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The role of stroboscopy in the management of a patient with a unilateral vocal fold paralysis

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Abstract
Stroboscopy is well established as an essential diagnostic tool in the assessment of the vocal folds during phonation. This paper analyses the stroboscopic findings in 100 patients with a unilateral vocal fold paralysis. Reliable stroboscopic signals were only obtained in patients with the paralysed fold close to the midline. These patients seldom require surgery however, usually responding to speech therapy with laryngeal compensation giving a good voice. Most patients that require surgery have a large glottal deficiency, but in this series these patients did not give an adequate signal for analysis. Although useful in the assessment of the muscle tone of the paralysed fold, the influence of stroboscopy on the surgical treatment in this series was limited.

Key words: Vocal fold, paralysis; Stroboscopy

Introduction

The adult human voice has a fundamental frequency range of around 90 to 250 Hz, which means that the vocal folds vibrate 90 to 250 times per second (Aronson, 1985). It is impossible for the human eye to see these individual vibrations, as Talbot's law states that the retina only responds to images at a rate of five per second (Bless, 1991). Stroboscopy creates the illusion of slow motion of the vocal fold mucosa by the generation of pulsed flashes of light at a rate slightly out of synchrony with the fundamental frequency of phonation so that a montage of the many cycles of vibration is produced. An image of the vocal fold vibration is therefore produced which allows visualization of the movement of the folds during phonation. This is referred to as the mucosal wave (Sercarz *et al.*, 1992). Stroboscopy is therefore a way of imaging the vibration of the vocal folds and indirectly assessing the state of the mucosa (cover) and the underlying laryngeal muscle tone (body) (Hirano and Kakita, 1985).

Following an insult to the laryngeal nerves, the intrinsic musculature of the larynx may show:

(1) Dennervation with a completely flaccid fold.

(2) Synkinesis; re-innervation in an irregular uncoordinated manner with mixing of abductor and adductor fibres that allows some muscle tone to be present. There is a ratio of 5:1 adductor to abductor fibres within the recurrent laryngeal nerve (Goding, 1991) and therefore non-selective axonal growth is highly likely with subsequent inappropriate re-innervation.

(3) Fibrosis and atrophy of the vocalis muscle. A recent publication based on laryngeal electromyography (EMG) studies states that only a very small number of cases have complete dennervation with muscle atrophy and most will have some degree of synkinesis due to unfavourable re-innervation as previously described (Kaufman, 1993).

Laryngeal EMG is the best method of assessing the neuromuscular status of the paralysed vocal fold. It can be diagnostic, by differentiating between cricoarytenoid joint fixation and vocal fold paralysis; prognostic, by showing early evidence of re-innervation in cases of paresis; and topognostic, in identifying whether the superior laryngeal nerve and/or the recurrent laryngeal nerve is affected by measuring the activity in the cricothyroid and the thyroarytenoid muscles. Laryngeal EMG requires expensive equipment, an experienced neurophysiologist for interpretation of recordings and is not available to most laryngologists. Stroboscopy can however play a conjunctive role with EMG readings in assessing the neuromuscular status of the paralysed vocal fold by assessing the muscle tone of the vibrating vocal fold.

More than one surgical method may be applicable to the management of a patient with a unilateral vocal fold paralysis. Identification of the neuromuscular state of the paralysed fold may influence the choice of surgical procedure, for example, a re-innervation procedure may be more appropriate than laryngeal framework surgery in a dennervated, flaccid fold.

This study looks at 100 patients with a unilateral

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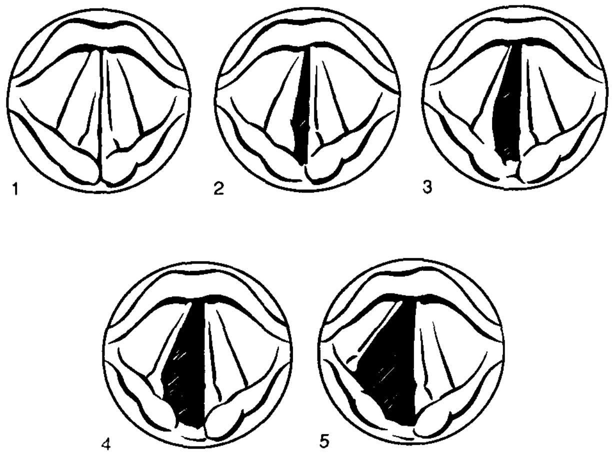

FIG. 1
A scoring system to determine the position of the paralysed vocal fold.

vocal fold paralysis specifically to see if stroboscopy is possible in every patient and to see if, or how, it can affect the choice of surgery.

