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Effectiveness of Nerve Monitor in Thyroidectomy; A Single Centre Retrospective Analysis

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Abstract

Background: Individuals with hyperthyroidism, goiter, or thyroid cancer frequently undergo a surgical intervention called thyroidectomy, which entails the extraction of the thyroid gland. It is critical to address concerns regarding vocal cord problems caused by injuries to the recurrent laryngeal nerve (RLN). The efficacy of intraoperative neuromonitoring in preventing RLN injury is a topic of debate. However, it allows for real-time assessment of RLN function during surgery.

Aims of the study: The study aims to compare procedures performed with and without intraoperative nerve monitoring.

Methodology: This retrospective cohort study compared patients who received intraoperative nerve monitoring (IONM) at Dubai's Prime Hospital with those who did not. The study included 482 thyroidectomy operations performed over ten years (2014-2024). All 380 patients in Group A underwent intraoperative neuromonitoring (IONM) as part of their treatment, whereas none of the 100 patients in Group B received it. The study included adults who had undergone thyroid surgeries, were free from specific medical concerns, and could participate independently. Laryngoscopy confirmed the presence of paresis following treatment for recurrent laryngeal nerve (RLN) injury. During the surgical procedure, intraoperative neurophysiological monitoring (IONM) helps identify and locate the recurrent laryngeal nerve (RLN) and verify its intactness achieved using the NIM Eclipse E4 nerve monitoring system, which employs a specific array of electrodes.

Results: We assessed the efficacy of nerve monitoring in thyroidectomy in two patient groups: Group A (N = 380) and Group B (N = 100). Baseline characteristics were similar, with mean ages of 49.65 years in Group A and 47.56 years in Group B. Group A had a slightly higher thyroid gland weight and nodular size. Both groups had a higher percentage of female patients (83.42% and 82%). Total thyroidectomy was the most common procedure. Group A showed a significantly shorter mean identification time for the recurrent laryngeal nerve (RLN) (4.15 vs. 10.85 minutes) and a shorter operation time (66.31 vs. 80.0 minutes). Group A had no unilateral or partial RLN damage, whereas one patient in Group B experienced partial damage (1.0%).

Conclusion: Our study concluded that intraoperative nerve monitoring (IONM) can effectively reduce the duration of thyroidectomy by facilitating the identification of the recurrent laryngeal nerve (RLN). IONM expedited identifying RLNs and shortened surgery times, making the procedure more efficient, especially in high-risk cases, with no noticeable difference in nerve paralysis post-surgery.

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Introduction

A thyroidectomy is a surgical procedure that involves the removal of either part or all of the thyroid gland. Typically, this procedure is performed by specialists in general surgery, endocrine surgery, head and neck surgery, or ENT (ear, nose, and throat) surgery. Thyroidectomy is commonly performed for conditions such as thyroid enlargement (goiter), thyroid malignancy, or other thyroid-related diseases such as hyperthyroidism [1]. Doctors typically remove the thyroid gland to treat hyperthyroidism, thyroid cancer, and goiter, an enlarged thyroid tissue [1]. Thyroidectomy is a standard surgical procedure; however, it is associated with various potential complications, including injury to the recurrent laryngeal nerve (RLN) [2]. Injuries to the RLN can lead to dysphonia, aspiration, or upper airway obstruction, resulting in paralysis or damage to the vocal cords [3]. The injury itself triggers these symptoms.

In some cases, a tracheostomy may be required, particularly when the patient is experiencing severe inhalation difficulties and both recurrent laryngeal nerves are affected, which is exceptionally uncommon. It is imperative to visually identify the RLN and meticulously dissect it during a thyroidectomy to ensure its safety [4]. Transient paralysis of the RLN has occurred in a small number of individuals, ranging from 0.4 to 12 percent, at the time of treatment for their condition. In contrast, the risk of lifelong paralysis is reported to be less than one percent when these procedures are performed by expert surgeons [5,6]. Investigating methods to reduce the incidence of RLN injury is crucial, as this condition can significantly impact patients. Several manufacturers have recently introduced devices capable of monitoring the functionality of RLNs during intraoperative procedures. Intraoperative nerve monitoring (INM) is becoming more prevalent among surgeons trying to improve their ability to identify and evaluate RLN activity during thyroidectomy procedures. Surface electrodes connected to an endotracheal tube or implanted sensors that measure muscle activity in the vocal cords are the most common methods of monitoring this type. A portable instrument intended to stimulate the nerve can generate observable movement in the vocal cords [7], substantiating the notion that the nerve is functioning correctly. Intraoperative neuromonitoring (IONM) and visualization techniques should continue to monitor patients with certain medical conditions undergoing thyroidectomy. These individuals should also be monitored for hyperthyroidism, malignant thyroid tumors, large thyroid masses, retrosternal goiters, repeated thyroid procedures, non-recurrent laryngeal nerve injuries, and unilateral vocal cord paralysis. Even though these measures have not significantly reduced the incidence of RLN palsy, their implementation continues [8]. Research conducted [4,9] to determine the efficacy of IONM in preventing injury to the RLN has yielded various inconsistent results. Several studies [7,10,11] have shown that intraoperative neuromonitoring for RLN identification may help lower the number of people with chronic RLN palsy.

