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LARYNGOLOGY

# Teaching laryngeal electromyography

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**Abstract** To achieve consensus in the methodology, interpretation, validity, and clinical application of laryngeal electromyography (LEMG), a working group on neurolaryngology from the European Laryngological Society (ELS) was founded in 2010. The main task of the working group was to teach key techniques like LEMG procedures. The objective of this study was to collect information on the teaching techniques used and describe them. A multicenter registry was created to analyze the data collected from LEMGs in 14 departments. We screened how often different departments participated in teaching events. Teaching events were classified retrospectively: presentations at conferences and meetings; workshops with hands-on training on patients; workshops with hands-on training on animal models; workshops with hands-on training on anatomic specimens; and supervision by experts to perform LEMG together. Both, supervision to perform LEMG together and the total number of PCA–LEMGs ($r = 0.713$), as well as supervision to perform LEMG together and the PCA/total-number-of-LEMG ratio ($r = 0.814$) were correlated significantly ($p < 0.05$). Similarly, the sum of teaching events was correlated significantly with the total number of PCA–LEMGs ($r = 0.605$), and so did the sum of teaching events with the PCA/total-number-of-LEMG ratio ($r = 0.704$). Participation in hands-on training in humans was correlated significantly with the PCA/total-number-of-LEMG ratio ($r = 0.640$). The data presented herein suggest that multimodal teaching techniques are most effective. To promote multimodal learning an interactive webpage (http://www.lemg.org) providing videos and animations, and the possibility to discuss cases with other experts was established.

**Keywords** Laryngeal electromyography · Computer-assisted learning · Neurolaryngology · Teaching · European Laryngological Society

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## Introduction

Laryngeal electromyography (LEMG) was introduced by Weddell et al. [1] in 1944. Throughout the 1980s and 1990s, many applications of LEMG as a tool for laryngological assessment, but also for the diagnosis and treatment of voice disorders were described.

However, LEMG is still sparsely implemented in clinical routine in most ENT or phoniatric departments. Where LEMG is used a lack of agreement on methodology, interpretation, validity, and clinical application of LEMG still exists [2–7]. Some steps to overcome these problems are developing guidelines for the use of LEMG, offering workshops on LEMG, building partnerships with neurological departments in order to share knowledge and equipment, and thus strengthening the integration into clinical routine.

A working group on neurolaryngology from the European Laryngological Society (ELS) (http://www.elsoc.org) was formed to: (1) evaluate existing guidelines for LEMG performance [3], and (2) identify issues requiring further clarification (http://www.elsoc.org/index.asp?seccion=7&apartado=16). The main task of the working group was to teach the key techniques of LEMG surgery. The group published a proposal for a set of recommendations for LEMG and initiated a registry with the aim of collecting LEMG data recorded according to these published recommendations [3, 8]. To achieve a sufficient level of standardization and data quality, meetings and workshops were organized for participants of the registry and other professionals interested in LEMG and neurolaryngology.

The objective of this study was to collect information on the teaching techniques used and describe them. We screened how often different departments, within the registry, participated in teaching events.

The aim of this study was to describe the teaching techniques that were used and to report retrospectively on the efficiency of the teaching techniques as determined using the number and position of LEMGs performed as a marker of experience.

## Methods

From May 2012 until March 2014, laryngologists from 14 different departments with special interest in neurolaryngology joined a multicenter registry to collect LEMG datasets, and to learn more about the indications for performing LEMG and the interpretation of the results. The local ethics committees gave approval in all participating hospitals. The departments had the possibility to send staff to meetings and workshops or to ask for supervision by experts to perform LEMG together. Participation was completely voluntary, because there was no minimal requirement of training set for the registry. Retrospectively, we classified the different types of learning and practical training offered into the following categories: presentations at conferences and meetings; workshops with hands-on training on patients; workshops with hands-on training on animal models; workshops with hands-on training on anatomic specimens; and supervision by experts to perform LEMG together.

To estimate the effect of the different learning modalities, we reviewed the protocols of the meetings and workshops. Every time a department sent at least one participant to an LEMG session at a conference, or to a hands-on training session, or asked for supervision by an expert, it was counted. As the number of physicians trained in LEMG in each department varied from one to four physicians, we simplified our evaluation by looking only at the dedication and the output, of the whole department.

