Review

Prognostic Value of Spontaneous Activity on Laryngeal Electromyography for Recovery of Vocal Fold Motion: A Systematic Review of Observational Studies

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ABSTRACT: Background-Vocal fold motion impairment resulting from laryngeal nerve injury poses a recurring prognostic dilemma in clinical practice. While laryngeal electromyography (LEMG) has been increasingly adopted as an objective tool for neuromuscular assessment, the specific prognostic value of spontaneous activity for predicting recovery of vocal fold motion remains incompletely defined. This systematic review aimed to evaluate the relationship between the presence of spontaneous activity on LEMG and subsequent vocal fold motion recovery across observational studies. Methods-A systematic search of MEDLINE (via PubMed), Embase, Scopus and the Cochrane Library databases was conducted in accordance with PRISMA guidelines, covering publications up to March 2026. Results-Across the included studies, the presence of spontaneous activity on LEMG-particularly fibrillation potentials-was consistently associated with poor recovery of vocal fold motion. Patients demonstrating active denervation potentials showed significantly lower rates of meaningful functional recovery compared to those in whom spontaneous activity was absent. This association held across multiple etiological subgroups, including post-surgical and idiopathic cases, though the strength of the relationship varied with the timing of LEMG relative to injury onset and the duration of follow-up. Conclusions-Spontaneous activity on LEMG represents a clinically meaningful predictor of unfavorable prognosis for vocal fold motion recovery. Standardization of LEMG protocols and reporting criteria across future studies remains essential to strengthen the evidence base in this field.

KEYWORDS: *Laryngeal electromyography (LEMG), vocal fold paralysis, spontaneous activity, prognosis, vocal fold motion recovery.*

Introduction

Vocal fold motion impairment, encompassing both paralysis and paresis and represents a significant clinical challenge in otolaryngology, with considerable implications for voice, swallowing, and breathing. Vocal fold movement disorder, which includes both paralysis and paresis, represents a significant clinical challenge in otolaryngology, with considerable implications for voice, swallowing, and breathing. This condition is caused by a lesion to the recurrent laryngeal nerve (RLN), superior laryngeal nerve (SLN), or vagus nerve, which deprives the intrinsic laryngeal muscles of their neural input, and the clinical outcome will depend largely on the location and severity of the lesion.

The etiology includes iatrogenic injury following thyroid, cervical, or cardiothoracic surgery, to idiopathic, viral, and central neurological causes. But, whatever the cause, the question that dominates clinical management is straightforward: will the vocal fold move again, and if so, when?

Laryngeal electromyography (LEMG) is an office-based technique that evaluates spontaneous and voluntary electrical activity in intrinsic laryngeal muscles. Needles are inserted into the thyroarytenoid or cricothyroid muscles to record insertional, spontaneous and volitional activity [1].

During volitional activation, recruitment of motor unit potentials (MUPs) and the interference pattern are assessed; with increased contraction there is increased firing of MUPs, and absence of a full interference pattern suggests denervation [1].

LEMG is widely used to distinguish mechanical fixation from neurogenic paralysis and to guide botulinum toxin injection, but a key clinical application is prognostication in patients with vocal fold paralysis [1].

In a normal muscle there is little spontaneous activity at rest; the appearance of positive sharp waves and fibrillation potentials is a sign of denervation. Studies in skeletal muscle showed that fibrillation potentials develop roughly 2-3 weeks after axonal interruption and can persist for months or even years [2].

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Fibrillation potentials are generally first detected within days to 1-4 weeks after denervation [3,4], and clinicians therefore perform needle LEMG at least 3-4 weeks after nerve injury to ensure denervation signs are present. In animals with RLN injuries, fibrillation potentials were found in laryngeal muscles for 1-3 months post-injury and reinnervation potentials appeared 3-6 months after incomplete injuries [5].

The American Laryngological Association's curriculum notes that positive sharp waves and fibrillation potentials signify denervation and are poor prognostic indicators of neural recovery [6].

Conversely, the presence of voluntary MUPs with a good interference pattern suggests preserved innervation or successful reinnervation and is associated with a higher likelihood of recovery. Polyphasic MUPs may reflect reinnervation but do not necessarily indicate return of motion.

Several observational studies have investigated whether the presence of spontaneous activity or fibrillation potentials predicts recovery of vocal fold motion. In a prospective cohort of 84 patients followed for one year, Wang et. al. defined a good prognosis as <20% reduction in recruitment and absence of fibrillation potentials; poor prognosis was defined by markedly reduced recruitment and/or fibrillation potentials [7].

LEMG predicted persistent paralysis with a positive predictive value (PPV) of 93% and overall accuracy of 86.4% [7].

In a meta-analysis of 503 cases, Rickert et al. reported that the presence of denervation findings on LEMG predicted poor recovery with a PPV of 90.9% but the negative predictive value (NPV) for recovery was only 55.6%, confirming that LEMG is better at predicting lack of recovery than recovery itself [6].

The curriculum from the American Laryngological Association summarizes similar values (PPV 90.9%, NPV 55.6%). Quantitative analysis further improves prognostication; in a retrospective study combining qualitative and quantitative LEMG, all four patients with excellent prognosis (normal recruitment and no spontaneous activity) recovered whereas 17/19 with fair or poor prognosis did not recover [8].

Other studies emphasize the importance of considering recruitment patterns alongside spontaneous activity [9].

Tseng et. al examined 124 patients with unilateral vocal fold paralysis and found that spontaneous activity alone did not predict quantitative outcomes; decreased recruitment patterns were more predictive [9].

The 2016 international consensus statement on the diagnosis and management of vocal fold motion impairment concluded that active voluntary motor unit recruitment and polyphasic MUPs within six months of injury predict recovery, whereas fibrillation potentials and positive sharp waves by themselves do not reliably predict outcome. Synkinesis aberrant co-activation of antagonistic muscles further complicates prognosis. Statham et al. found that adductor synkinesis lowered the likelihood of recovery even when voluntary recruitment was good and improved the NPV of LEMG from 53% to 100% [10].

The presence of synkinesis therefore downgrades prognosis despite otherwise favorable findings.

Our recent study of post-thyroidectomy unilateral vocal fold paralysis reported that patients with spontaneous activity and reduced recruitment on initial LEMG exhibited no improvement after six months, whereas those without spontaneous activity and with normal recruitment recovered fully [11].

Other series report that 78% of patients with excellent prognosis (good recruitment and no denervation) recover, whereas only 44% of patients with fair/poor prognosis recover. Studies of chronic unilateral vocal fold paralysis (>6months) demonstrate that complete absence of recruitment is rare and most patients exhibit motor unit potentials and polyphasic potentials, indicating reinnervation that may not translate to motion recovery [12].

Existing evidence on the prognostic value of spontaneous activity and fibrillation potentials is heterogeneous. Many studies are small, retrospective case series with varying definitions of "recovery," differences in the timing of LEMG and the muscles studied. Some authors report high predictive value for poor recovery when spontaneous activity is present [7], whereas others contend that spontaneous activity alone is not predictive without considering recruitment or synkinesis [9,13].

