

The utilization of intra-operative recurrent laryngeal nerve monitoring in predicting vocal fold mobility after thyroid and parathyroid surgery

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Abstract

The role of intraoperative nerve monitoring in thyroid and parathyroid surgery has evolved over the past 15 years. Despite advances in technology there remains controversy regarding the role of nerve monitoring. The purpose of this paper was to review the relevant literature on the topic of intraoperative nerve monitoring with a particular emphasis on the efficacy of nerve monitoring to predict postoperative vocal fold mobility. In addition the paper will assess the role of nerve monitoring as an adjunct to clinical judgment regarding staging bilateral thyroid surgery when the first nerve fails to respond to intraoperative stimulation.

Core Tip

Over the last 15 years there has been controversy regarding the role of intraoperative recurrent laryngeal nerve monitoring in thyroid/parathyroid surgery. This paper discusses the value of nerve monitoring and the role of nerve monitoring to predict postoperative recurrent laryngeal nerve function.

Introduction

Intraoperative recurrent laryngeal nerve (RLN) monitoring is a relatively new technology that has been utilized for its potential utility in helping surgeons identify the RLN, prevent and/or reduce iatrogenic nerve injury and predict post-operative vocal cord paralysis (VCP). Most authors agree that the critical factor in reducing iatrogenic injury to the RLN rests on sound anatomic knowledge and direct visualization of the nerve during surgery [1]. Over the last 10 to 15 years, the role of monitoring the RLN during endocrine surgery has been utilized in an attempt to reduce iatrogenic injury. Despite extensive use of a variety of nerve monitoring techniques, there is no clear cut evidence that routine nerve monitoring will reduce the incidence of iatrogenic nerve injury [1-11]. The utilization of IONM has also been suggested to aid in intraoperative nerve identification and provide feedback to the surgeon as they dissect and manipulate the nerve [12-33].

Another important role of intraoperative nerve monitoring is its ability to predict postoperative nerve function. This becomes particularly useful in surgical cases where intraoperative nerve dissection and traction/thermal injury may have resulted in a paresis of the nerve. In cases where the surgeon is going to dissect the contralateral nerve it is valuable to be able to reliably predict if the ipsilateral nerve is both anatomically and physiologically intact. This real time assessment of the nerve function allows the surgeon to integrate the information into intraoperative decision making, and in select cases consider staging the contralateral nerve dissection.

The purpose of this paper was to provide an overview of the role

of IONM in predicting postoperative RLN function in thyroid and parathyroid surgery.

Methods

The project was initiated by performing a Pubmed search with key words (intraoperative nerve monitoring, recurrent laryngeal nerve, thyroid surgery, predicting postoperative laryngeal nerve function, etc.) focusing on the predictive nature of IONM for predicting postoperative RLN function. The authors have no competing commercial, personal, political, intellectual, or religious conflicts to declare in relation to the submitted paper. The paper is a review article and as such did not require IRB approval.

A search of the literature revealed over 300 articles related to RLN monitoring in thyroid and parathyroid surgery over the past 15 years. When the search was narrowed to IONM ability to predict postoperative RLN function there were less than 15 recent articles. A particular emphasis was placed on reviewing prospective randomized clinical trials and prospective/retrospective clinical trials. A particular emphasis was placed on analyzing studies that provided clinical results that could be utilized to guide the surgeon in intraoperative decision making (stimulus intensity and stimulus response amplitudes).

Discussion

The role of intraoperative monitoring of the RLN has been frequently debated in the literature. Whereas the efficacy of RLN in

