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Evaluation of Vocal Cord Function with and without Intraoperative Neuromonitoring in Total Thyroidectomy Patients: A Randomized Controlled Study

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Abstract: ***Intraoperative neuromonitoring (IONM) is increasingly utilized in thyroid surgeries to minimize the risk of recurrent laryngeal nerve (RLN) injuries, which can result in vocal cord dysfunction. This study evaluates the effectiveness of IONM in preventing RLN injuries during total thyroidectomy by comparing postoperative vocal cord outcomes between patients operated on with and without IONM. A total of 60 patients undergoing total thyroidectomy were randomized into two groups: those monitored with IONM (Group 1) and those without IONM (Group 2). Vocal cord function was assessed pre- and postoperatively using indirect laryngoscopy. The results indicate that RLN injury rates were significantly lower in the IONM group (3.33%) compared to the non-IONM group (16.66%). The findings support the routine use of IONM in thyroid surgery to reduce the risk of vocal cord dysfunction.***

Keywords: Intraoperative neuromonitoring, recurrent laryngeal nerve, thyroidectomy, vocal cord palsy, vocal cord function

1. Introduction

Thyroidectomy is one of the most common surgical procedures performed worldwide, particularly for treating conditions such as thyroid cancer, goiter, and hyperthyroidism. Despite the relatively low morbidity associated with thyroidectomy, the procedure carries the risk of injury to the recurrent laryngeal nerve (RLN), which innervates the vocal cords. Damage to the RLN can result in vocal cord palsy, manifesting as hoarseness, voice weakness, or in severe cases, airway obstruction.

The advent of **Intraoperative Neuromonitoring (IONM)** has introduced a significant advance in the preservation of RLN function during thyroid surgery. IONM allows for real-time monitoring of the functional integrity of the RLN by providing visual and auditory feedback to the surgeon during dissection. Despite its widespread adoption, the effectiveness of IONM in reducing the risk of RLN injury is still debated, with varying results in the literature. This study aims to evaluate the efficacy of IONM in preserving RLN function during total thyroidectomy by comparing postoperative vocal cord outcomes in patients operated on with and without the use of IONM.

1.1 Background and Importance

RLN injury is one of the most serious complications of thyroidectomy, affecting both the quality of life and safety of the patient postoperatively. Injury rates have been reported between 1% and 2% for permanent damage, and up to 10% for temporary damage in centers using visual identification alone. The use of IONM has been proposed as a strategy to reduce these rates by providing real-time functional feedback. However, whether the additional cost and complexity associated with IONM are justified by improved clinical outcomes remains controversial. The present study adds to the growing body of evidence by providing a comparative analysis of RLN injury rates in patients with and without IONM.

2. Aims and Objectives

Aim:
To assess the impact of intraoperative neuromonitoring (IONM) on reducing the incidence of recurrent laryngeal nerve (RLN) injuries in total thyroidectomy patients.

Objectives:
1) To evaluate preoperative and postoperative vocal cord function in two groups of patients undergoing total thyroidectomy, one with IONM and one without.
2) To compare RLN injury rates between the two groups and establish the role of IONM in preventing postoperative vocal cord dysfunction.

3. Materials and Methods

3.1 Study Design

A **randomized controlled study** was conducted at the Department of General Surgery, Alluri Sitarama Raju Academy of Medical Sciences, Eluru, between September 2022 and June 2024.

3.2 Study Population

The study included **60 consecutive patients** scheduled for total thyroidectomy. These patients were divided into two groups:

- **Group 1 (n=30)**: Patients undergoing thyroidectomy with intraoperative neuromonitoring (IONM).
- **Group 2 (n=30)**: Patients undergoing thyroidectomy without IONM (visual identification of RLN only).

3.3 Inclusion Criteria

- Age above 18 years.
- Patients undergoing total thyroidectomy.
- Patients providing informed consent for participation in the study.

3.4 Exclusion Criteria

- Preoperative vocal cord palsy.
- Revision thyroid surgeries.
- Patients undergoing additional neck dissection.
- Patients under 18 years of age.

3.5 Methodology

- **Preoperative Evaluation**: All patients underwent preoperative evaluation, including thyroid function tests (T3, T4, TSH), ultrasound imaging, fine-needle aspiration cytology (FNAC), and indirect laryngoscopy to assess baseline vocal cord function.
- **Surgical Procedure**: Patients were randomized into two groups. Group 1 received IONM, which involved the use of an endotracheal tube with built-in electrodes placed between the vocal folds. Group 2 underwent surgery without IONM, relying solely on visual identification of the RLN.
- **Intraoperative Neuromonitoring Technique**: In Group 1, RLN monitoring was performed using a standardized IONM setup. The nerve was stimulated at regular intervals to ensure functional integrity during dissection. A loss of signal (LOS) indicated potential nerve injury.
- **Postoperative Assessment**: Two weeks after surgery, all patients underwent indirect laryngoscopy to assess postoperative vocal cord function.

