The Journal of Laryngology & Otology (2006), ***120***, *566–569*.

doi:10.1017/S0022215106000946
Printed in the United Kingdom
First published online 24 March 2006

Main Article

Thyroid surgery and recurrent laryngeal nerve monitoring

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Abstract

Recurrent laryngeal nerve paralysis is a much-dreaded complication of thyroid surgery.

Objective: To study the feasibility and the reliability of a recurrent laryngeal nerve monitoring technique.

Materials and methods: This was a prospective study including 36 patients proposed for thyroid surgery with recurrent laryngeal nerve monitoring. They underwent post-operative fibre-optic laryngeal examination and speech therapist consultation.

Results: Our technique of nerve monitoring showed a 98 per cent sensitivity and 86 per cent specificity.

Conclusions: Recurrent laryngeal nerve monitoring is a feasible and reliable technique. It can be used to avoid bilateral nerve injury and to increase the surgeon's confidence but not to replace a systematic nerve identification and a careful dissection.

Key words: Thyroidectomy; Recurrent Laryngeal Nerve; Neural Conduction

Introduction

Recurrent laryngeal nerve (RLN) palsy or paralysis is one of the most serious complications in thyroid surgery. It may be transient or permanent, but it is always serious when there is bilateral vocal fold immobility. Clinical signs range from various degrees of dysphonia to life-threatening airway obstruction.

The incidence of RLN injury in thyroid surgery reported by different authors ranges widely, from 0 to 20 per cent,[1,2] according to whether the intervention was a first or second procedure. Systematic identification and meticulous dissection of the RLN have decreased the incidence of RLN injuries, even transient ones. However, such identification and dissection is not always easy to achieve, particularly in the case of repeat surgery with dense scar tissue, or in cases in which malignant tumour abuts the nerve.

Improvements in electrophysiological techniques have permitted facial nerve monitoring during parotid and acoustic neurinoma surgery. Several methods of RLN monitoring are available. The aim of this prospective study was to analyse the feasibility and reliability of one of these techniques, using a silicone endotracheal tube with two surface electrodes applied to the vocal folds (NIM-Response®, Medtronic Xomed, Minneapolis, USA).

Materials and methods

We conducted a prospective study from May 2004 to October 2004, which included 36 patients proposed for bilateral thyroid surgery for multinodular goitre or potential bilateral surgery for a nodule suspected to be malignant (on clinical examination, ultrasonography, or fine-needle aspiration and histopathological examination). All surgery was conducted with continuous RLN electromyographic monitoring (NIM-Response®, Medtronic Xomed).

The NIM-Response® is an intra-operative nerve monitoring system including four detection channels. It records electromyographic activity from muscles innervated by an 'at risk' nerve, in order to aid early identification of the nerve at risk and to permit continuous intra-operative electromyographic monitoring and thus to enhance neural preservation.

The NIM-Response® is composed of a main frame computer (with a touch-sensitive monitoring screen) and a patient interface box used to connect the patient (via subdermal electrodes for ground and stimulation) to the main screen, to the surface electrodes placed on the endotracheal tube, and to the monopolar stimulation probe.

Subdermal electrodes were inserted after the anaesthetic induction but before intubation. The use of paralysing anaesthetic agents was avoided (these significantly interfere with, if not completely eliminate, the electromyographic response to direct neural stimulation). For the same reason, no local anaesthetic agent was used on the vocal folds.

The endotracheal tube included two surface electrodes above the cuff, which were later connected to the interface box.

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Accepted for publication: 28 October 2005.

Correct placement of the endotracheal tube was checked by the anaesthetist and also via the impedance measured on the main screen.

A standard surgical technique was used, beginning with ligature of the superior pole vessels to allow medial rotation of the thyroid lobe. The RLN was identified and an electromyographic response to electrical stimulation was attempted. Stimulation intensities were gradually increased until a response was obtained; the lowest intensity used was 0.15 mA and the highest was 2 mA (maximum intensity available, 3 mA).

The response obtained was audible, visual and printable: four characteristic, audible 'bips' and an event waveform over 100 μV. The identified RLNs were stimulated at the time of their discovery and again at the end of the surgery.

All patients underwent pre- and post-operative laryngeal examinations. On the first post-operative day, they underwent a voice quality test by a speech therapist and a laryngeal fibre-optic examination to assess vocal fold mobility. Statistical analyses used the chi-squared and Fisher exact tests.

