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"A Comparative Study of Thyroid Surgery with and Without Using Nerve Monitor"

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ABSTRACT

INTRODUCTION: *Nerve monitoring is an essential part of thyroid, parotid and vestibular schwannoma surgery in the present era. The use of nerve monitor can reduce damage to the vital structures while operating. Nerve injury is a serious complication of thyroid surgeries as damage to the recurrent laryngeal nerve (RLN) during thyroid surgery can result in compromising airways, voice changes and aspiration. Intraoperative nerve monitoring (IONM) has become one the most widely used adjunct for identifying the RLN and allows real-time identification and functional assessment of the RLN in the operative field. Although, the rate of injury to the nerve has been reported to be relatively low but most of them believes that these types of injury must be reduce further. The use of this technology in thyroid surgery has been a much-debated topic for years. No consensus exists regarding IONM's effectiveness in preventing RLN injury. So, it is recommended to assess the cost effectiveness of using IONM in thyroid surgeries.*

AIMS AND OBJECTIVES:

1. *To determine whether IONM during thyroidectomy predicts recurrent laryngeal nerve (RLN) functions.*
2. *To assess the cost effectiveness of IONM during thyroid surgery.*
3. *To compare the time duration of total thyroidectomies and thyroid lobectomies from a single surgeon with and without the aid of IONM.*
4. *To determine efficacy of IONM in revision thyroid surgeries.*

MATERIALS AND METHOD: *This study was performed in the Department of Otorhinolaryngology, MBS Hospital, Medical College Kota, Rajasthan from 01 August 2018 to 31st Dec. 2020. Institutional review board approval was obtained for the study and all patients who consented to hemithyroidectomy or total thyroidectomy were enrolled fulfilling the predefined inclusion and exclusion criteria and data was collected into predesigned proforma. Intraoperative RLN monitoring was performed while operating. Continuous variables were expressed as means and standard deviation and compared by paired t-test. Categorical variables were expressed as percentages. Statistical significance was set at p <0.05.*

RESULTS: *The study comprises of 2 groups- Group A (with IONM) and Group B (without IONM).Majority of the subjects in both group A (96%) and Group B (92%) were females, mostly in the age group of 21 – 30 years i.e., Group A (36%) and Group B (40%). According to their residence, urban predominance is noted in both the groups. No statistically significant difference is observed that ensured baseline similarity among the groups.Mean thyroid volume in Group A was 56.04 ± 4.32 ml ranging from 50 – 62 ml, while that in Group B was 56.66 ± 4.38 ml ranging from 48 – 65 ml and as observed statistically, there was also, no significant difference between the groups.Looking towards the chief complaints of patients enrolled for thyroid surgery,most of the subjects in both Group A (90%) as well as Group B (84%) presented with swelling in neck region. Perspiration and Tachycardia was present in only 4%in Group A and 6% in Group B. Exophthalmos was seen in 2% in Group A and 4% in Group B and the difference was found to be statistically not significant.Coming on nerve injury while operating for various thyroid diseases- Most of the subjects in both Group A (20%) and Group B (55.55%) got nerve injuries while operating for Malignancy thyroid. For Controlled toxic nodular goitre, it was seen in 0% in Group A and 33.33 % in Group B. In those having. Revision thyroid surgery, it was elicited in 0% in Group A and 33.33% in Group B. Operating for both Euthyroid nodular and Controlled Graves' disease resulted in nerve injuries to 0% in both Group A and Group B subjects. No significant difference was seen in thyroid disease among the two groups (p=0.693).IONM seemed to have impact over duration of surgery, as mean operative time in Group A was 79.24 ± 3.62 min ranging from 75 – 85 min, while that in Group B was 82.18 ± 2.16 min ranging from 80 – 86 min, significantly lower in group A (p<0.001). Regarding hospital stay, Group A had 4 days of stay (46%) followed by 3 days (34%) and only 20% had 8 days of hospital stay. In Group B also most subjects had 4 days of stay (48%) followed by 3 days (32%) and only 20% had 8 days of hospital stay. No significant difference was seen in duration of hospital stay among the two groups (p=0.975).*