To quantify the success of learning, we counted the number of datasets of LEMG recordings. The initial outcome parameter was the number of successful uploaded LEMG recordings. Only LEMG recordings matching the criteria published by the ELS 2012 [8] were rated. Departments that did not contribute at least one dataset were not considered in the further statistic evaluation. As an additional measure, datasets including the PCA were counted separately, since more skill is generally needed to record an LEMG of the PCA than of the thyroarytenoid muscle (TA). The ratio between the total number of LEMGs contributed by one department and the number of these LEMGs that included the PCA was calculated as a marker for experience (PCA–LEMG ratio).

### Statistical analyses

Correlation between the number of attended learning-events and the number of contributed LEMG datasets was determined using Pearson's correlation co-efficient. Subanalyses of the number of learning modalities was performed by splitting the different groups as described in the "Methods". The significance level was set to $p = 0.05$.

## Results

From the 14 departments included in this retrospective study, 11 departments (79 %) delivered at least one LEMG recording fulfilling the requirements for statistical analyses, seven departments (50 %) provided LEMG data from the PCA (Table 1).

Two departments contributed just over half of all LEMG recordings (51.7 %) and the PCA–LEMG recordings (52 %).

Special sessions dedicated to LEMG took place at three international conferences of the ELS in Vienna 2010, in Helsiniki 2012 and in Hamburg 2013 (Fig. 1). To achieve standardization, hands-on workshops were organized seven times: three used anesthetized pigs as models (Fig. 2), one used anatomic specimens, and in the other three workshops live LEMGs were performed on patients. Supervision by

**Table 1** Correlation between the number of attended learning-events and the number of contributed LEMG datasets was determined using Pearson's correlation co-efficient

| Department | No. of total LEMGs | | No. of LEMGs of PCA | | Ratio of PCA:total LEMGs % | Participation in | | | | Supervision to perform LEMG together | Sum of teaching-events | No. of years performing LEMGs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | absolute | % | absolute | % | | LEMG Congresses | hands-on-training in | | | | | |
| | | | | | | | humans | pigs | cadaver | | | |
| 1 | 30 | 33.0 | 8 | 32.0 | 26.7 | 2 | 1 | 2 | 1 | 3 | 9 | 1 |
| 2 | 17 | 18.7 | 5 | 20.0 | 29.4 | 3 | 3 | 3 | 1 | 4 | 14 | 12 |
| 3 | 11 | 12.1 | 2 | 8.0 | 18.2 | 2 | 2 | 3 | 1 | 2 | 10 | 8 |
| 4 | 8 | 8.8 | 4 | 16.0 | 50 | 1 | 2 | 1 | 1 | 1 | 6 | 1 |
| 5 | 6 | 6.6 | 0 | 0.0 | 0 | 2 | 1 | 1 | 1 | 0 | 5 | 8 |
| 6 | 5 | 5.5 | 3 | 12.0 | 60 | 3 | 2 | 2 | 1 | 3 | 11 | 13 |
| 7 | 4 | 4.4 | 3 | 12.0 | 75 | 3 | 2 | 2 | 1 | 5 | 13 | 13 |
| 8 | 3 | 3.3 | 0 | 0.0 | 0 | 3 | 1 | 1 | 1 | 0 | 6 | 8 |
| 9 | 3 | 3.3 | 0 | 0.0 | 0 | 3 | 1 | 1 | 1 | 0 | 6 | 11 |
| 10 | 2 | 2.2 | 0 | 0.0 | 0 | 2 | 1 | 1 | 1 | 0 | 5 | 8 |
| 11 | 2 | 2.2 | 0 | 0.0 | 0 | 3 | 1 | 0 | 0 | 0 | 4 | 8 |
| Pearson's r | | | | | Correlation | -.018 | .640* | .451 | .285 | .814* | .704* | .163 |
| | | | Correlation | | | -.240 | .459 | .580 | .285 | .713* | .605* | -.371 |
| | Correlation | | | | | -.263 | .211 | .545 | .244 | .468 | .408 | -.478 |

The significance level was set to $p = 0.05$. The amount of learning sessions, visited by at least one participant of the different ENT-departments (1–11), is spitted up into: workshops with hands-on training on patients; workshops with hands-on training on animal models; workshops with hands-on training on anatomic specimens; and supervision by experts to perform LEMG together. To quantify the success of learning, the number of datasets of LEMG recordings are counted. The initial outcome parameter was the number of successful uploaded LEMG recordings. Only LEMG recordings matching the criteria published by the ELS 2012 [13] were rated. As an additional measure, datasets including the PCA were counted separately, since more skill is generally needed to record an LEMG of the PCA than of the thyroarytenoid muscle (TA). The ratio between the total number of LEMGs contributed by one department and the number of these LEMGs that included the PCA was calculated as a marker for experience (PCA–LEMG ratio)

