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Name of Journal: *World Journal of Clinical Cases*

Manuscript NO: 83328

Manuscript Type: REVIEW

Presbyphagia: dysphagia in the elderly

Effect of aging on swallowing function

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Abstract

Dysphagia has been classified as a “geriatric syndrome” and can lead to serious complications that result in a tremendous burden on population health and healthcare resources worldwide. A characteristic age-related change in swallowing is defined as “presbyphagia.” Medical imaging has shown some changes that seriously affect the safety and efficacy of swallowing. However, there is a general lack of awareness of the effects of aging on swallowing function and a belief that these changes are part of normal aging. Our review provides an overview of presbyphagia, which has been a neglected health problem for a long time. Attention and awareness of dysphagia in the elderly population should be strengthened, and targeted intervention measures should be actively implemented.

Key Words: Aging; Dysphagia; Presbyphagia; Geriatric syndromes; Swallowing

FENG H, ZHANG P, WANG X. Presbyphagia: dysphagia in the elderly. *World J Clin Cases* 2023; In press

Core Tip: Dysphagia in older people is unfortunately considered a part of aging. Many factors contribute, such as decreased cognitive function, loss of teeth, reduced muscle strength, decreased taste and olfaction, altered salivary secretion, impaired cough and swallowing reflexes, altered hyoid bone and larynx position, reduced laryngeal adductor reflex, decreased tongue root retraction, incomplete esophageal sphincter opening, reduced pharyngeal constriction and sensation, reduced breathing and swallowing coordination, and decreased esophageal motility. Several may be amenable to therapeutic strategies, including rehabilitation, to improve, and even restore swallowing function at the anatomical and physiological levels. Improved screening, clinical assessment, and diagnostic procedures are needed.

INTRODUCTION

The effects of aging on swallowing are multifaceted, insidious, and frequently considered a natural part of aging. Older adults gradually develop characteristic changes in swallowing during aging; this phenomenon is called “presbyphagia”^[1]. Dysphagia can affect the safety and effectiveness of swallowing, causing severe complications, and affect social interactions, quality of life, and mental health due to fear and anxiety about eating^[2,3]. It also increases the financial burden on patients and the healthcare system. Bonilha *et al.*^[4] observed that yearly medical costs for patients with dysphagia were \$4,510 higher than those for patients without dysphagia.

However, the problem of presbyphagia continues to be overlooked by most patients, families, and medical practitioners due to the perception that these physiological changes constitute a part of aging. This review aims to raise awareness and understanding of presbyphagia as a critical health problem, improve the diagnostic criteria for presbyphagia, guide interventions, and enhance prevention and treatment performance.

EFFECTS OF AGING ON SWALLOWING FUNCTION

During aging, physiological functions continue to decline and gradually lose their integrity. This deterioration process is also a major contributor to the risk of dysphagia. Functional degradation is mediated by characteristic molecular and cellular phenomena associated with normal aging. These phenomena can be divided into three categories: primary, antagonistic, and integrative hallmarks^[5]. When environmental homeostasis mechanisms within the tissue cannot compensate for the cumulative damage caused by primary and antagonistic hallmarks, the integrative hallmarks arise and ultimately lead to age-related functional decline^[5,6].

Nervous system changes

Changes in neural structure, brain chemistry, and related functions occur and accumulate with age, making aging a major risk factor for neurodegeneration. Malandraki *et al.*^[7] used functional magnetic resonance imaging to compare sites of central nervous activation during swallowing in healthy older adults with those in

younger adults. They found that activation of the areas corresponding to sensory processing, sensorimotor integration, and motor coordination and control is diminished in healthy older adults compared to younger adults. The cerebral blood flow is reduced, the cortical sulcus is widened, and the ventricles are enlarged. Furthermore, the volume of some nuclei is reduced, and the ability to process neural information is diminished^[8]. The functional and electrophysiological properties of the peripheral nervous system are affected by aging, manifesting as decreased nerve conduction velocity, autonomic responses, endoneurial blood flow, and sensory discrimination^[9,10].

Skeletal changes

Cellular senescence increases with age, and senescent chondrocytes accumulate and produce a factor that inhibits cartilage regeneration^[11-13]. Epiglottis and paired arytenoid cartilages play an important role in preventing aspiration. Aged cartilage changes shape and becomes less elastic, weakening the protective capacity of the airway. More than 75% of adults aged >65 years suffer from degenerative changes in the cervical spine; cervical osteophytosis affects swallowing in older adults through various mechanisms, causing frequent coughing and choking^[14,15].