CONCLUSION: *The use of nerve monitor while operating, decreases the risk of damage to vital structures involve in various surgeries.Thyroid surgery is a technically specific surgery involving highly detailed anatomy. The gold standard for protecting RLN is identifying through careful dissection and then proceeding forward with the removal of concerned tissue.The adjunct of IONM, has helped surgeons in identifying the course of RLN and significantly decreased its chances of getting damaged during surgeries involving thyroid tissue.It also decreases the time needed for performing surgeries and thus may have little effect on hospital stay required post-operatively.*

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I. Introduction

Nerve monitoring is an essential part of thyroid, parotid and vestibular Schwannoma surgery in the present era.

The use of nerve monitor while operating, can reduce the damage to these vital structures. Since facial nerve, recurrent laryngeal nerve, hypoglossal nerve, spinal accessory nerve and vagus nerve have precious role in day-to-day life. The damage to these nerves can lead to-

- Change in voice
- Facial asymmetry
- Deviation of tongue
- Nasal regurgitation
- Aspiration etc.

In order to avoid these complications, we require extensive nerve monitoring during surgical procedures.

As this thesis is based on nerve monitoring during thyroid surgery in order to avoid RLN injury; we will discuss this in detail.

Thyroid surgery is a technically specific surgery which involvesa detailed anatomy. The recurrent laryngeal nerve (RLN) is the most important structure at risk during thyroidectomies.

In the 1950s, Riddell[1] reported a technique of comparing identification and non-identification of the nerve during thyroidectomies. Although, the rate of injury to the nerve has been reported to be relatively low i.e., up to 6% for temporary paresis and up to 2% for permanent paralysis but most of them believes that these types of injury must be reduce further.[2]

Multiple devices over the years have helped surgeons to identify the course of the RLN. Feinstein[3]was the first to mention Electromyography (EMG) use in diagnosing disorders of the RLN in 1946. Delgado et al[4] were the first to use EMG intraoperatively to identify the facial nerve in 1979 and Brennan and colleagues were the first to publish their data on RLN monitoring in 2001.[5]

The Nerve Integrity Monitor tube (Xomed, Jacksonville, FL) and the Dragon Stick-on Electrode (IOM Products, Inc., Ventura, CA) are 2 popular devices used to monitor the nerve via EMG.[6] The use of this technology in thyroid surgery has been a much-debated topic for years. No consensus exists regarding IONM's effectiveness in preventing RLN injury. Multiple papers have failed to prove with statistical significance that the use of IONM during thyroid surgery decreases the rate of RLN palsy or paresis.[7]

Nerve injury is a serious complication of thyroid. Damage to the recurrent laryngeal nerve (RLN) during thyroid surgery can result in voice changes, aspiration, and airway comptonization. Current literature states the rate of permanent RLN paralysis as 0.5% - 5%, and higher in revision cases. [8-12]

II. Aims And Objectives

5. To determine whether IONM during thyroidectomies predicts recurrent laryngeal nerve (RLN) functions.
6. To assess the cost effectiveness of IONM during thyroid surgery.
7. To compare the time duration of total thyroidectomies and thyroid lobectomies from a single surgeon with and without the aid of IONM.
8. To determine efficacy of IONM in Revision thyroid surgeries.

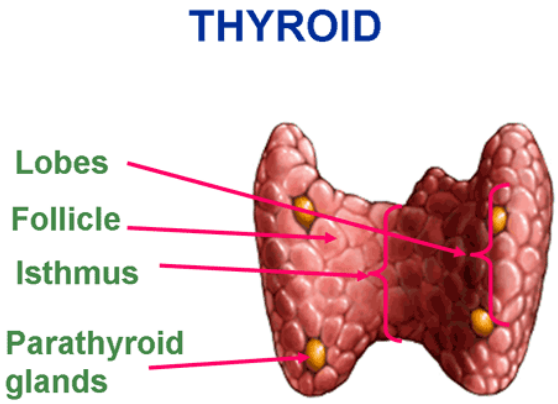
III. Anatomy Of Thyroid Gland

- Largest of all endocrine glands.
- Single, bi-lobed gland in the neck.
- Brown-red in color and soft in consistency.
- Usually weighs about 25-30g (larger in women).
- Right and left lobes are united by a narrow isthmus, which extends across the trachea anterior to second and third tracheal cartilages.