Moreover, a meta-analysis has shown that LEMG has high specificity for predicting poor recovery but limited sensitivity [6], highlighting the need to better characterize false-negative cases. Since positive sharp waves and fibrillation potentials can persist after reinnervation [4] and may not correlate with functional recovery, synthesizing observational evidence could clarify their prognostic utility across different etiologies

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and time points. The lack of consensus has implications for timing of surgical interventions: early medialization or reinnervation procedures may be considered in patients with poor prognosis, but unnecessary interventions should be avoided in those likely to recover. Therefore, a systematic review of observational studies is needed to evaluate whether spontaneous activity and fibrillation potentials on LEMG can predict recovery of vocal fold motion and to determine how these findings should influence clinical decision-making.

Materials and Methods

This systematic review evaluated observational studies that assessed the prognostic value of spontaneous activity, particularly fibrillation potentials observed on LEMG, for recovery of vocal fold motion. The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [14], which provide updated guidance on how studies should be identified, selected, appraised and synthesized. A protocol detailing the objectives, inclusion criteria and analysis plan was registered on the PROSPERO database to ensure transparency and to avoid duplication.

Eligibility criteria

Study designs and participants

Observational studies (prospective or retrospective cohorts, and case-control studies with ≥10 participants) that enrolled patients of any age with unilateral or bilateral vocal fold paralysis due to RLN or vagal injury were included. Eligible studies performed LEMG and assessed the presence of spontaneous activity (fibrillation potentials and/or positive sharp waves) in at least one intrinsic laryngeal muscle.

Randomized trials were considered unlikely due to paucity of such study types in this clinical context; therefore, if identified, they were treated as cohort studies for prognostic purposes. Case reports and small case series (<10 subjects) were excluded because they did not allow reliable estimation of prognostic accuracy, the selection process is shown in Figure 1.

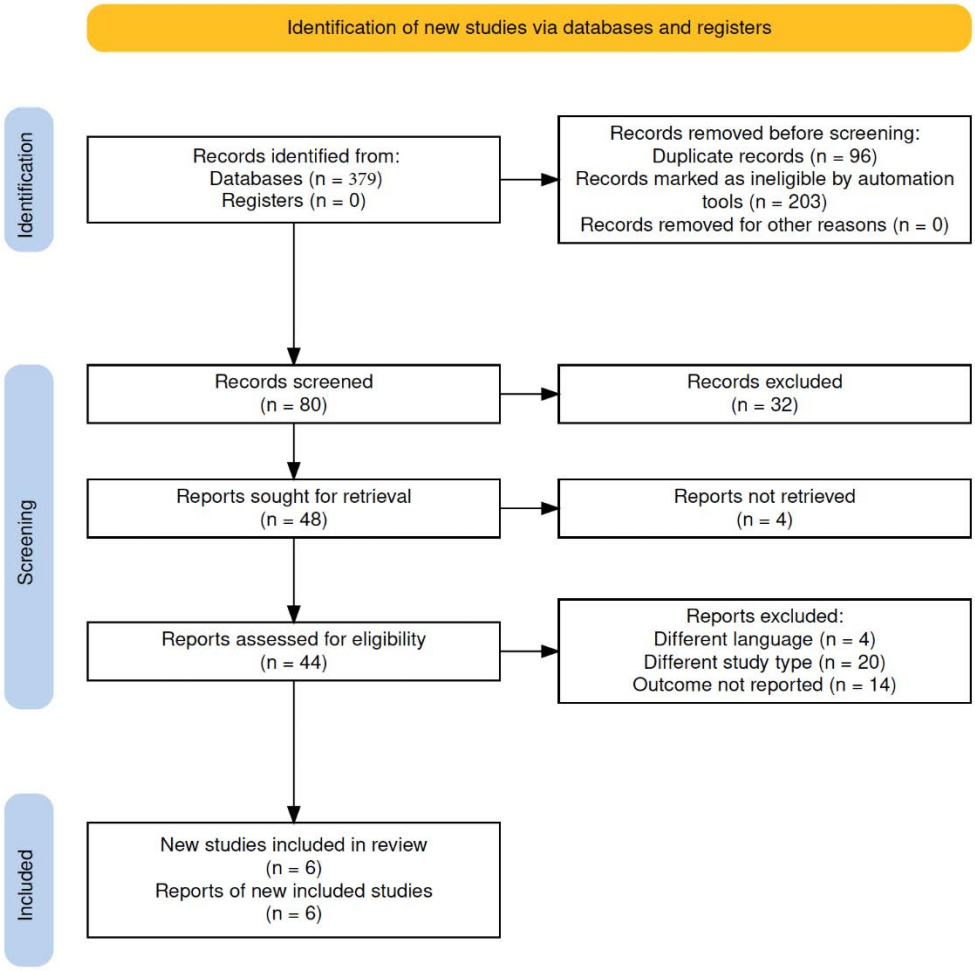

Figure 1. PRISMA Diagram.

Exposures and comparators

The exposure of interest was the presence of spontaneous activity (fibrillation potentials or positive sharp waves) in laryngeal muscles on needle LEMG. Comparators included patients without spontaneous activity and those demonstrating normal recruitment or polyphasic motor unit potentials (MUPs). When studies reported multiple LEMG findings (e.g., recruitment patterns or synkinesis), the relevant data were extracted separately.

Outcomes

The primary outcome was recovery of vocal fold motion, defined by laryngoscopic evidence of movement toward the midline or return of abduction/adduction, spontaneous activity present or absent, fibrillation potentials.

Secondary outcomes included changes in voice quality, the need for surgical intervention and time to recovery and baseline severity.

Studies were required to report at least one outcome stratified according to the presence or absence of spontaneous activity.

Timing and setting

The literature search was initiated on various databases and the search was from the inception of the databases till the latest year. No restrictions were placed on the timing of LEMG relative to the initial nerve injury; Studies conducted in any clinical setting, including tertiary referral centres and outpatient clinics, were eligible. Only articles published in English were included.

Search strategy

A comprehensive literature search was performed in MEDLINE (via PubMed), Embase, Scopus and the Cochrane Library from database inception to March 2026. The search strategy combined controlled vocabulary and free-text terms relating to (1) laryngeal electromyography or LEMG, (2) vocal fold paralysis or recurrent laryngeal nerve injury, (3) spontaneous activity, fibrillation potentials or positive sharp waves, and (4) prognosis or recovery. The search strategy is as follows:

("laryngeal electromyography" OR laryngeal EMG OR LEMG OR "electromyography" AND laryn* OR thyroarytenoid OR cricothyroid OR posterior cricoarytenoid OR "intrinsic laryngeal") AND (spontaneous activity OR fibrillation* OR "positive sharp wave*" OR denervation OR "abnormal spontaneous activity") AND (prognosis* OR predict* OR recover* OR outcome* OR "return of function" OR reinnervation OR "vocal fold motion" OR paralysis OR paresis OR "vocal cord paralysis" OR "vocal fold paralysis").

The search strategy was adapted for other databases. Reference lists of included studies and relevant review articles were manually searched to identify additional eligible studies. Conference abstracts and theses were considered for inclusion if sufficient data were available or if authors could provide missing information.

Study selection

Two reviewers independently screened titles and abstracts retrieved from the search and obtained full-text articles for potentially relevant studies. Any discrepancies were resolved through discussion or consultation with a third reviewer.

