Challenges and Opportunities in the Management of the Aging Voice

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Abstract
Presbyphonia, or age-related dysphonia, is a diagnosis of exclusion, and other comorbidities must be considered in a complete evaluation of elderly patients with dysphonia. The aging voice can have a significant effect on the quality of life of the patient. In addition to the molecular effects of aging on the laryngeal tissues, the etiology of presbyphonia is often multifactorial because of comorbidities in the other organ systems involved in phonation. After a comprehensive evaluation, presbyphonia may be treated conservatively with voice therapy or with a range of interventions. Research into tissue engineering and electrical reanimation offers future options for treatment of presbyphonia. Currently, a multidisciplinary approach offers the most complete improvement in the vocal quality of life in this patient population.

Keywords
aging, voice, larynx, presbyphonia, vocal atrophy, injection laryngoplasty, voice therapy, laryngeal framework surgery, elderly

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As the elderly population increases, the medical community must address quality-of-life issues affecting the aged. Presbyphonia, or age-related dysphonia, is a diagnosis of exclusion, and other comorbidities must be considered in a complete evaluation. The complexity of presbyphonia involves the changes in the diverse tissues of the true vocal folds, musculature, and cartilage. Patients benefit from treatment of voice therapy or surgical laryngeal augmentation procedures. In this commentary, we discuss the presentation, evaluation, and treatment of presbyphonia, as well as the molecular and cellular discoveries in laryngeal senescence and future directions.

The Aging of Society
In 2003, 35 million people in the United States were older than 65 years, and by 2030, that number will climb to 72 million.1 Because of the growing elderly population, changes in quality of life associated with aging have become a focus in health care. The incidence of disordered vocal function in elderly persons has been cited to be from 12% to 35%.2-5 These incidences have been misquoted for decades based on a 1986 reference in which of the 1000 patients seen at a Canadian voice center, only 121 were older than 70 years.6 In a recent community-based cross-sectional study, 20% of patients older than 65 years reported dysphonia of any kind.7

Quality of Life in Aging
As one ages, the decline in tissue strength, be it skeletal muscle, the integumentary system, or the nervous system, is accepted as a natural part of aging. Weakening of the voice is an overlooked issue in elderly persons that can significantly disrupt one’s quality of life. In patients 65 years and older, 13% noted their quality of life to be moderately to profoundly reduced related to their dysphonia.7 Altered acoustic properties of the voice, increased vocal roughness, increased patient-reported vocal instability, and avoidance of social events were all symptoms noted in 50- to 81-year-olds over a 5-year span.8 Voice-related effort and discomfort, combined with increased anxiety and frustration and the need to repeat oneself, are specific areas that adversely affect quality of life.9 Vocal quality-of-life studies have found significant correlations between a patient’s perception of life quality and vocal quality.10

It should also be noted that an individual’s voice is one of many traits that mark us as unique. Not all age-related changes in voice are pathological, and some voice changes may be desirable to the individual. Reconciling this notion with

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patients’ own perceptions of their voice in an important part of the evaluation of older patients presenting with voice change.

**Epidemiology of Presbyphonia**

Generally, presbyphonia, or age-related dysphonia, is regarded as a diagnosis of exclusion after completion of a full medical and vocal evaluation. Presbyphonia has been found to be the cause of dysphonia in less than 9% of patients and in 30% in another study. The etiology of dysphonia may be multifactorial and not due to aging alone. Roy and colleagues demonstrated a lifetime prevalence for a voice disorder in 47% of elderly patients 65 years of age and older. Dysphonia was often chronic, with 60% of the 29.1% with a current voice disorder having the problem for more than 4 weeks. Alternative causes of dysphonia in elderly patients include those processes with infectious, phonotraumatic, reflux, neurological, and neoplastic etiologies. Poor general health correlates to negative objective vocal and laryngeal changes, showing that physiologic age may be a greater factor than chronologic age in some patients with dysphonia.

**The Complexity of the Presbyphonia**

Patients present with a complicated array of symptoms such as a weak, thin, or breathy voice; reduced projection; decreased range; unsteadiness; and pitch changes. Speaking fundamental frequency actually decreases in both men and women with age. The etiology of presbyphonia is often multifaceted. Of the several organ systems that coordinate phonation, the actuator of voice is the lungs. In elderly persons, pulmonary function declines because of age, other comorbidities, and intrinsic pathologies. This contributes to poor pulmonary reserve, which can affect subglottal pressure and vocal loudness. Coordination between the larynx and respiratory movements also declines.