- In some people a third "pyramidal lobe" exists, ascending from the isthmus towards hyoid bone.
- Each lobe is pear-shaped and ~5cm long, extends inferiorly on each side of trachea (and oesophagus), often to the level of 6th tracheal cartilage.
- Surrounded by a thin, fibrous capsule of connective tissue.
- External to this is a "false capsule" formed by pre tracheal fascia.
- Clasps anterior and lateral surface of pharynx, larynx, oesophagus and trachea, like a shield.
- Lies deep to sternothyroid and sternohyoid muscles.
- Parathyroid glands usually lie between posterior border of thyroid gland and its sheath (usually 2 on each side of the thyroid), often just lateral to anastomosis between vessels joining superior and inferior thyroid arteries.
- Internal jugular vein and common carotid artery lies posterolateral to the thyroid gland.
- Produces hormones -

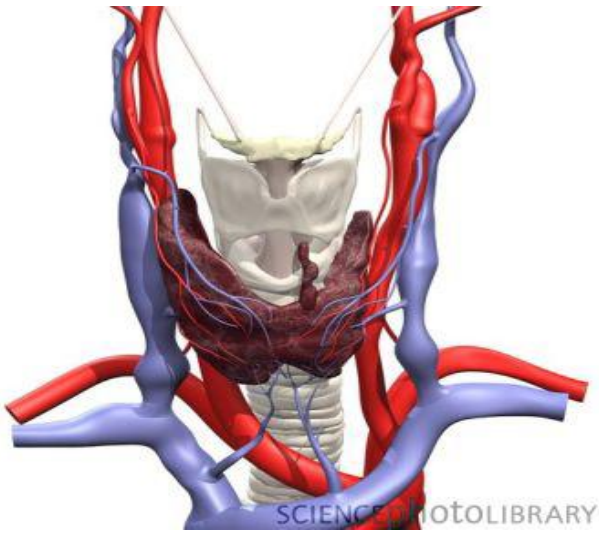
Thyroxine (T4) and Tri-iodothyronine (T3) which are dependent on iodine and regulate basal metabolic rate.
Calcitonin which has a role in regulating blood calcium levels.

- Unique among human endocrine glands as it stores large amount of inactive hormone within extracellular follicles.
- Attached to the arch of cricoid cartilage and to oblique line of thyroid cartilage moves up and down with swallowing and oscillates during speaking.



BLOOD SUPPLY

- Highly vascular.
- Main blood supply is from superior and inferior thyroid arteries.
- Usually, 3 pairs of veins drain venous plexus on anterior surface of thyroid.



LYMPHATIC DRAINAGE

- Lymphatics run in the interlobular connective tissue, often around arteries.
- Pass to Prelaryngeal LN's →Pretracheal and Paratracheal LN's