Method of analysis of video recordings

One hundred patients with a unilateral vocal fold paralysis seen at The Voice Disorders Clinic, Vancouver General Hospital over a 10-year period were reviewed. It has been the practice at this centre to record all voice patients with video-laryngoscopy and stroboscopy (when possible) for the last 10 years, thereby allowing accurate laryngoscopic analysis. Video-laryngoscopy on each case was done on super VHS videotape with a Wolf rigid laryngoscopic rod (Type 121105), Pentax flexible nasendoscope (Type FNL-13S), Stortz camera (Type CCM1), Bruel and Kaer Synchro-stroboscope (Type 4914), and a Sony video recorder and player with freeze and single frame advancement adaptor (Type SLV R5U5).

The horizontal position of the paralysed fold has been previously assessed using the terms median, paramedian, intermediate, neutral, lateral and/or cadaveric. These are poorly-defined, frequently misquoted and often confusing. To overcome this difficulty, a scoring system (shown in Figure 1) was introduced, with one being most medial and five most lateral. The video recording could then be compared with this chart to accurately place each case in the appropriate position and, if necessary, a transparency placed over the screen to improve accuracy. Freeze-frame analysis was invaluable for this assessment and we are not aware of any other scoring systems being applied to the analysis of the paralysed folds. It has an 88 per cent inter-observer correlation at this department when used prospectively at video-laryngoscopy and quantitative airflow measures of laryngeal competence confirm a very good linear correlation ($r = 0.85$) between this scoring system and airflow during phonation (Harries and Morrison, 1995).

Assessment of the position of the paralysed vocal fold was made using a flexible nasendoscope and/or a rigid laryngeal rod connected to a television monitor and video recorder. This was done with the patient breathing at rest as opposed to during phonation where due to false fold compensation and other supraglottic compression the position of the paralysed fold may be difficult to observe.

Video recordings were analysed for horizontal position of the paralysed vocal fold, whether a stroboscopic signal could be recorded or not, and the state of the mucosal wave on stroboscopy (Table I).

Results

In this series stroboscopy was possible in only 61 of the 100 patients. Of these, 38 patients had a paralysed vocal fold in horizontal position 1 or 2, and 23 patients were in position 3. It was not possible to obtain a clear and long enough (over three seconds duration) stroboscopic recording in any of the horizontal positions 5, or 4, or for 17/40 (42.5 per cent) in horizontal position 3 (Table I).

Where stroboscopy was obtained, flaccid flap (where the whole of the vocal fold vibrates during phonation rather than only the 'cover' during a normal mucosal wave) was seen in 16 patients. An incoordinated/reduced mucosal wave (due to synkinesis) was seen in 36 patients and a recordable signal but no mucosal wave (due to muscle atrophy) in only nine patients.

Discussion

There have been conflicting views regarding the value of stroboscopy in the assessment of vocal fold paralysis (Sataloff *et al.,* 1991). Stroboscopy is excellent for assessing asymmetric vocal fold muscle tone and does have a role in the management of the paralysed vocal fold, but only when a signal can be obtained. It is especially useful if re-innervation techniques are being considered where return of muscle tone and symmetry of the vocal folds are the goals of surgery (Sercarz *et al.*, 1992). Although a recent study reported a return to symmetric vibration in four out of five patients with vocal fold paralysis following re-innervation, as measured by

TABLE I
ANALYSIS OF VIDEO RECORDINGS

Position	5	4	3		2		1	
Number of patients	6	16	40		29		9	
Stroboscopy signal obtained	0	0	23		29		9	
Stroboscopy findings	None	None	Synkinesis	8	Synkinesis	20	Synkinesis	8
			Flaccid	11	Flaccid	5	Flaccid	0
			Atrophy	4	Atrophy	4	Atrophy	1

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stroboscopy (Crumley, 1991), it does not mention their pre-operative position.

Our findings in 36 patients agree with previously published data of the stroboscopic recordings in synkinetic folds (Moore *et al.*, 1987). There is a phase difference between each side, and an incoordinated mucosal wave with a decreased amplitude (lateral excursion) and decreased velocity on the paralysed side. This is due to the direct relationship between the stiffness of a material and the velocity of a harmonic wave (Sercarz *et al.*, 1992).

Atrophy of the vocalis muscle (stroboscopic signal but no mucosal wave) was seen in nine per cent of this series. Atrophy of the vocal fold is difficult to define clinically, indeed there is even uncertainty regarding what different authors mean by this term (Isshiki, 1989). Does this apply to the mucosa or the underlying muscle? Muscle tone tension and bulk although desirable for vocal fold function are not essential for phonation and a good result can be obtained if the non-atrophic mucosal edges can be opposed (Flint and Cummings, 1993). Tension imbalance will cause a phase lag between each vocal fold but provided there is closure of the glottic gap the voice quality should be acceptable (Slavit and McCaffery, 1991).