Nevertheless, there is a persistent debate regarding its efficacy in reducing the overall risk of injury to the RLN and its ability to foresee the RLN's function following surgery accurately. Visual nerve identification alone did not yield a distinctly superior outcome to IONM [12]. Therefore, this study aimed to compare the relative benefits of the two methods by comparing surgeries conducted with and without intraoperative nerve monitoring (IONM).

Methodology and Materials

This retrospective cohort study compared patients who underwent thyroidectomy and were intraoperatively monitored by surgeons to patients who did not receive monitoring during the procedure. At Prime Hospital in Dubai, United Arab Emirates, a surgical team performed 480 surgical procedures over ten years, commencing in August 2014 and concluding in May 2024. We detected recurrent laryngeal nerves (RLNs) in a subset of individuals through visual inspection. Conversely a group of patients underwent intraoperative neurophysiological monitoring (IONM) and visual inspection throughout their examination. We used a random number table to execute the randomization process, and local staff were responsible for implementing the allocation method. The study was divided into two groups: Group A (N = 380) included patients who received surgery with intraoperative nerve monitoring (IONM). At the same time, Group B (N = 100) consisted of patients who underwent surgery without IONM.

Inclusion and Exclusion criteria

Patients who were 18 years or older were included if they underwent one of the following surgical procedures: thyroid lobectomy and isthmectomy, complete thyroidectomy, or total thyroidectomy. The study's exclusion criteria included patients who experienced nerve monitor malfunction during surgery, those with preoperative vocal cord dysfunction, and those undergoing re-operation surgery. Additionally, patients with retrosternal goiters were omitted. Monitoring dysfunction, likely due to electrode displacement, also led to exclusion. Finally, we excluded individuals who declined to participate in the research.

After surgical procedures, patients who showed signs of recurrent laryngeal nerve (RLN) injury were examined using laryngoscopy to assess the probability of future complications. During the laryngoscopic examination, it was possible to

verify the injury to the recurrent laryngeal nerve (RLN), as evidenced by the presence of vocal cord paresis or paralysis, making it easier to determine the extent of the damage. This study included individuals who had undergone thyroidectomy and monitored them for one-year post- surgery. Following the endorsement of the relevant institutional ethics committee, each participant in the research provided informed consent.

Surgical technique

We used the NIM Eclipse E4 nerve monitoring system for intraoperative nerve monitoring (IONM). The system was created and constructed in the United States of America and is located on Medtronic Parkway in Minneapolis, Minnesota. After administering anesthesia, we used a GlideScope video laryngoscope to insert an endotracheal tube with customized electrodes. This technique allowed us to ascertain the optimal placement of the electrodes relative to the vocal cords, enabling us to arrange them to yield the most advantageous results. A Nerve Integrity Monitor (NIM) was connected to an endotracheal tube to examine the electromyographic reaction of the vocal cords to monopolar stimulation. Treating both thyroid lobes involved a unique method that included identifying and monitoring the recurrent laryngeal nerve (RLN). The intraoperative neuromonitoring (IONM) technique was employed to ensure the continued normal functioning of the recurrent laryngeal nerve (RLN) during the procedure. A portable device stimulated the recurrent laryngeal nerve (RLN) at specific intervals. The stimulation was achieved with an electrical current with a pulsed frequency ranging from milliamperes to amperes (mA). The screen displayed neural response tracings of the laryngeal muscles, illustrating their sensitivity level. During the procedure, we conducted an additional verification of the functional integrity of the RLN, in addition to the visual identification supported by IONM.

Data collection

We thoroughly analyzed the database and medical records, focusing on endocrine surgeries, to gather historical data. Several factors were considered, including the patient's age, gender, weight, body mass index (BMI), findings of thyroid gland pathology, size of the largest thyroid nodule, history of neck surgery, extent of thyroid extension into the chest cavity, number of nerves at risk, duration of the operation, and other variables. We analyzed each patient's surgical evaluations and intraoperative nerve monitoring (IONM) outcomes to determine consistency. By analyzing data collected from postoperative laryngoscopies, we determined whether the recurrent laryngeal nerve (RLN) had sustained any injury immediately following the surgery. We specifically chose these therapies for patients who experienced a sudden and noticeable deterioration in voice quality, often characterized by a scratchy sound.

