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Reviw Article

Video Laryngostroboscopy

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Abstract:

Stroboscopy has improved our understanding of the vocal cord function and has become an important tool in the diagnosis of voice disorders. It has led to changes in diagnosis in approximately 30% of cases when compared to examination with continuous light and mirror. It is important to understand the normal microscopic anatomy of the vocal folds- the plane of movement of the mucosal wave is the superficial layer (Reinke's space) of lamina propria-. Opening and closing of the vocal cords during phonation can be easily seen in mirror examination. The use of high speed motion photography demonstrates additional movements. The equipment required includes stroboscope, camera, recorder, monitor and 90 degree telescope. The following parameters are routinely noted -fundamental frequency, periodicity, amplitude, symmetry, glottic closure, mucosal wave, non vibrating portion, supraglottic activity of larynx. Videostroboscopy helps in differentiating superficial lesions of the epithelium from the deeper lesions involving the muscle. It is useful in diagnosis of early malignancy, vocal nodule, differentiating unilateral paralysis from ankylosis of the cricoarytenoid joint, planning and evaluating phonosurgery. The stroboscopy images can be recorded and stored for future medicolegal purposes in professional voice users and monitoring their treatment.

Key words: *Video; laryngostroboscopy*

Introduction:

The vocal cords converts the thoughts into words and thus into reality. The larynx was believed to be an invisible organ till 1854 when the Spanish singing teacher Manuel Garcia managed to see his vocal cords using dental mirror and sunlight.

This single event led to a lot of revival of interest in laryngology. It has always been seen that there is a lot of difference between the voice symptoms and the vocal cord findings seen on naked eye examination. The human eye does not perceive more than 5 images in 1 second. Human vocal cords move at the speed of 100 to 1500 excursions depending on the pitch at which one is speaking. This limitation can only be overcome with the use of ultra high speed cinephotography or Videostroboscopy. Ultra high speed photography is very expensive. Very difficult to carry out and is not practicable in the clinical settings[1].

The technique of Videostroboscopy produces optical illusion. Human vocal cords which are

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mov-ing very fast can be made to appear in slow motion or be frozen at any desired position. This is helped by the fact that any image presenting to the human retina persists for only 0.2 seconds (Talbot's law)[2]. Thus if the individual frame of the images are presented to the retina at intervals in less than 0.2 seconds, overlapping of these rapid images is perceived as continuously moving images. Stroboscopy helps in studying the illustrated view of the vocal cords and gives us details about the symmetry, mucosal wave, glottic closure, phase, regularity, periodicity, horizontal movements and the amplitude of the free edge[3].

Historical Perspective:

Stroboscopy was first discovered by Vienesse engineer Stamfer in 1833. It was first used in physics as a means of study of periodic oscillations of bodies to demonstrate undulation. Doppler in 1866 thought that this principle could be applied to medicine.

Oertel from Munich in 1878 was the first one to describe and clinically use the stroboscope. The aortal stroboscope was a disc stroboscope which was based on regular interruptions of the light beam by a perforated disc powered by electricity. Ternaud in 1932 in France made his own strobo-scope and used it in clinical setting.

However in the early days the stroboscopy did not become very popular as the early stroboscopes had the following limitations:

- Too much background noise.
- Frequency disturbance with slight variations of electrical potential.
- Decrease in illumination with increasing frequency of disc rotation.
- Problem with the subject in maintaining same pitch for prolonged periods.
- Discs needed to be changed frequently.

Kallen in the year 1932 made a new type of stroboscope using the principle of the flash tube which, in a different form, now a day is being used in the stroboscopes. Videostroboscopy has received further impetus with the development of high resolution camera, recorders and the development of good monitors. Now it has become a very standard investigation for diagnosis of voice disorders and is a must for any voice laboratory.

Principle:

Hirano has described in great detail the anatomy of the vocal cord folds. It is important to understand the normal microscopic anatomy of the vocal folds if we want to understand the pathology of vocal cords[4].

- Epithelium
- Superficial layer of the lamina propria
- Deep layer of lamina propria
- Elastic conus
- Vocalis muscle

According to Hirano, the cover is formed by the Epithelium and the superficial layer of the lamina propria and the body is formed by the vocalis muscle. The importance of knowing this is that the plane of movement of the mucosal wave is the superficial layer (Reinke's space) of lamina propria-.

