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SURGICAL TECHNIQUE

NERVE STIMULATION IN THYROID SURGERY: IS IT REALLY USEFUL?

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Background: Monitoring of the recurrent laryngeal nerve (RLN) has been claimed in some studies to reduce rates of nerve injury during thyroid surgery compared with anatomical dissection and visual identification of the RLN alone, whereas other studies have found no benefit. Continuous monitoring with endotracheal electrodes is expensive whereas discontinuous monitoring by laryngeal palpation with nerve stimulation is a simple and inexpensive technique. This study aimed to assess the value of nerve stimulation with laryngeal palpation as a means of identifying and assessing the function of the RLN and external branch of the superior laryngeal nerve (EBSLN) during thyroid surgery.

Methods: This was a prospective case series comprising 50 consecutive patients undergoing total thyroidectomy providing 100 RLN and 100 EBSLN for examination. All patients underwent preoperative and postoperative vocal cord and voice assessment by an independent ear, nose and throat surgeon, laryngeal examination at extubation and all were asked to complete a postoperative dysphagia score sheet. Dysphagia scores in the study group were compared with a control group (n = 20) undergoing total thyroidectomy without nerve stimulation.

Results: One hundred of 100 (100%) RLN were located without the use of the nerve stimulator. A negative twitch response occurred in seven (7%) RLN stimulated (two bilateral, three unilateral). Postoperative testing, however, only showed one true unilateral RLN palsy postoperatively (1%), which recovered in 7 weeks giving six false-positive and one true-positive results. Eighty-six of 100 (86%) EBSLN were located without the nerve stimulator. Thirteen of 100 (13%) EBSLN could not be identified and 1 of 100 (1%) was located with the use of the nerve stimulator. Fourteen per cent of EBSLN showed no cricothyroid twitch on EBSLN stimulation. Postoperative vocal function in these patients was normal. There were no instances of equipment malfunction. Dysphagia scores did not differ significantly between the study and control groups.

Conclusion: Use of a nerve stimulator did not aid in anatomical dissection of the RLN and was useful in identifying only one EBSLN. Discontinuous nerve monitoring by stimulation during total thyroidectomy confers no obvious benefit for the experienced surgeon in nerve identification, functional testing or injury prevention.

Key words: nerve stimulator, recurrent laryngeal nerve, superior laryngeal nerve, thyroidectomy.

Abbreviations: CI, confidence interval; EBSLN, external branch of the superior laryngeal nerve; EMG, electromyography; ENT, ear, nose and throat; PCA, posterior cricoarytenoid; RLN, recurrent laryngeal nerve.

INTRODUCTION

Injury to the recurrent laryngeal nerve (RLN) during thyroid and parathyroid surgeries can result in significant morbidity as a result of temporary or permanent paralytic dysphonia and dysphagia. To date it remains the most significant commonly found complication of endocrine surgery in the neck. Nerve injury rates in the published work are typically 1–2% and significantly higher for re-operation. Transient injury occurs in approximately 5% with 95% of the injuries recovering normal function.[1] It has long been accepted that anatomic identification of both the RLN and the external branch of the superior laryngeal nerve (EBSLN) is the safest way of reducing nerve injury rates to a minimum[2] and certainly injury rates are lowest when surgery is carried out by experienced endocrine surgeons or thyroid surgeons in specialized centres with high caseloads.[3] Nonetheless, identification and preservation of the RLN does not eliminate the possibility of nerve injury. An anatomically intact nerve may still show altered function postoperatively due to factors, such as neural stretch during goitre retraction.

Nerve monitoring of the RLN during thyroid and parathyroid surgeries has been claimed in some studies to reduce the rate of nerve injury;[4,5] however, other large studies have shown it to be of no benefit[6,7] compared with anatomic identification. Moreover, continuous nerve monitoring involves significant capital and ongoing disposable costs. As such the technique can never be cost-effective as measured by true cost per nerve injury prevented, assuming of course that any nerve injury is prevented at all. In contrast, the technique of laryngeal palpation with nerve stimulation offers an inexpensive method for discontinuous RLN monitoring, requiring only a single disposable nerve stimulator costing $A 128.[5] The technique can also be applied to assess the integrity and function of the EBSLN. The aim of this study was to assess the value of nerve stimulation during total thyroidectomy using the technique of laryngeal palpation.