**Fig. 1** A live demonstration of placing an EMG-needle is shown on a conference. By recording the neck of the patient and the hands of the examiner with a camcorder and projecting this live image for the whole audience, an impression of the procedure can be provided. However, in contrast to hands-on courses, no haptic feedback can be experienced by the audience

**Fig. 2** Hands-on courses using anesthetized pigs can provide good audiovisual but also haptic feedback. As shown in the *left upper corner*, with a fiber endoscope, the position of the EMG-needle can be verified. Verification by typical EMG-response to voluntary maneuvers like phonation or forced sniffing is not possible in anesthetized pigs

experts to perform LEMG was organized ten times. In total, 20 teaching events were organized for the participants in the multicenter registry. The numbers of participation on these 20 teaching events, splitted up into the different categories, was registered on attendance lists. These numbers are the baseline for calculating correlations intending to identify the most effective teaching modality.

In total, the 11 departments participated 91 times in these teaching events (Table 1). 10 out of 11 departments (90.9 %) participated in hands-on training of all three teaching types, i.e., patients, animal models, and anatomic specimens, and 6 out of 11 departments (54.5 %) received supervision by experts teaching them LEMG.

The number of LEMG recordings contributed by a department and their participation in any teaching event showed a non-significant positive correlation ($r = 0.408$; $p = 0.213$; $df = 9$). Performing LEMGs of the PCA, was positively correlated with the total number of teaching events ($r = 0.605$; $p = 0.049$; $df = 9$). Participation in any teaching event, was positively correlated with the PCA–LEMG ratio ($r = 0.704$; $p = 0.016$; $df = 9$). Being supervised by an expert was positively correlated with the PCA–LEMG ratio ($r = 0.814$; $p = 0.002$; $df = 9$).

The PCA–LEMG ratio was not correlated significantly with hands-on training in pigs ($r = 0.451$; $p = 0.164$; $df = 9$) or with hands-on training in cadavers ($r = 0.285$; $p = 0.396$; $df = 9$). The PCA–LEMG ratio was significantly correlated with hands-on training in humans ($r = 0.640$; $p = 0.034$; $df = 9$).

There was no significant correlation between the number of years of experience in performing LEMGs and the PCA–LEMG ratio ($r = 0.163$; $p = 0.632$; $df = 9$). The number of years of experience in performing LEMG was not correlated significantly with the total number of LEMGs uploaded ($r = -0.478$; $p = 0.167$; $df = 9$).

## Discussion

The study presented herein provides quantitative data about the process of establishing LEMG in 14 different otorhinolaryngology departments. Such data help to explain what complex clinical skills are needed for learning a new procedure. The initial motivation for having a closer look at the different teaching formats was to save resources by focusing only on the most effective teaching tools. We were also concerned that with different teaching formats it is difficult to transfer knowledge and skills in a consistent manner.

In surgical practice there is an increasing shift to training outside of the operating theater, for instance in workshops using artificial models in skills labs or wet labs. However, the weak correlation between visiting conferences with workshop character and ability to record high-quality LEMGs supports the idea that presenting practical step-by-step guidelines on performing LEMG is not enough instruction to start performing LEMGs on a routine basis. Therefore, training without real patients is not enough. It appears that there is no substitute for manual abilities and clinical competency obtained by hands-on training. In the presented study, participation at hands-on trainings was correlated with higher level of experience in performing LEMGs, as determined by the total number of LEMG provided, and the PCA–LEMG ratio. Similarly, a greater participation at any kind of teaching events was associated with better performance and skills in LEMG.

In our opinion, the strong positive correlation between the sum of teaching events and the PCA–LEMG ratio suggested that a combination of teaching modalities was an excellent incentive to collect experience in LEMG procedures. Unimodal teaching techniques are probably insufficient due to the complexity of the topic, requiring a deep electrophysiological and anatomical background and trained practical skills. Even in departments with access to the necessary equipment and the will to perform LEMGs—as is the case for all participants of the registry—the outcomes are dependent on the time invested in training and education.