Opening and closing of the vocal cords during phonation can be easily seen in mirror examination. The use of high speed motion photography demonstrates an additional movement- the mucosa covering appears to go up and down with phonation. The vocal folds vibrate as upper and lower margin, the lower margin separate first forming a

subglottic vault filled with a small volume of air. This air is then released into the vocal tract. The lower margins then return to midline and a gradual closing of the upper margin then follows.

When there is vocal cord paralysis, at first there is a loss of stiffness of the underlying body, reducing distinction between the upper and the lower margins and causing a loss of traveling wave- shown in the famous Bell laboratories in 1938[5].

Examination parameters in videostroboscopy:

Hirano (1981) has defined some characteristics of stroboscopy that can be evaluated for quantifica-tion of the stroboscopic examination. But there remains a subjective element in defining some of these parameters. There has also been a subjective difficulty in interpretation of stroboscopic im-ages. We normally follow the stroboscopic parameters given by Ford and Bless and Video stroboscopic rating scale of the University of Winconsin. All the parameters are labeled on a score of 1 to 7 [6].

- Fundamental frequency
- Periodicity
- Amplitude
- Symmetry
- Glottic closure
- Mucosal wave
- Non vibrating portion
- Supraglottic activity

The equipment required includes stroboscope, camera, recorder, monitor and 90 degree telescope. We prefer to use a 90 degree telescope as images obtained with it are better than fiberoptic laryngoscope.

A good srtoboscopic examination requires and a minimum of about 15 minutes need to be spend with each patient. The patient needs to be evaluated during

- Quiet breathing
- Sustained normal soft & loud vowel production
- Phonation of vowel “e” and “a”
- Upper and lower extent of voice range
- Rapid syllable production

* Though all these maneuvers may not be possible in one single patient.

1. **Fundamental frequency:** The fundamental frequency is measured by the strobe unit and used to set the frequency of the light flashes. Typically, the strobe light is produced at a frequency several hertz (cycles/second) slower than the vocal frequency to produce the illusion of a slow motion vibratory cycle. An identical frequency is emitted in the locked mode that produces a still image of a single portion of the vibratory cycle.
2. **Periodicity:** The periodicity refers to the regularity of successive vocal motions. Normal vibratory activity is regular and periodic.
3. **Amplitude:** Amplitude refers to the lateral excursion of the vocal folds during their displacement away from the midline in oscillation. Typical amplitude is approximately one third of the total width of the vocal fold. Amplitude generally graded as normal, less than normal, or greater than normal. Amplitude is diminished on the affected side in a case of vocal cord cyst and absent over the cyst itself, but it is diminished in case of vocal cord polyp (Figure 1).

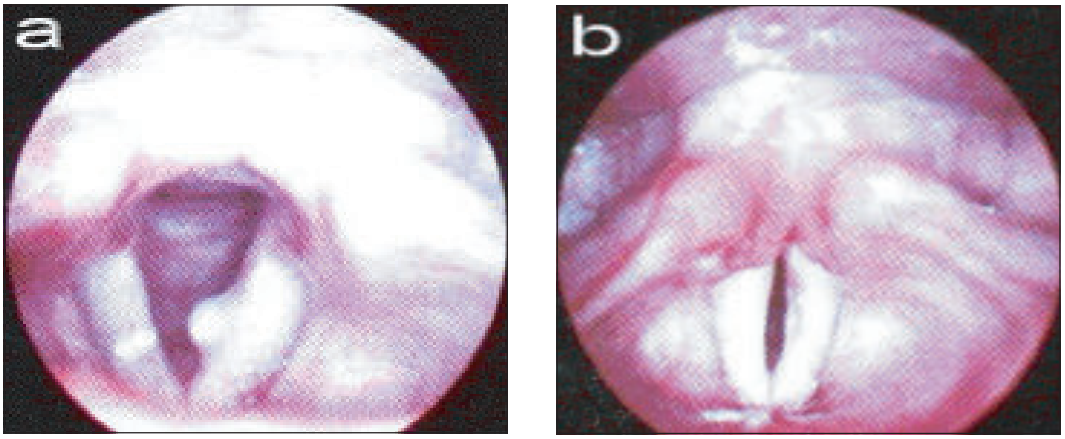

Figure 1: *Localisation of lesion: a case of vocal cord polyp on the inferior border of edge of left vocal cord. a = preoperative images, b = post operative image.*

The mucosal wave may be present over the polyp itself, depending upon its physical consistency.