Mucosal atrophy, however, will give a poor result even with symmetry of vocal fold movement due to the absent mucosal wave. Although collagen or fat injected into the superficial plane may help the return of a mucosal wave, long term studies regarding these materials are not yet available (Wexler *et al.*, 1989; Ford *et al.*, 1992).

Vocal fold atrophy is therefore an ambiguous term that is appled to thin or lateralized vocal folds and better distinction between the mucosal and muscle types should be made. The use of EMG will certainly help in the diagnosis of muscle atrophy but mucosal atrophy is best seen with stroboscopy (Sataloff *et al.*, 1991).

In this series, an adequate signal was obtained in only 61 per cent of cases. These were obtained in patients with the fold in position 1, 2 and in approximately 50% of the patients in position 3. Surgery was not considered for any of the patients in position 1 and 2 as they achieved an excellent voice with speech therapy alone. This is in accordance with other publications (Benninger *et al.*, 1994). In our series, only 28 patients required surgery; six patients in position 5, 10 patients in position 4, and 12 patients in position 3. In only two of these (both in position 3) did stroboscopy influence the decision of the type of surgery required. Both patients had incoordinated mucosal waves indicating synkinesis and therefore we did not think a re-innervation procedure necessary.

Although stroboscopy is very important in the analysis of the patient, it seems that it is only in a small percentage of patients that it affects the choice of surgical procedure due to the inability to produce an adequate signal.

References

Aronson, A. (1985) In *Clinical Voice Disorders.* (Aronson, A., ed.), 2nd Edition, Thieme Inc., New York, pp 42–55.

Benninger, M., Crumley, R., Ford, C., Gould, W., Hanson, D., Ossoff, R., Sataloff, R. (1994) evaluation and treatment of the unilateral paralysed vocal fold. *Head and Neck Surgery* **111:** 497–508.

Bless, D. (1991) Assessment of laryngeal function. In *Phonosurgery: Assessment and Surgical Management of Voice Disorders.* (Ford, C., Bless, D., eds.), Raven Press Ltd., New York, pp 95–121.

Crumley, R. (1991) Update: ansa cervicalis to recurrent laryngeal nerve anastomosis for unilateral paralysis. *Laryngoscope* **101:** 384–387.

Flint, P., Cummings, C. (1993) Phonosurgical procedures. In *Otolaryngology, Head and Neck Surgery.* (Cummings, C., ed.), 2nd Edition, Vol. 3, C. V. Mosby Co., St Louis, pp 2072–2109.

Ford, C., Bless, D., Loftus, J. (1992) Role of collagen in the treatment of glottic insufficiency: A study of 119 patients. *Annals of Otology, Rhinology and Laryngology* **101:** 237–247.

Goding, Jr. G. (1991) Nerve-muscle pedicle reinnervation of the vocal cord. *Otolaryngology Clinics of North America* **24:** 115–128.

Harries, M., Morrison, M. (1995) Short term results of laryngeal framework surgery. *Journal of Otolaryngology* **24:** 281–287.

Hirano, M., Kakita, Y. (1985) Cover body theory of vocal fold vibration. In *Speech Science* (Daniloff, R. G., ed.) College Hill Press, San Diego, California, pp 1–46.

Isshiki, N. (1989) *Phonosurgery; Theory and Practice.* Springer-Verlag, Tokyo, pp. 23–33.

Kaufman, J. (1993) Management of vocal fold paralysis. *The Visible Voice.* The Center for voice disorders of Wake University, Winston Salem, USA, Vol. 2, No. 3, pp 50–71.

Moore, D., Berke, G., Hanson, D., Ward, P. (1987) Videostroboscopy of the canine larynx: the effects of asymmetric laryngeal tension. *Laryngoscope* **97:** 543–553.

Sataloff, R., Spiegel, J., Hawkshaw, M. (1991) Strobovideolaryngoscopy: Results and clinical value. *Annals of Otology, Rhinology and Laryngology* **100:** 725–727.

Sercarz, J., Berke, G., Gerratt, B., Ming, Y., Natividad, M. (1992) Videostroboscopy of human vocal fold paralysis. *Annals of Otology, Rhinology and Laryngology* **101:** 567–577.

Slavit, D., McCaffery, T. (1991) Regulation of phonatory efficiency by vocal fold tension and glottic width in the excised canine larynx. *Annals of Otology, Rhinology and Laryngology* **100:** 668–677.

Wexler, D., Gray, S., Jiang, J., Titze, I. (1989) Phonosurgical studies: Fat-graft reconstruction of injured canine vocal cords. *Annals of Otology, Rhinology and Laryngology* **98:** 668–672.

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