Muscle changes

Research has shown that total muscle mass in older adults decreases by 0.5–1.0% per year, with a cumulative decrease of 30–50% by 80 years of age^[16,17]. Forty muscles are involved in the complex physiological activity of swallowing^[2,18,19]. The strength of muscle contraction decreases with age^[20]. The tendon transmits the force of the muscle fiber contraction to the bone. During aging, the water and proteoglycan content of tendons decreases, while calcification and fat accumulation increases, leading to decreased tensile strength and stiffness in the tendons, impaired flexibility and coordination of physiological activities required for swallowing, and increased risk of serious complications in older adults^[21-23].

Respiratory function

The number of lung epithelial cells gradually decreases with aging, the proportion of fibroblasts increases, and surfactant secretion is impaired, leading to a decline in lung

volume and elasticity^[24]. The change in thoracic shape serves to reduce chest wall compliance, as shown by altered spinal physiological curvature, increased sternal curvature, and thinning of chest wall muscles^[25-27]. Significantly reduced pulmonary function and chest wall compliance decrease the ability of older adults to clear respiratory residue and increase the risk of food entering the respiratory tract.

Overall situation

Older adults are more susceptible to weight loss and malnutrition due to a diminished sense of smell and taste, which affects their appetite and dietary preferences^[28,29]. Simultaneously, cortical decompensation reduces physiological sensitivity to osmotic pressure and volume stimuli in older adults, diminishes self-perception of thirst, causes defects in fluid regulation, and tends to result in dehydration^[30]. Weakness and aging go hand in hand, manifesting as a weakening of the body's ability to resist and adapt^[31]. Dehydration and malnutrition can worsen weakness and lead to muscle atrophy, decreased immunity, and reduced functional reserve. Weakness can, in turn, contribute to the deterioration of swallowing function, reducing the safety of swallowing and increasing the risk of aspiration.

STAGES OF PRESBYPHAGIA

Oral preparatory stage

The oral preparatory stage is controlled by human will (*i.e.*, food is placed in the mouth, stirred, chewed, and processed into a bolus) (Figure 1). The main changes occurring during this stage are as follows.

1. Decreased cognitive function

Overall, the brain's weight and cortical surface area decrease with age; a rigorous survey demonstrated that 40% of older adults show symptoms of cognitive impairment^[32]. Compared with younger adults, hemispheric specialization is reduced or altered in older adults, necessitating the recruitment of a higher volume of brain areas to compensate for the increased task demands during swallowing^[33,34]. The main manifestation of this stage is a cognitive bias regarding the texture, quantity,

temperature, taste, and smell of food. Affected individuals may also show the following symptomology: difficulty concentrating, lower responsivity, impaired casual eating movements, poor coordination, lack of flexibility in adjusting the speed of eating and food intake, and inability to judge in advance how the food will be handled in the mouth^[35].

2. Decreased number of teeth

A controlled trial conducted by Feldman *et al.*^[36] found that individuals with a greater number of teeth (within an age-matched group of older individuals) chewed more efficiently than those with a smaller number of teeth. Missing teeth reduced masticatory efficiency (16–50%), prolonged the residence time of food in the mouth, and affected older people's choice of food. The prevalence of root caries in people aged >60 years is twice as high as in young people, and 64% and 96% of people aged >80 years have root and crown caries, respectively^[37,38]. When the neurovascular structures in the dental pulp are involved, the teeth may become sensitive, painful, and even infected (*i.e.*, bacteremia)^[39]. This may lead to a reduced intake of vegetables, fruits, and nuts, thus affecting nutritional status. Hence, people without teeth are more likely to suffer from weight loss and malnutrition^[37,40].

3. Reduced muscle strength

Reduced contraction of the orbicularis oris muscle frequently occurs during aging—approximately 20% of older adults are unable to keep their lips closed while swallowing, and food and liquids flow out of their mouths^[41]. The cross-sectional area of the masticatory muscles (*i.e.*, the masseterica, temporalis, pterygoideus medialis, pterygoideus lateralis, buccinator, zygomaticus, and mentalis) decreases during the aging process, resulting in a decrease in the force of muscle contraction. The tongue muscles show muscle atrophy and increased connective tissue, reduced muscle strength and range of motion, and decreased flexibility^[1,42,43]. Moreover, older adults have a decreased swallowing pressure reserve and lower maximum tongue pressure compared to younger adults^[44]. Hence, food spreads in the mouth and stays longer.