4. **Symmetry:** Symmetry is quantitative rating of "mirror" wave of both vocal folds. Normal motion of the vocal folds is symmetrical, both in vibratory, adduction and abduction motion. Usually asymmetry is caused by the limited vibratory characteristic of a lesion, e.g. vocal cord paralysis (Figure 2); diffuse scar, localized cyst or leukoplakia.

Figure 2: *Symmetry is lost in a case of vocal cord palsy.*

5. **Glottic closure:** Typically, the healthy patient demonstrates complete closure of the membranous portion of the vocal folds during the vibratory cycle. The posterior cartilaginous glottis may remain open (posterior glottic chink) in some healthy patients[7].

The various types of glottal closure recorded include:-

* Dorsal (posterior triangular glottic chink): it is however important to consider that a slight dorsal insufficiency even reaching into the membranous portion of the glottis occurs in about 60% of middle aged healthy women during normal voice effort. 50% of the women close the glottis completely during loud voice.
* Ventral: anterior glottic chink seen in posterior glottic lesions.
* Irregular: Granulomatous lesions, vocal cord polyps show irregular glottic closure.
* Oval: over the whole length of the glottis, but with dorsal closure. This is seen in cases of sulcus vocalis (Figure 3), presbyphonia.

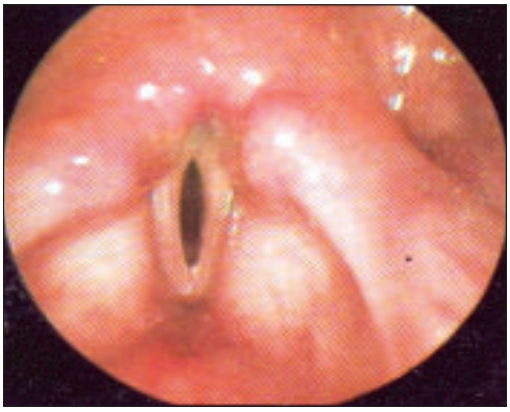

Figure 3: *Oval glottic closure- a case of sulcus vocalis.*

* Hour-glass shape - This is classically seen in cases of vocal nodule (Figure 4).

Figure 4: *Hour-glass glottic closure in vocal nodule.*

* Longitudinal: over the whole length of the glottis and without sufficient adduction e.g. vocal cord paralysis. (Figure 5)

6. **Mucosal wave:** This is the pattern of light traveling from medial to lateral along the superior surface of the vocal fold under illumination during vibration. Disruption of the normal visco-elastic properties of the superficial lamina propria results in aberrant vocal fold vibration and mucosal wave propagation which helps to localize pathology within the vocal fold[8].

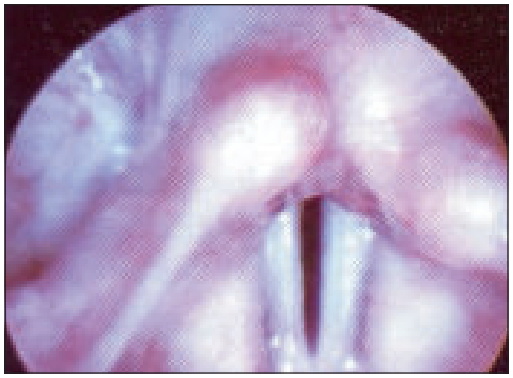

Figure 5: *Longitudinal glottic closure: case of bilateral abductor paresis.*

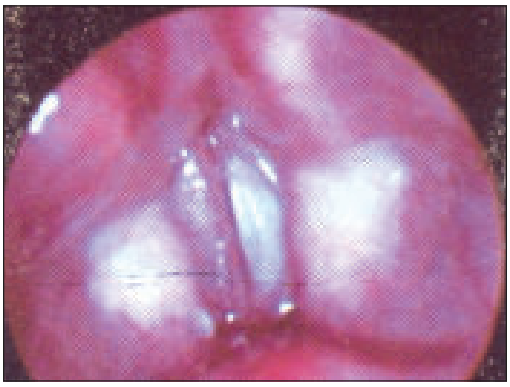

Figure 6: *Loss of mucosal waves: a case of right vocal and glottic carcinoma (T1N0M0).*

Mucosal wave is diminished or absent in cases of early malignancies (Figure 6) of the glottic region depending upon the extent of vocal ligament invasion[9].

