Electrophysiological neuromonitoring of the laryngeal nerves in thyroid and parathyroid surgery: A review

Ahmed Deniwar, Parisha Bhatia, Emad Kandil

Ahmed Deniwar, Parisha Bhatia, Emad Kandil, Division of Endocrine and Oncologic Surgery, Department of Surgery, Tulane University School of Medicine, New Orleans, LA 70112, United States.

Author contributions: Deniwar A performed research, analyzed data and wrote the paper; Bhatia P revised data analysis and revised the paper; Kandil E revised research, analyzed data and revised the paper.

Conflict-of-interest: The authors declare that they have no competing interests.

Open-Access: This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/

Correspondence to: Emad Kandil, MD, FACS, FACE, Chair, Division of Endocrine and Oncologic Surgery, Department of Surgery, Tulane University School of Medicine, 1430 Tulane Avenue, Room 8510 (Box SL-22), New Orleans, LA 70112, United States. ekandil@tulane.edu

Telephone: +1-504-9887520
Fax: +1-504-9884762
Received: August 26, 2014
Peer-review started: August 26, 2014
First decision: November 14, 2014
Revised: December 20, 2014
Accepted: February 4, 2015
Article in press: February 9, 2015
Published online: May 20, 2015

Abstract

Recurrent laryngeal nerve (RLN) injury is one of the most common complications of thyroid surgery. Injury to the external branch of the superior laryngeal nerve is less obvious and affects the voice variably; however, it can be of great significance to professional voice users. Recent literature has led to an increase in the use of neuromonitoring as an adjunct to visual nerve identification during thyroid surgery. In our review of the literature, we discuss the application, efficacy and safety of neuromonitoring in thyroid surgery. Although intraoperative neuromonitoring (IONM) contributes to the prevention of laryngeal nerves injury, there was no significant difference in the incidence of RLN injury in thyroid surgery when IONM was used compared with visual identification alone. IONM use is recommended in high risk patients; however, there are no clear identification criteria for what constitutes "high risk". There is no clear evidence that IONM decreases the risk of laryngeal nerve injury in thyroid surgery. However, continuous IONM provides a promising tool that can prevent imminent nerve traction injury by detecting decreased amplitude combined with increased latency.

Key words: Neuromonitoring; Superior laryngeal nerve; Recurrent laryngeal nerve; Thyroid surgery

© The Author(s) 2015. Published by Baishideng Publishing Group Inc. All rights reserved.

Core tip: As recurrent laryngeal nerve injury is one of the most common causes of medicolegal litigation after thyroid and parathyroid surgery, securing the nerve is an increasing demand in these surgeries. Although visual identification has been used as the gold standard and had been proved to reduce the rate of laryngeal nerves injury, intertwining with inferior thyroid vessels and unusual course of the nerve may be challenging. Neromonitoring has been introduced as a novel technique to help identifying the nerve and prevent misidentification of any cord-like structure as a nerve, the thing that can reduce rate of laryngeal nerves injury.
INTRODUCTION

Visual identification of the recurrent laryngeal nerve (RLN) is considered the gold standard in the prevention of nerve injury during thyroid surgery[1-3]. Although visual identification of RLN during thyroid surgeries decreases the rate of permanent RLN injury, it remains the most common cause of medicolegal litigations after these surgeries[4].

In addition to the morbidity caused by bilateral vocal cord paresis, monetary settlements to plaintiffs can reach up to millions of dollars[5]. The RLN is at higher risk of injury during thyroidectomy in high risk patients, including patients with substernal goiter, advanced thyroid cancer, or patients undergoing reoperation[6-8].

Intra-operative nerve monitoring (IONM) technologies were first reported to decrease the risk of RLN injury by Shedd and Durham in 1965[9]. Intramuscular vocal cord electrodes were described by Basmajan in 1970[10]. It was proposed that IONM could be useful in nerve identification and prevention of RLN injury in thyroid surgery[11,12]. However, IONM was not proven to decrease the rate of permanent RLN palsy[13,14]. Since IONM has been introduced, it has gained popularity, especially in the last decade[2]. It was reported that over recent years, about 65% of otolaryngologists and 53% of general surgeons use IONM in some or all of their cases[13,14].

