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Original article

Intraoperative neuromonitoring in traditional and miniinvasive thyroidectomy. A single center experience in 1652 nerve at risk

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Summary. *Background:* The world is rapidly urbanizing, causing alarming health problems to their citizens. The Cities Changing Diabetes program aims to address the social factors and cultural determinants that can increase type 2 diabetes (T2D) vulnerability among people living in cities. *Methods:* Public data of Italian Institute for Statistics (ISTAT) and available scientific reports were reviewed and findings integrated. The prevalence of T2D in the 8 health districts of Rome was mapped and the correlation between prevalence and social and cultural determinants was assessed. *Results:* The metropolitan area of Rome has 4.3 million inhabitants. People over 65 has increased by 136,000 units in the last decade, reaching 631,000 citizens in 2015. Elderly people living alone are 28.4%. The obesity prevalence is 9.3%, as compared to 8.2% in the year 2000. The prevalence of T2D is 6.6%, varying in the different 8 health districts between 5.9% and 7.3%. A linear correlation exists between the prevalence of diabetes in the districts, unemployment rate and use of private transportation rate (Pearson R 0.52 and 0.60, respectively), while an inverse correlation is present with aging index, school education level, and slow mobility rate (Person R -0.57, -0.52, and -0.52, respectively). *Conclusions:* Important socio-demographic changes have occurred in Rome during the last decades with a raise in the prevalence of obesity and diabetes. A wide variation exists in the prevalence of T2D among the districts of Rome, associated with social and cultural determinants. This study model can help rethinking diabetes in an urban setting. (www.actabiomedica.it)

Key words: thyroidectomy, videoassisted thyroid surgery, MIVAT, I-IONM, C-IONM, vocal cord palsy, dysphonia

Introduction

The injury of laryngeal recurrent nerve (RLN) is one of the most severe adverse event in thyroid surgery. The rate in literature is reported as 2-11% for transient palsy and 0,6-1,6% for permanent palsy (after 6 months from surgical procedure) (1).

In the last years the use of Intraoperative Nerve Monitoring (IONM) is improved using different devices in order to identify the correct elettromiographic (EMG) signal; in our practice we used the NIM-Response 3.0 System (1-2).

The IONM technique combines the anatomical evaluation of RLN, gold standard in thyroid surgery with the EMG signal. There are several advantages in using the combined technique, such as facilitation in identification, localization and distribution of the RLN and reduction of the incidence of RLN damages (Table 1). These specific procedures require a collaboration between surgical and anesthsiological team.

Table 1. The advantages of the combined technique (anatomical evaluation and elettromiographic signal)

Specific advantages
1. Facilitates the identification, localization and distribution of the RLN
2. It allows the identification of possible anatomical variants of the RLN
3. Facilitates the exposure and dissection of the RLN
4. It is useful for the completion of the thyroid resection
5. Facilitates the evaluation of functional integrity and eventually the recognition of nerve damage mechanisms
6. Reduces the incidence of damages of the RLN
7. Facilitates learning for unskilled. surgeons in training, as it guides them to nerve identification
8. It is also useful for experienced surgeons in bilateral thyroid surgery

The anesthesiologist plays a role during the NIM use, especially in the selection of drug for the induction and maintenance of anesthesia and in the correct placement of endotracheal tube (ET) (3).

Currently, RLN lesions can be classified into segmental lesion (Type 1) and global lesion (Type 2) (2).

Recent studies report that more than 70% of lesions appear to be of type 1, defined as the interruption of RLN conduction at a specific point or segment. Usually this type of injury is related to traction, clamping, compression and/or thermal spread damage (4-5).

A normal function of the RLN evidenced by the presence of laryngeal contraction, in the absence of the EMG signal is defined as false LOSS. This is the situation in which there is no damage at the level of the exposed region of the RLN and no response from the contralateral nerve stimulation is elicited. False signal losses may result from incorrect functioning of the equipment, or erroneous placement of the ET tube equipped with the electrodes. Uncorrect placing or misplacement of ET tube can also be caused by excessive traction on the trachea, especially during thyroidectomy for great goiter (6).

The aim of this study was to describe the frequency of the injury of RLN in our hospital during thyroid surgery, in which the IONM was applied.

Materials and methods

In this retrospective study, approved by Ethics Committee of Parma, the patients undergoing thyroid surgery associated to IONM have been enrolled consecutively from 21/08/2014 to 30/08/2018. Patient data was collected in a database.

Patient data is related to :

• Age

• Sex

• Type of surgery (thyroidectomy, lobectomy)

• Type of thyroid pathology (Thyr3, Thyr 4, Thry 5 or Thyr 6 nodules considering the Bethesda System for Reporting Thyroid Cytology, Basedow-Graves disease, Medullary Carcinoma and uninodular or multinodular goiter)

• Pre-operative clinical symptomatology, ENT evaluation highlighting dysphonia, dysphagia, dyspnoea.