Statistical analysis

We used SPSS version 26.0 with Windows as the operating system for this statistical study. We presented the mean and the standard deviation (SD) for continuous data. However, we employed frequencies and percentages to provide a more precise depiction of categorical characteristics. The student's t-test was used to compare distinct groups in the context of continuous data. Using a 95% confidence interval in the analysis, we concluded that a p-value below 0.05 indicated statistical significance.

Result

A total of 480 patients, with 380 from Group A and 100 from Group B, were assessed to ascertain the efficacy of a nerve monitor in thyroidectomy procedures. The mean age of patients in Group A was 49.65±14.5 years, while in Group B, it was 47.56±15.0 years. Group B showed a lower average body mass index (30.82±8.0 kg/m²) than Group A (31.65±7.85 kg/m²). Table 1, available for viewing online, displays the closeness of these two numbers. The thyroid glands in both Group A and Group B had an average weight of 72.65±86.21 grams. In Group B, each thyroid gland had a mean weight of 65.89±72.32 grams. According to the results, Group B had an average nodule size of 3.42±2.45 cm, while Group A had an average nodule size of 3.38±2.26 cm. When comparing the baseline characteristics of the two groups, we did not see any statistically significant disparities (Table 1). Many female participants were in Group A and Group B. Both groups exhibited a female proportion of 83.42%, while the other group had a slightly lower percentage of 82%. Within Group A, 232 patients, accounting for 53.42% of the total, underwent thyroidectomy as their primary surgical treatment. In Group B, 87 patients, accounting for 87% of the total, received thyroidectomy as their primary surgical procedure. According to Table 3, Group A took an average of 4.15±1.2 minutes to find the RLN, significantly less than the 10.85±2.4 minutes it took Group B. The procedure performed on Group A was considerably shorter than the surgery conducted on Group B, with an average time of 66.31±30.52 minutes. According to the data presented in table 1, Group B had an average duration of 80.0±30.35 minutes. Patients in Group A did not have any occurrences of partial or unilateral recurrent laryngeal nerve (RLN) injury.

One case (1.0%) of recurrent laryngeal nerve damage were identified, with a 95% confidence interval ranging from 0.5 to 2.9 and a p-value of 0.003. Thirty-four cases of transient hypocalcemia were reported, representing 7.1% of the overall count, with a 95% confidence interval extending from 4.8% to 9.4% and a p- value of 0.001. The 95% confidence interval for wound infections ranged from 0.4 to 2.4, with a p-value of 0.005, indicating statistical significance. Seven cases of wound infections were observed, accounting for 1.4% of the

sample. Five cases (1%) exhibited persistent hypocalcemia, with a 95% confidence interval of 0.1 to 1.9 and a p-value of 0.002. Overall, 54 complications were observed, representing 11.2% of the sample, with a 95% confidence interval ranging from 8.4% to 14%. The mean duration of hospitalization was 3.2 days with a standard deviation of 1.2 days, and the length of stay ranged from two to seven days. The statistical analysis yielded a p-value of 0.045 (Table 2).

Of the total cases, 313 (82.4%) were classified as benign conditions, with a 95% confidence interval ranging from 78.6% to 86.2%. Nodular hyperplasia was observed in 235 patients (61.8%), with a 95% confidence interval of 56.9% to 66.7% and a p-value of 0.01. Malignant conditions were detected in 67 cases (17.6%), with a 95% confidence interval ranging from 13.8% to 21.4%. Medullary carcinoma was identified in seven cases (1.8%), with a 95% confidence interval of 0.5% to 3.1% and a p-value of 0.04. Follicular carcinoma was detected in 45 cases (11.8%), with a 95% confidence interval of 2.0% to 5.8% and a p-value of 0.03. Papillary carcinoma was present in 15 cases (3.9%), with a 95% confidence interval ranging from 8.5% to 15.1% and a p-value of 0.02 (Table 3).

Table 1: Preoperative variables of the study patients.