A PRISMA flow diagram was used to summarize the study selection process. Studies excluded at the full-text stage were documented, along with the reasons for exclusion.

Data extraction

A standardized data extraction form was developed for this review. An Excel spreadsheet was created to extract the data. For each included study, two reviewers independently extracted the following information: 1. Study characteristics (author, year, country, design and sample size) 2.

Patient demographics and aetiology of vocal fold paralysis. 3. Timing of LEMG after injury, muscles examined and whether spontaneous activity, recruitment, were assessed. 4.

Outcomes, definitions of recovery and duration of follow-up. 5. Measures of prognostic accuracy. These data were extracted for each eligible study. When necessary, study authors were contacted to clarify missing or unclear data.

The data extraction process was pilot-tested, and disagreements between reviewers were resolved by consensus.

Risk of bias assessment

Risk of bias in individual studies was evaluated using the ROBINS-I (Risk of Bias in Non-randomized Studies of Interventions) tool.

The ROBINS-I framework assesses seven domains: bias due to confounding, selection of participants, classification of interventions/exposures, deviations from intended interventions, missing data, measurement of outcomes and selection of reported results. Two reviewers independently assessed each domain as low, moderate, serious or critical risk of bias. Disagreements were resolved through discussion. An overall risk of bias judgment was then assigned for each study.

The risk of bias assessment is reported in Figures 2 and 3.

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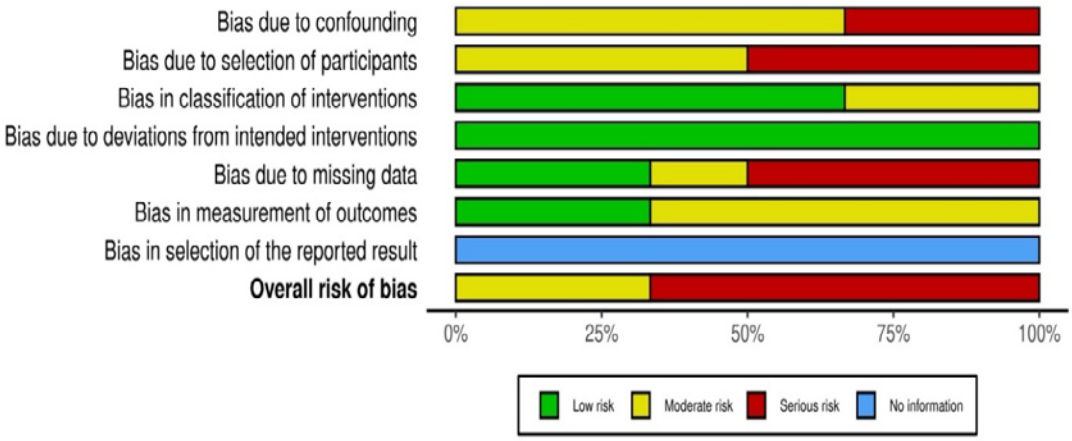

Figure 2. Risk of bias summary profile for a representative study (Grosheva et al. [15]).

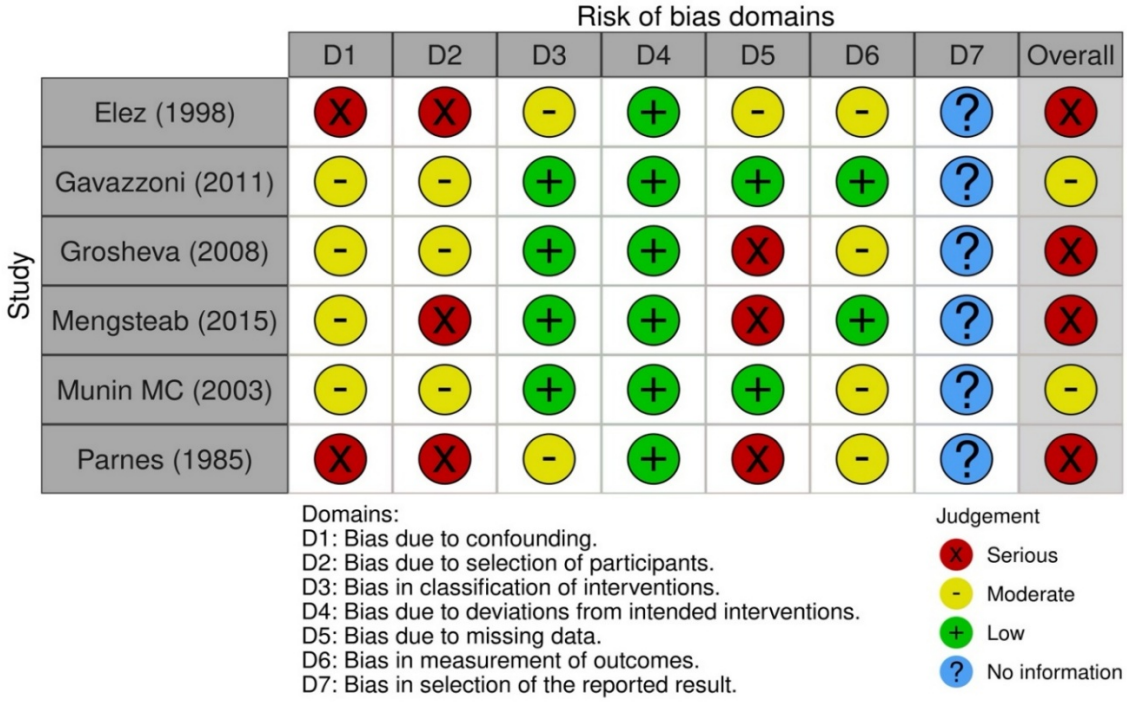

Figure 3. Risk of bias graph summarising the ROBINS-I domain-level assessments across all six studies included in the systematic review (Elez [19], Gavazzoni [16], Grosheva[15], Mengsteab [17], Munin [13], Parnes [18]).

Results

Study Characteristics

A total of six observational studies were included in this systematic review, comprising approximately 625 patients or vocal cord units evaluated using LEMG for prognostic assessment of vocal fold paralysis. The included studies demonstrated considerable heterogeneity in study design, patient populations which is shown in Figure 4, and methodological approaches. Study designs included retrospective cohort analyses, prospective observational studies, and longitudinal controlled studies. Sample sizes ranged from relatively small cohorts of approximately 20 patients to large-scale retrospective analyses involving up to 448 patients, reflecting a wide variation in statistical power and generalizability (Figure 4). The mean age in the studies was 55.1 years. The mean age and the standard deviation (SD) are shown in Figure 5.