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PATIENTS AND METHODS

This is a prospective case series. The study group comprised 50 patients undergoing total thyroidectomy (100 RLN and 100 EBSLN at risk) in a tertiary referral endocrine surgical unit between March 2005 and January 2006. In addition, the study included a dysphagia control group of 20 patients undergoing total thyroidectomy without nerve stimulation (at a different hospital but without facilities for nerve stimulation). In the study group, the mean age was 52.4 years and the female : male ratio was 38:12. In the dysphagia control group, the mean age was 49.6 years and the female : male ratio was 18:2. These differences were not statistically significantly different. The final pathological diagnosis showed that 10 of 50 (20%) patients in the study group had a diagnosis of thyroid cancer and 40 of 50 (80%) had benign thyroid disease. In the control group, 4 of 20 (20%) had malignant disease and 16 of 20 (80%) had benign disease (Table 1). The two groups were therefore statistically similar.

The protocol for assessment of the laryngeal nerves included the following: (i) clinical examination; (ii) assessment of vocal cord function at extubation by the anaesthetist; and (iii) voice assessment and routine preoperative and postoperative laryngoscopy at 2 weeks by an independent ear, nose and throat (ENT) surgeon blinded to the results of the nerve monitoring study. Follow up of any patient with a voice problem at 2 weeks was carried out by the ENT surgeon till resolution was obtained. Stroboscopy and electromyography (EMG) assessment were not used in this study.

The protocol for nerve identification and stimulation was as follows: total thyroidectomy carried out by the standard unit technique of capsular dissection with attempted anatomical observation of both RLN and EBSLN; stimulation of all four nerves with a hand-held Medtronic Varistim III Nerve Stimulator (Medtronic Inc., Minneapolis, MI, USA) at currents of 1–2 mA on completion of dissection.[2,8] The RLN was stimulated at the most proximal exposed site of the nerve and assessment of function was made by laryngeal palpation with the surgeon sliding his finger into postcricoid region of the larynx to sense posterior cricoarytenoid (PCA) muscle contraction through the posterior hypopharyngeal wall in response to ipsilateral RLN stimulation. The EBSLN was stimulated proximal to the superior pole of the thyroid with assessment by studying a cricothyroid muscle twitch.

The protocol included the following option if the RLN could not be identified anatomically: reversal of residual muscle relaxation; nerve stimulation of the tracheo-oesophageal groove with laryngeal palpation in an attempt to locate the RLN; completion of the operation following nerve identification. This option was never used.

All patients were asked to complete a postoperative dysphagia score sheet as this was the only potential adverse association with the technique of laryngeal palpation. The dysphagia score consisted of a visual analogue scale numbered 0–10. On the scale, the number 0 was described as 'no symptoms', 5 as 'awareness of tightness' and 10 as 'real difficulty swallowing'.

Table 1. Final pathology in both patient groups

Pathology	Study group (n = 50)	Dysphagia control group (n = 20)
Multinodular goitre (%)	24 (48)	11 (55)
Graves' disease (%)	12 (24)	4 (20
Thyroid cancer (%)	10 (20)	4 (20)
Hashimoto's thyroiditis (%)	4 (8)	1 (5)

RESULTS

Intraoperative results

In this study, 100% (100/100) of RLN and 86% (86/100) of EBSLN at risk were located without the need for the nerve stimulator. Only once was the nerve stimulator required to locate a right EBSLN (1/100, 1%). The protocol for RLN identification with the nerve stimulator in the event of it not being located anatomically was never required. Thirteen per cent (13/100) of EBSLN at risk could not be identified either by anatomical observation or by nerve stimulation. Of these, the EBSLN was not identified bilaterally in three patients (six nerves), only on the left in six patients (six nerves) and only on the right in one patient (one nerve). All RLN and EBSLN that were seen were anatomically intact.

