Dysphagia in the Elderly

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Introduction

The capacity to effectively and safely swallow or eat is one of the most basic human needs and also can be a great pleasure. Sustaining oneself nutritionally and maintaining adequate hydration while enjoying the process has become intertwined with the activities of society. In fact, older adults look forward to more opportunities to share mealtimes and participate in social interactions including holidays, family occasions and traditions centered on meals and specific foods. Therefore, the loss of the capacity to safely swallow and enjoyably dine can have far reaching implications from sustaining life to quality of life. An ultimate irony is that as we grow older, the ability to swallow, a function very much taken for granted, undergoes changes that increase the risk for disordered swallowing. This occurs with increasing age and exposure to age-related diseases and conditions. Indeed, the loss of the capacity to swallow can have devastating health implications, including nutrition and hydration deficits, especially for older adults.

According to the US Census Bureau, as of July 1, 2005, there were an estimated 78.2 million American baby boomers (those born between 1946 and 1964). In 2006, baby boomers began turning 60 at a rate of about 330 every hour. With the rapid and dramatic growth in the U.S aging population, dysphagia is becoming a national health care burden and concern.

Dysphagia prevalence depends on the specific population sampled, with community dwelling and more independent individuals having rates near 15 percent. Upward of 40 percent of people living in institutionalized settings such as assisted living facilities and nursing homes are dysphagic[1]. With the projected growth of individuals living in nursing homes, there is a compelling need to address dysphagia not only in ambulatory and acute care settings but also in long-term care settings.

Presbyphagia versus Dysphagia

Although the anatomical, physiological, psychological and functional changes that occur in the dynamic process we refer to as "aging" place older adults at risk for dysphagia; a healthy older adult's swallow is not inherently impaired. *Presbyphagia* refers to characteristic changes in the swallowing mechanism of otherwise healthy older adults[2]. Clinicians are becoming more aware of the need to distinguish among dysphagia, presbyphagia (an old, yet healthy, swallow) and other related diagnoses in order to avoid over diagnosing and over treating dysphagia. With the increased threat of acute illness, multiple medications, and any number of age-related conditions, older adults are more vulnerable and can cross the line from a healthy older swallow to a person with dysphagia in association with certain perturbations including acute illness, surgery, chemo radiation and other factors. Previous work has focused primarily on the anatomy and physiology of the oropharyngeal swallowing mechanism. Age effects on the temporal evolution of isometric and swallowing pressure[2–8] indicate a progression of change that, when combined with naturally diminished functional reserve (the resilient ability of the body to adapt to physiological stress[9] make the older population more susceptible to dysphagia. We review age-related changes in peripheral and central nervous system control of head and neck structures for swallowing in this paper. In addition, we briefly discuss promising strategies for neurorehabilitation of dysphagia that are based upon the recognition that swallowing disruption may, in part, be a manifestation of "sarcopenia", the age-related loss of skeletal muscle mass, organization and strength[10] as well as age-related changes in sensorimotor acuity and efficiency.

Healthy Swallowing Overview

Normal oro-pharyngeal swallowing involves closely integrated sensory and motor events that begin with the sight and smell of approaching food until material has safely entered the esophagus. The tongue propels the bolus posteriorly into the pharynx and numerous and varied sensory receptors are stimulated along the way, triggering the pharyngeal swallow[11]. The oral cavity and pharynx contain some of the richest and most diverse sensory receptors of the body, represented by dense intricate nerve supply to the oral cavity, pharynx and larynx. Thus, exact timing of the onset of the pharyngeal swallow is imperative and highly sensory-reliant, such that even a one-second delay, or less, in initiation can result in airway invasion of ingested material[12]. Dysphagia and subsequent aspiration are often the manifestation of a break-down in one or more of the many sensory-motor events that comprise normal swallowing.