4. Decreased taste and olfaction

The number of nerve fibers and receptors on the olfactory bulb decreases significantly with age. Olfactory function deteriorates progressively with aging such that >34.5% of older adults have olfactory impairment^[45]. Older adults have thinner oral mucosa, weaker secretion, fewer chemoreceptors, and reduced taste perception^[46]. During the oral preparation period, olfactory and gustatory information converges on specific brain neurons, activating the amygdala, insular cortex, and anterior cingulate cortex regions; reduced olfaction and gustation can lead to reduced appetite^[47]. Compared to younger adults, older adults need two to three times the salt concentration to experience the same saltiness in their food. Older adults prefer sweet and salty foods due to a diminished sense of taste; this increases their risk of obesity, cardiovascular disease, and metabolic disorders^[48,49]. Therefore, nutritional problems are important complications of olfactory and gustatory disorders. A 5-year follow-up study^[50] showed that a reduced sense of taste and smell affects the quality of life of older persons and is detrimental to their mental health.

5. Altered salivary secretion

¹ The prevalence of xerostomia increases with age, affecting approximately 30% of the population aged ³⁶⁵ years^[51,52]. Aging affects salivary gland secretion and decreases inorganic ion concentrations, thereby increasing the threshold for eliciting taste sensations. Further, the number of salivary secretory cells decreases with age, causing diminished sensitivity in taste receptor cells and affecting taste perception^[53]. Reduced saliva production also affects the forward movement of food in the mouth, increases oropharyngeal residue, aggravates xerostomia, and increases the risk of poor oral hygiene in older adults.

Oral transport stage

The tongue pushes the bolus backward towards the pharynx in a process termed the oral transport stage. The soft palate plays an important role in this stage: it hangs between the oropharynx and nasopharynx, preventing food from falling into the pharynx prematurely and/or flowing backward into the nasopharynx during swallowing^[47] (Figure 2).

1. Diminished flexibility tension in the soft palate

The soft palate is composed of connective tissue and muscle. Muscle fiber number, length, and cross-sectional area all decrease due to aging, and increased connective tissue and lipid deposition in the soft palate reduce its flexibility and range of motion^[54-56]. When the closure of the tongue and soft palate is inadequate, food can fall into the pharynx and the open expiratory pathways before the swallowing response is triggered, leading to pre-swallowing aspiration^[57]. Aerodynamic studies have shown that older speakers exhibit a similar nasal airflow and air volume compared to younger speakers and that velopharyngeal function does not deteriorate with age^[58].

Pharyngeal stage

The pharyngeal stage represents the period when the bolus enters the pharynx and reaches the esophagus through the open upper esophageal sphincter (UES) (Figure 4). Physiological activity during this period is rapid and complex. In a previous study, videofluoroscopic swallowing studies (VFSSs) were performed on 56 healthy older people, and only 16% of them had normal swallowing function^[59]. Pharyngeal residue was the most frequent phenomenon during imaging, though it did not cause significant clinical symptoms in most cases^[59-61]. Increased pharyngeal residue is usually associated with weak tongue extrusion and diminished pharyngeal clearance^[62]. VFSSs revealed that frail older individuals had severely impaired swallowing and coughing reflexes. Up to 55% of older adults show fluid penetration into the laryngeal vestibule during swallowing; approximately 15% show fluid crossing the vocal cords to reach the trachea and bronchi, which eventually causes aspiration^[41]. Studies^[63-67] have also shown physiological changes in older adults, such as delayed swallowing response, altered distance and time with respect to hyoid and laryngeal elevation, delayed laryngeal closure, and incomplete opening of the UES. These age-related changes result in a higher incidence of permeation and aspiration, significantly reducing the safety of swallowing in older adults (Figure 3).

1. Impaired cough and swallowing reflexes

The airway protective reflexes include coughing and swallowing reflexes, which are important for preventing aspiration pneumonia^[68]. Tracy *et al.*^[69] measured the initiation time of the swallowing reflex in different age groups; they found that the swallowing response initiation time was on average 0.4 s longer and the sensitivity of the swallowing reflex area was reduced in older adults. The decrease in the number of myelin sheaths with age leads to reduced sensory input, and older adults require a larger bolus volume to elicit a swallowing reflex^[70-72]. Frequently, the bolus has fallen into the pharynx by the time older adults begin swallowing. Most older adults with impaired swallowing reflexes also have impaired cough reflexes. The cough reflex is significantly weakened and suppressed in older patients with aspiration pneumonia; this may be related to the disruption of the cortical facilitation pathway and the medullary reflex pathway of cough caused by aging^[73,74].