3.6 Statistical Analysis

Data were analyzed using chi-square tests to compare RLN injury rates between the two groups. A p-value of less than 0.05 was considered statistically significant.

4. Results

4.1 Patient Demographics

The demographic characteristics of the study population are shown in Table 1. There were no significant differences between the two groups in terms of age, gender, or preoperative thyroid function.

Variable	IONM (n=30)	Non-IONM (n=30)
Age (Mean ± SD)	38.7 ± 12.3	40.5 ± 11.7
Gender (Male/Female)	12/18	10/20
Thyroid Disorder (%)		
- Goiter	60%	63%
- Thyroid Cancer	40%	37%

4.2 Intraoperative and Postoperative Outcomes

Intraoperative and postoperative outcomes are presented in Table 2 and Figure 1. Vocal cord palsy (unilateral and bilateral) was significantly lower in the IONM group compared to the non-IONM group.

Outcome	IONM (n=30)	Non-IONM (n=30)
Unilateral Vocal Palsy	1 (3.33%)	4 (13.33%)
Bilateral Vocal Palsy	0 (0%)	1 (3.33%)
Normal Vocal Function	29 (96.66%)	25 (83.33%)

4.3 Statistical Analysis

The chi-square test revealed a statistically significant difference in RLN injury rates between the two groups ($p < 0.05$), with a significantly lower incidence of RLN palsy in the IONM group.

5. Discussion

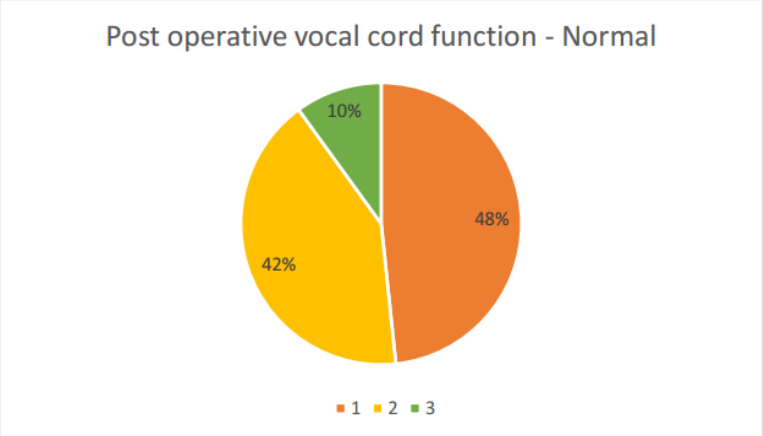

Figure 1: Postoperative Vocal Cord Function
1 – With IONM 2 – without IONM 3 – Normal

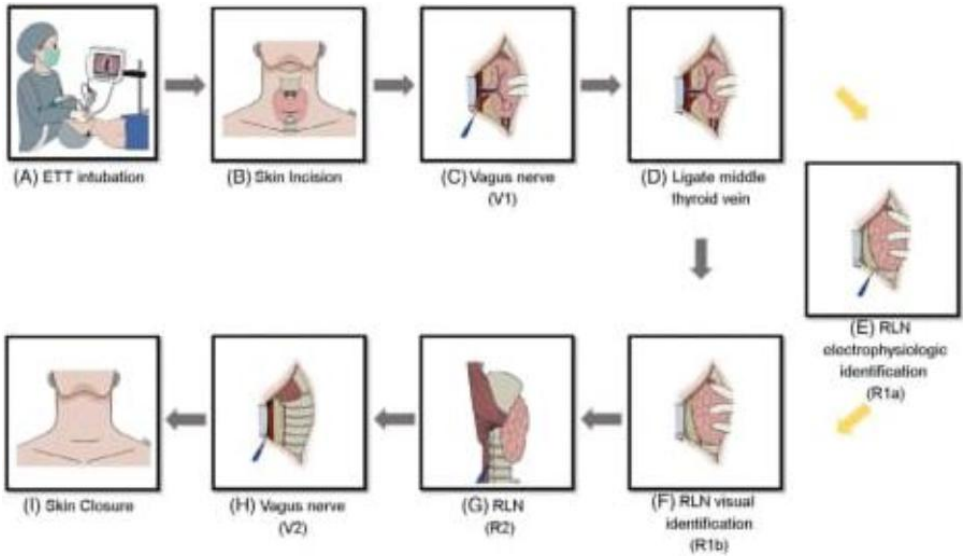

Figure 2: Schematic of IONM Setup and Procedure

(Insert illustration showing the placement of electrodes on the endotracheal tube and their positioning relative to the vocal cords during IONM)

5.1 Recurrent Laryngeal Nerve Injury in Thyroid Surgery

The preservation of RLN function during thyroidectomy is essential for preventing postoperative vocal cord dysfunction. Injury to the RLN can lead to vocal cord palsy, resulting in hoarseness, voice weakness, and in severe cases, airway obstruction requiring tracheostomy.

