

Otolaryngology- Head and Neck Surgery

JUNE 2001

VOLUME 124

NUMBER 6

ORIGINAL ARTICLES

Diagnostic laryngeal electromyography: The Wake Forest experience 1995-1999

JAMES A. KOUFMAN, MD, GREGORY N. POSTMA, MD, CHRIS S. WHANG, MD, CATHERINE J. REES, BS, MILAN R. AMIN, MD, PETER C. BELAFSKY, MD, PhD, PAUL E. JOHNSON, MD, KIERAN M. CONNOLLY, MD, and FRANCIS O. WALKER, MD, Winston-Salem, North Carolina, and Philadelphia, Pennsylvania

BACKGROUND: Laryngeal electromyography (LEMG) is a valuable diagnostic/prognostic test for patients with suspected laryngeal neuromuscular disorders.

OBJECTIVE: To report our experience with diagnostic LEMG at the Center for Voice Disorders of Wake Forest University and to evaluate the impact of LEMG on clinical management.

METHODS: Retrospective chart review of 415 patients who underwent diagnostic LEMG over a 5-year period (1995-1999).

RESULTS: Of 415 studies, 83% (346 of 415) were abnormal, indicating a neuropathic process. LEMG results altered the diagnostic evaluation (eg, the type of radiographic imaging) in 11% (46 of 415) of the patients. Unexpected LEMG findings (eg, contralateral neuropathy) were found in 26% (107 of 415) of the patients, and LEMG results differentiated vocal fold paralysis from fixation in 12% (49 of 415). Finally, LEMG results altered the clinical manage-

ment (eg, changed the timing and/or type of surgical procedure) in 40% (166 of 415) of the patients.

CONCLUSIONS: LEMG is a valuable diagnostic test that aids the clinician in the diagnosis and management of laryngeal neuromuscular disorders. (Otolaryngol Head Neck Surg 2001;124:603-6.)

Diagnostic laryngeal electromyography (LEMG) reliably evaluates the electrophysiologic status of the larynx and often provides critical clinical information that no other test can provide. LEMG is considered by some clinicians to be the diagnostic sine qua non for certain neuromuscular disorders of the larynx, such as vocal fold paresis.¹ The clinical use of LEMG remains controversial. However, in our hands, it has become a valuable tool for the care of patients with certain voice and swallowing disorders. LEMG is useful in the diagnosis of most neuromuscular diseases of the larynx. Table 1 summarizes our indications for LEMG. Since 1987, we have performed more than 1000 diagnostic LEMGs. A review of our experience of the past 5 years is reported herein.

MATERIALS AND METHODS

A retrospective review of the patient records and an established LEMG database was conducted from January 1, 1995 through December 30, 1999 at the Center for Voice Disorders of Wake Forest University. This report summarizes the retrospective review of those data as well as the complete review of the medical records of the 558 patients who underwent diagnostic LEMG during that time. Medical records of 143 patients were excluded

From the Center for Voice Disorders, Department of Otolaryngology (Drs Koufman, Postma, Whang, Belafsky, Johnson, Connolly and Ms Rees), and Department of Neurology (Dr Walker), Wake Forest University School of Medicine; and Department of Otolaryngology (Dr Amin), Hahnemann University School of Medicine.

Reprint requests: James A. Koufman, MD, Center for Voice Disorders of Wake Forest University, Department of Otolaryngology, Medical Center Boulevard, Winston-Salem, North Carolina 27157-1034; e-mail, jkoufman@wfubmc.edu.

Copyright © 2001 by the American Academy of Otolaryngology-Head and Neck Surgery Foundation, Inc.