2. Altered anatomical position of the hyoid bone and larynx

The anatomical positions of the hyoid bone and larynx are altered in older persons due to changes in spinal morphology and reduced muscle tone. Additionally, the larynx descends to a position close to C7 in older persons aged >70 years. However, the distance traversed by the larynx during swallowing does not decrease^[43]. Accordingly, older individuals need more time to complete the movement that mediates laryngeal elevation^[75]. Functional reserve describes the difference between a maximal effort and a normal swallowing task^[76]. Aging decreases the speed of hyoid bone and laryngeal elevation, reducing the functional reserve in older adults and increasing the risk of swallowing problems^[66,75]. Changes in the anatomical positions weaken the protective mechanisms of the respiratory tract and affect the duration and degree of opening of the UES, hence preventing the smooth passage of the bolus from the pharynx into the esophagus^[47,77,78]. The hyoid bone is connected to the larynx through the thyroid hyoid membrane; the movement of the hyoid bone generates a pulling force on the larynx, which is then transmitted to the UES by means of the cricoid cartilage. This is the initial force that causes the cricopharyngeal muscle to open by approximately 8 mm^[75,79-81].

3. Reduced laryngeal adductor reflex

Superior laryngeal nerves play an important role in sensation and autonomic innervation. Mortelliti *et al.*^[82] used electron-microscopic morphometric techniques to observe the difference between the superior laryngeal nerves of older adults and younger people. They showed that the myelinated nerve fiber count in older people decreased by 31% compared to that in younger people ($P = 0.032$). The ammonia concentration required to trigger laryngeal closure is six times higher in older adults than in younger adults^[83]. The occurrence of silent aspiration is not only related to motor abnormalities, but is also largely influenced by sensory abnormalities^[84]. Randomized controlled trials have shown that patients with laryngopharyngeal sensory deficits have difficulty inducing the laryngeal adductor reflex (even under intense stimulation) and a significantly higher risk of penetration and aspiration than controls^[85]. Patients lacking the laryngeal adductor reflex have a 6.8 times increased risk of pneumonia (odds ratio: 6.75; 95% confidence interval: 1.76–25.96)^[86].

4. Decreased tongue root retraction

Retraction of the tongue root is one of the main driving forces on the bolus during the pharyngeal stage and is especially important for the smooth entry of the bolus into the pharynx. Cook *et al.*^[87] found that aging causes a decrease in tongue root retraction. It is speculated that this is a compensatory mechanism due to the increased threshold of the swallowing reflex in older persons; reductions in tongue root retraction movement can increase the accumulation of food in the oropharynx, making it easier to trigger pharyngeal-stage swallowing. On the other hand, the reduced retraction of the tongue root weakens its ability to remove food from the pharynx, resulting in increased pharyngeal residue^[88,89].

5. Incomplete opening of the UES

The resting pressure of the UES in older persons is 43 ± 5 mmHg, which is significantly lower than that in younger persons (71 ± 8 mmHg; $P < 0.05$)^[90]. With aging, the number of UES muscle fibers decreases, and the excitatory impulses that maintain cricopharyngeal tension also gradually reduce^[91]. An inadequate UES pressure decrease during swallowing was observed in 15.4% of older adults aged 60–69 years and 30.4%

of older adults aged 70–83 years, while 39% had inadequate UES opening^[59, 92]. The UES pressure decreased more slowly in older adults, and there was a delayed opening time and significantly fewer UES openings than in younger adults^[92-94]. Aging increases muscle connective tissue, which results in a decrease in the elasticity and compliance of the UES^[94]. The degree and duration of UES opening are abnormal, increasing the risk of pharyngeal residual and aspiration.

6. Reduced pharyngeal constriction and sensation

There is prolonged bolus passage through the pharynx when healthy older adults swallow their food^[92]. The pharyngeal sensation is significantly reduced in older adults compared to younger adults. A disrupted pattern of cortical activation is observed in older adults, and their ability to find and remove residual food from the pharynx is reduced^[90,95,96]. Increased pharyngeal residue is the most common imaging sign in older adults, and the amount of pharyngeal residue is positively correlated with age^[87, 89]. Reginelli *et al.*^[97] conducted a VFSS study on older adults and observed that they had a higher prevalence of post-swallowing aspiration than younger adults—this is usually caused by foods remaining in the pharynx.

7. Reduced coordination of breathing and swallowing

Swallowing and breathing share a common anatomy; hence, food and liquids must be secured as they enter the digestive tract by ensuring that the respiratory tract is closed. Shaker *et al.*^[98] reported reduced coordination between swallowing and breathing in older persons and found that aging leads to substantially longer pauses in breathing during swallowing. Older adults take longer to return to normal tidal breathing than young individuals^[47]. Aging also reduces respiratory function and weakens airway clearance^[24].

