

Practice Parameter: Laryngeal Electromyography (An Evidence-Based Review)

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Abstract: This paper reports on an evidence-based review of laryngeal electromyography (EMG) as a technique for use in the diagnosis, prognosis, and treatment of laryngeal movement disorders including the laryngeal dystonias, vocal fold paralysis, and other neurolaryngological disorders. The authors performed a systematic review of the medical literature from 1944 through 2001 on the clinical application of EMG to laryngeal disorders. Thirty-three of the 584 articles met the predefined inclusion criteria. The evidence demonstrated that in a double-blind treatment trial of botulinum toxin versus saline, laryngeal EMG used to guide injections into the thyroarytenoid muscle in persons with adductor spasmodic dysphonia was beneficial. A cross-over comparison between laryngeal EMG-guided injection and endoscopic injection of botulinum toxin into the posterior cricoarytenoid muscle in abductor spasmodic dysphonia found no significant difference between the two techniques and no significant treatment benefit. Based on the evidence, laryngeal EMG is possibly useful for the injection of botulinum toxin into the thyroarytenoid muscle in the treatment of adductor spasmodic dysphonia. There were no evidence-based data sufficient to support or refute the value of laryngeal EMG for the other uses investigated, although there is extensive anecdotal literature suggesting that it is useful for each of them. There is an urgent need for evidence-based research addressing other applications in the use of laryngeal EMG for other applications.

INTRODUCTION

Mission Statement

Although laryngeal electromyography (EMG) is utilized today by practitioners, a comprehensive review of its value in the diagnosis, prognosis, and treatment of laryngeal movement disorders has not been undertaken previously. For this reason, the American Association of Electrodiagnostic Medicine (AAEM) established the Laryngeal EMG Task Force to develop a practice parameter to guide clinical utilization of laryngeal EMG.

Background and Justification

Development of Laryngeal Electromyography

Laryngeal EMG was introduced in 1944 by Weddel and colleagues,⁶⁴ and advanced substantially in the 1950s by Faaborg-Andersen, Buchthal, and others.^{6,14,15} Additional research by various investigators in the 1960s and 1970s began to clarify the potential importance of EMG in laryngology.^{1,4,8,9,13,16,18,21,22,24,26-28,34-38,40-42,44,50,60,62,65}

Many studies were investigations of the role of the laryngeal muscles in speech and voice production^{18,34} or were aimed at increased understanding of laryngeal biomechanics.^{26-28,34,35,36,38} Most of these studies used bipolar hooked wire electrodes and did

not address a clinical role for the technique. In the later 1980s and the 1990s, laryngeal EMG was added to the laryngologic assessment and treatment of voice disorders.^{30-32,39,43,47,57} The laryngeal EMG procedure is usually performed by a neurologist, physiatrist, or laryngologist skilled in electrodiagnostic medicine. Laryngeal EMG techniques utilize primarily needle recordings of voluntary activity.

Current Uses of Laryngeal Electromyography and Clinical Question Statements

Laryngeal EMG is currently being utilized with greater frequency for the diagnosis, prognosis, and treatment of voice disorders. Unfortunately, relatively few professionals trained in EMG have practical experience in laryngeal EMG or a comprehensive understanding of the anatomy and physiology of laryngeal disorders. The AAEM's Laryngeal EMG Task Force identified seven clinical questions that encompass the current common applications of laryngeal EMG as follows:

1. Does laryngeal EMG provide accurate diagnostic information for differentiating vocal fold paresis and paralysis from mechanical fixation of the cricoarytenoid

joint?

2. Does laryngeal EMG provide accurate prognostic information regarding the likelihood of recovery from vocal fold paresis and paralysis?
3. Is laryngeal EMG accurate in the diagnosis of diseases affecting the neuromuscular junction?
4. Can laryngeal EMG differentiate malingered or psychogenic dysphonia from normalcy and neurological dysfunction affecting the laryngeal muscles?
5. Can laryngeal EMG aid in the identification of muscle activation abnormalities in laryngeal dystonias?
6. Does laryngeal EMG provide accurate diagnostic information of systemic neuropathic and myopathic disorders involving the larynx?
7. Is laryngeal EMG a beneficial technique for guiding the treatment of laryngeal dystonias?