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preventing or lowering the incidence of iatrogenic nerve injury has not been shown, a number of studies point to the role of intraoperative monitoring in predicting postoperative nerve function [9-30]. Clinical studies have demonstrated that surgeons are not very accurate at predicting RLN integrity by simple observation. In several studies it has been noted that only 10% to 14 % of injured nerves are identified as being injured by the operating surgeon [22,31,32]. Given the limitations on direct visualization to predict nerve function it is imperative to utilize new technology and objective data to assess nerve function. The key question centers on the accuracy and reliability of the intraoperative nerve monitor to predict postoperative recurrent laryngeal nerve function. In a retrospective observational study Genther *et al.* analyzed 997 at risk RLN [12]. They identified post dissection EMG amplitude of 200 uV as the critical threshold to predict normal vocal cord mobility postoperatively. A stimulus response of >200 uV (with 1 mAmp stimulus) had a sensitivity of 95.5% and a specificity of 99.2%. The authors concluded that evoked EMG amplitudes can reliably predict immediate postoperative vocal cord function in patients undergoing thyroid and parathyroid surgery. Phelan *et al.* utilized continuous vagal IONM to detect signal changes in the vagal nerve/RLN complex [13]. This continuous monitoring provides real time RLN evaluation during various surgical maneuvers and can guide the surgeon to avoid specific surgical behaviors that may negatively influence nerve function. The focus of this study was to provide the surgeon with real time feedback during nerve dissection to minimize the risk of nerve paresis or injury.

Pavier *et al.* performed a study which assessed the ability of IONM to predict postoperative nerve function [14]. In this study of 216 RLN they identified post dissection EMG amplitude of 280 uV (with stimulus of 1-1.5 mAmp) as predictive of normal vocal cord mobility with a sensitivity of 100% and specificity of 94.1%. The risk of postoperative palsy was approximately 50% in patients with EMG amplitude less than 280 uV. Eid *et al.* analyzed 909 RLN at risk during thyroid and parathyroid surgery [16]. Using a post dissection stimulus of 0.5 mAmp they demonstrated an overall sensitivity of 98.4% and a specificity of 62.5% to predict postoperative vocal cord function. No specific post dissection EMG amplitude was recorded in this study. They further identified an interesting small sub group (n=12) of patients with a false positive stimulation test (positive stimulation at 0.5 mAmp on EMG but immobile vocal cord postoperatively). Despite the false positive in this small sub group of patients eleven of the twelve recovered normal vocal cord mobility in the first 3 to 12 weeks after surgery.

In an interesting study Sadowski *et al.* analyzed the value of IONM in changing the operative strategy in patients undergoing planned bilateral (total) thyroidectomy [17]. In a series of 220 patients undergoing planned bilateral thyroidectomy 9 of the 220 had a loss of intraoperative EMG signals on the first surgical side. The surgeon then deferred the contralateral dissection to minimize the risk of bilateral nerve paralysis. In these 9 patients there were two false positive IONM loss. In the remaining seven all demonstrated total or partial laryngeal nerve palsy at postoperative day 1. In all seven cases the nerve recovered over 1 to 4 months. The authors concluded that IONM can reduce the rate of bilateral laryngeal nerve palsy to near 0% if the second side is deferred to give the ipsilateral nerve time to recover. Another study by Sitges-Serra *et al.* took this analysis a step further in assessing the initial nerve dissected during thyroid surgery [19]. In a series of 259 patients they noted the loss of signal in 16 nerves loss of intraoperative nerve signal defined as. In 15 of the 16 nerves the signal recovered (mean amplitude of 132 uV) in 10-35 minutes. Only 3 of the 15 nerves that recovered its signal demonstrated transient vocal cord

paresis. The loss of the intraoperative nerve signal may not be an all or none phenomenon. The authors concluded that judicious bilateral thyroidectomy may be considered even in the event that the signal is lost on the ipsilateral nerve.

Tomoda *et. al.* in an older study from 2006, analyzed 2197 RLN utilizing a palpation technique to assess intraoperative nerve function [20]. They stimulated the RLN with a disposable hand held nerve stimulator (setting 1.0 mAmp) while they performed manual palpation of the posterior cricoarytenoid muscle. This older technique demonstrated a sensitivity and specificity of 69.3% and 99.7% respectively in predicting postoperative vocal cord palsy. Even in situations where there was no contraction of the PCA and postoperative vocal cord palsy, they noted that in the majority of cases the vocal cord will regain mobility within one year if the nerve was anatomically intact at the end of the surgical case.

