Swallowing impairment, or dysphagia, is highly prevalent in the aging population. Common sequelae include malnutrition, dehydration, pneumonia, pulmonary abscess, depression, social isolation, and ultimately death. Healthy aging can deleteriously affect central neural mechanisms governing swallowing, peripheral muscle strength and endurance, and upper aerodigestive tract sensation. Collectively, these age-related alterations to the swallowing mechanism of otherwise healthy individuals are termed presbyphagia and functionally equate to a diminished functional reserve, making the older population more susceptible to dysphagia. In addition to the effects of natural aging on deglutitive function, a higher incidence of medical comorbidities and pharmacologic treatments known to adversely affect swallowing contribute to a high prevalence of dysphagia in older adults. As the aging population represents the fastest growing demographic in the world, an advanced understanding of the effects of aging on swallowing function is essential for health-care professionals. The purpose of this article is to provide a review of age-related changes in the swallowing mechanism across the lifespan.

**KEY WORDS:** Deglutition - Aging - Deglutition disorders - Eating - Pneumonia.

Deglutition is a highly complex process involving both volitional and non-volitional components and the intricate coordination of over 26 pairs of muscles and six cranial nerves (V, VII, IX, X, XI, XII). On average, the human swallows approximately 600 times a day and will spend an estimated 1.5 hours eating each day, the equivalent to 40,000 hours of eating in his or her lifetime.¹ The ability to swallow safely and efficiently is a basic human need and a pleasurable daily experience. Impairment in swallowing function has devastating health implications that include increased risk of chest infection, disability, length of hospital stay and institutional care;² malnutrition;³ compromised quality of life, mental well being, social functioning anxiety, depression, and death. These serious and life-threatening sequelae are particularly apparent in elderly individuals who demonstrate swallowing impairment.

The aging population and swallowing

Epidemiological data denotes that the prevalence of dysphagia, or swallowing impairment, increases with age. In assistive living facilities, it has been reported that 40% of residents demonstrate swallowing impairments,⁴ while in a nursing home setting, 75% of occupants have been diagnosed with dysphagia. In the general population, swallowing difficulties have been reported in approximately 22% of adults over 50 years, 40% over 65 years and are present in most individuals by 80 years.⁵ Finally, in an acute care teaching hospital, Leder and Suiter⁶ noted that 70%
of referrals were in individuals older than 60 years of age and that referrals almost doubled for individuals aged 80-89 and more then tripled in patients over the age of 90.

The etiology for the noted decline in swallowing function with increasing age is likely attributable to general changes associated with healthy aging. These include: 1) changes in the central neural mechanisms governing swallowing; 2) anatomic changes in peripheral corticobulbar structures and 3) degradation of efferent and afferent processes of the upper aerodigestive tract. Collectively, these age-related alterations in the swallowing mechanism of otherwise healthy individuals are termed presbyphagia and functionally equate to a diminished functional reserve, making the older population more susceptible to dysphagia. An additional etiology of the noted age-related increase of dysphagia is that general disease prevalence also increases with age and dysphagia is a known comorbidity of many age-related illnesses.

While the prevalence of dysphagia in the aging population may seem alarming, there is potential for increased numbers in the near future since older adults are the fastest growing age group in the United States. In 2011, the oldest of the baby boomers will be turning 65 at a rate of 7000 per day and it is estimated that by the year’s end, a total of 2.5 million baby boomers will have turned 65. Further, while individuals over the age of 65 years comprised 12.9% of the US population in 2009, they are expected to represent 19% of the population by 2030. Given our aging population and growing evidence that dysphagia affects a significant number of elderly individuals, our need to understand associations between aging and swallowing is clear. The purpose of this article is to provide a review of age-related changes in the swallowing mechanism across the lifespan.

**Changes in central neural mechanisms governing swallowing**

It is now well known that cortical, sub-cortical and brainstem structures all play a critical role in deglutition. Two recent studies have specifically investigated the effects of aging on neural activation patterns during swallowing using functional magnetic resonance imaging (fMRI). Humbert et al. reported significant neurophysiological age-related changes during swallowing of saliva and a 5ml liquid bolus. Specifically, healthy older participants were observed to activate greater neural activity (higher BOLD responses) across a larger region of the cortical swallowing network that included the pre- and postcentral gyri, frontal lobes, superior temporal gyrus and the ventro-lateral post-central gyrus as compared to the healthy young adults during equivalent bolus swallows. It was hypothesized that the increased neural activation observed in older adults to swallow was likely attributable to a requirement for greater effort and resources as has been noted across other motor modalities.