Results

The study included 36 patients (31 women and five men). Patients' average age was 48.8 ± 17.5 years (range, 16 to 80 years old). We collected data on 61 RLNs at risk (from 25 total thyroidectomies and 11 lobo-isthmectomies).

The indications for surgery were: Graves' disease, three patients; multinodular goitre, 21; medullary thyroid carcinoma, one; and suspicion of papillary thyroid carcinoma, 11. Six patients had previously undergone thyroid surgery. All the patients had normal laryngeal mobility before surgery.

In four cases, we obtained a positive electromyographic response by stimulating the vagus nerve (stimulation intensities ranged from 0.4 to 0.7 mA). These were all adenocarcinoma cases, involving more extensive neck dissection.

For one case, a right parotidectomy was indicated (for cystadenolymphoma), associated with a total thyroidectomy (for benign multinodular goitre). The availability of four detection channels permitted facial monitoring (one electrode in the periorbicular muscle and one in the triangularis oris) and laryngeal monitoring at the same time.

The minimal RLN stimulation intensity needed for an electromyographic response ranged from 0.15 to 0.50 mA. For six patients, initial stimulation at 2 mA did not induce any electromyographic response. For seven patients, final stimulation at 2 mA did not induce any electromyographic response.

In seven cases, thyroid carcinoma was found on peri-operative histological examination. These patients underwent total thyroidectomy with ipsilateral tracheal lymphadenectomy.

Laryngeal fibre-optic examination on the first post-operative day revealed seven cases of impaired vocal fold mobility (four cases of palsy and three of paralysis). It is interesting to notice that these cases did not always present with dysphonia, even on systematic, specialized orthophonist examination.

Fifty-nine results were concordant; the presence of an electromyographic response to final RLN stimulation was correlated with normal vocal fold mobility on post-operative day one in 54 cases, and the lack of an electromyographic response to final RLN stimulation was correlated with abnormal vocal fold mobility on day one in five cases.

One patient was found to have a vocal fold palsy at day one (regressing in the third post-operative week), despite an electromyographic response from initial (0.25 mA) and final (0.50 mA) peri-operative stimulation.

For another patient, no response was obtained at final peri-operative RLN stimulation (all parameters were checked), but vocal fold mobility was normal on day one.

None of our patients sustained bilateral vocal fold injury.

Six patients suffered regressive RLN injury; normal function was recovered between the fourth day and the third month post-operatively.

One patient suffered RLN injury which, after six months follow up, was considered to be permanent. This patient had undergone subtotal thyroidectomy 10 years earlier, and presented with stony nodules highly suspicious of malignancy on both clinical assessment and echographic imaging. These nodules were found to be due to an inflammatory reaction to non-resorbable sutures, with the RLN impossible to dissect. A lack of response on the initial side prompted a unilateral dissection.

No possibility of 'alert' function was noted (that is, (soft) dissection of the RLN did not induce any electromyographic response).

Statistical tests (chi-squared and Fisher exact tests) showed a high sensitivity (98 per cent) and a specificity of 86 per cent for the NIM-Response® monitor.

Discussion

Many techniques are currently available for intra-operative nerve monitoring, but each presents several disadvantages.

The initial studies in the 1970s involved placement of intramuscular electrodes in the vocal folds themselves. This required the operator to perform a direct laryngoscopy in order to visualize the vocal folds and place the electrodes. This increased the operating time and required interpretation by an electrophysiologist.[3,4] For the same reasons, we believe that postcricoid surface electrodes inserted by direct laryngoscopy[5] are quite difficult to use, even if results seem to be convincing.

Sterile electrodes inserted in the cricothyroid membrane can be used,[6] but this requires blind placement that cannot be checked. Moreover, these cause a small laryngeal breach that might contaminate the sterile field.

Some studies describe a technique using a laryngeal mask airway (LMA), in which a fibre-optic scope is inserted in order to view the larynx.[7–9] As there are several contra-indications to the use of

https://doi.org/10.1017/S0022215106000946 Published online by Cambridge University Press

the LMA (including intra-operative airway problems when used alone), Hillermann *et al.*[10] secured the airway with a 5.0 microlaryngeal tube. This should ensure a good quality of ventilation, and the removal of the endotracheal tube under deep anaesthesia (while the LMA is kept in place) potentially reduces haemorrhage. Nevertheless, we believe that these techniques are difficult to implement and increase pre-operative installation time.