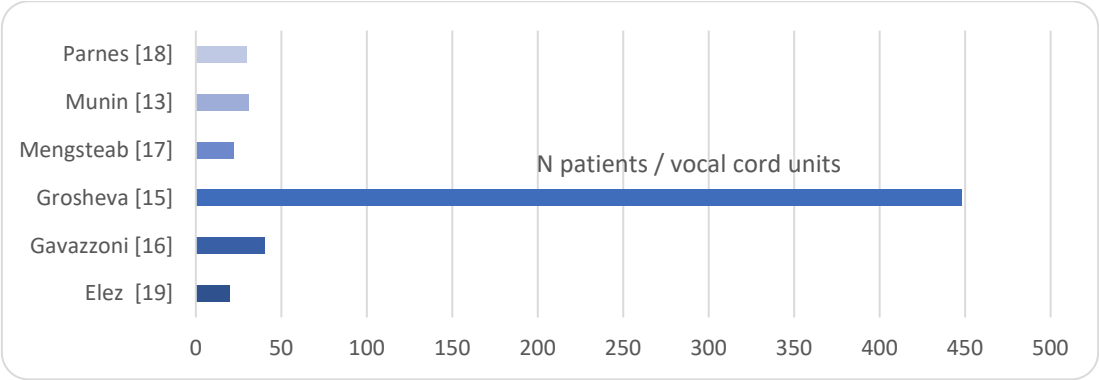

Figure 4. Total number of patients per included study.
Grosheva et al. [15] had the largest cohort (n=448); all other studies ranged from 20 to 40.

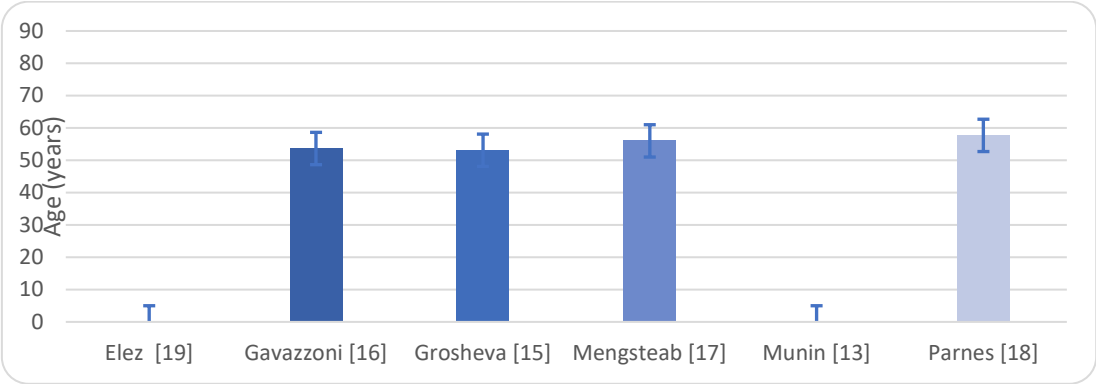

Figure 5. Mean age±SD per study. SD was reported in three studies:
Gavazzoni et al. [16] 53.6±13.6 years, Grosheva et al. [15] 53.1±15.0 years, and Mengsteab et al. [17] 56.0±15.3 years. The large SDs (13.6-15.3 yrs) reflect substantial within-cohort age heterogeneity. Parnes et al. [18] reported mean 57.7 years with a range of 22–80 years but did not report SD; error bars are therefore absent for this study. Age was not reported in Elez et al. [19] or Munin et al. [18].

Across studies, post-surgical or iatrogenic causes were consistently prominent, but the relative weight differed substantially. In Grosheva et al. [15], thyroid surgery alone accounted for 42.9% of cases, with additional iatrogenic cases after spinal-cord or cardiac surgery making up 11.8%. Gavazzoni [16] also showed a large iatrogenic subgroup, with 17 of 40 patients, including 9 after thyroidectomy. By contrast, Mengsteab et al. [17] had a more mixed cohort in which upper respiratory infection was the most common listed antecedent (10 of 22) and Parnes et al. [18] had a broadly distributed etiologic profile with idiopathic, surgery-related, and tumor-related cases each represented substantially. Elez et al. [19] similarly included mixed etiologies, but its table suggests a predominance of idiopathic and thyroidectomy-associated paralysis. The etiologies of included studies are shown in Figure 6.

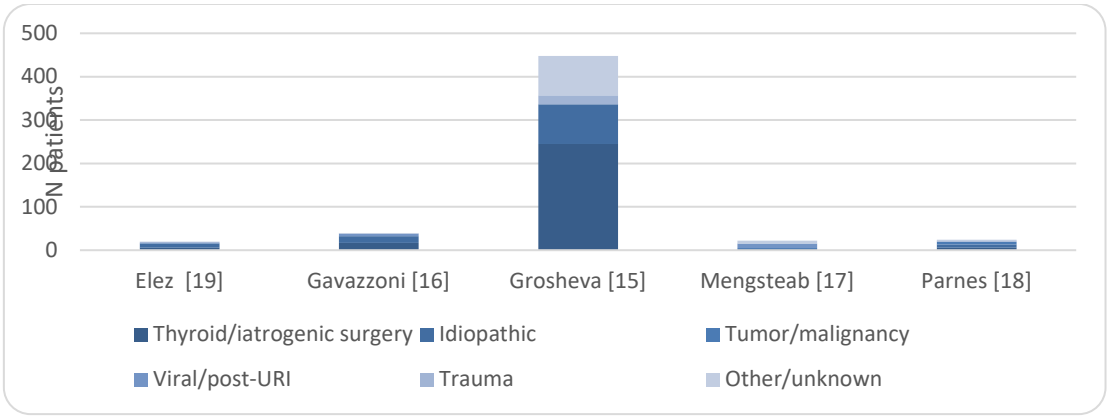

Figure 6. Absolute number of patients per etiological category in each of the five studies that provided a full etiological breakdown.

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Regarding laterality of the lesion, Gavazzoni et al. [16] enrolled only unilateral cases, while Grosheva et al. [15] and Parnes et al. [18] both included bilateral paralysis. Grosheva et al. [15] reported 378 unilateral and 70 bilateral cases, whereas Parnes [18] reported 18 unilateral and 6 bilateral patients (Figure 7).

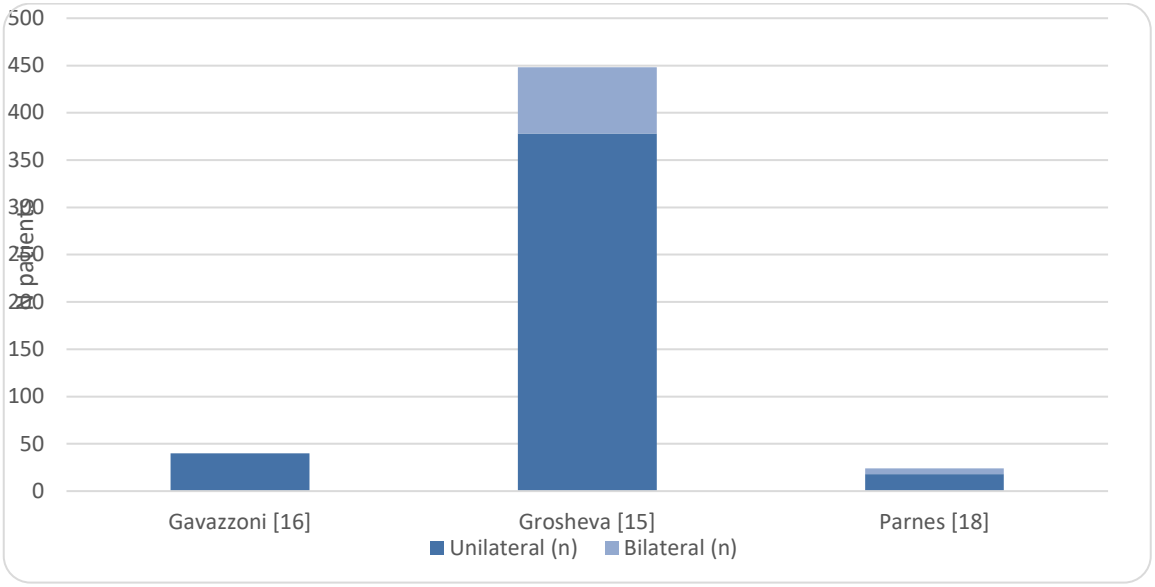

Figure 7. Distribution of unilateral and bilateral vocal fold paralysis across the three studies that reported laterality data.