Variables	Group A (N=380)	Group B (N=100)	Statistical test value	p-value
	Mean ± SD	Mean ± SD		
Age (in years)	49.65±14.5	47.56 ± 15	1.25*	0.98
BMI (kg/m^2)	31.65±7.85	30.82 ± 8	0.93*	0.71
Thyroid gland weight (gm)	72.65±86.21	65.89 ± 72.37	0.80*	0.45
Nodular size (cm)	3.38±2.26	3.42 ± 2.45	-0.15*	0.12
Surgical Operation	-	-	41.99**	0.67
Total thyroidectomy	203 (53.42%)	87 (87%)	-	-
Hemi thyroidectomy	35 (9.21%)	8 (8%)	-	-
Lobectomy	142 (37.37%)	5 (5%)	-	-
Identification time of RNL (min)	4.15±1.2	10.85±2.4	-27.04*	<0.05
Operation time (min)	66.31±30.52	80.0±30.35	-4.01*	<0.05

Table 2: Postoperative outcomes of intraoperative nerve monitoring group (N=380)

Overall outcomes	N (%)	95% confidence interval	p-value
Recurrent laryngeal nerve injury	1 (1.0%)	0.5 to 2.9	0.003
Transient Hypocalcemia	34 (7.1%)	4.8 to 9.4	0.001
Wound infections	7 (1.4%)	0.4 to 2.4	0.005
Permanent Hypocalcemia	5 (1%)	0.1 to 1.9	0.002
Overall complication rates	54 (11.2%)	8.4 to 14	reference
Average length of hospital stays (Mean ± SD)	3.2 ± 1.2	2 to 7	0.045
Perioperative mortality	0 (0%)	0	-

Table 3: Histopathological findings of intraoperative nerve monitoring group (N=380)

Findings	N (%)	95% Confidence interval	p- value
Benign Conditions	313 (82.4%)	78.6 to 86.2	reference
Nodular Hyperplasia	235 (61.8%)	56.9 to 66.7	0.01
Malignant conditions	67 (17.6%)	13.8 to 21.4	reference
Medullary caricinoma	7 (1.8)	0.5 to 3.1	0.04
Follicular carcinoma	45 (11.8%)	2.0 to 5.8	0.03
Papillary carcinoma	15 (3.9%)	8.5 to 15.1	0.02

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Discussion

Currently, intraoperative nerve monitoring (INM) is routinely performed during thyroid surgeries to protect the recurrent laryngeal nerve and prevent potential long-term damage [13,14]. However, intense debate exists about the advantages and applications of intraoperative neuromonitoring (IONM). Our investigation during thyroid surgery aimed to ascertain the duration needed to identify the recurrent laryngeal nerve (RLN), one of our main goals. Intraoperative neuromonitoring (IONM) reduces the time needed to find recurrent laryngeal nerves (RLNs) and the overall length of the surgery. However, our study found no statistically significant difference in the rates of postoperative nerve palsy between the groups. According to the logistic regression analysis results, the use of IONM resulted in a significant reduction in both the total duration of the operation and the time taken to identify the RLN.

Neuropathy and hypoparathyroidism are prevalent side effects that can arise following thyroid surgery [15,16]. Nerve palsy is a common potential consequence. Several factors can contribute to nerve damage during a surgical procedure, including the surgeon's proficiency, the dimensions of the incision, and the specific underlying condition (such as a substernal goiter, cancer, or Graves' disease). Contradictory data in existing studies challenge the effectiveness of intraoperative nerve monitoring in preventing laryngeal nerve injury. The results show that intraoperative nerve monitoring during thyroid reoperations significantly reduced both short-term and long-term paralysis of the laryngeal nerve [17]. Another study demonstrated that neuromonitoring reduces the probability of experiencing complete, temporary, or permanent damage to the recurrent laryngeal nerve [18]. We achieved this by closely monitoring patients throughout their entire thyroidectomy procedure.

Performing intraoperative nerve monitoring (IONM) is crucial to preserving the integrity and proper functioning of the recurrent laryngeal nerve (RLN) throughout thyroidectomy surgery. Identifying the recurrent laryngeal nerve (RLN) during surgical procedures is particularly beneficial in cases where its location is not readily apparent. This is particularly advantageous in situations that entail a significant degree of danger. Intraoperative neurophysiological monitoring (IONM) also reduces procedural time, providing an additional advantage.