Neurologically, aging effects are evident from the central nervous system (CNS) to the motor end units of the laryngeal muscles. The CNS loses fine control, and disease manifestations such as tremor, parkinsonism, amyotrophic lateral sclerosis, and stroke may present. The peripheral nerves of the larynx undergo changes with age because of an increase in length and volume of the laryngeal cartilages ossify, altering the resonant properties of the larynx and pharynx. This is likely due to the impairment of compression of the thyroid cartilage by the inferior constrictor, thereby impeding adduction. The joints undergo thinning of articular surfaces, breakdown of collagen fiber organization, and degenerative changes in the tendon attachments, limiting range of motion of the cricoarytenoid joint.

**A Mature Evaluation and Diagnosis**

Common etiologies of dysphonia must be excluded in the workup of presbyphonia. A complete history is a vital portion of the laryngological examination. The vocal demands of the aging patient can indicate the phonotrauma endured and the level to which they need their voice to perform daily activities. Dietary information, as well as a complete social history such as tobacco and alcohol use, are also important questions. Ultimately, the highest yield examination is laryngoscopy. Characteristic findings on stroboscopy are glottal gap, vocal fold bowing, prominence of vocal processes, edema, and atrophy. Glottal gap is not found to be consistent with the degree of bowing, allowing for some compensatory mechanisms in the presbylarynx. In evaluation of vocal fold motion, any asymmetry should lead to consideration of other diagnosis than presbyphonia. The aged vocal folds will exhibit an aperiodic or irregular vibration, increased amplitude, asymmetric mucosal wave, and a midline glottal gap. As a diagnosis of...
Currently, almost half of all surgical procedures in the United States are performed in patients older than 65 years. Using an index that Frailty identifies patients at high risk of adverse clinical outcomes, including falls, disability, dependency, and mortality. Frailty has been validated frailty syndrome results when multiple components are present, including low energy or exhaustion, low physical activity, slowed walking speed, and weight loss. Frailty develops along a continuum of severity and may include a latent phase of vulnerability that is not clinically apparent in the absence of stressors. Early stages are likely responsive to intervention, while late stages indicate high risk of short-term mortality. Preventive interventions include maintaining muscle mass and strength and ensuring adequate nutrition and hydration. Frailty identifies patients at high risk of adverse clinical outcomes, including falls, disability, dependency, and mortality. Frailty has been associated with several postoperative outcomes including increases in surgical complications, hospital length of stay, and likelihood of discharge to a skilled nursing facility. The presence of frailty has been shown to increase the predictive power of organ-based indices (such as Lee’s revised cardiac risk index and American Society of Anesthesiologists score) in estimating postoperative morbidity and mortality. Currently, almost half of all surgical procedures in the United States are performed in patients older than 65 years. Using an index that measures the components of frailty can help identify patients at increased risk of postoperative complications and improve clinical decision making among physicians and patients.

Table 1. Frailty and Surgical Outcomes in Older Patients

Older patients are at increased risk for postoperative complications. Commonly used scales for predicting surgical outcome in geriatric patients are based on organ systems and do not estimate physiologic reserve. Frailty has emerged as an important predictor of postoperative outcomes in elderly persons.

Frailty is a clinical syndrome characterized by an age-related decrease in physiologic reserves and increased vulnerability to stressors. A validated frailty syndrome results when multiple components are present, including low energy or exhaustion, low physical activity, slowed walking speed, and weight loss.

Rejuvenating the Aging Voice

Decision-Making Framework

Dysphonia in elderly patients requires an investigative approach to diagnosis and a multidisciplinary team for treatment. As discussed earlier, presbyphonia is a diagnosis of exclusion, and other plausible etiologies or confounding symptoms must be incorporated into the decision-making framework. This multi-hit theory of aging will help guide the treatment plan of voice therapy and surgical intervention. Decision making should also include an evaluation of the elderly patient as a surgical candidate with regard to their overall frailty and recovery potential (Table 1).

Voice Therapy

Current therapeutic tools for rehabilitation of presbyphonia include voice therapy, injection augmentation, and laryngeal framework surgery. Voice therapy is the first-line treatment. Strengthening exercises for respiratory and phonatory control likely increase neuromuscular coordination. This modality may result in subjective improvement in quality of life and perceived voice. Therapy consists of vocal education regarding the physiology of the problem, practice producing a resonant tone for optimal vocal postures, and standard vocal function exercises to enhance the balance, strength, and tone of the vocal mechanism. Voice therapy requires multiple clinic visits and may be less beneficial in severe cases.

Injection Laryngoplasty

If a patient fails voice therapy, procedures to improve glottic closure may be employed. Often used for recurrent laryngeal nerve paralysis, augmentation of the paraglottic space provides medialization of the true vocal fold. This has been shown to be effective for bilateral vocal fold atrophy to improve glottal competence. Injection augmentation may be performed for temporary means to plump the glottis and improve closure. Multiple substances may be used, most being an absorbable dermal or collagen matrix. The augmenting material is injected laterally to the superficial lamina propria (SLP), deep to the vocal ligament, in the paraglottic space medializing the vibratory vocal fold. Injection laryngoplasty is performed in the operating room or as an in-office procedure. In the operating room, direct laryngoscopy provides the most control. This procedure, however, requires general anesthesia and does not allow one to titrate the injection with vocal improvement.

