Relationship Between Laryngeal Electromyography and Video Laryngostroboscopy in Vocal Fold Paralysis

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Summary: Objectives/Hypothesis. The objective of this study was to better define the relationship of laryngeal electromyography and video laryngostroboscopy in the diagnosis of vocal fold paralysis.

Study Design. Retrospective diagnostic cohort study with cross-sectional data analysis

Methods. Data were obtained from 57 patients with unilateral vocal fold paralysis who attended a large tertiary voice referral center. Electromyographic findings were classified according to recurrent laryngeal nerve, superior laryngeal nerve, and high vagal/combined lesions. Video laryngostroboscopy recordings were classified according to the position of the immobile fold into median, paramedian, lateral, and a foreshortened/hooded vocal fold. The position of the paralyzed vocal fold was then analyzed according to the lesion as determined by electromyography.

Results. The recurrent laryngeal nerve was affected in the majority of cases with left-sided lesions more common than right. Vocal fold position differed between recurrent laryngeal and combined vagal lesions. Recurrent laryngeal nerve lesions were more commonly associated with a laterally displaced immobile fold. No fold position was suggestive of a combined vagal lesion. The inter-rater reliability for determining fold position was high.

Conclusion. Laryngeal electromyography is useful in diagnosing neuromuscular dysfunction of the larynx and best practice recommends its continued implementation along with laryngostroboscopy. While recurrent laryngeal nerve lesions are more likely to present with a lateral vocal fold, this does not occur in all cases. Such findings indicate that further unknown mechanisms contribute to fold position in unilateral paralysis.

Key Words: Neurolaryngology–Vocal fold paralysis–Laryngeal electromyography–Electromyography–Laryngostroboscopy.

INTRODUCTION

Laryngeal electromyography (LEMG) and video laryngostroboscopy (VLS) are commonly employed techniques used in the assessment of individuals with vocal fold paralysis. LEMG is an effective means of evaluating neuromotor function[1–5] and is able to identify impairments in neural transmission and muscle activity.[6] It does not, however, provide information regarding functional capacity or vocal fold pathology. Visualization of the vocal folds, using VLS, is important in the assessment of vocal fold disorders as it provides crucial information regarding abnormalities in vocal fold anatomy, motion, and function.[7–9] Combined with high-quality clinical examination, these two investigations form the basis of laryngeal neuromuscular assessment.

Vocal fold paralysis is complex and its natural history is poorly understood.[6] Several theories have been proposed to explain the appearance of the glottis following neural injury to the larynx.[10,11] Both Semon's law and the Wagner-Grossman hypothesis posit theories that endeavor to explain the position of paralyzed vocal folds. Semon's law states that, in progressive lesions of the recurrent laryngeal nerve (RLN), the abductors are paralyzed before the adductors, thus bringing the vocal fold toward the midline. As complete denervation occurs, the vocal fold then shifts to a lateral position.[11] Wagner and Grossman later hypothesized that, in the case of RLN paralysis, the vocal fold was maintained in a medial position by the activity of the cricothyroid muscle.[10,12]

Current evidence suggests that these long-held theories may be flawed because of a lack of consistency and reproducibility. While studies have reported that the state of the cricothyroid muscle does not influence vocal fold position,[13–15] understanding as to whether certain vocal fold positions are suggestive of underlying neuromuscular dysfunction is limited. Specifically, it is not consistently reported whether vocal fold position differs in isolated lesions of the RLN, the superior laryngeal nerve (SLN), or lesions of both the RLN and SLN, including those at higher levels of the vagus nerve (combined vagal; CVL).

The aim of this study was to better define the relationship of LEMG and VLS in the diagnosis of vocal fold paralysis. While it has been suggested that clinical examination and visualization of the vocal folds alone is not sufficient in diagnosing neuromuscular dysfunction,[16] we sought to identify if any association exists. Vocal fold positions that are pathognomonic for certain lesions could assist clinicians in decisions regarding treatment.

We hypothesized that vocal fold position would be different in isolated lesions of the RLN, SLN, and in CVL (both RLN/SLN or higher vagal) lesions. Specifically, we believed that CVL lesions would present with a foreshortened or "hooded" fold due

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to loss of the cricothyroid muscle, and RLN lesions would present with either a paramedian or lateral vocal fold with significant posterior glottal gap.

MATERIALS AND METHODS

Ethical permission for this study was obtained through the St Vincent's Hospital Human Research Ethics Committee (LNR/15/SVH/86). To investigate the outcomes of interest, a retrospective diagnostic cohort study was designed with cross-sectional data analysis. The medical records of all patients who presented to a large tertiary voice referral center between the years of 2004 and 2014, with a diagnosis of vocal fold paralysis, were reviewed in detail. Individuals with vocal fold paresis, bilateral vocal fold paralysis, or normal LEMG examinations were excluded from the study. Patients were also excluded if there was a time frame of greater than 3 months between VLS and LEMG.