A lack of RLN twitch was found in five patients (in two patients this was bilateral and in three it was unilateral), comprising 7 of 100 (7%) RLN stimulated. However, in only one patient did this prove to be a true palsy on postoperative testing (1/100, 1% of nerves tested). This single injury was also noted by the anaesthetist at the time of extubation. The other four patients showed normal vocal cord function postoperatively and were thus false positives. Overall the test, in relation to RLN stimulation, had a sensitivity of 100%, a specificity of 94%, a positive predictive value of 14% and a negative predictive value of 100%.

In eight patients there was an absence of cricothyroid twitch on EBSLN stimulation unilaterally and in a further three patients there was an absence of cricothyroid twitch on EBSLN stimulation bilaterally totalling 14/100 nerves at risk (14%). In two of these eight patients, stimulation of both RLN and EBSLN gave no twitch response, although this occurred after reversal of a neuromuscular blocking agent. The lack of twitch response may have been due to residual effect of the neuromuscular blocking agent or secondary blocking effects of the reversal agent. In both patients, vocal cord function was normal at extubation and postoperatively. There were no instances of equipment malfunction. In four patients the movement of the vocal cords was not tested at extubation and in six patients the vocal cords could not be seen. In all of these 10 patients postoperative vocal cord function was subsequently found to be normal.

Postoperative results

Of the 50 patients in the study, 44 underwent postoperative laryngoscopy (44/50, 88%). Six patients (6/50, 12%) either refused or did not turn up for postoperative laryngoscopy despite having agreed to such a protocol preoperatively. All of these six patients reported an entirely normal voice postoperatively.

There were three instances of altered vocal cord function postoperatively. Of these, there was only one instance of a complete unilateral temporary RLN palsy, predicted by nerve monitoring, which recovered fully with return of function by 7 weeks. In the second patient mild dysphonia was reported postoperatively and ENT laryngoscopy showed supraglottic oedema and decreased quality of movement of one vocal cord. The third patient reported voice weakness at the end of each day. Neither of these latter two patients had altered RLN or EBSLN function intraoperatively that might have predicted these complications and in both cases the

voice recovered completely. They are not considered true RLN injuries. There were no instances of bilateral nerve palsies and no cases of permanent vocal cord paralysis in the study group. Other postoperative complications included four patients with postoperative temporary hypocalcaemia (4/50 patients, 8%) and one with haematoma (1/50 patients, 2%). In the control group there were two patients with temporary hypocalcaemia (2/20 patients, 10%) and one patient required re-operation because of haemorrhage (1/20 patients, 5% of cases).

The dysphagia score was completed in 82% (41/50) of patients in the study group and all patients in the control group (n = 20, 100%). The averaged dysphagia score in the study group was 3.60 (95% confidence interval (CI) 2.99–4.20). The averaged dysphagia score in the control group was 3.40 (95%CI 2.52–4.28). The two scores showed no statistically significant difference indicating that there was no higher incidence of dysphagia associated with placement of a finger in the retrolaryngeal space in the study group compared with the control group.