• Post-operative symptomatology.

Data collected also concern the type of device used, i.e. NIM Response 3.0 (Medtronic Xomed, Jacksonville, Florida, USA) with intermittent monitoring system (I-IONM) and stimulation specifications; in particular:

1. Amplitude of the Vagus nerve (VN) and RLN as standardized protocol

2. Signal anomalies.

We collected data from I-IONM and not by Continuos IONM because we have interrupted C-IONM after a case of cardiac arrest (15^{TH} patient) during the APS placement.

The statistical software used for data analysis was SPSS.

The utility of the intraoperative neuro-monitoring system was evaluated with the following statistical methods:

• Mann Withney U-test with independent samples is used to evaluate any existing relationships between pre-operative symptomatology and VN and RLN pre dissection voltages (ie V1, RLN 1 according to the guidelines of the IONM Group) and for evaluate the relationships between post-operative symptomatology and VN and RLN post dissection voltages, comparing with asymptomatic cases.

• T-samples with coupled samples has been applied to assess if there was a specific trend of VN pre-dissection and VN post-dissection voltage in symptomatic patients, making a comparison with asymptomatic cases.

• Wilcoxon signed sign test has been used to related correlated samples to assess if goiter pathology could result in a statistically significant NV and RLN values variation pre and post dissection.

Chi square test to asses the rate of vocal cord palsy in traditional and videoassisted procedure.

• Positive predictive value (PPV) expresses the probability that a patient with intraoperative evidence of disappearance of the electromyographic signal at neuromonitoring is really affected by a nerve injury;

• Negative predictive value (NPV) expresses the probability that a subject with intraoperative evidence of electromyographic signal is really not affected by a nerve injury.

We considered the values for $p < 0.05$ statistically positive.

Results

We collected data on 928 consecutive patients, 689 were female and 239 male, ratio of 3: 1.

The mean age was 55.14±13.5 years (range 15-89).

The mean age in relation to gender was 53.51±13.6 years in the female and 56.03±13.5 years in the male.

On 928 cases, 54 patients were treated for Basedow-Graves disease, 388 for goiter, 59 cases for thyr 3, 167 cases for thyr 4, 43 cases thyr 5, and finally 215 treated for Thyr 6 nodule. We identified also 2 cases treated for medullary cancer and lymphoadenectomy (Table 2).

The surgical procedure were 204 lobectomy , 724 total thyroidectomy. 129 cases were treated with minimally invasive video assisted technique (61 lobectomy; 68 total Thyroidectomy) (7, 8). We identified 1652 nerves at risk (Figure 1).

We have analyzed separately the cases with preoperatively symptomatology compatible with hoarseness in the absence of positive ENT evaluation (no cordal hypomotility).

Table 2. Surgically treated cases

Thyroid disease	Treated cases
Thyr 3	59
Thyr 4	167
Thyr 5	43
Thyr 6	215
Goiter	388
Basedow	54
Medullary	2