Data were collected by retrospectively reviewing stored VLS recordings and LEMG reports. For each patient, the findings of these examinations were compared to determine if there was a relationship between vocal fold position and LEMG activity.

Video laryngostroboscopy

VLS examinations were performed by a senior otolaryngologist using flexible laryngoscopes (flexible endoscope, Model-8043 with distal chip; Vision Sciences (Brighton, Aus); or Digital Video Stroboscopy System, Model-9295; Kay Elemetrics Corporation (Lincoln Park, NJ, USA)). The standard examination protocol included assessment of the glottis in both continuous phonation and connected speech.

The same senior otolaryngologist and one of two senior speech pathologists reviewed all VLS recordings. Each examination was watched in full until both assessors had reached an opinion of vocal fold position, blind to the other assessors' result. The criteria for determining vocal fold position were slightly modified from those accepted in the literature, for simplicity.[14,17] The position of the vocal fold was defined as the degree of displacement from anatomical midline while phonating /i/ in the mid-phonational range; median (0–1.5 mm), paramedian (1.5–3.5 mm), lateral (>3.5 mm), or hooded (foreshortened fold with hooding of the arytenoid complex). If the examiners disagreed, discussion was undertaken to determine an agreed position for use in the final analysis. The original positions were recorded to calculate a measure of inter-rater reliability in determining vocal fold position using these criteria.

Laryngeal electromyography

All recordings were obtained using concentric bipolar recording needles in awake, unanesthetized patients. The thyroarytenoid muscle was sampled 2–3 mm lateral to the midline at the level of the cricothyroid membrane, while the patient was instructed to phonate /i/ in the mid-phonational range. The cricothyroid muscle was sampled lateral to, and slightly above the lateral border of the cricothyroid notch, while the patient phonated /i/ in the high end of phonational range. Electromyography (EMG) recordings were made using an analog Medelec Neurostar EMG machine (Oxford Instruments Medical, Old Woking, UK). The EMG signals were amplified, band pass filtered, and displayed at 100 μV per division. Interpretation was performed in real time by two senior neurologists. Parameters assessed included insertional activity, spontaneous activity, motor unit potential morphology, and recruitment. The level of denervation was graded based on the reduction in motor unit recruitment.

LEMG reports of all identified patients were reviewed retrospectively. Denervation of the thyroarytenoid muscle was designated as a lesion of the RLN whereas denervation of the cricothyroid muscle was designated as an SLN lesion. If both muscles showed evidence of denervation, a CVL lesion was recorded. Denervation was then subjectively graded on a 0–3 ordinal scale according to reductions in motor unit recruitment and the presence of associated fibrillation potentials; 0—no denervation, 1—mild denervation, 2—moderate/severe denervation, and 3—complete denervation.

Statistical analyses

All statistical analyses were undertaken using R (version 3.2.1, R Foundation for Statistical Computing, Vienna, Austria) and graphical illustrations developed using GraphPad Prism (version 6.00 trial for Mac, GraphPad Software, La Jolla California, USA). To determine if vocal fold position differed between RLN, SLN, and CVL lesions, a Fisher's exact test was used. This allowed conclusions to be drawn regarding whether specific nerve lesions altered glottal appearance according to vocal fold position. Further, the use of logistic regression allowed for the calculation of odds ratios (OR) in predicting the nerve lesion based on the fold position. To ascertain the inter-rater reliability of VLS, a Cohen's kappa coefficient was calculated. Statistical significance was assumed at $P < 0.05$ for all outcomes.

RESULTS

A total of 110 patients were identified with a documented diagnosis of vocal fold paralysis. Twenty-five of these patients were excluded after VLS indicated paresis, rather than paralysis, as the correct diagnosis. Fourteen patients were excluded because of normal LEMG recordings, indicating potentially confounding non-neurological injuries, and a further 12 were excluded as they exhibited bilateral signs. Of the remaining 59 patients, two underwent LEMG more than 3 months after VLS and were therefore not included in the analysis. A total of 57 patients were identified as having unilateral vocal fold paralysis, confirmed by the presence of an immobile vocal fold on VLS and denervation on LEMG.

Demographic and descriptive data

Of the 57 patients, 24 (42%) were male and 33 (58%) were female, with an age range of 20–90 and a mean of 48.17 (SD ± 17.43). The etiologies identified as the underlying cause of vocal fold paralysis are listed in Table 1.

Outcome data

Twenty-nine of the 57 patients underwent LEMG assessment on the same day as the VLS examination. The mean delay from VLS to LEMG was 8.92 ± 14.76 days and only two patients were delayed more than 1 month. Of the 57 nerve lesions, 35 (61%) were isolated lesions of the RLN, 21 (37%) were classified as CVL, and only 1 (2%) isolated SLN lesion was identified. The