HISTOLOGY

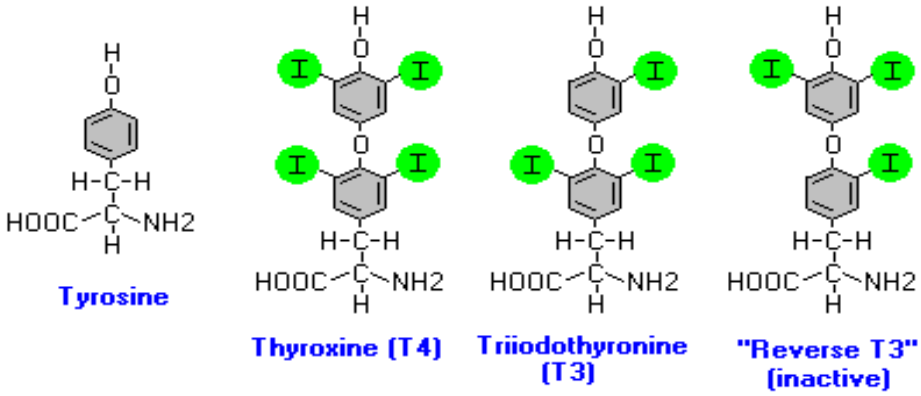
- Functional units are follicles–responsible for synthesis and secretion of T3 and T4.
- Occasionally scattered "clear cells/parafollicular cells/C cells"produces and secretes calcitonin.
- Colloidis the secretory product of follicular cells.
- Extra-cellular proteinaceous substance composed of thyroid hormones linked together with protein is "thyroglobulin".

PHYSIOLOGY

Thyroid hormones structure-

Two principal thyroid hormones are

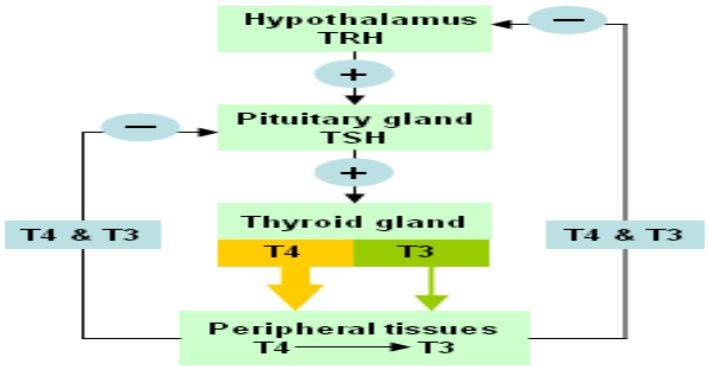
1. Thyroxineor Tetra-iodothyronine (T4)
2. Tri-iodothyronine(T3)



PRODUCTION OF T4 AND T3

- Hypothalamus releases Thyroid Releasing Factor (TRF) to pituitarywhich in turn releases Thyroid Stimulating Hormone (TSH) into blood.
- Follicular cells normally synthesize thyroglobulin and secrete it into the follicular lumen.
- Thyroid peroxidase, found in apical membrane of thyroid follicular cells; catalyzes iodination of tyrosine residues on thyroglobulin molecule and coupling of iodotyrosyl residues to form T4 (thyroxine) and T3, which are still bound to thyroglobulin, making them inactive and gets stored as colloid.
- In response to TSH, follicular cells pinocytosis the colloid, release the thyroglobulinand secrete active T4 and T3 into bloodstream.
- Body needs 100 mg of iodide per day from diet to synthesize adequate T4.
- Most T4/T3 is reversibly bound to thyroid binding globulin.
- Free T4/T3 enters cells, binds to nuclear receptors and increases basal metabolic rate.
- Decreased serum T4/T3 stimulates release of TRF and TSH via negative feedback regulation.Elevated levels have opposite effect.

THYROID REGULATION



EFFECTS OF TSH ON THYROID GLAND

- Increased thyroglobulin proteolysis → Increases circulating thyroid hormones
- Increased activity of "iodide pump"- Increases cellular iodine uptake
- Increases iodination of tyrosine and coupling

- Increases size and secretory activity of thyroid cells.
- Increases number of thyroid cells including changes from cuboidal to columnar epithelial structure.

PATHOLOGY

HYPOTHYROIDISM

- Deficiency of thyroid hormone - secretion and action.
- Common 2-15%
- Clinical symptoms: lethargy, fatigue, cold intolerance
- Two types-
- Primary: impaired synthesis of T4 & T3
- Secondary: decrease in TRH, TSH

HYPERTHYROIDISM

- Hypermetabolic condition caused by excessive production of thyroid hormones.
- Most common
- Grave's Disease

Grave's disease

- Most important cause of hyperthyroidism
- Autoimmune thyroiditis
- Diffuse thyroid enlargement and exophthalmos
- Follicular cells stimulated by IgG antibody (LATS) that causes constant thyroid hormone production, independent of TSH
- Large, fleshy thyroid gland with large follicles lined by active cells.