Web-based tools can be used as an adjunct to teaching. The use of computer-assisted learning (CAL), as used in teaching basic science students [9], could be used to teach physicians in highly specialized clinical skills. CAL programs allow professionals and students to learn at a time and location of their own choice. The applications can be helpful for teaching material that has strong visual and spatial components [10, 11]. In addition, these programs

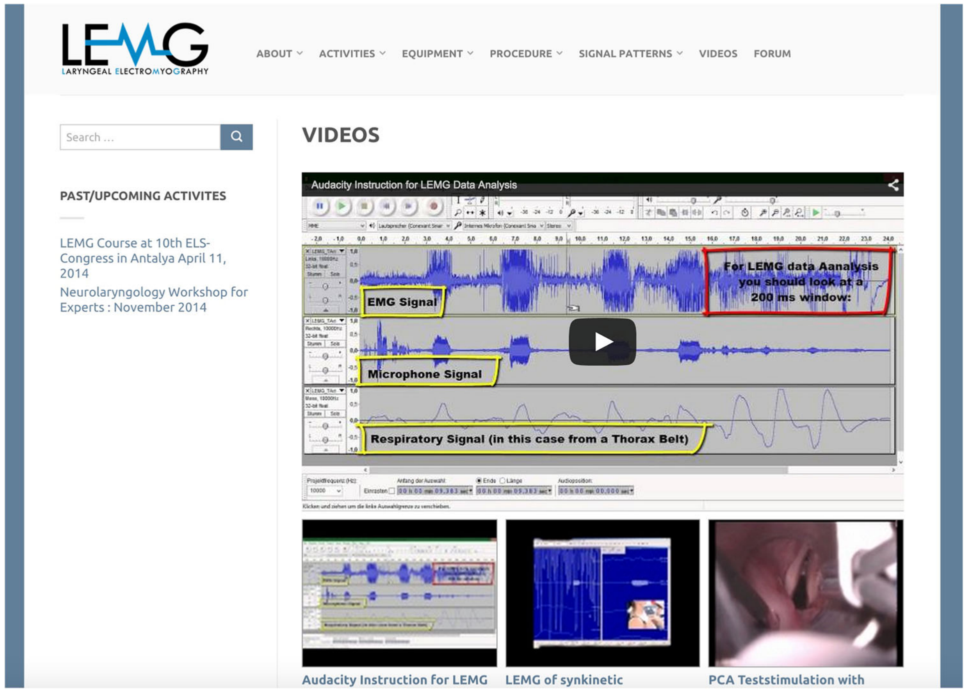


**Fig. 3** To provide access to the required multimodal teaching modalities for everyone interested, an interactive webpage (http://www.lemg.org) providing video files animations and the possibility to discuss cases with other experts was established

can facilitate learning by providing questions and feedback in a manner that makes learners feel comfortable [12, 13]. The use of CAL modules is becoming increasingly widespread and the use of CAL is cost-effective [12]. Therefore, CAL has the potential to enhance learning and cooperation for geographically widespread groups; such as the multicenter registry presented herein. LEMG is often only performed by one or two people at specific centers (even at voice centers), and could benefit from improved communication between the experts at the different centers at distant locations to each other [14–16].

Self-directed learning via interactive websites would also be another possibility to learn in a different way. Self-directed learning involves learners identifying the knowledge in which they are deficient and pursuing information to fill in these gaps. Interactive websites, using functions like blogs, forums or quizzes can assist learners in this process by providing feedback. With these considerations in mind, the authors set up a website (http://www.lemg.org) providing basic knowledge on electrophysiology and neurolaryngology, multimedia video examples of LEMG examinations, and guidelines for interpretation (Fig. 3). Tools like a forum for discussions and the possibility to upload one's own interesting cases was intended to provide additional value compared with classic media like books or papers. The authors hope that the website will also be beneficial for promoting the use of the published guidelines [3, 8], and to analyze their strengths and weaknesses. Further evaluations (web-based prospective evaluations) are planned in order to optimize both the content provided and training courses available. However, it is unlikely that web-based tools will ever substitute formal teaching. Rather, they are a useful tool to improve technique retention after teaching [17, 18]. We anticipate that with widespread internet access web-based training will become a useful adjunct to hands-on training techniques.

## Conclusion

Classic publications and presentations can provide background-knowledge and introduce novel aspects of LEMG; however, practical work on patients or animal models is necessary to learn how to get the EMG-needle in the correct position. To provide access to the required multimodal teaching modalities for everyone interested, an interactive webpage, providing video files and animations, and the possibility to discuss cases with other experts was established. It should help integrating LEMG into clinical routine as a standard technique in neurolaryngology.

**Conflict of interest** The authors indicate that they have no conflict of interest.

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