Peripheral sensory-motor swallowing

Age-related changes in specific physiologic parameters

Sensory-motor function becomes increasingly dampened with senescence throughout the body[13–17] and rate and extent depend on personal habits (e.g. smoking, alcohol, may increase physiologic change). Structures of the head and neck that are important for normal swallowing also are prone to age-related changes in the peripheral nervous system. These changes have been defined by measures of specific physiologic parameters such as muscle activity, motor-unit density, or assessments of somatosensory perception. Physiologic parameters (i.e reduced pharyngeal pressure) are the basis or cause of age-related changes in general function in swallowing behavior (i.e. slow swallow) between healthy young and old individuals. Anatomical differences in the old include a smaller cross-sectional area of masticatory muscles (masseter and medial pterygoid), increased lingual atrophy and fatty infiltration and decreased lingual muscle fiber diameter[18, 19], and atrophied type 1 (slow twitch) fibers in the thyroarytenoid muscle[20]. Beyond anatomical measures, functional changes in muscle activity between young and old include longer muscle activity (twitch prolongation) of the masseter[21], obicularis oris, supra- and infra-hyoid muscles[22] and the thyroarytenoid muscle[23] as well as slower waveforms of the pharyngeal constrictors and lower resting tone of the upper esophageal sphincter [24, 25]. Age-related diminishment in strength, mobility and endurance is also evident in the tongue [3, 5, 26, 27] and lips [28, 29]. Sensory function, which is understudied in the swallowing literature, despite its influence on the pharyngeal swallow response, also changes with age and is influenced by declining perception of spatial tactile recognition on the lip and tongue [30–32], diminished perception of viscosity in the oral cavity [33], poorer oral stereognosis[34, 35], and reductions in taste perception[36, 37] with increasing age. Although physiological parameters are typically measured at rest, postmortem, or during non-swallowing tasks and may not show immediate or direct clinical relevance to general swallowing function, they can be extrapolated or inferred to age-related changes in swallowing behavior and enhance the global understanding of swallowing abnormalities.

Age-related changes in general sensory-motor swallowing function

It is generally accepted in published studies that swallowing, as in sensory-motor physiology throughout the body, becomes slower with increasing age[2, 38–40] beginning in middle age[2]. As well, the pharyngeal swallow response often initiates later in older adults[2, 8, 41].

In normal swallowing, the properties of a bolus (i.e. volume, viscosity, temperature) are detected by oro-pharyngeal sensory receptors and are used to guide motor function for swallowing. Increasing bolus volume and viscosity minimizes the delay in pharyngeal swallow initiation[42–44] and increases laryngeal closure durations[2, 43] in healthy adults. Taste stimuli have also modified swallowing timing [45, 46], contraction of muscles in the submental region (laryngeal movement) [47–49], and lingual pressure [50] compared to a neutral stimulus. To date, much of swallowing research has examined either sensory or motor components with little consideration for the complementary dynamic, despite the intimate synchrony of sensation and movement. Furthermore, given the known multimodal deficiencies in oral-pharyngeal sensation, it is no surprise that the swallowing motor response in older adults is less responsive to taste and somatosensory stimuli[51] compared to a younger cohort. A recent study found that combining sensory stimuli (consistency and taste) minimizes the age differences in motor responses to sensation[47], likely because older adults benefit from increased exogenous sensory input to drive motor responses.

Central swallowing control

Dysphagia prevalence increases in advancing age due to more frequent neurological damage or disorders such as stroke[52], Alzheimer's disease[53], and Parkinson's disease[54]. Therefore, it has become very important that peripheral differences be investigated along-side central nervous system control. Recent advances in medical technology have facilitated functional brain imaging studies of swallowing, incorporating techniques that include positron emission tomography (PET) [55–58], magnetoencephalography (MEG) [59–63], transcranial magnetic stimulation (TMS) [55, 64–66], electroencephalography [67–69] (EEG), and functional MRI (fMRI)[65, 70–81]. Functional MRI is among the fastest growing brain-imaging technologies because it is minimally invasive compared to some other brain imaging systems and is becoming increasingly accessible for research purposes.

In a systematic review of fMRI studies of healthy swallowing[82], the primary motor cortex was the most prevalent region of activation, followed by the primary sensory cortex. Activation was also common in the insula and the anterior cingulate gyrus, but fewer studies found activation in the prefrontal, parietal or temporal lobes consistently or across subjects. Other areas of activation included motor planning areas (supplementary motor area, premotor area), other subcortical regions (internal capsule, thalamus, basal ganglia, putamen, globus palidus) and the cerebellum. All but one of the studies included in this review involved young adults (mean age 35 years). These pioneering fMRI studies of normal swallowing included primarily younger individuals likely because of increased procedure tolerance, task compliance and reduced head movement.