PROCESS

Panel Selection

A panel of experts was selected to serve on the task force and to undertake an evidence-based review of the literature to answer each of the seven clinical questions defined above.

Literature Review Process

Search Terms

The task force conducted a review of the scientific literature supporting the utilization of laryngeal EMG for the diagnosis, prognosis, and treatment of voice disorders. The National Library of Medicine’s MEDLINE database was searched from 1966 through January 2001. As recommended in Appendix 4 of the American Academy of Neurology – Therapeutics and Technology Assessment (AAN-TTA) Process Document¹⁹, a MEDLINE search was conducted using the terms “laryngeal” and “electromyography” in combinations as follows: “all [larynx or laryngeal] and all [electromyography or EMG].” This initial search was augmented with the search term

“botulinum toxin”.

Databases

The articles retrieved by the search were sorted according to the proposed uses and questions. Further subsearches for each topic then were used to identify individual articles of interest for classification (Class I, II, III, and IV) using the terms “diagnosis” or sensitivity or specificity or “prognosis”.

Inclusion/Exclusion Criteria and Process of Selection of Articles

The 1999 practice parameter criteria developed by the AAN were followed to classify all articles identified in this evidence-based review.¹⁹ The Criteria of Classification of Article Strength are provided in Table 1. In most cases, the reference standard for diagnosis of laryngeal disorders is laryngeal videostroboscopy with fiberoptic nasolaryngoscopy.

Table 1. Criteria for Classification of Article Strength (abbreviated from Goodin and colleauges¹⁹)

Class I: Prospective, blinded study with randomized, controlled treatment for clinical trial or with broad cohort size, a reference standard, and the determination of sensitivity and specificity for a diagnostic or prognostic study.
Class II: For a clinical trial, prospective, blinded study with either randomized, controlled treatment and no accounting of dropouts or with matched control group and accounting for dropouts. For a diagnostic or prognostic study, a prospective study with a narrow cohort size or a retrospective study with a broad cohort size with a reference standard, and the determination of sensitivity and specificity.
Class III: Prospective, unblinded study with neither randomization nor matched control group for clinical trial. Retrospective, blinded study without determination of sensitivity or specificity for diagnostic or prognostic study.
Class IV: Retrospective, unblinded study.

Number of Abstract and Articles Found/Excluded

Initially 584 studies were retrieved using the search terms. However, very few were formal studies aimed at establishing the potential use of laryngeal EMG as a diagnostic, therapeutic, or prognostic procedure. To date, 33 articles qualified for inclusion in the Evidence Tables using the criteria in Table 1 for diagnostic, prognostic, and therapeutic studies. None of the articles were Class I or Class II with regard to laryngeal EMG. Regarding the use of laryngeal EMG for the treatment of laryngeal dystonias, two were Class III. All other articles were Class IV which were selected for inclusion because they (1) provided sufficient information to allow the reader to understand the methodology clearly enough to repeat the study, (2) utilized standard clinical and electromyographic techniques (3) provided information on methods for clinical diagnosis, and (4) Either reported a substantial series of 20 or more patients,^{4,5,8,12,14,29,33,40,45,46,55,61,67} or a smaller number of patients illustrating the use of laryngeal EMG for evaluation of specific clinical problems (all other studies). The reference standard is clinical diagnosis, including laryngoscopy. The task force member utilized the definitions for elements of evidence and classifications of evidence as defined in the AAA-TTA Process Document.¹⁹

Development of Evidence Tables

The evidence results were classified based on the experimental design for each study and compiled in Evidence Tables for each of the seven proposed clinical applications for laryngeal EMG. These tables were then used as the basis for establishing recommendations for the various applications. The Evidence Tables are available at www.aaem.net or from the AAEM Executive Office.

Internal and External Review of the Document

Based on the criteria for establishing recommendations used by the AAN-TTA, the following were used in developing a Rating of Recommendation:

Recommendation A: Class I studies are required for establishing a technology as useful or predictive for a given condition in the specified population and require at least one convincing class I study or at least two consistent convincing class II studies.