Goretski *et al.*, assessed the value of IONM in the surgical strategy in bilateral thyroid surgery [21]. They retrospectively analyzed 1333 consecutive patients with benign thyroid disease to assess the value of IONM in impacting the decision process to proceed with bilateral thyroidectomy/nerve dissection. They advocate a staged operation in the setting of an ipsilateral RLN that fails to respond to nerve stimulation at 1.0 mAmp and an absent or reduced stimulation amplitude of less than 100 uV. This lack of response had a sensitivity and specificity of 93% and 80%. This approach can minimize the risk of postoperative bilateral nerve paralysis while allowing the surgeon to complete the operation after the nerve has recovered (typically within 10-12 weeks).

Caragacianu *et al.*, performed a very interesting study to determine normative nerve monitoring values associated with normal postoperative glottis function [22]. In a series of 125 patients with 167 nerves at risk they identified a stimulus amplitude of 247 uV (with a stimulus level of 1.0 mAmp) as the threshold that can positively predict normal vocal cord mobility. In cases which the nerve stimulus response amplitude is less than 247 uV (and clearly if <100 uV) the surgeon can consider delaying the surgery on the contralateral side to lower the risk of bilateral RLN injury and subsequent bilateral vocal cord paralysis.

In a recent study Faden *et al.* analyzed the optimal stimulation threshold to predict postoperative vocal cord mobility [30]. The stimulus threshold was set at 150 mV and incremental stimulation levels were utilized at 0.3 mAmp, 0.5 mAmp, 0.8 mAmp, and 1.0 mAmp. A stimulation threshold of 0.5 mAmp optimized the predictive value of nerve monitoring (sensitivity 68% and specificity 84% with excellent positive predictive value) but stimulation at multiple levels significantly improves the overall predictive value of IONM. The lower level of stimulation at 0.3 mAmp had high sensitivity but low specificity and low positive predictive value meaning that low levels of stimulation are excellent at confirming that the RLN that stimulates at 0.3 mAmp will have normal function postoperatively. As the stimulus intensity increases the sensitivity decreases and the specificity rises. This paper also discusses some of the complex issues involved in assessing the response of the nerve to stimulation including different IONM techniques, accurate assessment of RLN function postoperatively, location of stimulus application to RLN, and the role of various stimulation thresholds on the predictive value of IONM.

As with any technology there are limitations with IONM of the RLN. Nerve monitoring requires accurate placement of an endotracheal tube with surface electrodes in contact with the vocal folds. The accuracy of IONM depends on accurate utilization of the system and an understanding how to trouble shoot problems that may arise. This

technology requires the surgeon to obtain the necessary training and experience to use the system efficiently and accurately.

Some authors have suggested selective use of the IONM system for the “difficult cases” but our opinion is that if a surgeon plans on using IONM then one should strongly consider using it in all cases. Even small tumors may be adherent to RLN and it is difficult to predict the difficult case prior to surgery. The routine utilization of IONM allows the surgeon to steepen the learning curve and improve interpretive skills and ability to troubleshoot system malfunction [35]. The time to set up the system becomes minimized with routine use and in most cases requires less than 5 to 10 min to set up and troubleshoot. The cost of IONM is minimal and mainly related to the cost of the nerve monitoring endotracheal tube (typical cost approximately \$150 in US dollars).

Conclusion

1. The risk of RLN injury during thyroid/parathyroid surgery ranges from 2% to 4% in experienced surgical hands.
2. There is no evidence that routine IONM of the RLN can reduce the risk of iatrogenic RLN injury.
3. IONM is a valuable adjunct to RLN identification but does not replace an understanding of the detailed surgical anatomy.
4. IONM can be a valuable tool to help the surgeon predict postoperative vocal fold mobility and postoperative paresis/paralysis.
5. The optimal nerve stimulus intensity to assess the RLN is 0.5 mAmp to 1.0 mAmp. A nerve stimulus response greater than 200 uV can reliably predict normal vocal fold mobility postoperatively with an excellent positive predictive value of 95% to 99%.
6. The information obtained from IONM can guide the surgeon to proceed with bilateral thyroidectomy (bilateral RLN dissection) or to consider staged surgery when the nerve stimulus response is less than 150 uV to 200 uV.
7. Further research should evaluate methods of incorporating standardized stimulation and response amplitude values for IONM as intermittent fluctuations throughout surgery may have a predictive value.

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