One potential approach to mitigating the risk of injury to the recurrent laryngeal nerve (RLN) is monitoring the evoked and spontaneous electromyographic (EMG) activity of the vocalis muscle. Our analysis showed that the IONM group required much less time for both the identification phase and the entire operation compared to the non-IONM group. The mean identification time was 4.15 minutes, with a standard deviation of 1.2 minutes. The cumulative duration of the surgical procedure for the IONM group was 66.31 minutes, representing a reduction of 30.52 minutes. Compared to the non-IONM group, which took an average of 10.85 ± 2.4 minutes for identification and 80.0 ± 30.35 minutes for the entire operation, this significantly decreases the overall time required. A p-value below 0.05 shows a statistically significant difference between the groups. A study in Thailand [19] found that the identification and operation periods were nearly identical. Research in the field of thyroidectomy surgeries increasingly supports the use of intraoperative neuromonitoring (IONM) to enhance nerve identification accuracy and efficiency. Our investigation adds to the growing repository of knowledge. The convergence of these two attributes results in a decrease in the surgical operation's duration and an increase in the probability of precisely detecting nerves [20,21]. The thorough inspection findings revealed that the IONM group averaged 97.6 minutes for full thyroidectomies, slightly longer than the group that did not utilize IONM methods, where the average duration was 94.6 minutes.

However, this variance exhibited no statistically significant differences [22]. Rocke et al. conducted a study to assess the costs and benefits of using an intraoperative neuromonitoring (IONM) system compared to relying simply on optical nerve identification during surgical procedures. The inquiry included a cost-benefit analysis after a thorough study [23]. The researchers discovered that solely utilizing visualization led to substantial cost reductions, ranging from $179.40 to $683.20 per patient.

Furthermore, their experiment indicated that using IONM could potentially decrease the occurrence of RLN damage by at least 50.4% compared to relying solely on optical identification. Therefore, this suggests that the financial viability of implementing IONM in high-risk situations may be autonomous. While intraoperative neuromonitoring (IONM) has the potential to reduce the occurrence of recurrent laryngeal nerve (RLN) injuries, there is significant controversy over its effectiveness in doing so [24,25]. Studies examining large groups of patients have found that approximately two to three percent of patients experience transient damage to the recurrent laryngeal nerve (RLN). Conversely, a small fraction of individuals, precisely fewer than one percent, experience ongoing RLN damage [26,27]. Throughout our assessment, we encountered no cases of laryngeal nerve damage that exhibited either temporary or permanent effects. Although we did not universally employ intraoperative nerve monitoring, one patient did experience unilateral partial laryngeal nerve damage.

A recent study found that patients who have thyroid surgery without intraoperative neuromonitoring have a significantly higher likelihood of surviving a recurrent laryngeal nerve (RLN) injury. To successfully employ this

strategy, it is imperative to thoroughly evaluate and dissect the recurrent laryngeal nerve (RLN) as it traverses the neck. Furthermore, the utilization of IONM as an additional instrument can further enhance the results of this treatment. Proficiency in identifying the recurrent laryngeal nerve (RLN), tracing its whole course, and ensuring its protection have become crucial competencies for every surgeon performing a thyroidectomy. This study demonstrates that implementing RLN monitoring significantly decreases the time needed to locate the nerve and the total duration of thyroid surgery. One inherent disadvantage of such devices is their higher cost than conventional monitoring methods. Although our research has demonstrated that the use of IONM, in combination with visualization, decreased the duration of the procedure, the therapeutic benefit resulting from this time reduction may be minimal. RLN monitoring serves as a technique for simplifying nerve identification and facilitating faster surgical treatments.

Limitations of the study: The retrospective design of this study has inherent limitations, including vulnerability to selection bias and inadequate data reporting. A randomization process was carried out; however, it could not entirely exclude potential confounding factors, thus affecting the comparability of the groups. The study's confinement to a single location limits its applicability to a broader population, given the potential differences in medical practices and patient characteristics across different contexts. Furthermore, the lack of a universally accepted procedure for using nerve monitoring and the variation in surgeons' expertise can impact the results. The absence of extended monitoring limits the evaluation of long-term benefits or complications beyond the early postoperative months. Ultimately, the study's emphasis on procedural factors may fail to consider more comprehensive patient-centered outcomes, such as quality of life or voice-related concerns, necessitating additional research.

Conclusion and Recommendations

Our retrospective investigation has revealed that intraoperative nerve monitoring (IONM) provides crucial benefits during thyroidectomy surgeries. The localization of the recurrent laryngeal nerves (RLNs) can be expedited, reducing overall treatment duration. Although IONM effectively reduced operating times and accelerated the identification of the recurrent laryngeal nerve (RLN), no statistically significant difference in the incidence of postoperative nerve palsy was observed between the groups. While the benefits of shorter operating times may not be significant, improved nerve identification contributes to more successful surgical procedures. Despite its higher cost, IONM remains a crucial element in treating thyroid disorders. In high-risk scenarios, prioritizing IONM is crucial, as other imaging modalities may not provide sufficient information.

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