Additionally, IONM has been reported to be a safe and feasible adjunct to the routine visual identification of the laryngeal nerves[7,15]. Some studies showed that IONM decreases the prevalence of transient RLN injury[6,16,17]. This may be due to its ability to aid in the dissection of the RLN near the Berry’s ligament, as it enhances the detection of branched nerves and reduces traction injury of the anterior branches of these nerves[18]. Another study reported that IONM is effective in video-assisted thyroidectomy as it makes surgeons more comfortable[18].

In contrast, studies comparing IONM to the routine visual identification of RLN showed no statistically significant differences in the rate of overall, transient or permanent RLN palsy[16,19-21], but this may simply be due to the low incidence of RLN palsy. It has been reported that at least 39907 nerves at risk for RLN injury or loss of contact between vocal cords and recording electrodes. In addition, EMG signal can also be affected by anesthesia and manipulation of trachea.

Continuous IONM assessment of nerve integrity is limited to the short interval of direct stimulation. Hence, RLN palsy is usually detected after it has occurred. It is also limited to testing the part of the nerve distal to the point of nerve stimulation, thus it can easily miss proximal nerve injury, or injury in the gap between 2 stimulations.

Continuous IONM was introduced as a superior modality that can avoid periodic short timed stimulation and more accurately detect proximal injuries. A clip is placed over the vagus nerve and stimulates it periodically at short intervals. This allows it to recognize any lesion along the RLN or external branch of the superior laryngeal nerve (EBSLN), even the most proximal[22]. By providing vital intraoperative information about impending RLN injury caused by suture compressing the nerve or traction, continuous IONM allows surgeons to take measures to reverse the adverse condition and save the nerve. Traditional stimulator probes should still be used in conjunction with the continuous IONM system as it helps in mapping the nerves.

Supporters of IONM claim that its use helps to protect the RLN and EBSLN by detecting them before visualization, providing information about nerve function during surgery, and by detecting anatomical variants that are at higher risk of injury[3]. However, some disadvantages include possible technical failures such as electrode displacement, and a high rate of false positive results leading to unnecessary staging in bilateral surgeries[3].

CONCLUSION

IONM has some advantages over visual identification
alone. Most injured nerves appear intact by visual inspection, but IONM provides a more accurate prediction of postoperative neural function. In addition, IONM helps avoid bilateral RLN injury by staging the operation if a nerve injury is encountered in the initial side of a bilateral operation. Continuous IONM is a promising improvement over traditional monitoring as it can give timely information about nerve status which may reverse impending nerve injury. Additionally, it can detect proximal nerve injury which might be missed by intermittent IONM of the RLN. Although some studies showed that IONM decreases the rate of RLN palsy, most of the studies reported no statistically significant difference between it and visual identification regarding laryngeal nerves injury. Due to the low incidence of permanent RLN palsy, more controlled studies with larger populations are warranted to provide a better assessment of this technique in preventing laryngeal nerve injury.

REFERENCES

1. Stevens K, Stojadinovic A, Helou LB, Solomon NP, Howard RS, Shrider CD, Backenmaier CC, Henry LR. The impact of recurrent laryngeal neuromonitoring on multi-dimensional voice outcomes following thyroid surgery. J Surg Oncol 2012; 105: 4-9 [PMID: 21882195 DOI: 10.1002/jso.22063]

2. Dralle H, Sekulla C, Haerting J, Timmermann W, Neumann HJ, Kruse E, Grond S, Mühlhop HP, Richter C, Voss J, Thomusch O, Lippert H, Gastinger I, Brauckhoff M, Gimm O. Risk factors of paralysis and functional outcome after recurrent laryngeal nerve monitoring in thyroid surgery. Surgery 2004; 136: 1310-1322 [PMID: 15657592 DOI: 10.1016/j.surg.2004.07.018]