While visual identification of the RLN is the traditional method used during thyroid surgery, it is not always sufficient to prevent injury, particularly in complex cases such as reoperations or large goiters. In recent years, IONM has emerged as an adjunct tool to aid in the identification and preservation of the RLN.

5.2 Efficacy of IONM in Reducing RLN Injury

This study demonstrated that the use of IONM significantly reduced the rate of RLN injuries during total thyroidectomy. In the IONM group, only 1 patient (3.33%) experienced unilateral vocal cord palsy, compared to 4 patients (13.33%) in the non-IONM group. Additionally, there were no cases of bilateral vocal cord palsy in the IONM group, whereas 1 patient in the non-IONM group required emergency intervention for bilateral vocal cord palsy.

The reduced incidence of RLN injuries in the IONM group is consistent with previous studies, which have shown that IONM can assist in the identification of the RLN and provide real-time feedback on its functional status. This is particularly beneficial in cases where the RLN is anatomically difficult to locate or where there is significant scarring from previous surgeries.

5.3 Limitations of IONM

Despite its advantages, IONM is not without limitations. The cost of the equipment and the need for specialized training can be barriers to its widespread adoption. Additionally, IONM may not detect all forms of nerve injury, particularly those resulting from stretching or ischemia rather than direct trauma. Further research is needed to refine IONM

5.4 Cost-Effectiveness of IONM

Another important consideration in the adoption of IONM is its cost-effectiveness. While IONM provides significant benefits in terms of nerve preservation, it requires specialized equipment, including an endotracheal tube with built-in electrodes, nerve stimulators, and an electromyographic (EMG) monitor. These tools increase the overall cost of the procedure, which may limit their availability, especially in resource-constrained settings. The question remains whether the reduced incidence of RLN injuries justifies the additional expense associated with IONM.

Cost-effectiveness studies have shown that while IONM increases the upfront cost of surgery, it may reduce long-term costs by preventing complications such as vocal cord palsy, which can require further interventions, prolonged hospital stays, and even tracheostomy in severe cases. Therefore, IONM may be particularly beneficial in high-risk cases or in hospitals with less experienced surgical teams, where the risk of nerve injury is higher.

5.5 Surgical Learning Curve and Resident Training

The use of IONM also provides an invaluable tool for surgical education and training. For less experienced surgeons and residents, IONM offers real-time feedback on nerve function, aiding in the identification of the RLN and improving dissection technique. By helping to reduce the risk of nerve damage, IONM can shorten the learning curve for residents and improve surgical outcomes in training hospitals. The feedback provided by IONM enhances anatomical understanding and facilitates the development of more refined surgical skills, leading to safer operations and reduced complication rates.

5.6 Limitations of the Study

This study, although providing significant insights into the role of IONM in reducing RLN injuries during thyroidectomy, has some limitations:

1) **Sample Size**: The sample size of 60 patients, while adequate for detecting statistically significant differences, may not capture the full variability in RLN injury rates that could be observed in larger populations. A larger, multicenter study could provide more robust data.
2) **Short-Term Follow-Up**: The follow-up period in this study was limited to two weeks postoperatively. While this is sufficient for identifying immediate postoperative complications, it does not capture long-term outcomes such as the recovery of transient vocal cord palsy or the potential for delayed-onset RLN injury.
3) **Generalizability**: The study was conducted in a single institution, which may limit the generalizability of the findings to other healthcare settings with different levels of surgical expertise and access to IONM equipment.

6. Conclusion

This study demonstrates that intraoperative neuromonitoring (IONM) significantly reduces the incidence of recurrent laryngeal nerve (RLN) injuries during total thyroidectomy. Patients who underwent surgery with IONM had lower rates of both unilateral and bilateral vocal cord palsy compared to those whose RLN was identified by visual inspection alone. These findings suggest that IONM should be considered as a routine tool in thyroid surgery, particularly in cases where the risk of RLN injury is high or in settings with less experienced surgeons.

The benefits of IONM, including improved nerve identification, reduced operative time, and decreased postoperative complications, outweigh the additional costs, particularly in high-risk cases. However, further research is needed to assess the long-term outcomes of IONM and to optimize its use in different surgical settings.

Given the significant impact of RLN injuries on patient quality of life, the routine use of IONM in thyroidectomy represents a valuable advancement in improving surgical safety and patient outcomes.

7. Recommendations for Future Research

While this study provides valuable insights into the role of IONM in thyroid surgery, further research is needed in the following areas:

1) **Long-Term Outcomes**: Future studies should include longer follow-up periods to assess the recovery of transient RLN injuries and the long-term impact of IONM on vocal cord function.
2) **Cost-Benefit Analysis**: More comprehensive cost-benefit analyses are needed to determine the financial implications of routine IONM use, particularly in low-resource settings where the additional costs may be prohibitive.
3) **Multicenter Studies**: Large, multicenter studies with diverse patient populations and varying levels of surgical expertise are required to validate the generalizability of the findings and to establish standardized guidelines for the use of IONM in thyroidectomy.

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