DISCUSSION

Nerve monitoring of the RLN during thyroid and parathyroid surgeries has been proposed by some as the new standard of care. There are a wide variety of techniques for both nerve monitoring that can be either continuous, such as with endotracheal electrodes, or discontinuous with a nerve stimulator. Intraoperative monitoring of the RLN was first described by Flisberg and Lindholm in 1969 and various forms of nerve monitoring have gained popularity for thyroid surgery, including those that provide an audible signal for the surgeon as dissection approaches the nerve.[9] However, controversy remains as to whether nerve monitoring confers any significant benefit in nerve identification, injury prevention and prediction of postoperative vocal cord function compared with current practice of anatomical dissection to identify and preserve the RLN. Although some studies have claimed that routine nerve monitoring reduces the rate of nerve injury, several other large series have shown no benefit. Other studies claim that the nerve monitoring is really only of value with high-risk surgery or in re-operative cases. A large multicentre study of 4382 patients found a statistically significant reduction in rates of transient and permanent RLN paralysis with use of intraoperative nerve monitoring in surgery for benign goitre.[4] Nonetheless, subgroup analysis of the same study found higher rates of RLN injury when intraoperative nerve monitoring was used for total thyroidectomy. In contrast, a large single-centre study from Hong Kong of 1000 consecutive RLN at risk found that continuous nerve monitoring offered absolutely no benefit in reducing the risk of nerve injury compared with the adoption of routine RLN identification, with no difference in both the temporary (3.4 vs 4.0%) and the permanent (0.8 vs 1.2%) nerve injury rates in the neuromonitored and control groups.[7] The largest study so far is the German cooperative study of nearly 30 000 nerves at risk.[6] Intraoperative nerve monitoring did not lower the risk of nerve injury (0.84% of nerves at risk) although failure to visually identify the nerve was associated with a higher rate of injury. Interestingly, nerve injury rates were also higher for low-volume hospitals and low-volume surgeons.[6]

Routine nerve monitoring is not cost-effective. Start-up costs for continuous nerve monitoring equipment are approximately $A 40 000 and cost per operation in disposables is approximately $A 500. As such the technique of continuous nerve monitoring can never be cost-effective as measured by true cost per nerve injury prevented (assuming of course that any nerve injury is prevented at all). In contrast, the technique of laryngeal palpation offers an inexpensive method for discontinuous nerve monitoring, requiring only a single disposable nerve monitor costing $A 128 and was therefore evaluated in this study as the reduced cost may have justified its more routine use in thyroid surgery compared with continuous monitoring.[5] However, the results of this study lead us to conclude that there are no significant benefits in using the technique at all.

Available techniques of intraoperative nerve monitoring involve either continuous or discontinuous monitoring. Continuous methods involve the use of EMG electrodes placed on an endotracheal tube or insertion of electrodes into muscles innervated by the RLN. Discontinuous monitoring can be carried out using a nerve stimulator and observing for twitch or using laryngeal palpation. This latter method involves nerve stimulation of the ipsilateral RLN with simultaneous palpation by the surgeon of the posterior plate of the cricoid cartilage to sense the contraction of the PCA muscle, also known as the 'laryngeal twitch'.[5] This technique was first described by Riddell in 1970.[10] A recent study has shown that nerve stimulation with laryngeal palpation correlates well to continuous monitoring with EMG-evoked potentials. Case series using laryngeal palpation have found the technique to be safe and less costly than continuous monitoring.[11]

This study aimed to evaluate the usefulness of this nerve stimulation technique in locating both the RLN and the EBSLN during thyroidectomy, as well as to determine whether discontinuous intraoperative nerve monitoring was useful in predicting postoperative nerve injury. Testing of the EBSLN was included for several reasons. The functional significance of the EBSLN is less well recognized than that of the RLN and identification is not always carried out routinely. The EBSLN innervates only the cricothyroid muscle and is smaller and more anatomically variable than the RLN. Injury to this nerve, however, can cause some voice hoarseness and inability to produce higher vocal frequencies or project the voice. Although many such injuries tend to recover, a number of authors now recommend routine identification and preservation of the EBSLN as well as the RLN.[12,13] Dysphagia scores in the study group were also compared with a control group of patients undergoing total thyroidectomy without electrical nerve stimulation to determine whether use of the nerve stimulator with laryngeal palpation caused increased symptoms of dysphagia – the only potential complication of the technique other than nerve injury.