3. Snyder SK. Hendricks JC. Intraoperative neurophysiology testing of the recurrent laryngeal nerve: plaudits and pitfalls. Surgery 2005; 138: 1183-1191; discussion 1191-1192 [PMID: 16360407]

4. Poveda MCD, Dionigi G, Sitges-Serra A, Barczynski M, Angelos P, Dralle H, Phelan E, Randolph G. Intraoperative monitoring of the recurrent laryngeal nerve during thyroidectomy: A standardized approach (Part 1). World J Endo Surg 2011; 3: 144-150 [DOI: 10.5005/jp-journals-1002-1079]

5. Caragacianu D, Kamani D, Randolph GW. Intraoperative monitoring: normative range associated with normal postoperative glottic function. Laryngoscope 2013; 123: 3026-3031 [PMID: 23686787 DOI: 10.1002/lary.24195]

6. Barczynski M, Konturek A, Cichoni S. Randomized clinical trial of visualization versus neuromonitoring of recurrent laryngeal nerves during thyroidectomy. Br J Surg 2009; 96: 240-246 [PMID: 19177420 DOI: 10.1002/bjs.6417]

7. Calò PG, Pisanò G, Medas F, Tatti A, Pittau MR, Demontis R, Favoriti P, Nicolosi A. Intraoperative recurrent laryngeal nerve monitoring in thyroid surgery: is it really useful? Clin Ter 2013; 164: e193-e198 [PMID: 23886637]

8. Schedd DP, Durham C. Electrical identification of the recurrent laryngeal nerve. I. Response of the canine larynx to electrical stimulation of the recurrent laryngeal nerve. Ann Surg 1966; 163: 47-50 [PMID: 5904908 DOI: 10.1097/00000638-196601000-00006]

9. Caviezel D, Calciuti U, Fernandez IJ, Macri G, Di Lieto C, Mancalloni A, Ceroni AR, Piccin O. The value of neurostimulation and intraoperative nerve monitoring of inferior laryngeal nerve in thyroid surgery. Otolaryngol Head Neck Surg 2009; 140: 866-870 [PMID: 19467405 DOI: 10.1016/j.otohns.2008.12.047]

10. Shindo M, Chheda NN. Incidence of vocal cord paralysis with and without recurrent laryngeal nerve monitoring during thyroidectomy. Arch Otolaryngol Head Neck Surg 2007; 133: 481-485 [PMID: 17520762 DOI: 10.1001/archotol.133.5.481]

11. Atallah I, Dupret A, Carpentier AS, Weigertner AS, Volkmar PP, Rodier JP. Role of intraoperative neuromonitoring of the recurrent laryngeal nerve in high-risk thyroid surgery. J Otolaryngol Head Neck Surg 2009; 38: 613-618 [PMID: 19558722]

12. Camani D, Darr EA, Randolph GW. Electrophysiologic monitoring characteristics of the recurrent laryngeal nerve preoperatively paralyzed or invaded with malignancy. Otolaryngol Head Neck Surg 2013; 149: 682-688 [PMID: 24046274 DOI: 10.1177/0194599812439278]

13. Sturgeon C, Sturgeon T, Angelos P. Neuromonitoring in thyroid surgery: attitudes, usage patterns, and predictors of use among endocrine surgeons. World J Surg 2009; 33: 417-425 [PMID: 18758849 DOI: 10.1007/s00268-008-9724-4]

14. Singer MC, Rosenfeld RM, Sundaram K. Laryngeal nerve monitoring: current utilization among head and neck surgeons. Otolaryngol Head Neck Surg 2012; 146: 895-899 [PMID: 22393282 DOI: 10.1177/0194599812439278]

15. Terris DJ, Anderson SK, Watts TL, Chin E. Laryngeal nerve monitoring and minimally invasive thyroid surgery: complementary technologies. Arch Otolaryngol Head Neck Surg 2007; 133: 1254-1257 [PMID: 18086968 DOI: 10.1001/archotol.133.12.1254]