Recommendation B: Class II studies are required for classifying a technology as probably useful or predictive for a given condition in the specified population and require at least one convincing class II study or at least three consistent class III studies.

Recommendation C: Class III studies are required for determining that a technology is possibly useful or predictive for a given condition in the specified population and require at least two convincing and consistent class III studies.

Recommendation U: The unknown recommendation is to be used when data are inadequate and the technology is unproven.

ANALYSIS OF THE EVIDENCE

Two studies provide Class III evidence that laryngeal EMG may be useful in the treatment of abductor or adductor spasmodic dysphonia.^{2,49} Bielamowicz and colleagues conducted a randomized cross-over comparison of the use of laryngeal EMG with the use of endoscopic-guided injection for the treatment of abductor spasmodic dysphonia by botulinum toxin injections into the posterior cricoarytenoid muscle.² Blinded measures demonstrated no significant reduction in breathy breaks with either technique and no differences between the techniques in abductor spasmodic dysphonia. A study by Ludlow and colleagues used laryngeal EMG to administer botulinum toxin injections into the thyroarytenoid muscle in adductor spasmodic dysphonia with a blinded comparison of baseline and post-treatment speech measures.⁴⁹ This study demonstrated a significant improvement in speech following treatment. Truong and colleagues performed a double-blinded, randomized, placebo-controlled study of botulinum toxin injection treatment of patients with adductor spasmodic dysphonia. Although this study provides Class II evidence for improvement with botulinum toxin and not saline treatment, laryngeal EMG was used to guide injection with both treatments, so this article does provides Class IV evidence on the usefulness of laryngeal EMG over other methods for injection.⁶³ The usefulness of laryngeal EMG in the treatment of spasmodic dysphonia is also supported by two other studies with class IV evidence.^{4,5} Thus, this evidence-based medicine review supports the possible usefulness of laryngeal EMG in the treatment of spasmodic dysphonia.

It has been asserted that laryngeal EMG may be preferable to direct visualization for guidance of botulinum toxin injections for three main reasons. First, using direct visualization requires either sedation/anesthetic in the operating room (direct laryngoscopy) or transoral injection. Many patients find the transoral procedure uncomfortable, and it can only be performed in patients with easily controlled gag reflexes. The use of a flexible injection needle through a bronchoscope is not standard. With this method, precision is difficult to control; and an unacceptable amount of botulinum toxin is wasted because of the length of the flexible, trans-bronchoscopic syringe. Second, when utilizing direct visualization, only the location of the thyroarytenoid can be well visualized. The locations of the lateral cricoarytenoid and posterior cricoarytenoid are more difficult to establish visually. The cricothyroid muscle cannot be seen, although its points of attachment and insertion can be palpated through the neck. Third, laryngeal EMG permits functional confirmation that the needle is in the correct muscle (each muscle has a different electrophysiologic response). It also allows the physician to select the most active part of the muscle, as well as permitting an assessment of the effect of any residual botulinum toxin in patients who are undergoing re-injection. Hence, laryngeal EMG has been considered helpful in facilitating treatment with botulinum toxin.

Class IV evidence also suggests the usefulness of laryngeal EMG in diagnosis and prognosis. A large number of articles suggest that laryngeal EMG is useful in distinguishing vocal fold paresis from mechanical fixation or no abnormality.^{3,8,10,14,23,25,33,40,45,46,48,52,56,58,66,67} Seven of these articles suggest that the sensitivity of laryngeal EMG may range from 33% to 100% in detecting vocal fold paresis and that its specificity ranges from 12% to 50%.^{3,8,23,33,40,46,48} Regarding the prognosis of vocal fold paresis, the sensitivity for laryngeal EMG is predicting recovery ranges from 13% to 100%, whereas the specificity for predicting poor recovery has varied from 20% to 100%.^{12,17,20,33,53,55,59,61,66} Laryngeal EMG may be useful in aiding the identification of muscle activation abnormalities in laryngeal dystonias.^{7,29,54,66} Two case reports have suggested that laryngeal EMG was helpful in the diagnosis of a systemic neuropathy.^{11,51}

CONCLUSIONS BASED ON REVIEW OF EVIDENCE-BASED DATA

Based on the previously discussed studies, use of laryngeal EMG in the administration of botulinum toxin in the treatment of adductor spasmodic dysphonia is supported by current research at a *Recommendation C* level - possibly useful or predictive for a given condition in the specified population.