Awake procedures are becoming more commonplace with the use of local and topical anesthetic. Per oral or percutaneous injections also allow for vocal titration but are often technically difficult. Patients may require multiple injections to achieve the desired effect, but this obviates the need for general anesthesia. The pitfalls of injection laryngoplasty include superficial injection or excessive overinjection. Also, elderly patients are more likely to be on anticoagulation medications that can be a relative contraindication to office-based procedures. Awake injections, therefore, have a higher morbidity than using direct laryngoscopy in the operating room.

Laryngeal Framework Surgery

Thyroplasty augmentation provides static medialization of the vocal folds. The aging larynx with muscle atrophy that benefits from injection laryngoplasty is a candidate for framework surgery as a permanent solution. Multiple synthetic materials are used, such as silastic and Gore-Tex. Bilateral medialization laryngoplasty is an effective option for the presbylaryngis. With the administration of local anesthetic and light sedation, the neck is opened and the thyroid cartilage window is fashioned to expose the paraglottic space. The implant is strategically advanced in the paraglottic space while the patient phonates to locate the optimal placement of the implants, while cautiously avoiding glottal obstruction. Limitations of this
procedure, as with injection laryngoplasty, are an adynamic glottal closure and failure to correct vocal fold vibratory or mucosal bulk, and because of its permanence, there is a risk of foreign body reaction, extrusion, or inflammation.\textsuperscript{44,55}

**Advancing the Possibilities**

As we learn more of the histomorphology of vocal fold aging, techniques for tissue rejuvenation are revealed. The changes in the complex matrix of collagen, elastin, and hyaluronic acid have been described. Hirano et al\textsuperscript{56} showed that basic fibroblast growth factor (bFGF) and hepatocyte growth factor (HGF) stimulates cultured fibroblasts and increases the production of HA and decreases collagen.\textsuperscript{56} They then went on to decrease the atrophy in aged rat larynges by injecting bFGF intracordally.\textsuperscript{57} Likewise, Ohno et al\textsuperscript{58} administered HGF by injection into rat vocal folds. This increased matrix metalloproteinase and hyaluronic acid synthase (HAS) and decreased procollagen, thus augmenting the production of HA and reducing the collagen in aged rat vocal folds.\textsuperscript{58} Improved glottal gap and decreased atrophy in human vocal folds were recently reported with injections of HGF.\textsuperscript{59} Thibeault and Duflo\textsuperscript{60} described injection of a modified synthetic derivative of HA into SLP to restore viscoelasticity with minimal inflammation.\textsuperscript{60} Tissue engineering, with the use of cell cultures or stem cells, is under way at some institutions. Work with fibroblast cell lines, different biomaterials such as collagen, acellular human-derived dermal preparations, and HA hydrogels as scaffolds are recent projects.\textsuperscript{61}

Other surgical technologies have been used to augment or revitalize the aged larynx. One author proposed the use of balloon thyroplasty for adjustable vocal fold augmentation.\textsuperscript{62} For some time, electrodes have been used to reanimate paralyzed vocal folds for abduction in respiration.\textsuperscript{63} In unilateral vocal fold paralysis, laryngeal adduction for airway protection and phonation has been described using electrodes to pace off the fold paralysis, laryngeal adduction for airway protection and management of age-related voice changes.\textsuperscript{64} However, this method is adynamic and results in failure to correct vocal fold vibratory or mucosal bulk. This method is not without complications, such as foreign body reaction, extrusion, or inflammation.\textsuperscript{60,65} Tissue engineering, with the use of cell cultures or stem cells, is under way at some institutions. Work with fibroblast cell lines, different biomaterials such as collagen, acellular human-derived dermal preparations, and HA hydrogels as scaffolds are recent projects.\textsuperscript{61}

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**Conclusions**

While much has been discovered with regard to the histological changes in the aged vocal fold and musculature, much still remains to be learned of viable treatments that can translate into improved vocal quality. Our current treatment modalities and multidisciplinary approach offer significant improvements in vocal quality of life. With the elderly population increasing, as a medical community we will address the issue of presbyphonia and other age-related disorders more frequently. A patient’s vocal health must not be overlooked along with its impact on overall general health.

**Author Contributions**

Michael M. Johns III, corresponding author, concept, interpretation, design, writing, review, approval; Lindsey Clemson Arviso, writing, review, approval; Fadi Ramadan, content, interpretation, writing, review, approval.

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