Cause	*Hormone concentrations*	*Goitre*
Primary failure of thyroid gland	↓T_3 and T_4, ↑ TSH	Yes
Secondary to hypothalamic or pituitary failure	↓T_3 and T_4, ↓ TSH and/or ↓ TRH	No
Dietary iodine deficiency	↓T_3 and T_4, ↑ TSH	Yes

Cause	*Hormone concentrations*	*Goitre*
Abnormal thyroid-stimulating immunoglobulin (eg. Grave's disease)	↑ T_3 and T_4, ↓ TSH	Yes
Secondary to excess hypothalamic or pituitary secretion	↑ T_3 and T_4, ↑ TSH and/or ↑ TRH	Yes
Hypersecreting thyroid tumour	↑ T_3 and T_4, ↓ TSH	No

Thyroid Swelling

IV. Review Of Literature

The thyroid gland is an H-shaped gland that lies just in front of the trachea in the neck. The thyroid gland lies close to the voice box (vocal cords in the larynx) and its nerves (the right and left recurrent laryngeal nerves [RLN]). Occasionally, these nerves are damaged during thyroid surgery (through traction, diathermy injury, or ligation and division). Injury to the RLN can result in temporary or permanent paralysis of the vocal cords. Unilateral nerve damage may cause voice changes including hoarseness. Bilateral nerve damage may result in breathing difficulties and an inability to speak.

V. Materials And Methods

This study was performed in the Department of Otorhinolaryngology, MBS Hospital, Medical College Kota, Rajasthan from 01 August 2018 to 31st Dec. 2020.

Institutional review board approval was obtained for the study, and all patients who consented to hemithyroidectomy or total thyroidectomy were enrolled.

Intraoperative RLN monitoring was performed.

Preoperative flexible laryngoscopy confirmed the normal vocal cord mobility in all patients.

The MEDTRONIC NIM 3.0 monitoring system was used in all cases to monitor, test and confirm visual identification of the RLN at the completion of the case.

Patients were intubated with the NIM 3.0 contact endotracheal tube.

Electrodes was placed at the level of the true vocal cords.

Endotracheal tube position was confirmed by the surgeon and anesthetic with appropriate electromyographic signaling and direct laryngoscopy.

The nerve stimulator was set at 0.5 mA and when the RLN was visually identified, it was stimulated with 0.5 mA to confirm identification and machine function. In some cases, if there was no response, 1.0-mA and then 2.0-mA stimuli was used.

The number of times that the RLN was stimulated during the case was also recorded.

Once the specimen was removed and hemostasis was obtained, each nerve was stimulated at the cricoarytenoid joint at 0.25 mA and if there was no response, the stimulus was increased successively to 0.35, 0.5, 1.0, and 2.0 mA until a positiveNIM 3.0 response was achieved.

Nerve testing was repeated at the most distal location of RLN dissection from the cricoarytenoid joint and the smallest stimulus to generate a response at the cricoarytenoid joint and distal dissection was recorded for each nerve.

The length of the dissected nerve was measured and recorded.

At the first postoperative appointment, 1 to 2 weeks after surgery, flexible laryngoscopy was performed in all cases.
Pathology reports and information regarding patients' preoperative and postoperative vocal cord mobility was reviewed and documented.
Permanent vocal cord paralysis was defined as impaired mobility at 3 to 4 months after surgery and for this follow-up of the cases was done till 4months.
Statistical analysis was performed using a t test for continuous data. Statistical significance was set at P^{L} .05.M

VI. Operative Technique

Intraoperative neuromonitoring has been introduced in thyroid surgery as an adjunct to standard visual identification of the recurrent laryngeal nerve (RLN) to prevent nerve lesion.