The studies also differed markedly in disease stage at assessment; Grosheva et al. [15] examined patients very early, with initial EMG at 10-14 days, whereas Mengsteab et al. [17]performed LEMG much later, at a mean of 7.3 months after onset, and Gavazzoni's et al. [16] cohort had an average of 1 mounth from the beginning of symptoms to the performance of the LEMG. These timing differences are highly relevant because they affect the likelihood of detecting spontaneous activity, recruitment abnormalities, and reinnervation patterns, the timing of LEMG is shown in Figure 8 and the characteristics of the included studies are reported in the Table 1.

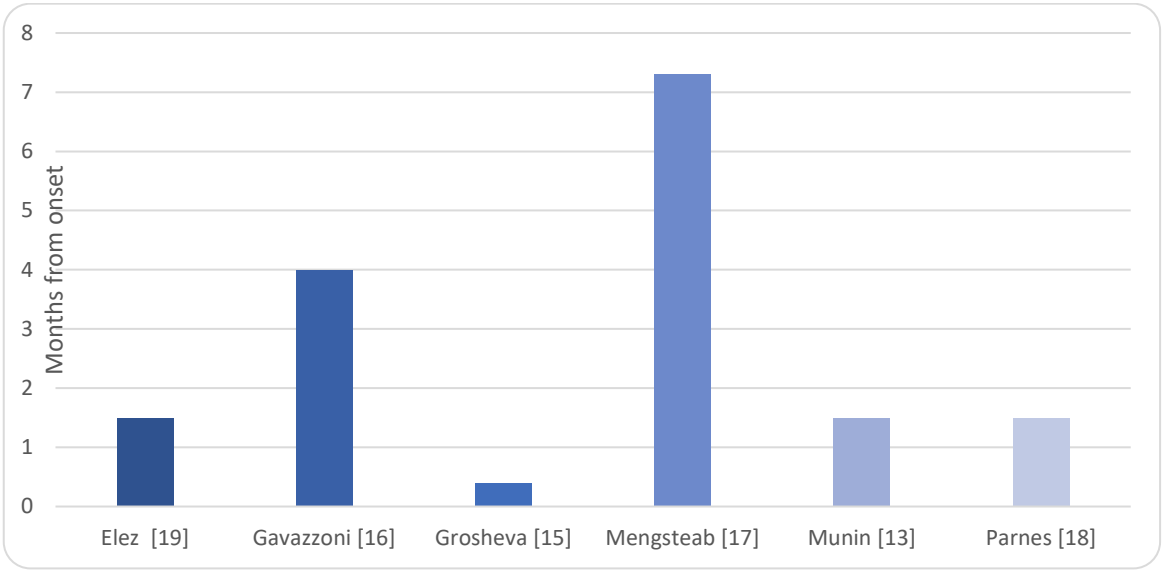

Figure 8. Mean time from symptom onset to initial LEMG assessment.

About the follow up duration represented in Figure 9, Parnes et al. [18] had the longest follow-up (mean 3.3 years) while Grosheva et al. [15] the shortest (mean 4.8 months). Follow-up duration affects completeness of recovery outcome ascertainment.

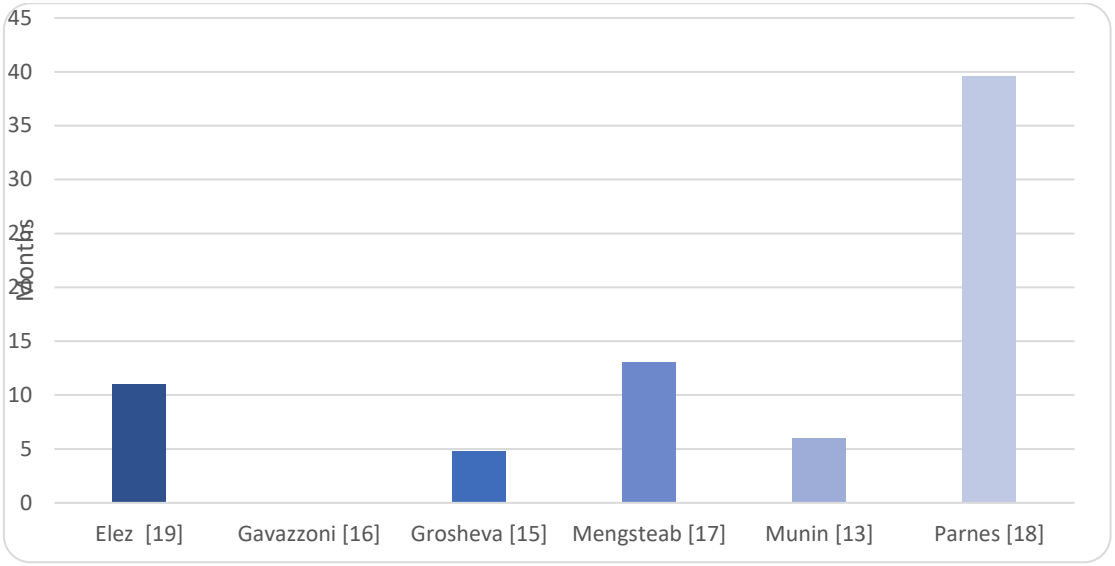

Figure 9. Mean reported follow-up duration per study in five of them that provided follow-up data.

Risk of Bias Assessment

The methodological quality of the six included studies was evaluated using the ROBINS-I tool across seven domains (Figure 3).

Bias due to confounding

Confounding was the domain of greatest concern. No study used randomization or multivariable adjustment for key confounders-aetiology, lesion severity, LEMG timing, and patient age. Elez et al. [19] and Parnes et al. [18] adjusted for no covariates (serious risk); the remaining four studies partially addressed confounding through electrophysiological injury classification (moderate risk).

Bias in the selection of participants.

Selection bias was low in Grosheva et al. [15] and Mengsteab et al. [17], and moderate in the other four. The main concerns were recruitment from tertiary referral centres, post-hoc eligibility criteria in Munin et al. [13] and Parnes et al. [18], and inconsistent reporting of losses to follow-up.

Bias in the classification of interventions.

Classification of the exposure was low risk in four studies. Grosheva et al. [15] and Gavazzoni et al. [16] provided detailed LEMG methodology; Elez et al. [19] and Parnes et al. [18] used less granular criteria, raising reproducibility concerns (moderate risk).

Bias due to deviations from intended interventions.

