system. For example, motor neuron counts in the spinal cord showed that the number of cells declined by approximately 200 neurons/segment/decade [3]. A study that counted the pigmented neurons in the locus ceruleus in the brainstem found a decline averaging 2,000 cells/decade after the age of 60 [4]. Likewise, the number of neurons in the substantia nigra decreased by 34% after the age of 50 years [5]. Contrarily, aging did not affect the neuronal numbers in the inferior olivary complex [6], the cerebellar nuclei [7], the facial nerve nucleus [8], or the ventral cochlear nucleus [9]. Cell counts in various glossopharyngeal and vagus nuclei within the brainstem are lacking in the human brain and therefore no conclusions can be drawn pertaining to aging.

The effects of aging can be divided into primary or secondary.

Primary Causes

Age-Related Changes in the Oral Cavity

Age-related changes in the oral cavity are important in the first phase. The changes consist of increase in the amount of connective tissue in the tongue, loss of denti-

tion, and reduced masticatory strength [1]. One radiologic study examined 56 elderly persons referred for upper gastrointestinal tract evaluation without eating or swallowing difficulties and found various abnormalities of the oral phase in approximately two-thirds [10]. Another study using videofluoroscopy and manometry compared subjects of various ages and found evidence for significant prolongation of the oropharyngeal phase in healthy elderly persons [11]. Similar findings were seen with ultrasonography [12]. Compounding factors would include poorly fitted dentures, as well as reduced various velopalatine reflexes. Measurements of two-point discrimination thresholds showed significant increase with age for the lateral tongue and the floor of mouth, but not for the tongue tip [13].

Age-Related Changes in the Pharynx

The pharyngeal phase of the swallowing also shows age-related alterations. The anterior elevation of the larynx is less pronounced in the elderly and the initiation of hyolaryngeal excursion is delayed [11]. The pharyngeal swallowing phase is mildly but significantly prolonged and the changes appear to be greater in women [12]. The duration of the pharyngeal pressure wave increases with age, particularly in men [14]. The pharyngeal peristaltic motion is also significantly slowed above the age of 60 [15]. The cricopharyngeal opening time was found to be slightly prolonged by some investigators [11] and shortened by others [15]. Quantitative determination of the pharyngeal mechanical sensory threshold using standardized air pulses showed significant increase with aging, indicating an impairment of the afferent limb as well [16]. Radiologic studies have confirmed significant abnormalities of the pharyngeal phase in approximately one-fourth of the patients [10], but there were no significant changes in the pharyngeal pressure peak duration or in the rate of propagation of contractions [11]. However, healthy elderly subjects did not have any residual accumulation in their pharynx after swallowing [15].

Age-Related Changes in the Esophagus

The esophageal phase is delayed in the elderly because of longer upper esophageal sphincter (UES) relaxation time [11]. Aging leads to reduced UES pressure [17,18], but with preserved response to esophageal distension [18]. One study found that men had greater UES axial asymmetry, whereas women had greater UES pressure after wet swallows [19]. Radiologic abnormalities involving the pharyngoesophageal segment or the esophageal phase were seen in approximately one-third of older patients without dysphagia [10].

Secondary Causes

Secondary causes result from various pharmacologic agents, medical conditions, and neurologic conditions that affect the elderly [1,20].

Drugs

Most drugs that interfere with neurotransmitters, with oro-lingual activity, or with salivary production can result in significant alteration of swallowing.

Neurologic Conditions

Various neurologic conditions, including cerebrovascular accidents, head trauma, motor neuron disease, neuromuscular transmission disorders, and extrapyramidal conditions will lead to significant impairment of swallowing [21]. These conditions result in additional compromise of the oropharyngeal swallow safety mechanism. A recent study [22] found correlation between the impairment of the oropharyngeal swallowing phase and the presence of unidentified bright objects observed incidentally on head magnetic resonance images (MRIs) performed on elderly subjects. Another study also found alteration of pharyngeal clearance and swallowing pressure in patients with prominent cervical osteophytic formations [23].

Finally, various other conditions, particularly malignancies, will affect the swallowing of elderly subjects. These factors must all be taken into account during the evaluation and management of elderly subjects.

Summary

A review of the main phases of swallowing reveals several age-related alterations in the oral, pharyngeal, and esophageal phases of deglutition. These variations in the healthy elderly must be taken into account during their clinical and radiologic evaluation. Despite their presence, these changes do not normally impair the safety and efficiency of the swallowing process. However, they can result in significant alterations in reaction to various secondary factors.

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