Only one known neuroimaging study (fMRI) examined swallowing in healthy older women and reported similar patterns of activity as in younger individuals in the bilateral sensory-motor cortices, insula/operculum, and cingulate cortex for saliva and water swallows. [75] Although Martin *et al* (2006) did not include young adults for a prospective comparison, two separate studies of young women[76] and old[75] healthy adults have both shown strong left-hemisphere lateralization for swallowing. An interesting difference was that the older females recruited far more activity for water swallows[75], primarily in motor planning areas (bilateral middle frontal gyrus and right superior frontal gyrus), while younger females showed more activation for saliva swallows[76].

When a bolus is being manipulated in the oral cavity, afferent signals enter the brainstem and their representative cranial nerve nuclei, synapsing in the thalamus, and then projecting to sensory specific areas of the cortex [83]. Before the primary motor area can execute movement, the primary sensory cortex sends information to higher-order association areas for a single sensory modality (i.e. temperature, pressure) and for multi-modal processing for attention, motor planning, and memory[84]. These data suggest that the older women required more motor planning for safe swallowing than the young females did. Increased activity in motor planning areas might be the result of reduced peripheral sensory abilities in the oral cavity, requiring motor planning areas to become more active (or work harder) in the absence of adequate stimulation to guide motor movements. Overall, Martin et al has provided the first look into the central control of swallowing in older adults. Future neuroimaging studies should focus on normal aging and swallowing to enhance what is known about peripheral sensory-motor swallowing across the age-span. Furthermore, the effects of increased oropharyngeal sensory stimuli on central control remain uninvestigated. So far, there is only one known experiment where sensation was manipulated (anesthesia) to determine how the brain responds during swallowing (decreased cortical activation in primary sensory-motor regions)[85].

Changes in skeletal muscle in limbs are similar to head and neck

Age-related sensory-motor changes have been more extensively studied in the limbs, with similar findings as those described previously in the head and neck. Muscle loss in the limbs, which has been reviewed elsewhere[86–88], begins in middle age and may be due to loss of muscle fibers[89–92], fewer motor units[14, 93–95] and progressive denervation and changes in nerve conduction[17, 96]. Sensory losses in the extremities with age involve declining ability to detect vibratory stimulation[97] and spatial tactile discrimination (particularly in the hands and feet). These sensory-motor losses translate into gross functional deficiencies in manual dexterity[13, 98], limb strength[15, 99, 100] and walking speed[16, 101, 102].

Peripheral changes to limb anatomy and function occur along-side increased neural activation during limb movement in old compared to young within certain brain regions[103–107]. Heuninckx et al (2008) recently investigated whether the elaborate cortical responses in the old is related to compensation for increased task effort or dedifferentiation (age-related inability to activate specialized neural mechanisms unrelated to task performance) using a complex interlimb coordination task. Results showed that additional cortical recruitment (primary sensory-motor cortices and motor planning areas) was positively correlated with increased motor success within older adults, but not in younger adults. Therefore, the over-activation in the old for motor tasks compared to young is consistent with the compensation hypothesis, where task-related changes are positively correlated with neural activation.

Although some discourage extrapolating limb muscle function to head and neck musculature[108], these reports of over-activation in the brain relative to limb motor function may be useful leads toward hypotheses for swallowing studies of neurophysiology in healthy aging. Future studies of the effects of age on swallowing neurophysiology should determine whether age-related differences in peripheral movement (i.e. slower swallows in older individuals[2]) appear to occur along side differences in neural control of swallowing. Furthermore, incorporating effortful swallowing might convey information about increased neural activation with increased effort with a swallowing task in elders. Overall, knowledge of swallowing neurophysiology in healthy aging is becoming more important as we approach the possibility of using neuroimaging techniques for clinical purposes to understand dysphagia. Without age-matched controls, dysphagic patients with decreased brain activation for swallowing might show "normal" activation compared to young healthy adults, who normally have less activation than their older counterparts.

Therapy

With advancing age, lean protein tissue diminishes, contributing to the loss of muscle protein mass, while adipose tissue increases in skeletal muscle of the limbs[109]. Many studies are showing increased rates of muscle protein synthesis with acute resistance exercise and resistance exercise training programs in middle aged and frail older adults[110–112]. Functional gains with exercise include upper- and lower body strength and balance, agility and endurance[113–117].