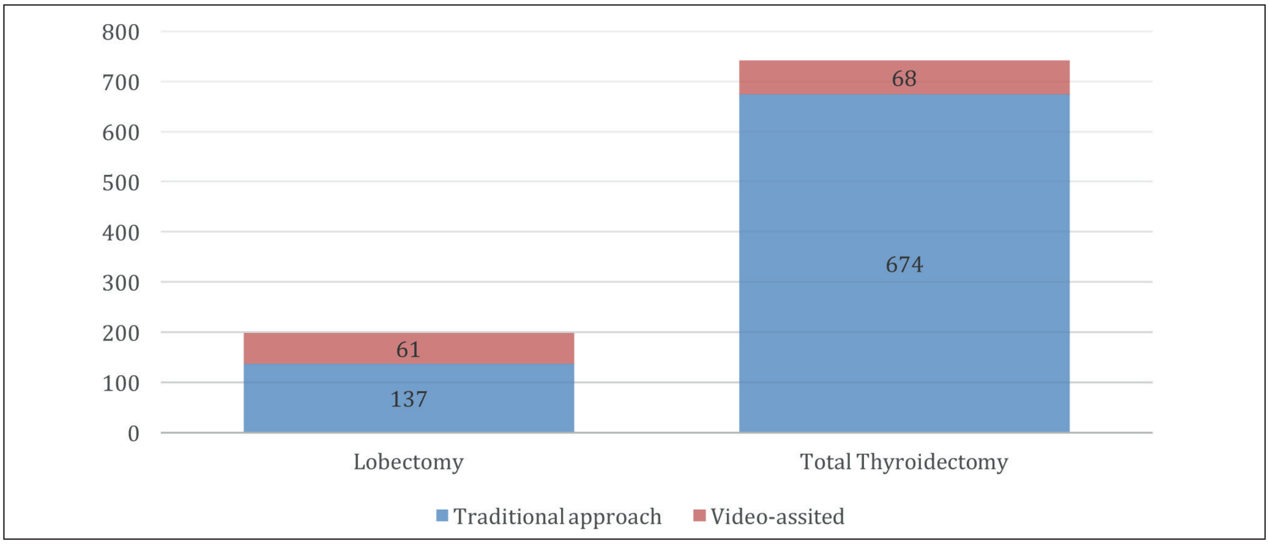

Figure 1. Surgical procedures performed

No relationship between preoperative symptom and voltage at initial stimulation (pre-dissection RLN and VN voltage) has been identified; even the distribution of voltages (right VN pre-dissection, left VN pre-dissection, right RLN pre-dissection and left RLN pre-dissection) was found not to be different between these patients and the group without preoperative symptomatology.

The same procedure was applied to cases with a pre-operative symptomatology compatible with dysphagia, dyspnea and compression, obtaining the same results.All patients were treated with traditional thyroidectomy.

The symptoms reported after surgical procedure were then assessed (focusing mainly on dysphonia, dysphagia, dyspnoea). We analyzed cases that showed a symptomatology compatible with dysphonia without intraoperative signal loss; it was observed that no relation related to postoperative symptom and voltage can be proved in these cases. From this analysis, obtained with Mann-Whitney U test application, the same distribution was obtained in symptomatic and asymptomatic patients.

The same results were obtained in case of occurrence of postoperative dyspnoea and dysphagia.

Using the neuromonitoring procedure 8 cases of signal loss occurred during the dissection of the first lobe in course of total thyroidectomy; in 2 cases it was found to be related transitory dysphonia, in 5 cases to technical problems, in 1 case in patient with pre-existing cordal paresis.

It was necessary perform a two-stage thyroidectomy in 7 cases.

In patients who were candidates for total thyroidectomy, we recorded the loss of the signal after the second lobe in 20 cases, of which 9 cases showed dysphonia in the post-operative period(Ent evaluation after 48 hours).

The sensitivity and the specificity of the instrument are respectively equal to 100% and 98%.

The PPV (positive predictive value) was found to be about 52%. Instead the NPV (negative predictive value) turned out to be 100%. We recorded a transitory dysfunction in 16 cases equal to 0,9% and definitive in 7 cases equal to 0.4% after 6 months with an ENT revaluation.

No case bilateral dysphonia is recorded.

Analyzing the traditional and videoassited thyroidectyomy we report 2 cases of transitory dysfunction in 129 MIVAT and 14 cases in Traditional Thyroidectomy (p=ns); 1 persistent palsy in MIVAT and 6 cases in traditional thyroidectomy (p=ns).

Discussion

In recent years there has been a progressive increase in the use of IONM both during procedures with open standard technique and during MIVAT (5).

The increase of application of IONM is related to a *feel safety* from surgeon during surgical procedure. IONM helps the surgeon in localization and identification of the RLN. IONM permits to evaluate its functional integrity (in addition to the classical anatomical integrity).

Neuromonitoring would constitute an improvement to thyroidectomy. Moreover, this device seems to have an application to reduce the rate of transitory and permanent paralysis of the RLN.

Through our study it is not possible to identify a relationship between pre-dissection voltages and non-certified ENT pre-operative symptomatology, it is not possible to find a relationship between post-dissection voltages and post-operative symptomatology (compression, disphagya) unrelated to cordal hypomotility. It is not possible to find a specific variation of the voltages from the pre-dissection to the post-dissection that allows to predict the postoperative symptomatology, except a PPV of 52% in case of nerve injury stupor.

IONM is extremely valuable tool to reduce the percentage of hoarseness. In this research, it was found to be <1%. It also helps the surgeon to choose the intraoperative strategy, reducing the incidence of bilateral paralysis to zero. In case of loss of the signal during the dissection of the first lobe, it is necessary to proceed firstly with the assessment of lesion site, following the different steps provided by the resolution algorithms. A two-stage thyroidectomy should be performed to eliminate this risk of bilateral paralysis that could result from the continuation of the procedure on the second lobe. In our study there were 8 loss of signal during the dissection of the first lobe (5 of which were attributable to technical problems), which led to the need to adopt this scheme in 7 patients, performing a two-stage thyroidectomy.