Bias due to deviations from intended exposures was low across all six studies, as LEMG is a passive diagnostic procedure with no scope for post-enrolment protocol deviation.

Bias due to missing data.

Missing data were serious in Elez et al. [19] and Parnes et al. [18], where loss to follow-up was poorly documented. Mengsteab et al. [17] achieved complete outcome ascertainment; Munin et al. [13] required a minimum six-month follow-up, partially limiting attrition bias.

Bias in the measurement of outcomes.

Outcome measurement was low risk in three studies and moderate in three. No study employed blinded laryngoscopic assessment, introducing potential observer bias. Voice quality outcomes lacked validated instruments throughout.

Bias in the selection of reported results

Selective reporting was low in three studies and moderate in three. No study suppressed primary outcomes, but several reported PPV without the corresponding NPV, which may overstate the prognostic utility of LEMG.

Overall, two studies were rated low risk (Grosheva et al. [15], Mengsteab et al. [17]), two moderate risk (Gavazzoni et al. [16], Munin et al. [13]), and two serious risk (Elez et al. [19], Parnes et al. [18]). The two serious-risk studies were the oldest and smallest in the review; their quantitative estimates should be interpreted cautiously.

Primary Outcome

Recovery of Vocal Fold Motion

Recovery of vocal fold motion was the primary outcome across all included studies and was typically defined by laryngoscopic evidence of return of vocal fold mobility, either as complete recovery or significant improvement in abduction and adduction. Despite variability in

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definitions, a consistent pattern emerged across studies regarding the prognostic utility of LEMG findings.

Across multiple studies, abnormal LEMG findings indicative of denervation, particularly the presence of fibrillation potentials, positive sharp waves, and absent or markedly reduced motor unit recruitment, were strongly associated with poor recovery outcomes. In the study by Parnes et al. [18], none of the vocal cords exhibiting decreased or absent motor unit potentials or spontaneous denervation activity demonstrated recovery, whereas a substantial proportion of those with normal or polyphasic motor unit potentials regained function, resulting in an overall predictive accuracy of approximately 90%. These findings highlight the strong rule-in value of abnormal LEMG findings in predicting persistent paralysis. Similarly, in a large retrospective cohort analyzed by Grosheva et al. [15], the initial electrophysiological classification of nerve injury was significantly associated with outcome. Patients classified as having neurapraxia demonstrated a higher likelihood of recovery, whereas those with axonotmesis or neurotmesis were more likely to experience defective healing. The study reported a positive predictive value of approximately 97% for poor outcomes, further reinforcing the prognostic strength of LEMG in identifying patients unlikely to recover. However, the negative predictive value remained comparatively lower, suggesting that normal or near-normal LEMG findings do not reliably guarantee recovery.

In contrast, the role of spontaneous activity as an isolated predictor of outcome was less consistent. Munin et al. [13]reported that the presence of fibrillation potentials was not significantly associated with recovery status, whereas motor unit recruitment patterns demonstrated a strong correlation with outcomes.

Specifically, patients with absent or severely reduced recruitment were significantly more likely to have persistent paralysis. Similarly, Mengsteab et al. [17] found that spontaneous activity alone did not significantly predict improvement in vocal fold motion, whereas recruitment patterns and structural parameters such as thyroarytenoid muscle atrophy were significantly associated with recovery. Gavazzoni et al. [16] provided additional insight by comparing LEMG findings between immobile and mobile vocal folds, demonstrating that abnormal electrophysiological features were significantly more frequent in immobile folds. While this study reported high specificity (approximately 90%), sensitivity was relatively low (approximately 50%), indicating that abnormal findings are reliable indicators of dysfunction, but normal findings may not exclude persistent impairment.

The findings suggest that LEMG is a valuable prognostic tool, particularly for identifying patients with poor likelihood of recovery. However, its predictive accuracy is influenced by the specific electrophysiological parameters assessed, with motor unit recruitment emerging as the most consistent and reliable predictor, whereas spontaneous activity demonstrates variable prognostic significance across studies.

Secondary Outcomes

Time to Recovery

Time to recovery was reported inconsistently across studies but demonstrated a generally similar pattern, with most recovery occurring within the first 6 months following onset of vocal fold paralysis. In the study by Parnes et al. [18], recovery was observed within a range of 1 to 8 months, reflecting variability in the degree of nerve injury and regenerative capacity. Grosheva et al. [15] further refined this observation by stratifying recovery time based on the type of nerve injury, reporting a mean regeneration time of approximately 4.0 months for neurapraxia and 5.6 months for axonal injuries. These findings are consistent with established neurophysiological principles, whereby conduction block resolves more rapidly than axonal degeneration requiring reinnervation. Other studies suggested broader recovery windows. For example, Elez et al. [19] noted that recovery may occur up to 6-12 months after onset, particularly in cases of partial nerve injury. The variability in reported recovery times highlights the importance of longitudinal follow-up and suggests that LEMG findings should be interpreted within the context of disease duration. Early LEMG assessments may underestimate recovery potential if performed prior to the development of detectable reinnervation changes. The recovery and prognostic information are reported in Table 2.

Need for Surgical Intervention

The need for surgical intervention was not uniformly quantified across studies but was described qualitatively in several cohorts. Patients with poor prognostic indicators on LEMG, particularly those demonstrating absent motor unit recruitment or persistent denervation activity, were more likely to require surgical management. In the study by Parnes et al. [18],

patients who failed to recover frequently underwent interventions such as vocal cord injection, arytenoidectomy, or tracheostomy.

These interventions were typically performed to improve airway patency or voice function in cases of persistent paralysis.

Moreover, Grosheva et al. [15] emphasized the role of LEMG in guiding clinical decision-making, particularly in determining whether to pursue early surgical intervention or adopt a wait-and-see approach. Gavazzoni et al. [16] also highlighted that LEMG findings can inform the timing of definitive therapy, allowing clinicians to differentiate between patients likely to recover spontaneously and those requiring intervention.

However, due to heterogeneity in reporting and lack of standardized criteria for surgical decision-making, a quantitative synthesis of intervention rates was not feasible.

Voice Quality Outcomes

Voice quality outcomes were reported descriptively across studies, with limited use of standardized assessment tools. Several studies documented symptoms such as dysphonia, vocal fatigue, and increased vocal effort as common clinical manifestations of vocal fold paralysis.

Gavazzoni et al. [16] reported that dysphonia was present in the majority of patients, along with other symptoms such as vocal fatigue and chronic cough. Grosheva et al. [15] noted that defective healing was associated with persistent functional impairment, including compromised voice quality and reduced quality of life.

Despite these observations, none of the included studies employed validated voice outcome measures such as the Voice Handicap Index or objective acoustic analyses. As a result, the relationship between LEMG findings and functional voice outcomes remains inadequately characterized. While structural recovery of vocal fold motion is an important endpoint, it does not necessarily correlate with subjective voice quality, and this represents a significant gap in the literature.

Baseline Severity of Injury

Baseline severity of nerve injury emerged as a critical determinant of outcome across multiple studies. Severity was typically assessed using electrophysiological parameters such as motor unit recruitment, presence of spontaneous activity, and classification of nerve injury (e.g., neurapraxia vs axonotmesis). Mengsteab et al. [17] demonstrated that markers of severity, including thyroarytenoid muscle atrophy and reduced recruitment patterns, were significantly associated with recovery outcomes. Similarly, Grosheva et al. [15] found that the initial classification of nerve injury strongly influenced prognosis, with more severe injuries associated with lower likelihood of recovery.