RECOMMENDATIONS

Practice Recommendations

In the treatment of spasmodic dysphonia, laryngeal EMG localization for the injection of botulinum toxin Type A into the thyroarytenoid muscle for the treatment of adductor spasmodic dysphonia is possibly equal in effectiveness to endoscopic guided injection (Recommendation C).

Recommendations for Future Research on Potential Clinical Utility of Laryngeal Electromyography for Patients with Suspected Laryngeal Movement Disorders

Although evidence-based research is lacking regarding the utility of laryngeal EMG for patients with suspected movement disorders, the large number of studies suggesting its utility^{1,6,8,9,13-16,18,21,22,24,26-28,30-32,34-44,47,50,57,60,62,64,65} and its current clinical use indicate the urgent need for a well-controlled study of the accuracy and clinical value of this procedure. The current lack of evidence is because of the absence of high-quality evidence-based research investigating these applications. There is no evidence suggesting that laryngeal EMG is not useful. Research is therefore needed to confirm or refute the clinical value of laryngeal EMG for the other clinical questions investigated.

The studies currently available on this issue include biases and lack standardization in methodology. Few evidence-based studies have investigated the many common clinical uses of laryngeal EMG. Masking (blinding) is a critical feature of the study design that must be included in future studies. To determine the diagnostic or prognostic utility without bias, clinical investigators need to be blinded to patient diagnosis or treatment outcome when interpreting laryngeal EMG findings. For example, representative segments of laryngeal EMG recordings from patients and control subjects could

be randomized and interpreted by independent electrodiagnostic medicine consultants at different sites. Random insertion of repeats of some of the individual recordings would permit assessment of intra-rater as well as inter-rater reliability for the proposed application. For therapeutic studies, double blinding (masking of both patient or subject and the investigator) should be employed if possible to minimize bias and to allow assessment of placebo effects.

Careful consideration should be given to selection of the best possible “reference standard” by which the presence or absence of a condition is determined for diagnostic or prognostic applications of laryngeal EMG. If the validity of the reference standard in a study is suspect, the validity of the results will be limited accordingly. For applications in which the current reference standard is based on subjective assessments (e.g., interpretation of laryngeal endoscopic examinations for the diagnosis of vocal fold paralysis) attempts should be made to define clearly the criteria used for the assessment and consideration should be given to the use of multiple raters to enhance the accuracy of the determination.

In conclusion, additional evidence-based studies are recommended to determine the value of laryngeal EMG for each of the clinical uses for which it is currently being employed; the optimal electrode type for specific clinical purposes; the validity and reliability of techniques used for quantification of laryngeal EMG signals; and the predictive and diagnostic accuracy of EMG findings and their relation to treatment outcomes.

TOOLS

The review of the articles for the evidence-based tables was conducted by reading the articles and recording the results in excel files under each of the headings provided. No automatic algorithms were used in the procedures.

DISCLAIMER

This report is provided as an educational service of the AAEM, The American Academy of Otolaryngology – Head and Neck Surgery, and The Voice Foundation. It is based on an assessment of the current scientific and clinical information. It is

not intended to include all possible methods of care of particular clinical problem, or all legitimate criteria for choosing to use a specific procedure. Neither is it intended to exclude any reasonable alternative methodologies. This statement is not intended to address all possible uses of, or issues regarding, laryngeal EMG and in no way reflects upon the usefulness of laryngeal EMG in those areas not addressed. The AAEM recognizes that specific patient care decisions are the prerogative of the patient and his/her physician and are based on all of the circumstances involved. These guidelines are not a substitute for the experience and judgment of a physician. This review was not written with the intent that it be used as a basis for reimbursement decisions.

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