Mucosal wave may be diminished or absent in cases of vocal fold scarring or spasmodic dysphonia. Scarring may be the result of infection like diphtheria, vocal cord trauma or radiation. The trauma may be surgical, intubation or accidental. The mucosal wave is examined before and after laser phonosurgery to examine the scarring caused by excess heat dispersion to normal tissue[10].

The mucosal wave helps in differentiating a paralyzed vocal cord from a fixed vocal cord. The mucosal wave is absent in cases of vocal

cord fixation but it is always present in paralyzed vocal cord.

Use of videostroboscopy:

Stroboscopy improves the accuracy of diagnosis. It has led to changes in diagnosis in approximately 30% of cases when compared to examination with continuous light alone[11, 12, 13].

1. Depth of laryngeal disease:

Videostroboscopy helps in differentiating superficial lesions of the epithelium from the deeper lesions involving the muscle. One is guided by the presence or absence of the mucosal wave. One can differentiate a superficial vocal (soft) nodule from a fibrous (hard) nodule. A superficial nodule may respond to speech therapy while a fibrous nodule may require microlaryngeal surgery. A nodule might need to be differentiated from cyst.[14]

2. Early diagnosis of malignancy:

One of the best uses of videostroboscopy is to diagnose early malignancy which may be easily missed on naked eye examination. Any patient with a suspicious lesion should be subjected to videostroboscopy. Accurate diagnosis can be challenging and depends on a detailed history, the use of stroboscopy and to some extent objective measures[15, 16]

3. Laryngeal trauma:

Helps in assessing the degree of trauma, choice of therapy and guides as when to stop speech therapy. At times, trauma produces scar tissue which causes hoarseness without much structural change to the cord. This can only be picked up on stroboscopy which can be medicolegaly important.

4. Laryngeal paralysis:

Videostroboscopy helps in differentiating unilateral paralysis from ankylosis of the cricoarytenoid joint. It provides information about type and degree of paralysis. It helps in predicting recovery. A return of the mucosal wave means that the cord is recovering.

5. During microsurgery of the larynx:

In fact in some centers e.g. Saito have used videostroboscopic examination preoperatively[17]. They performed more than 200 stroboscopic microsurgeries of the larynx under neurolep analgesia. The vibratory pattern was stroboscopically examined through the operating microscope throughout the procedure. He demonstrated that excellent phonatory outcome can be obtained in cases with near normal vibratory patterns as per stroboscopy.

6. Planning and evaluating Phonosurgery:

Complete assessment of a patient with a voice disorder should now include video laryngoscopy, stroboscopy and other laboratory recordings including laryngeal electromyography and quantitative voice measurements. [18] Stroboscopy is essential in the assessment of the mucosal wave of the vocal fold and electromyography can aid in the localization of lesions in the vagus/ superior laryngeal/recurrent laryngeal nerve network and identify signs of reinnervation in a paralyzed vocal cord. The important perceptual characteristics are degree of incomplete anterior glottic closure, reduced mucosal waves and wave asymmetry.

7. Record keeping and Medicolegal purposes:

Due to digitalization of images and the availability of better recorders the stroboscopy images can be recorded and stored for future medicolegal purposes in professional voice users and monitoring their treatment. Functional disorders are at times a difficult problem for the laryngologist. Videostroboscopy offers an accurate evalution

in these cases and also allows monitoring during therapy.

Hence stroboscopy has improved our understanding of the vocal cord function and has come to stay as an important tool in the diagnosis of voice disorders.

Limitations of Videostroboscopy:

Videostroboscopy despite its usefulness has following limitations;

1. At times recording is difficult due to anatomical and neurological disturbances.
2. Presents only one-dimensional view of the larynx.
3. Patients with aperiodicity and tremor are poor candidates.
4. Cost of the equipment is high.
5. An element of subjective interpretation of perceptual characteristics.

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