0194-5998/2001/\$35.00 + 0 23/1/115856

doi:10.1067/mhn.2001.115856

Table 1. LEMG: Indications and applications

1. Site-of-lesion testing and prognosis in vocal fold paralysis
2. Differentiation of vocal fold paralysis from fixation
3. Diagnosis, site-of-lesion testing, and prognosis in vocal fold paresis
4. Diagnosis of neurologic diseases (eg, amyotrophic lateral sclerosis)
5. Needle localization for Botulinum toxin injections

Table 2. Paresis and paralysis: Identified risk factors and presumed causes of patients with abnormal LEMG findings

	n	Percentage
Neck/chest surgery	128	31%
Viral infection*	66	16%
Neurologic disorder	38	9%
Neck/chest neoplasm	35	8%
Endotracheal intubation	34	8%
Neck/chest trauma	17	4%
Idiopathic*	97	23%
Total	415	100%

*Although these 2 subgroups are usually lumped together into the idiopathic category, we have identified a large subgroup of patients who related having had a viral upper respiratory infection at the time of development of vocal symptoms. This condition appears to be analogous to "Bell's palsy of the larynx."

Table 3. Clinical impact of LEMG (N = 415)

	n	Percentage
LEMG altered the type of radiologic imaging or the decision to image	46	11%
LEMG differentiated vocal fold fixation from paresis/paralysis	49	12%
LEMG altered the timing and/or type or surgical intervention	166	40%

due to incomplete records leaving a total of 415 patients. Specifically excluded were patients with laryngeal dystonias undergoing botulinum toxin injection. Demographic and relevant clinical information were reviewed specifically for items related to disease causes and the onset of symptoms. This included factors such as: (1) prior intubation; (2) prior head, neck, or chest surgery; (3) prior head, neck, or chest trauma; (4) neoplastic disease; (5) neurologic disease; and (6) prior viral illness.

The medical record of each study patient was reviewed to determine if the LEMG results influenced clinical management, ie, subsequent evaluation and treatment. The central research question was, "Does LEMG impact clinical care?" We investigated this issue by addressing 5 specific management questions:

1. Did LEMG data alter the type of radiologic investigation, ie, was the subsequent radiographic evaluation LEMG-guided?
2. Did LEMG data determine whether to use radiographic imaging at all?

3. Was LEMG used to differentiate vocal fold fixation from paralysis?
4. Did LEMG data change the timing of surgical intervention?
5. Did LEMG data alter the selection or type of surgical procedure?

The answers to these questions, ie, the clinical impact of LEMG, are the focus of this article.

Technique and Interpretation of LEMG

LEMG is performed with a standard protocol that uses both an otolaryngologist and a neurologist. The otolaryngologist places the needle electrodes; the neurologist operates the EMG machine, and both interpret the LEMG results. We use a Nicolet Viking Electromyograph (Nicolet Biomedical Inc, Madison, WI) and disposable monopolar needle electrodes (902-DMF37, Teca Corp, Pleasantville, NJ) in preference to concentric electrodes. In our opinion, monopolar electrodes reduce the chance of sampling error. Two recording channels, one to record the EMG signal and the second for the voice signal, are used.

Both the cricothyroid and thyroarytenoid muscle are routinely tested bilaterally. Multiple sweep speeds are used to assess overall LEMG patterns as well as waveform morphology. Four parameters are assessed for each muscle tested: (1) recruitment, (2) waveform morphology, (3) presence or absence of spontaneous activity, and (4) the presence or absence of synkinesis. Additional details of LEMG technique and interpretation have been previously reported.¹⁻³

RESULTS

Of the patients in this study, 57% (235 of 415) were female and 43% (180 of 415) were male. The mean age of the study patients was 51 (± 16) years. Possible causes for paresis/paralysis (Table 2) were identified in 77% (318 of 415) of the patients.

Eighty-three percent (346 of 415) of the patients had abnormal diagnostic LEMG results. Unexpected LEMG findings (ie, contralateral neuropathy) were identified in 26% (107 of 415) of the patients. LEMG results revealed that 29% (121 of 415) of the patients had paresis of the right cricothyroid muscle; 33% (135 of 415) had a left cricothyroid paresis; 45% (187 of 415) of the patients had a right thyroarytenoid paresis; and 63% (261 of 415) had a left thyroarytenoid paresis.

The impact of LEMG on clinical management is shown in Table 3. In 11% (46 of 415) of the patients, LEMG data altered decisions concerning radiographic imaging. In 12% (49 of 415) of the patients, LEMG was used to differentiate vocal fold fixation from paralysis. Finally, in 40% (166 of 415) of the patients, LEMG results altered the timing and/or type of rehabilitative laryngeal surgical intervention.

