ASSESSMENT OF VOICE
Nancy G. Jones, MD
July 30, 1992

Voice is a complex phenomenon that requires multiple measures to describe its characteristics. Subjective evaluation of the patient and routine examination are certainly valuable in the assessment of vocal function. However, it is no longer adequate to listen to the patient's voice and document preoperatively "the voice sounds hoarse," or, postsurgically, the "voice sounds better." Today, with the concept of accountability and the reality of litigation, it is necessary to objectively record the results of therapy. Objective measures not only provide an unbiased documentation of change, but can also provide information that neither the eye nor the ear can discern. There are a multitude of modalities used to assess vocal fold function, including electromyography of laryngeal muscles, airflow tests of lung and larynx, and acoustic analyses of voice signals. Tests of phonatory ability, perceptual evaluation of voice and studies of vocal fold vibration also define the activity of the larynx. This abstract focuses on the examination of vocal fold vibrations.

The vocal folds vibrate at 100-300 Hz during normal conversation, but they may exceed 1000 Hz during singing. Here are some of the parameters that should be assessed in vocal fold vibrations: 1) Horizontal excursion of the vocal fold edge assesses the medial to lateral movement. The edge is defined as the most medial portion of the vocal fold. The location of the edge varies in each part of the vibratory cycle. The edge also may move vertically or
longitudinally, but these movements are more difficult to quantify. 2) Upper lip, lower lip. The vocal fold edge vibrates with two distinct portions denoted as lips. They are best observed immediately after maximal opening of the true vocal folds. During the opening phase, the lower lip is covered by the upper lip and not viewed from above. The edge of the vocal fold represents mainly the upper lip. During the closing phase the two lips are usually observable from above. The closed phase usually begins with an approximation of the lower lips. The edge of the vocal fold, therefore, represents mainly the lower lip during the closing phase. In the closed phase, the upper and lower lips usually become indistinguishable. Note that these are not defined portions of a vocal fold - they vary within each vibratory cycle. 3) Fundamental period. This is the time span required for one vibratory cycle. The fundamental frequency is the number of vibratory cycles completed per second. 4) Amplitude. This denotes the size of the greatest vocal fold displacement from the midline. 5) Periodicity or regularity of successive vibrations. Here the cycle-to-cycle variations of fundamental period, amplitude, or waveform are examined for consistency. 6) Symmetry of bilateral vocal folds should be assessed. 7) The mucosal wave is evident during vibrations except during falsetto. This is also called the "traveling wave" of the mucosa.

Stroboscopy is derived from the Greek words *strobos* which means "swirling," and *scopien* which denotes "watching" or "observing." Stroboscopy is as useful to the clinician as indirect or direct laryngeal endoscopy, since it allows evaluation of the dynamic aspects of vocal fold vibrations. Stroboscopic examination of the vocal folds provides information for a quick, precise diagnosis useful for both surgical therapy and followup. Many clinical difficulties can be attributed to anomalies of the mucosal wave of the vocal folds. Stroboscopic examination permits assessment of vocal fold flexibility. Commonly, the instrument is coupled to video recording systems for research, teaching, treatment, and documentation. Stroboscopy may be performed orally through a telescope or a nasopharyngoscope. The stroboscopic effect is based on an optical illusion caused by persistence of visual images. The eye cannot discriminate separate images that last less than 0.32 seconds because of the interaction between the length of the stimulus image and the persistence of the image on the retina. This explains why, to the unaided eye, the vibrating vocal folds seem to be stationary except for some low frequency movements under certain conditions. The problem of resolving the too-rapid motion is solved by illuminating the larynx with brief flashes of light at a frequency just slightly less than the vibratory rate (by about 2 Hz). This produces a visible, slow motion effect of the glottic wave. With practice, perceptual judgments of stroboscopic images provide a great deal of information. The things to specifically describe include: fundamental frequency, symmetry, periodicity (regularity of vibration), failure of glottic closure, amplitude of vibration, presence of mucosal wave, and the location of nonvibrating segments.
Ultra-high-speed photography was developed by the Bell Telephone Laboratories in 1937. Performed by providing a bright light source and optical reflecting unit from the larynx to a camera setup, pictures are taken at extremely high speeds - 20 to 30 times the fundamental frequency of phonation. This method is extremely expensive, time consuming, and is generally used for research and teaching purposes.

Photoelectric glottography was first used in 1950. It converts light intensity to electrical voltage. A light receptor is positioned at the glottis. A light source rod (such as a nasopharyngoscope) is placed in the nose to transilluminate the glottis. The light receptor picks up the light intensity and, by way of a photoelectric device, converts to an electrical waveform. The assumption is that if the glottis is in the open phase of vibration, then more light will be transmitted and this will be reflected in the waveform. It has been compared to ultra-high-speed photography and is noted to have fairly good accuracy. Photoelectric glottography best provides a means to assess the open phase of the glottis.

One of the most popular methods of measuring vocal fold vibration is the electroglottograph which is noninvasive, innocuous, inexpensive, and easy to perform. An electrode is positioned on each side of the thyroid cartilage. A high frequency current is passed between the electrodes. The principle of electroglottography is based on the fact that tissue is a moderately good electrical conductor, whereas air is an extremely poor conductor. Therefore, during the glottal cycle, the electrical impedance across the larynx rises (as the glottis opens) and falls (as the vocal folds come into increasingly intimate contact). Electroglottography, therefore, provides a measure of vocal fold contact. It can be correlated with stroboscopic images. Electroglottography provides a perspective on vocal cord contact unobtainable in any other practical way.

Ultrasound uses high frequency sound waves passed through body tissues. The sound waves are reflected at the interface between two media differing in specific acoustic impedance. The difference in acoustic impedance between tissues and the surrounding air is so large that the transmission of ultrasound from the tissue to air is negligible. In ultrasonography, two transducers are placed on both sides of the neck and echoes from the vocal cords are recorded. Images are obtained in rapid sequence and the appearance of continuous motion is given. Dr. Friedman, at Baylor College of Medicine, has pioneered the use of ultrasound for laryngeal diagnosis. Ultrasound can be a useful modality in the assessment of vocal fold vibration.

Measurements of vocal fold vibration represent only a fraction of the tests used to evaluate and document laryngeal function. Their use greatly contributes to our understanding of the human voice.
Case Presentation

A 41-year-old white female presented with intermittent hoarseness. Seven years previously, she had a hemangiopericytoma of the base of tongue and preepiglottic space that extended to the false vocal fold and posteriorly to the aryepiglottic fold. This was completely excised by way of a thyrotomy approach with submucosal excision. On physical exam at the time of followup, she was noted to have a cyst of the right true vocal fold and no evidence of recurrent tumor. Stroboscopy revealed the absence of a normal mucosal wave on the right. MRI confirmed that recurrence was not present. The patient underwent microsuspension laryngoscopy with excision of the right true vocal fold cyst and has had no problems since.

Bibliography