In high-volume centers the rate of transitory/permanent vocal cord palsy is low but also in these Units the need of *feel safety* is related to IONM. The use of the IONM is an helpful tool for dissection and anatomical identification of the nerves. IONM has a high specificity and sensitivity and a high negative predictive value. PPV as 52% definable low, may be related to the transient stupor of nerve function. In all patients a bolus of cortisone e.v. is administered intraoperatively and a rate of these patients can already recover in the early hours after lobectomy with negative feedback to the ENT visit after 48 hours.

From a medico-legal point of view, the neuromonitoring data can not yet be considered as objective evidence. To avoid legal disputes it is suggested to establish a good doctor-patient relationship; correct information about the pathology, the better treatment and potential consequences are crucial (9). We have to compile a detailed report of any procedure performed. If neuromonitoring is used, it is suggested to apply it following the standardized steps and to report the complete documentation of EMG signals derived from the stimulation of the VN and the RLN.

The CIONM technique is reported as an excellent aid for the surgeon during routine thyroid surgery, providing an excellent tool to prevent harmful maneuvers especially in complex cases (such as recurring pathologies with numerous adhesions, infiltrating tumors adjacent to the structures, stalking goons with mediastinal sinking or with tracheal deviation). CIONM is able to provide real-time information in an uninterrupted manner,-allowing a continuous evaluation. It is to be interpreted as a repeated stimulation that is induced by the probe positioned on VN. Every time you exercise any type of movement during the surgical procedure the EMG signal is registered. The possible advantage of C-IONM derives from its potential to monitor, simultaneously with the surgical maneuvers, step by step, the functional integrity of the vagus, of the RLN and trasmit abnormal EMG signal. We have interrupted our experience with C-IONM after the reported case of cardiac arrest after 28 cases tretaed; few cases are reported (10).

We think that the concept of C-IONM is the better form of stimulation but that we must improve the device, the intraoperative handling of VN to reduce the dissection and torsion. In a recent metanalysis authors underline that the IONM could reduce the incidence of RLN injury (11).

Conclusion

Our study confirmed a high specificity, sensitivity and NPP of the IONM application in thyroid surgery; however, a low PPV in our sample has been identified, probably caused by transient stupor of nerve function.

In particular, no correlation between pre-dissection voltages of VN and RLN and preoperative symptomatology, characterized by a negative ENT evaluation, has been found.

We think that the use is indicated in all endocrine cervical surgical procedure, also in high volume centers, in research and teaching hospital.

Note: Compliance with ethical standards

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

References

1. Wojtczak B, Kaliszewski K, Sutkowski K, Bolanowski M, Barczynski M. A functional assessment of anatomical variants of the recurrent laryngeal nerve during thyroidectomies using neuromonitoring. Endocrine Surgery 2017.
2. Durán Poveda MC, Dionigi G, Antonio Sitges-Serra A, et al. Intraoperative Monitoring of the Recurrent Laryngeal Nerve during Thyroidectomy: A Standardize approach part 2. World journal of Endocrine Surgery 2011.
3. Pi-Ying Chang, Che-Wei Wu, Hsiu-Ya Chen, Hui-Chun Chen, Kuang-I Cheng. Influence of intravenous anesthetics on neuromonitoring of the recurrent laryngeal nerveduring thyroid surgery. Kaohsiung Journal of Medical Science 2014.
4. Del Rio P, Nisi P, Benedicenti S, Bertocchi E, Luzietti E, Sianesi M. Intraoperative neuromonitoring in thyroidectomy:t he learning curve. Ann Ital Chir 2016; 87: 298-305.
5. Del Rio P, Cozzani F, Nisi P, Loderer T, Piva G, Bonati E. IONM and minimally invasive videoassisted thyroidectomy. G Chir 2018 Sep-Oct; 34(5): 291-296.

6. Schneider R, Randolph GW, Barczynski M, et al. Continuous intraoperative neural monitoring of the recurrent nerves in thyroid surgery: a quantum leap in technology. Gland Surg 2016 Dec; 5(6): 607-616.
7. Del Rio P, Arcuri MF, Pisani P, et al. Minimmally invasive video assisted thyroidectomy (MIVAT): what is the real advantage? Langenbecks Arch Surg 2010; 395(4): 323-6.
8. Dionigi G, Kim HY, Wu CW, et al. Neuromonitoring in endoscopic and robotic thyroidectomy. Updates Surg 2017 Jun; 69(2): 171-179.
9. Hoob Yub Kim, Xiaoli Liu, Hui Sun, et al. Medico-legal issues of intraoperative neuromonitoring in thyroid surgery. Journal of Endocrine Surgery 2017.
10. Terris DJ. Continuos vagal nerve monitoring: too much of a good thing? World J Surg 2016; 40: 681-682
11. Binglong B, Wuzhen C. Protective effects of intraoperative nerve monitoring (IONM) for recurrent laryngeal nerve injury in thyroidectomy: Meta analysis. Scientific reports 2018; 8: 7761.

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