Table 4. Classification of LEMG findings

Class	Spontaneous activity	Recruitment	Motor unit morphology	Interpretation (prognosis)
I	Absent	Normal	Normal MUPs*	Normal†
II	Absent	Reduced	Nascent polyphasic MUPs	Reinnervation‡
III	Absent	Reduced	Giant MUPs	Old injury§
IV	Present	Reduced	Polyphasic MUPs	Equivocal
V	Present	Absent	Fibrillations, etc.	Denervation¶

*MUPs, Motor unit potentials.

†Normal LEMG rules out a neuropathic process. If the EMG of a hypomobile vocal fold is normal, then the problem is related to some type of arytenoid fixation, ie, the problem is not paralysis.^{7,8}

‡Low-amplitude, complex, polyphasic (nascent) MUPs indicate ongoing reinnervation. With relatively full recruitment and a predominance of nascent MUPs, the prognosis for neural recovery is relatively good.

§High-amplitude (giant) MUPs indicate an old neuropathy that has stopped regenerating, ie, further recovery is not expected.

||These EMG findings may indicate ongoing denervation, partial recovery, or both; polyphasic MUPs may vary from nascent to giant. This pattern is difficult to interpret, however, it may be seen in degenerative neurologic diseases such as amyotrophic lateral sclerosis.

¶Fibrillations, positive waves, and complex repetitive discharges are all electromyographic manifestations of ongoing neural denervation or neural injury, indicating an acute or active neuropathic process. When its cause is unknown, a medical/radiographic evaluation should be initiated to attempt to identify the cause of the neuropathy.

DISCUSSION

LEMG has evolved from work in 1957 by Faaborg-Anderson⁴ to become an extremely valuable diagnostic and prognostic test for patients with neuromuscular disorders of the larynx. LEMG technology has advanced at a faster pace than reports of its use in the otolaryngologic literature, so that many voice clinicians still underuse LEMG. At the Center for Voice Disorders of Wake Forest University, we have found that LEMG provides critical data in the diagnosis/prognosis of vocal fold paresis, the prognosis and site-of-lesion testing of vocal fold paralysis, the differentiation of vocal fold fixation from paralysis, the diagnosis of laryngeal movement disorders, and for needle localization for botulinum toxin injection therapy.^{2,3,5}

Although the technique and interpretation of LEMG are beyond the scope of this article, we have found that using a team approach (an otolaryngologist and a neurologist) provides an easy and reliable method of performing LEMG. The LEMG data are analyzed to determine the level of recruitment, waveform morphology, synkinesis, and the presence or absence of spontaneous activity. With these parameters, the LEMG interpretation commonly falls into the 5 classes listed in Table 4.³

The timing and severity of a neuropathic laryngeal injury as well as prognosis for recovery can thus be determined by LEMG. However, the question remains, does the information affect the clinical management of patients?

Clinical Impact of LEMG

In this series, LEMG altered the type of radiographic imaging or the decision to image or not in 11% (46 of 415) of the patients. The decision whether to radiologically evaluate at all was based on the patient's history and the "age of the neuropathy." The presence of spontaneous

activity on LEMG suggests an ongoing neuropathic process (ie, denervation). When denervation is encountered, and the etiology is unknown, EMG-guided radiologic evaluation is recommended. Conversely, if the LEMG shows decreased recruitment, very large motor units, and no spontaneous activity, this is indicative of an old neuropathy and radiographic imaging is unnecessary.

When a relatively recent and unexplained neuropathy was found, the patient's subsequent radiologic evaluation was LEMG-guided, ie, the choice of imaging studies was based on the site-of-lesion data.^{9,10} Patients with isolated involvement of the recurrent laryngeal nerve (RLN) underwent CT imaging of the course of the vagus nerve from the skull base through the superior mediastinum. If both the RLN and the superior laryngeal nerves (SLN) were involved, an MRI of the brain and skull base was obtained in addition to the CT scan of the neck.