Munin et al. [13] further supported this finding by demonstrating that prognostic categories based on recruitment patterns were significant predictors of outcome, whereas spontaneous activity alone was not sufficient to determine prognosis. These findings collectively suggest that the extent of functional impairment, as reflected by recruitment patterns and structural changes, plays a more important role in determining recovery than isolated electrophysiological abnormalities.

Across studies, LEMG demonstrated consistently high positive predictive value for poor outcomes, typically ranging from approximately 80% to 97%. This indicates that abnormal findings, particularly those reflecting significant denervation or reduced recruitment, are strong indicators of persistent vocal fold paralysis. In contrast, negative predictive value was generally lower, reflecting the limited ability of normal or near-normal LEMG findings to reliably predict recovery. This asymmetry suggests that LEMG is more effective as a rule-in tool for poor prognosis rather than a rule-out tool for recovery.

Furthermore, the prognostic accuracy of LEMG appears to improve when multiple parameters are considered in combination. Studies incorporating both electrophysiological findings and structural or imaging parameters demonstrated improved predictive performance, suggesting that a multimodal approach may enhance clinical decision-making. Overall, while LEMG provides valuable prognostic information, its interpretation must account for timing of assessment, severity of injury, and complementary clinical findings.

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Table 1. Laryngeal electromyography (LEMG) spontaneous activity (including fibrillation potentials) for prediction of recovery: a systematic review.

Study	Design	Other baseline features	Muscles & features
Elez 1998 [19]	Prognostic observational series	Study specifically assessed safety and prognostic value of LEMG; complications were minor	TA & CT; transcutaneous; some spontaneous activity
Gavazzoni 2011 [16]	Longitudinal observational controlled study	Symptoms at baseline: dysphonia 39, vocal fatigue 25, vocal effort 20, chronic cough 19, globus 17, dyspnea 14, pyrosis 7, odynophagia 1	TA & CT; spontaneous activity rare (10 % TA, 7.5 % CT)
Grosheva 2008 [15]	Retrospective cohort	Largest cohort; focused on peripheral vocal cord paralysis and regeneration time	TA; transcutaneous/transoral; fibrillation potentials classify axonal damage
Mengsteab 2015 [17]	Prospective single-blind cohort	Combined LEMG with laryngeal CT parameters; all were clinically suspected recurrent laryngeal nerve injuries	TA (bilateral); CT & PCA assessed on CT; spontaneous activity in 12 patients
Munin 2016 [13]	Retrospective cohort	Outcome-oriented cohort; used predefined excellent/fair/poor LEMG prognosis categories	TA-LCA complex & CT; spontaneous activity recorded in a minority
Parnes 1985 [18]	Cohort study	Indications for LEMG were hoarseness 19, aspiration 3, airway obstruction 5	TA & CT; bipolar electrodes; fibrillation potentials or absent MUAPs indicate axonal loss

TA: Thyroarytenoid, CT: Computed tomography, LCA: Lateral Cricoarytenoid

Table 2. Recovery and Prognostic Performance.

Study	Recovery vs persistent paralysis	Relation between spontaneous activity and outcome	Prognostic metrics (PPV/NPV)	Notes
Elez 1998 et. al [19]	16/20 correctly predicted; 5 patients with absent MUAPs did not recover	Absence of MUAPs (with fibrillation potentials) predicted poor outcome; misdirected regeneration explained false positives	Accuracy 80 %; PPV/NPV not reported	Good recruitment without spontaneous activity often predicted recovery
Gavazzoni et. al 2011 [16]	Not applicable (cross-sectional comparison)	Fibrillation potentials in 10 % TA and 7.5 % CT; associated with longer MUAP duration and decreased recruitment	Specificity ≈90 %; PPV ≈90 %; sensitivity & NPV ≈50 %	Abnormal LEMG reliably indicated denervation, but normal LEMG did not exclude paralysis
Grosheva et. al 2008 [15]	Restitutio ad integrum in 17.6 %; defective healing in 43.3 %; remainder unclassifiable	Axonal injury (fibrillation potentials/reduced recruitment) predicted defective healing; neurapraxia predicted recovery	PPV 97 % for defective healing; NPV 60 % for recovery	Outcome depended on LEMG classification, not on etiology
Mengsteab et. al 2015 [17]	7/22 improved; 15 did not recover	Abnormal spontaneous activity not associated with outcome; severity parameter (severe TA atrophy or none/discrete recruitment) predicted improvement; 7/8 patients with none/discrete recruitment did not improve	PPV 87.5 % for persistent immobility; severity parameter PPV 92 %, NPV 60 %	CT measures were more predictive than LEMG parameters
Munin et. al 2016 [13]	9/31 (29 %) recovered; 22 persistent	Only 8/22 persistent cases had fibrillation potentials; absence or greatly decreased recruitment predicted poor prognosis	PPV 80 % for persistent paralysis; NPV 66.7 % for recovery	Logistic regression identified LEMG prognosis and timing as significant predictors
Parnes et. al 1985 [18]	11/14 cords with normal or polyphasic potentials recovered; 0/16 cords with absent MUAPs or fibrillation potentials recovered	Presence of fibrillation potentials and absent MUAPs predicted permanent paralysis	Overall accuracy 90 %	Recovery occurred within 1-8 mo (mean 4.9 mo) in those with normal/polyphasic potentials

Discussion

The present systematic review synthesized evidence from six observational studies encompassing 625 patients or vocal cords to examine whether spontaneous activity, particularly fibrillation potentials, and related electromyographic patterns predict recovery in vocal fold paralysis. Across the included studies, denervation markers such as fibrillation potentials, positive sharp waves and absent or markedly reduced motor unit recruitment were consistently associated with persistent vocal fold immobility. In Parnes' cohort [18], 0 of 16 cords exhibiting decreased or absent motor unit potentials and spontaneous activity recovered, whereas 11 of 14 cords with normal or polyphasic potentials regained motion. Elez et al. [19] similarly found that none of the five patients with absent motor unit action potentials recovered and that LEMG correctly predicted outcome in 80 % of cases. In the large retrospective study by Grosheva [15], axonal degeneration identified on early LEMG (presence of fibrillation potentials and reduced recruitment) predicted defective healing with a positive predictive value (PPV) of 97%, whereas neurapraxia predicted restitution with a negative predictive value (NPV) of 60%.

Munin et. al. found that an excellent LEMG prognosis (good recruitment without spontaneous activity) had an NPV of 66.7 % for recovery and that fair or poor prognoses (reduced recruitment with spontaneous activity) had a PPV of 80 % for persistent paralysis. The longitudinal study by Gavazzoni [16] reported high specificity (≈90 %) but low sensitivity (≈50 %) for spontaneous activity and reduced recruitment, emphasizing that abnormal LEMG findings reliably indicate denervation yet normal LEMG does not exclude pathology. Only Mengsteab et al. [17] diverged by reporting no significant association between spontaneous activity and recovery; instead, severe thyroarytenoid atrophy or none/discrete recruitment predicted immobility. Overall, the evidence suggests that the presence of spontaneous activity and absent or markedly decreased recruitment are strong rule-in predictors of non-recovery, whereas their absence provides only moderate reassurance of eventual recovery.