Malandraki et al. also utilized fMRI to examine cortical laterality activation patterns during swallowing and three swallow-related tasks (tongue tapping, throat clearing and preparing to swallow) in “young” and “old” healthy adults. In this study, cortical hemispheric control of swallowing and throat clearing became more symmetric and bilateral with increasing age. Malandraki et al. posited that the observed cortical alterations in older adults represented neural compensatory mechanisms of the aging brain during swallowing. Certainly a more widespread neural swallowing network with less lateralization (as is seen in younger adults) would provide the framework for a built in neural reserve and greater capacity for compensation in the face of focal neurologic insult as is commonly observed in the elderly.

These preliminary data in healthy adults suggest that the neural network governing deglutition changes with normal aging and specifically is activated to a greater extent and across a wider and less lateralized network during swallowing. These changes may reflect the need for increased neural drive to perform the same motor sequence with aging and represent a form of neural compensation in a system with less neural resources and with a greater risk for disease or insult to focal areas. Future studies are needed to further elucidate the precise nature of these differences in both healthy and disordered (dysphagic) individuals across the life span.

**Anatomic changes in peripheral corticobulbar structures**

Alterations in the peripheral corticobulbar structures involved in swallowing have been widely documented. Sarcopenia, the age-related loss of muscle
mass, strength and function is a well-known phenomena that occurs with normal aging, and has been documented across peripheral swallow structures, chambers and valves that comprise the upper aerodigestive tract critical for safe, timely and efficient swallowing.

Specific anatomic differences noted in structures of the upper aerodigestive tract in older adults include: increased atrophy, increased fatty infiltration and decreased muscle fiber diameter of the tongue, decreased muscle, elastic and collagenous fibers in the hyoepiglottic ligament, atrophy of slow twitch fibers in the thyroarytenoid muscle; diffuse dilation of the pharynx; decreased thickness of the posterior pharyngeal wall; smaller upper esophageal sphincter diameter (UES); the appearance of cricopharyngeal bars in nondysphagic elderly; rigidity of the esophagus and lower esophageal sphincter (LES). These noted anatomical differences transcend functionally to reduced physiological reserve, strength and pressure generation capabilities during the various stages of swallowing. During the oral phase, reductions in lingual strength, maximum lingual isometric pressure, time taken to reach peak pressure and multiple lingual gestures required to reach peak pressure (termed “pressure building”) have been noted with advanced age. During the pharyngeal phase of deglutition, reductions in pharyngeal pressures have been noted and the aforementioned smaller UES diameter associated with a reduction in sphincter distensibility, as well as reduced anterior excursion of the larynx and the hyoid bone. Diminished respiratory muscle strength and decreased elasticity of the lungs reduce older individuals ability to efficiently protect their airway and thereby place them at higher risk for aspiration and subsequent pneumonia. During the esophageal phase, rigidity of the esophagus is characterized functionally by reduced primary and secondary peristalsis in the elderly and less frequent LES relaxation is observed in the aging population.

Physiologic changes in the sensory-motor control of swallowing

The aforementioned age-related central and peripheral alterations in the upper aerodigestive tract lead to physiologic sensory-motor changes in swallowing in older adults. Efferent alterations include changes in bolus transit durations, timing of swallow gestures, range of motion of corticobulbar structures and coordination of oropharyngeal swallowing with the respiratory system. Swallowing is generally known to become slower with increasing age with noted increases in the time and effort required to prepare and masticate food during the oral preparatory stage; longer oral transit times (on average by 0.5-0.6 seconds); longer oropharyngeal transit times; delayed triggering of the pharyngeal swallow; prolonged pharyngeal wall contraction times; longer pharyngeal transit times; prolonged esophageal transit time; delayed esophageal emptying; increased duration of esophageal peristaltic pressure waves; and increased total swallow duration documented with increasing age.

Subtle changes have also been noted in respiratory patterns during swallowing in older adults. Specifically, older adults have demonstrated longer apnea duration during the swallow; close the airway significantly earlier prior to UES opening and demonstrate prolonged swallow apnea offsets compared to younger adults. These temporal changes are thought to be a compensatory mechanism to protect the airway during the prolonged oral and pharyngeal transit times observed in older adults.