Esophageal stage

The esophageal stage begins at the tip of the esophagus. The bolus passes through the esophagus under peristaltic contraction and gravity, the lower esophageal sphincter opens, and the bolus enters the stomach (Figure 4).

1. Decreased esophageal motility

Myenteric neurons in the esophagus steadily decline with age, causing dysmotility associated with denervation^[99]. Secondary esophageal peristalsis removes refluxed contents from the esophagus and is one of the airway protective mechanisms^[100]. Ling *et al.*^[101] found a reduced incidence of secondary esophageal peristalsis and a decreased esophageal response to low-volume ultra-slow reflux in older adults. In the absence of secondary peristalsis of the esophagus, reflux containing gastric acid will stay in the esophagus for a longer time and easily cause reflux esophagitis^[102]. Biomechanical changes in the esophagus during aging were observed: the esophageal wall changed in stiffness, circumferentially and longitudinally, with age ($P < 0.05$ and $P < 0.01$, respectively)^[103]. Although the percentage of muscle fiber types in the esophagus does not change meaningfully in older persons, a prior study demonstrated a statistically significant increase in muscle fiber diameter due to atrophy and compensatory hypertrophy^[104].

INTERVENTION MEASURES

Rehabilitation education

Rather than directly improving the physiological function of swallowing in older adults, rehabilitation education minimizes or eliminates the symptoms of swallowing dysfunction and reduces the occurrence of adverse events. These include postural adjustment, adjustment of eating strategies, use of assistive devices, and periodic oral care^[105,106]. Swallowing forcefully in older adults can help to increase pharyngeal pressure, and the downward swallowing position of the lower jaw can change the biomechanical relationship during swallowing and reduce the occurrence of aspiration^[106]. Adjustments to diet and eating strategies are the most common compensatory methods. For example, older people should eat slowly, not eat while watching TV, not talk while eating, avoid eating when tired or in a hurry, avoid taking too much in one bite, and avoid swallowing mixed foods and liquids. Single texture foods are easier to swallow. Foods that are relatively viscous and easy to form are also easier to swallow. Assistive devices, such as those used for placing, guiding and

controlling food or fluids during swallowing, can increase or prolong eating independence. Paying attention to oral hygiene can also reduce the risk of developing aspiration pneumonia in older people with dysphagia.

Rehabilitation therapy

Rehabilitation training can improve the physiological function of swallowing and reduce the risk of complications^[105], and ageing-induced muscle weakness can be improved by rehabilitation training. In a study involving older people, isometric resistance training of the buccal surface, lips, tongue and related oropharyngeal muscles for 8 wk significantly improved swallowing function^[107]. In another study, ice stimulation improved sensitivity of the soft palate and pharynx, increased sensory input, excited neurons in the motor pathway and promoted axonal regeneration of neurons^[108]. Additionally, respiratory training improved the coordination of swallowing and breathing and enhanced the ability of the respiratory tract to clear foreign bodies^[109]. Finally, simple shaker training in older people improved cricopharyngeal opening, prolonged its opening time, and improved the strength of the supraglottis muscle group and the thyrohyoid muscle^[105].

CONCLUSION

Many people, including healthcare practitioners, assume that some age-related changes in swallowing are part of natural aging. However, imaging signs show that some changes may affect the effectiveness and safety of swallowing and lead to severe complications^[41,64,89]. Presbyphagia is a common and dangerous, but widely neglected health problem. First, improving the awareness of presbyphagia among medical staff is necessary. We need to understand the mechanisms through which aging affects swallowing function, as well as improve our ability to recognize presbyphagia and its manifestations. Second, screening and assessment of high-risk groups should be performed as early as possible. However, the current screening and clinical assessment process for dysphagia in older adults is not standardized. Further research is needed to improve and standardize screening tools, clinical assessments, and instrumental

diagnostic procedures. Finally, it has been well documented that rehabilitation therapy positively affects the anatomical structures and sensory-cortical-motor circuits related to swallowing. Additionally, it can directly and effectively improve and restore swallowing function at the anatomical and physiological levels^[105,110-112]. In recent years, non-invasive brain stimulation has been shown to induce plasticity changes in the swallowing motor cortex, resulting in increased cortical excitability and ultimately improving swallowing disorders in older adults^[113,114]. Taste^[115], olfaction^[116], and vision^[117] can also alter cortical excitability or activate the swallowing motor cortex. However, there is no standard intervention at present to manage dysphagia in older adults. Further clinical research is required to facilitate the development of clear guidelines to address this issue.

ORIGINALITY REPORT

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Jonathan A. Ship. "Xerostomia and the Geriatric Patient", Journal of the American Geriatrics Society, 3/2002

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