In this series, 49 patients with hypomobile or immobile vocal folds were found to have normal LEMGs. Many of the patients in this group had had prolonged endotracheal intubation or trauma. In this group, LEMG accurately predicted that the problem was fixation and not paresis. These data confirm previous reports that LEMG reliably differentiates the 2 conditions.^{6,7}

One of the interesting findings of this study was that 26% (107 of 415) of the patients had unexpected LEMG findings; this had a heterogeneous impact. In some cases, the finding of a contralateral weakness led to a bilateral medialization procedure being performed (rather than just a unilateral procedure). In some cases, the unexpected finding of spontaneous activity led to early detection of an unsuspected neoplasm. In some cases, contralateral neuropathic findings changed the presumed etiologic diagnosis. For example, after anterior cervical discectomy with ipsilateral paresis, con-

tralateral LEMG abnormalities might suggest the possibility of an etiologic factor other than surgical technique or trauma, such as endotracheal intubation.

Finally, LEMG altered the timing or type of rehabilitative laryngeal surgical intervention in 40% (166 of 415) of our patients in 1 of 3 ways: (1) altering the type of surgery selected, (2) early surgical intervention, or (3) delayed or no surgical intervention. The decision-making algorithm was always complex, based on the prognostic data, severity of symptoms, and the vocal needs of the patient. In patients with vocal fold paresis or immobility and a good prognosis for recovery based on LEMG, a conservative path was usually selected. Conversely, in severely symptomatic paralysis patients with a poor prognosis based on LEMG, a more aggressive surgical intervention often was used. For example, an elderly clergyman who is aphonic and aspirating 1 month after thyroid surgery (lateralized unilateral paralysis with an open posterior larynx and poor LEMG prognosis) may be a candidate for early medialization laryngoplasty with arytenoid adduction.

Overall LEMG affected the clinical management of the majority of the patients in our study population. Thus, the data support the notion that LEMG is important in the accurate diagnosis and management of patients with neuromuscular diseases of the larynx.

CONCLUSIONS

Laryngeal electromyography is a valuable diagnostic

test that reliably evaluates the neuromuscular status of the larynx. It provides information about the site-of-lesion, age and prognosis for recovery of the neuropathy, and differentiates fixation from paralysis. LEMG data aid the clinician in decision-making with respect to the medical and radiographic evaluation of patients with vocal fold paresis/paralysis. In addition, it may alter the timing and type of laryngeal rehabilitative surgery.

REFERENCES

1. Koufman JA, Postma GN, Cummins MM, et al. Vocal fold paresis. *Otolaryngology Head Neck Surg* 2000;122:537-41.
2. Postma G, Koufman J. Laryngeal electromyography. *Curr Opin Otolaryngol Head Neck Surg* 1998;6:411-5.
3. Koufman J, Walker F. Laryngeal electromyography in clinical practice: indications, technique, and interpretation. *Phonoscope* 1998;1:57-70.
4. Faaborg-Anderson K. Electromyographic investigation of the intrinsic laryngeal muscles in human. *Acta Physiol Scand* 1957;41(Suppl 140).
5. Yin S, Qiu W, Stucker F. Major patterns of laryngeal electromyography and their clinical application. *Laryngoscope* 1997;107:126-36.
6. Carrat X, Verhulst J, Duroux S, et al. Postintubation interarytenoid adhesion. *Ann Otol Rhinol Laryngol* 2000;109:736-40.
7. Yin S, Qiu W, Stuckler F. Value of electromyography in differential diagnosis of laryngeal joint injuries after intubation. *Ann Otol Rhinol Laryngol* 1996;105:446-51.
8. Rontal E, Rontal M, Silverman B, et al. The clinical differentiation between vocal cord paralysis and vocal cord fixation using electromyography. *Laryngoscope* 1993;103:133-7.
9. Dursun G, Sataloff R, Spiegel J, et al. Superior laryngeal nerve paresis and paralysis. *J Voice* 1996;10:206-11.
10. Koufman J, Walker F, Joharji G. The cricothyroid muscle does not influence vocal fold position in laryngeal paralysis. *Laryngoscope* 1995;105:368-72.