In addition to these temporal variations in the aged swallow, reductions in range of motion of various corticobulbar structures have been noted that include the base of tongue; hyoid bone; hyolaryngeal complex; pharynx; UES; esophagus and LES.

Afferent function of the upper aerodigestive tract is also known to deteriorate with age. In the oral cavity, noted sensory alterations include diminished perception of viscosity and taste; increased sensory discrimination thresholds; decrease spatial tactile recognition on both the tongue and lips. In the pharynx and upper airway, thresholds to elicit vocal fold adduction during swallowing and the pharyngo-UES contractile reflex are higher in elderly adults, and sensation in the esophagus is reduced as evidenced by increased tolerance to typically painful distention in older adults.

Comorbidities and aging

An increase of neurologic disease, a decline in nutrition and the addition of medications to abate aging
ailments are also known to contribute to swallowing impairments in older adults. As we age, neurologic insult and disorders including stroke, Alzheimer’s disease, dementia and Parkinson’s disease are more prevalent and affect swallow function.61 The noted prevalence of neurologic disease along with alterations in pharmacokinetics and tissue sensitivity leads in turn to a higher prevalence of adverse drug reactions in the aging population.62 This finding likely further inflates the number of older adults experiencing dysphagia. Further, older individuals are more likely to use prescription and non-prescription drugs than younger adults 62 that can cause detrimental side-effects that either directly or indirectly affect swallowing function. For example, anticholinergic drugs such as those used to treat depression are known to decrease salivation and contribute to a ‘dry mouth’, poor bolus formation, decreased lubrication and bolus clearing. Other noted side effects to pharmacologic interventions include: alterations in alertness; increased fatigability; slowed coordination; deterioration in mastication; taste perception; cough sensitivity; bolus control; laryngeal elevation; and glottal closure.51

Nutritional decline represents another comorbidity associated with aging that can influence swallowing function. Advancing age has been associated with loss of appetite, metabolic disturbances leading to the loss of tissue protein, inadequate protein balance, diminished reserves, catabolic states, weight loss and malnutrition.3 Older individuals are therefore highly vulnerable to infection and conditions of stress that adversely affect tissue growth, wound healing and cell-mediated immune responsiveness.3 Therefore nutritional decline represents another age-related condition that predisposes individuals to an increased risk of developing dysphagia and as a result, further nutritional deficits most notable of which is malnutrition.3

Conclusions

In summary, older adults swallow with a diminished reserve in the presence of central and peripheral nervous system changes, efferent and afferent deterioration of the upper aerodigestive tract and age-related comorbidities. With the rapidly approaching increase in the aging population, there is great need for effective service delivery and sufficient resources to manage swallowing disorders in the elderly.

Riassunto

Affezioni centrali, periferiche e da comorbilità sulla deglutizione legate all’invecchiamento normale e patologico

La compromissione della deglutizione, o disfagia, è molto diffusa nella popolazione che invecchia. La sequela comune include malnutrizione, disidratazione, polmonite, ascesso polmonare, depressione, isolamento sociale e in-fine morte. Anche in buona salute l’invecchiamento può influire, in modo deleterio, sui meccanismi neurali centrali che regolano la deglutizione, la forza e la resistenza dei muscoli periferici e la sensibilità del tratto aero-digestivo superiore. Complessivamente, queste alterazioni, legate all’età, del meccanismo di deglutizione di soggetti altrimenti sani vengono denominate presbi-fagia e funzionalmente equiparate a una ridotta riserva funzionale che rende la popolazione più anziana maggiormente suscettabile alla disfagia. In aggiunta agli effetti dell’invecchiamento naturale sulla funzione deglutitiva, una maggiore incidenza di comorbilità mediche e trattamenti farmacologici noti per influenzare negativamente la deglutizione portano a un’elevata prevalenza di disfagia negli adulti più anziani. Dato che la popolazione anziana sta crescendo rapidamente a livello demografico nel mondo, diventa essenziale per gli operatori sanitari avere una conoscenza approfondita degli effetti dell’invecchiamento sulla funzione deglutitiva. Lo scopo di questo articolo era fornire una recensione dei cambiamenti, nel corso della vita, del meccanismo di deglutizione legato all’età.

PAROLE CHIAVE: Deglutizione - Invecchiamento - Deglutizione, disordini - Alimentazione - Pneumonia.

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