The use of IONM, besides helping to identify the RLN, gives an objective evaluation of its function during the whole dissection.

IONM was introduced about 50 years ago and various neuromonitoring methods (glottis pressure method, glottic monitoring method, insertion of needle electrodes in vocal cords endoscopically or through cricothyroid membrane, laryngeal palpation method, and monitoring via endotracheal tube with surface electrodes) have been utilized.

For several reasons, such as simplicity, non-invasiveness and safety; IONM via endotracheal (ET) tube with surface electrodes has become the standard method. It consists of an electromyography (EMG) that evaluates the vocal cord adductor function by using surface electrodes on the ET tube. NIM-Response 3.0 System (Medtronic Xomed, Jacksonville, Florida, USA) is the most widely used device for RLN monitoring. It transforms laryngeal muscle activity into audible and visual EMG signals whenever the RLN or vagus nerve is stimulated intraoperatively.

VII. Discussion

The thyroid gland lies close to the vocal cords and the nerves that control movement of the vocal cords (recurrent laryngeal nerves). Occasionally, during thyroid surgery these nerves got damaged (through traction, diathermy injury, or ligation and division). It can result in temporary or permanent paralysis of the vocal cords. Unilateral nerve damage may cause voice changes including hoarseness. Bilateral nerve damage may result in breathing difficulties and an inability to speak. The external branch of the superior laryngeal nerve is also at risk of injury during thyroid surgery. Damage to it may cause a slight deterioration in vocal quality.

Conventional thyroid surgery is done without the aid of continuous intraoperative nerve monitoring (IONM). Intraoperative nerve monitoring (IONM) has become the most widely used adjunct identification of the RLN and allows real-time identification and functional assessment of the RLN in the operative field. Use of IONM is quite debated topic and still consensus is underway,so this study is conducted to add to the existing research in the way of assessing use of IONM in terms of its utility, cost effectiveness, effect on duration of surgery and efficacy as compared to traditional thyroid surgery.
In the present study,

- Most of the subjects in both Group A(with IONM)(36%) and Group B(without IONM) (40%) were in the age group of 21 – 30 years.
- Majority of the subjects in both group A (96%) and Group B (92%) were females.
- According to their residence, urban predominance is noted in both the groups.
- No statistically significant difference is observed in terms of those demographic variables among both the groups, that ensured baseline similarity among the groups.

VIII. Summary

Nerve monitoring is an essential part of thyroid, parathyroid and vestibular schwannoma surgery in the present era.
The RLN is the most important structure at risk during thyroidectomies. The variability in nerve course can lead to trouble in identification of the nerve and increases chances of injury. Thus, IONM has become most widely used adjunct for identifying RLN.
In this study, we found that, overall operative time for the surgery, with the use of IONM, was significantly less and it also decreases the chances of nerve injury as compared to those surgeries where we did not use IONM. However, there was no significant difference seen in the duration of hospital stay.
By analysis the distribution of study subjects according to thyroid diseases, the RLN injury can be summarized as follows-
In malignancy thyroid, the chances of RLN injury with IONM and without IONM was 20% and 55.55% respectively.
In Controlled toxic nodular goitre, it was 0% and 33.3% respectively.

In Revision thyroid surgery, it was elicited in 0% and 33.33% respectively.
So, we concluded that, with the variation in thyroid diseases and their surgeries; the chances of RLN injury were very low with the use of IONM but chances increase in those where there was no intraoperative monitoring done.

IX. Conclusion

The use of nerve monitor while operating, decreases the risk of damage to vital structures involve in various surgeries.

Thyroid surgery is a technically specific surgery involving highly detailed anatomy. The gold standard for protecting RLN is identifying through careful dissection and then proceeding forward with the removal of concerned tissue.

The adjunct of IONM, has helped surgeons in identifying the course of RLN and significantly decreased its chances of getting damaged during surgeries involving thyroid tissue.

It also decreases the time needed for performing surgeries and thus may have little effect on hospital stay required post-operatively

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