16. Barczynski M, Konturek A, Stropa M, Hubalewska-Dydejczyk A, Richter P, Nowak W. Clinical value of intraoperative neuromonitoring of the recurrent laryngeal nerves in improving outcomes of surgery for well-differentiated thyroid cancer. Pol Przegl Chir 2011; 83: 196-203 [PMID: 22166358 DOI: 10.2478/v10035-011-0003-8]

17. Frattini F, Mangoano A, Boni L, Rausse S, Biondi A, Dionigi G. Intraoperative neuromonitoring for thyroid malignancy surgery: technical notes and results from a retrospective series. Updates Surg 2010; 62: 183-187 [PMID: 21153003 DOI: 10.1007/s13304-010-0036-5]

18. Dionigi G, Boni L, Rovera F, Bacuzzi A, Dionigi R. Neuro-monitoring and video-assisted thyroidectomy: a prospective, randomized case-control evaluation. Surg Endosc 2009; 23: 996-1003 [PMID: 18806939 DOI: 10.1007/s00464-008-0009-3]

19. Yarbrough DE, Thompson GB, Kasperbauer JL, Harper CM, Grant CS. Intraoperative electromyographic monitoring of the recurrent laryngeal nerve in reoperative thyroid and parathyroid surgery. Surgery 2004; 136: 1107-1115 [PMID: 15657563 DOI: 10.1016/j.surg.2004.06.040]

20. Witt RL. Recurrent laryngeal nerve electrophysiologic monitoring in thyroid surgery: the standard of care? J Voice 2005; 19: 497-500 [PMID: 16102675 DOI: 10.1016/j.jvoice.2004.05.001]

21. Chan WF, Lang BH, Lo CY. The role of intraoperative neuromonitoring of recurrent laryngeal nerve during thyroidectomy: a comparative study on 1000 nerves at risk. Surgery 2006; 140: 866-872; discussion 872-873 [PMID: 17188132]

22. Pisanà U, Porceddu G, Podda M, Cois A, Uccheddu A. Systematic review with meta-analysis of studies comparing intraoperative neuromonitoring of recurrent laryngeal nerves versus visualization alone during thyroidectomy. J Surg Res 2014; 188: 152-161 [PMID: 24433860 DOI: 10.1016/j.jss.2013.12.022]

23. Alesina PF, Rolfs T, Hommeltenberg S, Hinrichs J, Meier B, Mohmand W, Hofmeister S, Walz MK. Intraoperative neuromonitoring does not reduce the incidence of recurrent laryngeal nerve palsy in thyroid reoperations: results of a retrospective comparative analysis. World J Surg 2012; 36: 1348-1353 [PMID: 22411090 DOI: 10.1007/s00268-012-1548-6]

24. Sari S, Erbil Y, Slümer A, Agcaoglu O, Bayraktar A, Issyver H, Ozarmagan S. Evaluation of recurrent laryngeal nerve monitoring in thyroid surgery. Int J Surg 2010; 8: 474-478 [PMID: 20601257 DOI: 10.1016/j.ijsu.2010.06.009]

25. Randolph GW, Dralle H, Abdullah H, Barczynski M, Bellantone R, Brauckhoff M, Carnaille B, Cherenko S, Chiang FY, Dionigi G, Finck C, Hartl D, Kamani D, Lorenz K, Miccoli P, Mihai R, Miyachi A, Orloff L, Perrier N, Poveda MD, Romanchischen A, Serpell J, Sitges-Serra A, Sloan T, Van Slycke S, Snyder S, WJEM | www.wjgnet.com 122 May 20, 2015 | Volume 5 | Issue 2 |
Takami H, Volpi E, Woodson G. Electrophysiologic recurrent laryngeal nerve monitoring during thyroid and parathyroid surgery: international standards guideline statement. *Laryngoscope* 2011; 121 Suppl 1: S1-S16 [PMID: 21181860 DOI: 10.1002/lary.21119]

**P- Reviewer:** Gudlavalleti SK, Mashreky SR, Sugawara I

**S- Editor:** Tian YL

**L- Editor:** A

**E- Editor:** Lu YJ