Another technique of intra-operative nerve monitoring is the laryngeal palpation.[11–14] Electrical stimulation of the RLN induces posterior cricoarytenoid muscle contraction that is palpable through the wall of the hypopharynx, deep to the posterior lamina of the cricoid cartilage. This contraction, called the 'laryngeal twitch', is supposedly easy to palpate in expert hands and is well correlated to the presence of electromyographic activity.[13] This technique seems attractive, but the response obtained is neither measurable nor printable and is operator-dependent as it requires experience. However, it could be useful in particular cases, for example, if there is a detection failure when the endotracheal tube is disconnected peri-operatively.

Several studies[14,15] have used endotracheal tubes similar to our technique, using a disposable electrode system attached to the tube. The main advantage of this technique is that the cost is a tenth that of our equipment. Our use of an endotracheal tube is relatively costly; however, no specific knowledge is required to interpret the data, and the equipment is easy to use. Moreover, four detection channels are available, which permits the monitoring of other nerves, such as the facial nerve.

Thomusch *et al.*[16] conducted a multicentre study that concluded that the rate of transient and permanent RLN injury when intra-operative monitoring was used was significantly lower compared with that sustained when using intra-operative visual RLN identification without intra-operative monitoring. Our study does not prove that intra-operative monitoring reduces the rate of RLN injury; however, it does improve the surgeon's confidence.

Recurrent laryngeal nerve injury is a classic and feared complication of thyroid surgery. Our experience of RLN monitoring, even in this preliminary report, was convincing; it was a reliable and reproducible technique, with 98 per cent sensitivity and 86 per cent specificity.

The stimulation intensities we used tended to be relatively low, ranging from 0.15 to 0.50 mA, whereas most other authors used higher intensities (0.5 to 1 mA). Our aim was to define the lowest intensity for inducing an electromyographic response. To avoid RLN hyper-dissection, which might lead to transient injury, we believe that one should use higher stimulation intensities, beginning at 0.50 mA at least.

We did not find any intensity threshold which could predict post-operative RLN damage – this seems to be an 'on–off' phenomenon, i.e. whatever the stimulation intensity, when there is an electromyographic response there is normal vocal fold mobility, and when there is no response there is impaired vocal fold mobility. We did not find any factor predicting time of recovery. It seemed worthwhile to stimulate the vagus nerve, particularly when a laterotracheal lymphadenectomy was required, because this eliminated RLN injury proximal to the stimulation site.

There are many mechanisms that may lead to RLN damage. The first of these is thyroid lobe exteriorization, which might explain why, in a few cases, initial stimulation did not induce any response. Fortunately, those injuries are usually transient. Other injuries may also occur: the RLN might be crushed, burned, stretched or cut. Some of these injuries are transient, but they are always dramatic if bilateral.

As anatomic preservation of the RLN does not ensure its intra-operative function, laryngeal peri-operative monitoring is a reassuring option. For this reason, we recommend laryngeal monitoring in situations in which the RLN is at risk, such as potential carcinoma or repeated surgery – not as a substitute for surgical knowledge and rigorous technique, but to prevent bilateral RLN injuries. Indeed, we recommend delaying contralateral exploration in cases of lack of response.

Conclusions

To date, RLN monitoring in thyroid and parathyroid surgery has not found its definitive place. It is a valuable adjunct, especially in difficult cases such as patients who have had previous surgery. If there is a non-recurring nerve, or if it is thin and divided, monitoring may be helpful. However, such cases are not predictable pre-operatively, and one could argue for wider utilization.

The technique of RLN monitoring that we have used showed a 98 per cent sensitivity and an 86 per cent specificity. Operating time duration was not increased. Data did not require any specific knowledge to interpret and was printable, which may be legally useful. We conclude that use of the NIM-Response® monitor is a feasible and reliable technique of RLN monitoring, even though it is more costly than the alternatives.

At present, such monitoring should not be seen as a way to decrease RLN injury but as a way to avoid bilateral injury. It is advisable to delay contralateral dissection, or at least to take extreme care, if the ipsilateral RLN is unresponsive. Recurrent laryngeal nerve monitoring can never replace meticulous surgical technique together with systematic identification and careful dissection of the RLN.

- **This study investigated the feasibility of recurrent laryngeal nerve monitoring using electrodes placed on the vocal folds during thyroid surgery**
- **The technique appeared reliable and reproducible when used in 36 patients undergoing thyroid surgery**
- **The authors emphasize that nerve monitoring does not replace meticulous surgical technique with identification and careful dissection of the recurrent laryngeal nerve**

https://doi.org/10.1017/S0022215106000946 Published online by Cambridge University Press

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Dr S Bailleux takes responsibility for the integrity of the content of the paper.
Competing interests: None declared