In traditional swallowing, compensatory treatment strategies are used to alter the flow of material in the pharynx. Chin tuck and head rotation decreased choking during swallowing immediately [118], reduced aspiration in 81% of patients [119], and reduced aspiration in 25% of patients who used it for all volumes swallowed [120]. Head rotation was 20–75% effective in reducing aspiration [120–122], and increasing the duration of laryngeal elevation [122]. A large multisite randomized clinical trial recently indicated the need to better understand the relationship between material properties of thickened fluids often provided to elders who aspirate thin fluids relative to changes in health status. The investigators conclude that the future need is to examine efficacy of a *combination* of physiologically sound interventions relative to solely modifying diet (based on a cohort of 512 research participants)[123, 124], particularly in the older populations with dysphagia secondary to dementia or Parkinson disease. Despite some success with compensatory maneuvers, and modifying food consistencies, these techniques offer patients little in the way of rehabilitation for functional swallowing. Research to date primarily has focused on non-swallow and enhanced swallowing (i.e. effortful swallowing[125]) motor exercises to increase muscle strength and range of motion in oropharyngeal structures. Exercise has shown to be effective in increasing strength of the tongue and improving functional swallowing in the healthy old[3, 5, 126, 127] and in dysphagic individuals[128, 129].

Sensory modalities have garnered little attention for long-term swallowing treatment, despite many reports of positive effects of increased intra-oral stimulation (i.e. taste, texture, temperature, viscosity) on swallowing biomechanics and bolus flow kinematics[45, 47–49, 130]. In addition to intra-oral stimulation, electrical stimulation to the submental and neck regions at low sensory threshold levels reduced aspiration frequency and residue amounts in individuals with chronic pharyngeal dysphagia[131]. Each of these sensory modalities is exogenous or externally-cued forms of stimulation to improve a motor response. Endogenous or internally cued stimulation involves increased attention to a task, resulting in top-down initiation and increased neural activation of motor planning and execution areas of the cortex during a motor task in healthy adults[132]. All forms of increased sensory stimulation or attention to a task should be incorporated into swallowing therapy, especially given known diminishment in oropharyngeal sensation, attention and memory in older adults.

Sensory-based swallowing therapies that aim to increase a motor response (i.e. sour or cold bolus), rather than modify bolus flow (i.e. thickened liquids) might receive little attention because they are not routinely included in assessments of swallowing function. Also, their usefulness has not been researched over the long-term, despite the likelihood that adaptation to a sensory stimulus might gradually decrease the effect of stimulus on the motor response. Some studies have reported oral and tongue sensory assessments[133, 134]; these could be included in swallowing assessments. Also, older participants demonstrated more difficulty with taste components of the sensory assessments compared to oral somatosensory measures[135]. Sensory assessments of the oropharynx for swallowing to understand healthy aging might be limited by the use of psychophysical measures (relationship between physical stimuli and their subjective percepts), where the clinician relies heavily on subjective reports of intensity for stimuli. Thus, cognitive differences may affect the accuracy of responses. In addition, assessing sensory ability requires knowledge and expertise to create, conduct and interpret valid and reliable measures of oropharyngeal sensation. Therefore, as in many clinical and research foci of swallowing, multidisciplinary collaborations will be necessary to derive useful sensory assessments for swallowing.

As medical technology for neuroimaging becomes more useful and available, more neurorehabilitation treatments will be examined for both peripheral and central changes in disordered populations as a means of determining effectiveness[136]. With impending changes, it is imperative that sensory-motor abilities in healthy older adults are thoroughly researched so that correlations between the brain and swallowing biomechanics can be interpreted accurately for comparison to the dysphagic population.

Footnotes

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Article information

Phys Med Rehabil Clin N Am. Author manuscript; available in PMC 2011 Sep 29.

Published in final edited form as:

Phys Med Rehabil Clin N Am. 2008 Nov; 19(4): 853–x.

doi: 10.1016/j.pmr.2008.06.002

PMCID: PMC3182519

NIHMSID: NIHMS79128

PMID: 18940645

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Keywords: deglutition, aging, presbyphagia, sensory-motor, neurophysiology

The publisher's final edited version of this article is available at Phys Med Rehabil Clin N Am

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