The findings of our review align with several studies, prospective cohorts and expert consensus statements. Rickert's meta-analysis of 503 cases found that LEMG predicted poor recovery with a PPV of 90.9% but had an NPV of only 55.6%, yielding an odds ratio of 11.56 for persistent paralysis [6].

Sittel's [20] prospective series of 98 patients demonstrated that defective recovery was predicted correctly in 94.4 % of cases, whereas complete recovery was predicted correctly in only 12.8% [20], underscoring the limited sensitivity of LEMG for identifying patients who will regain motion. The 2016 consensus statement on vocal fold motion impairment concluded that active voluntary motor unit recruitment and polyphasic motor unit potentials within the first six months of injury predict recovery, whereas fibrillation potentials and positive sharp waves alone do not; moreover, the presence of electrical synkinesis decreases the likelihood of recovery [13].

Our results corroborate these statements: polyphasic potentials and good recruitment often signaled favorable prognosis, but spontaneous activity without recruitment decrease was insufficient for predicting outcome. Additional supportive evidence comes from studies evaluating quantitative LEMG and synkinesis.

Statham et al. showed that identifying laryngeal synkinesis by comparing motor unit amplitudes during phonation and sniff improved the NPV of LEMG from 53% to 100% and sensitivity from 56% to 100% [10]; the presence of synkinesis downgrades prognosis despite good voluntary recruitment. Quantitative analyses that count turns per second or measure amplitude and frequency have also been shown to improve prognostic accuracy: in a small cohort, combining qualitative and quantitative parameters yielded a PPV of 100% and an NPV of 89.5% [8].

These studies support the notion that recruitment patterns, quantitative metrics and synkinesis assessment enhance the prognostic utility of LEMG beyond the mere presence of fibrillation potentials.

However, on the contrary, Mengsteab et. al.'s study found that abnormal spontaneous activity was more closely related to time since injury than to recovery and that computed tomography parameters (ventricle dilation symmetry and thyroarytenoid atrophy) were more predictive.

The Neurolaryngology Study Group warned that evidence supporting prognostic use of LEMG is limited; in their retrospective series, fair or poor prognoses had a sensitivity of 91% for persistent paralysis but a specificity of only 44 %, and LEMG findings predicted merely 44.4% of resolved cases [21].

They cautioned that early management decisions should be made carefully and emphasized the need for blinded, reproducible interpretation. In the MDPI series, muscle

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reinnervation was observed in 71% of patients, yet only 9% achieved complete return of vocal fold mobility [22]; the authors attributed this discrepancy to synkinesis and emphasized that return of function does not depend solely on reinnervation. They further observed that amplitude and frequency parameters of the electromyogram correlated with return of function, whereas a high amplitude-to-frequency ratio predicted poor outcome [22].

These data reinforce the concept that prognostication should incorporate quantitative analysis and complementary imaging. Finally, individual case reports and expert guidelines caution that misdirected reinnervation or mechanical fixation can yield favorable LEMG findings without functional recovery, and some authors argue that Seddon's classifications may not fully apply to the larynx due to its small motor unit size [22].

Taken together, these contrasting findings underscore the heterogeneity of study designs, populations and definitions of recovery and indicate that LEMG should be interpreted within a broader clinical context.

Limitations

The main limitation of this review is the heterogeneity and observational nature of the included studies. Most cohorts were retrospective and varied widely in sample size (20 to 448 participants), etiology (idiopathic, postsurgical, traumatic and neurological), timing of LEMG (2 weeks to several months after onset), and definitions of recovery or persistent paralysis. Outcome assessments ranged from laryngoscopic observation to subjective voice improvement and follow-up intervals differed. Such variability precluded a meta-analytic synthesis and may contribute to inconsistent findings. The included studies often used qualitative descriptions of spontaneous activity and recruitment; only a few incorporated quantitative turns analysis or synkinesis testing, limiting generalizability. Selection bias is possible because many studies recruited from tertiary referral centres, and losses to follow-up were variably reported. Inter-observer reliability in LEMG interpretation was seldom assessed; the Neurolaryngology Study Group noted that judgments were unblinded and replicability is uncertain. Our review was restricted to studies available in English and full-text attachments provided by the user, which may have excluded relevant research and introduced publication bias.

Future implications

Future research should prioritize prospective, multicenter studies with standardized LEMG protocols, blinded interpretation, and clearly defined outcome measures to improve the evidence base. Quantitative metrics such as motor unit turns per second, amplitude-frequency ratios and automated pattern recognition should be incorporated alongside qualitative descriptors to reduce subjectivity and enhance sensitivity.

Because synkinesis appears to be a key determinant of outcome, future trials should routinely assess synkinetic activity using amplitude ratios during phonation and respiration and evaluate posterior cricoarytenoid innervation. Integration of LEMG findings with imaging modalities such as laryngeal ultrasonography or MRI and with structural assessments like CT-derived muscle atrophy may improve prognostic models. The timing of LEMG also warrants investigation; data suggest that performing the examination after at least two months from symptom onset optimizes PPV and specificity, but the optimal interval may vary by etiology. Longitudinal studies should explore the relationship between reinnervation, synkinesis and functional recovery, ideally correlating electrophysiologic data with voice quality and quality-of-life outcomes. Emerging techniques such as machine learning could be applied to large LEMG datasets to identify complex patterns predictive of recovery. Finally, clinical trials assessing early interventions such as injection laryngoplasty or reinnervation surgery in patients stratified by LEMG prognosis are needed to determine whether LEMG-guided management improves voice outcomes and reduces morbidity.

Conclusion

Spontaneous activity on laryngeal electromyography, particularly fibrillation potentials and positive sharp waves, is a strong rule-in marker for poor recovery of vocal fold mobility when accompanied by absent or markedly reduced motor unit recruitment. Across diverse observational cohorts, the presence of denervation patterns yielded high positive predictive values (80-97 %) for persistent paralysis, whereas negative predictive values for recovery were modest (40-68 %), reflecting false reassurance in some patients. Polyphasic motor unit potentials and good recruitment were associated with a favorable prognosis but did not guarantee recovery, and synkinesis substantially lowered the likelihood of regaining motion. Our findings reinforce meta-analytic results showing that LEMG is more reliable for predicting poor outcomes than for predicting recovery. They also highlight the need to consider recruitment patterns, quantitative metrics, synkinesis and timing of testing to interpret LEMG accurately. Clinicians could use LEMG as part of a comprehensive assessment when counselling patients about prognosis and when deciding on early interventions.

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Contribution of authors

Conceptualization, S.T, C.A.M and C.S; Methodology, S.T, C.A.M and C.S; Data analysis, S.T, C.A.M and C.S; Manuscript writing and initial draft preparation, S.T, C.A.M and C.S; Manuscript review and editing, S.T, C.A.M and C.S; Supervision, S.T, C.A.M and C.S. All authors read and approved the final manuscript.

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All data presented in the manuscript are available from the authors upon request.

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