The results showed that the use of intermittent nerve stimulation with the technique of laryngeal palpation is simple, safe and inexpensive, but at the same time of no value in either aiding anatomical localization or preventing nerve injury. In this series, the RLN was able to be identified anatomically without difficulty in 100% of cases without the use of the stimulator. The nerve stimulator was useful only once in identifying a single EBSLN that could not be seen, but was not useful in identifying 13 EBSLN (six bilateral, seven unilateral) that could not be seen anatomically

Overall the technique was highly sensitive (1.0), but not specific (0.94) in identifying RLN injury. These results show a number of problems with the use of intermittent monitoring. The false-positive rate of neuropraxia comprised 6% of RLN tested, compared with a true-positive rate of 1%. The false-positive rate was therefore significantly higher than the rate of nerve injury reported in the published work. Even disregarding results from two patients in whom anaesthetic reasons may have contributed to bilateral absence of laryngeal twitch, the false-positive rate was still double the true-positive rate for detection of RLN injury, that

is, 2 versus 1% of nerves tested. The nerve stimulator was not useful for the functional testing of the EBSLN and the prediction of postoperative vocal problems. In none of the patients in whom no EBSLN twitch was identified were any postoperative vocal problems reported; however, this study relied on reported symptoms and did not use video stroboscopy or EMG, which are the (invasive) gold standard of postoperative cricothyroid muscle functional testing.

Since nerve monitoring during thyroidectomy is of no value in either assisting anatomical identification or preventing nerve injury, the issue of any other potential benefits needs to be raised. The proponents of routine nerve monitoring claim that its use can still be justified for bilateral surgery stating that if nerve monitoring is undertaken after completion of one side of the procedure and there is evidence of impaired function, then the procedure should be abandoned to avoid the risk of bilateral damage and tracheostomy. We believe that this is a hypothetical situation that could lead to more harm than good with a surgeon having to abandon a thyroidectomy at the unilateral lobectomy stage to avoid potential tracheostomy based on an apparent nerve injury identified by neuromonitoring alone. A retrospective review of the data from our unit of 4026 primary total thyroidectomies carried out over the last 20 years to June 2006 has shown only four cases where a postoperative tracheostomy was required. One case was due to postoperative wound haematoma with tracheal obstruction and another due to anaesthetic-related haemorrhage from the tongue, with only two cases (0.05%) resulting from bilateral RLN palsy, both involving locally invasive papillary carcinoma. In neither case would this devastating complication be avoided by the use of nerve monitoring – the first was due to intended nerve sacrifice on one side with malignant involvement of the RLN, followed by accidental vagal division on the contralateral side during selective neck dissection and the second involved intended sacrifice on one side with malignant involvement of the RLN, with a palsy on the contralateral side following attempts to remove an unresectable cancer invading trachea and oesophagus.

Another issue is that nerve monitoring might be used by less experienced surgeons to assist with anatomical identification. We have previously shown that RLN injury rates are no higher when thyroid surgery is undertaken either by trainees (under supervision)[14] or by provincial surgeons who have had appropriate training in the techniques of nerve identification at thyroidectomy.[15] There is no substitute for quality training and to suggest that a technological toy might take the place of training and allow inexperienced surgeons to attempt thyroid surgery is clearly inappropriate.

These results are consistent with previous studies that have shown that intraoperative nerve monitoring (whether continuous or discontinuous) does not reduce rates of nerve injury or accurately predict postoperative vocal cord paralysis and lend further support to the evidence that there is no real benefit of nerve monitoring where the operation is carried out by an experienced surgeon.[12,16,17] Duh, in a recent editorial called into question the value of routine nerve monitoring, stating that 'taken together these studies support routine visual identification of the RLN and EBSLN, but do not support routine use of intraoperative nerve monitoring'.[1] Interestingly, the issue of routine nerve monitoring was identified at a recent meeting of the American Association of Endocrine Surgeons as being an important issue facing endocrine surgery over the next few years and one which would need to be addressed with prospective data collected by experienced endocrine surgeons. This study was undertaken with the initial intent of assessing whether discontinuous nerve monitoring by the technique of laryngeal palpation might be of some value given that it is substantially cheaper than continuous monitoring – we conclude that it is simply not a useful tool at all.

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