REVIEW ARTICLE

Endocrine Surgeon and Voice

Sabaretnam M.,[1] Babu S.,[2] Chitra S.,[2] Bharghav PRK.[3]

ABSTRACT

Thyroid and parathyroid surgeries form a major bulk of cases for an Endocrine surgeon. Voice changes following thyroid and parathyroid surgery is challenging problems which can be of distress for the knife happy surgeon, intellectual physicians and the affected patient. In this article we try to address the basics of voice and the causes of voice change post thyroid and parathyroid surgery.

INTRODUCTION

Voice is an auditory perceptional term that means the auditable sound produced by the larynx, which embodies such parameters as pitch, loudness, quality and variability.

- Pitch is the perceptual correlate of frequency. Loudness is the perceptional correlate of intensity.
- Quality is the perceptional correlate of complexity.
- Variability is the perceptional Correlate of variations of the above parameters.

Phonation : is the physical physiological act of sound production, the oscillations of the vocal folds driven by exhaled air stream. Clinical terms denoting abnormal voice are dysphonia, aphonia and muteness. Dysphonia describes any voice that abnormal its psychoacoustic parameters of pitch, loudness, quality and variability (e.g.) high or low pitch and excessively loud voice.

Aphonia is the absence of laryngeal tone (e.g.) sounds like whispered speech.

Muteness denotes the patient who has no voice or articulation.

NORMAL VOICE

Curtis *et al* listed several criteria.

- Quality must be pleasant with certain musical quality and absence of voice, inappropriate breaks, voice perturbations or atonality
- Pitch must be appropriate to the age and gender of the speaker.
- Loudness appropriate to the communication event
- Adequate Flexibility
- Adequate sustainability

ABNORMAL VOICE

By definition abnormal voice is any voice that calls attention to itself, does not meet the occupation or social needs of the speaker or is inappropriate to age, gender or situation. Fairbanks classified voice defects into three categories harshness, breathiness and hoarseness.

Voices are as distinctive as human faces and no two are exactly alike. Some of the traits that make human voices unique can be formed into well-defined categories; fundamental frequency (high and low) and intensity (loud or soft), are examples. Other attributes fall into a general set of characteristics called vocal qualities. Register is generally considered in the category of voice qualities, although unlike the others, it tends to be quantal, rather than continuous perceptually.

Voice Quality = vocal tract configuration
+ laryngeal anatomy
+ learned component

The shape of an individual's vocal tract is partly genetic, partly learned. Necks are long or short; pharynxes may be narrow or wide. While these attributes are genetically determined (except for configurations due to trauma or disease), individuals may also manipulate vocal tract shape. Highly trained singers have many tricks to change the contours of their vocal tracts to improve the sound coming out of their mouths. Likewise, laryngeal anatomy is partially determined at birth; the length of one's vocal folds is determined by genes. However, the general hydration of one's

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1. Assistant Professor, Endocrine Surgery Department, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India.
2. Professor, SurgeryDepartment, Govt. Sivagangai Medical College, Sivagangai, India.
3. Consultant, Endocrine Surgery Department, Vijayawada, India.

vocal fold tissues or muscular agility of laryngeal muscles can be at least partly controlled by vocal health and training.

The learned component of the equation could also be called vocal habits. These would be items such as rhythm and rate of speech and vowel pronunciation. Rhythm, obviously, includes mannerisms such as periodic pauses to search for the right word, while rate refers to the speed of an individual's syllables and speech. A speaker's habits also influence how much air pressure is used to produce sound and how s/he uses laryngeal muscles to open and close the vocal folds.

Despite their training, vocologists and voice researchers also disagree about exact descriptions of vocal qualities. Below is a table of terms suggested by Dr. Ingo Titze at the 8th Vocal Fold Physiology Conference in April 1994. The list is likely incomplete and does not necessarily reflect a consensus of the conference or the field of vocology as a whole. Ideally, a group of researchers and vocologists would organize a consensus conference in the future.

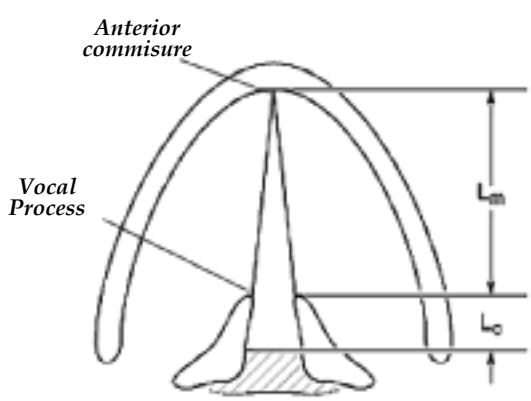
VOICE CHANGES THROUGHOUT LIFE

There are several major factors that affect voice classification as a person ages:

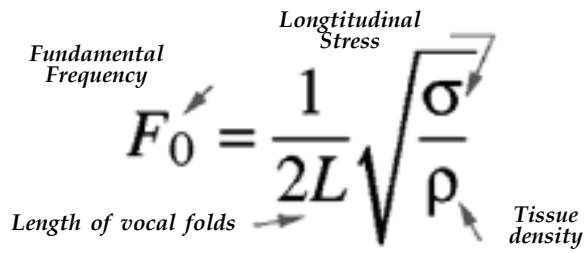
- growth, especially changes in vocal fold length
- development of the cricothyroid and thyroarytenoid muscles
- changing structure of vocal fold tissues
- ossification of the cartilage in the larynx

Childhood

During childhood, the most significant changes in the voice result from the rapid growth of the larynx, the vocal folds and the surrounding support structures. At birth, the membranous length of the vocal folds (the part that actually vibrates) is around 2 mm males and females. An illustration to show the difference between the membranous length (shown as L_m) and total vocal fold length ($L_m + L_c$, where L_c is the cartilagenous length):



For the first 20 years or so of life, the growth rate is approximately 0.7 mm per year for males, and 0.4 mm per year for females, which results in a maximum adult length of about 16 mm for men, 10 mm for women. This growth of the vocal folds causes F0 to drop as predicted by the equation below:



Since children have smaller lungs and smaller vocal folds, it is expected children to be quieter than adults. Children can produce sounds as loud as adults despite their smaller apparatus, because higher F0's guarantee higher intensity. Also, lung pressure is 50-60% higher for children than adults, so children also make up for their smaller size by working harder vocally.

Adolescence

For adolescents, the big vocal changes occur during puberty, especially in men. The male hormone testosterone causes many significant changes to the male voice, including faster growth of the larynx than in women, along with increases in the size and thickness of the vocal folds themselves. Having longer folds of course decreases the F0 for males, and the thicker folds produce a register change - a change in the quality or timbre of the voice.

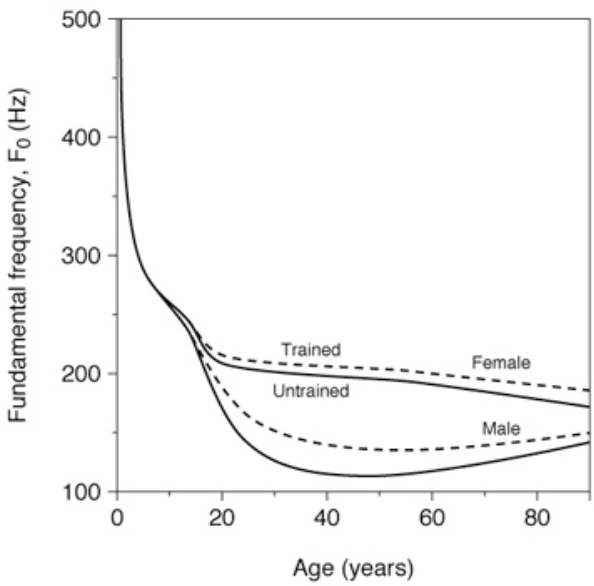
Choir directors of middle-school aged boys would likely appreciate specific guidelines regarding the vocal changes of their groups' members. However, because voice changes in pubescent males can vary widely between young men, only general statements may be made. Adolescent boys' voices often begin to mutate at 12-13 years of age and taper between 15-18. During this time, lower pitches tend to be more stable than upper pitch ranges, and most of the active changes tend to occur within one year.

Female pubertal voice changes are often less obvious than that of males. However, adolescent girls' voices tend to exhibit increased breathiness or huskiness, occasional "cracking", a lowering of average speaking fundamental frequency, and increased pitch inaccuracy while singing. The physiologic components that account for voice changes include facial development (related

to voice resonance), a descent of the larynx (effectively lengthening the vocal tract), and increased circumference of chest wall and lung (providing greater breathing capacity).

Adulthood and Advanced Age

Once the voice matures at around age 20, it tends to remain relatively stable until around age 60, assuming that the person is healthy and getting proper diet and exercise. Average Fo as a function of age for men and women is shown in the figure below:



Although the voice itself remains stable, physiological changes do occur in middle age, most significantly ossification (hardening) of the laryngeal cartilages. In some individuals, these changes can actually improve the singing voice, since a more bony support framework in the larynx better supports the tension in the vocal folds. If you compare the voice to a piano, for instance, the strings in a piano are attached to solidly-anchored metal posts at each end. This allows the piano strings to stay in tune and make a predictable sound. At younger ages when flexible cartilage supports the vocal folds, there is a greater chance for unpredictability, but with stiffer, more bony supports, it is logical that the voice could perform more reliably.

Other changes in middle age can be less beneficial to the voice. These age-related changes affect soft tissues:

atrophy : wasting away of cells
dystrophy : malfunctioning of cells
edema : swelling due to excessive accumulation of fluids in tissue

As various muscles and connective tissue in the vocal folds **atrophy** or degenerate with age, it can become more difficult to make the voice perform normally. Since the thyroarytenoid muscle helps to control pitch, intensity and register, any loss of function in that muscle will have an adverse effect on vocal performance.

Some cells become **dystrophic** with age and no longer perform their normal tasks. Muscle fibers lose their ability to obey nerve impulses telling them to contract. Nerve cells lose the ability to transmit neural signals properly. As a result, the voice may become weak or fluttery.

Finally, **edema** or swelling of the vocal fold cover interferes with the normal vibration of the folds, which can lower the voice, or cause roughness.

POST THYROIDECTOMY SYNDROME

Many patients have suffered from unexplained discomforts after simple thyroidectomy, without evidence of recurrent laryngeal nerve (RLN) injury. Typical symptoms are easy fatigue during phonation and difficulty with high pitched and singing voices; other symptoms are paresthesia, vague voice changes, throat discomfort, swallowing difficulties, and the feeling of choking. This collection of symptoms appears to be a real syndrome, which have been named post-thyroidectomy syndrome (PTS). Various causes of PTS have been suggested, including laryngotracheal fixation, direct injury of superior laryngeal nerve, and laryngeal lymph edema following thyroidectomy. Among these causes, laryngotracheal fixation is the most suggested cause of PTS, however, the exact cause of PTS is not clear until.

Management is difficult. Most of the parameters improve gradually over time but some changes persist for a long time.

VOICE CHANGES FOLLOWING THYROIDECTOMY

Multiple causes can be there. Patient reassurance is of paramount importance followed by treatment of the cause if found. If routine indirect laryngoscopy is done postoperatively then the incidence of vocal cord palsy may be higher even in the expert centers.

Factors that may be related to postoperative thyroidectomy voice changes Endotracheal tube associated laryngeal injury.

a. Vocal cord injury /edema
b. Arytenoid dislocation
c. Paralysis or paresis (rare)

Neural Injury:

RLN

Neuropraxia, Axonotomesis, Neurotomesis

External branch SLN

Voice Quality	Perception	Physiologic component
aphonic	no sound or a whisper	inability to set vocal folds into vibration, caused by lack of appropriate power (air pressure) or a muscular/tissue problem of the folds
biphonic	two independent pitches	two sources of sound (e.g., true folds and false folds, or two folds and whistle due to vortex in air)
bleat (see *flutter*)		
breathy	sound of air is apparent	noise is caused by turbulence in or near glottis, caused by loose valving of laryngeal muscles (lateral cricoarytenoid, interarytenoid and posterior cricoarytenoid).
covered	muffled or 'darkened' sound	lips are rounded and protruded or larynx is lowered to lower all formants so a stronger fundamental is obtained
creaky	sounds like two hard surfaces rubbing against one another	a complex pattern of vibrations in the vocal folds creates a intricate formation of subharmonics and modulations
diplophonic	pitch supplemented with another pitch one octave lower, roughness usually apparent	a period doubling, or F0/2 subharmonic
flutter	often called bleat because it sounds like a lamb's cry	amplitude changes or frequency modulations in the 8-12Hz range
glottalized	clicking noise heard during voicing	forceful adduction or abduction of the vocal folds during speech
hoarse (raspy)	harsh, grating sound	combination of irregularity in vocal fold vibration and glottal noise generation
honky	excessive nasality	excessive acoustic energy couples to the nasal tract
jitter	pitch sounds rough	fundamental frequency varies from cycle to cycle
nasal (see *honky*)		
pressed	harsh, often loud (strident) quality	vocal processes of the arytenoid cartilages are squeezed together, constricting the glottis, and causing low airflow and medial compression of the vocal folds
pulsed (fry)	sounds similar to food cooking in a hot frying pan	sound gaps caused by intermittent energy packets below 70 Hz and formant energy dies out prior to re-excitation
resonant (ringing)	brightened or 'ringing' sound that carries well	epilaryngeal resonance is enhanced, producing a strong spectral peak at 2500-3500 Hz; in effect, formants F3, F4 and F5 are clustered
rough	uneven, bumpy sound appearing to be unsteady short-term, but persisting over the long-term	modes of vibration of the vocal folds are not synchronized
shimmer	crackly, buzzy	short-term (cycle-to-cycle) variation in a signal's amplitude
strained	effortfulness apparent in voice, hyperfunction of neck muscles, entire larynx may compress	excessive energy focused in laryngeal region

Voice Quality	Perception	Physiologic component
strohbass	popping sound; vocal fry during singing	sound gaps caused by intermittent energy packets below 70 Hz and formant energy dies out prior to re-excitation
tremerous	affected by trembling or tremors	modulation of 1-15 Hz in either amplitude or pitch due to a neurological or biomechanical cause
twangy	sharp, bright sound	often attributed to excessive nasality, but probably also has an epilaryngeal basis
ventricular	very rough (Louis Armstrong-type voice)	phonation using the false folds anterior rather than the vocal folds; unless intentional due to damage to the true folds, considered an abnormal muscle pattern dysphonia
wobble	wavering or irregular variation in sound	amplitude and/or frequency modulations in the 1-3 Hz range
yawny	quality is akin to sounds made during a yawn	larynx is lowered and pharynx is widened, as people do when yawning - hence the name

REGIONAL NONNEURAL EFFECTS

a. Strap muscle injury or deneryation
b. Global perilaryngeal plexus neural injury (non-RLN, non-SLN)
c. Regional scanning/laryngeal fixation
d. Direct cricothyroid muscle myositis

COINCIDENT VOICE CHANGE DUE TO NONSURGICAL FACTORS

a. Viral
b. Other

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