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RESEARCH ARTICLE

NERVE MONITORING IN THYROID SURGERY: A RETROSPECTIVE COHORT STUDY

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Abstract

Background: The proximity of the Recurrent Laryngeal and External Branch of Superior Laryngeal Nerve to the Thyroid Gland has been a key factor for a profound interest of surgeons and clinicians in the clinical outcomes and Vocal changes in the post operative period in the patients undergoing thyroid surgery. The presence of Recurrent Laryngeal nerve in proximity of Thyroid poses a significant risk of damage to the nerve during surgery. The Recurrent Laryngeal Nerve SuppliesLarynx below the level of vocal cords and all the muscles except Cricothyroid. Posterior Cricoarytenoid, the only abductor of vocal cord is also supplied by this nerve. So, any damage to the nerve during surgery causes significant changes in pitch and texture of voice, commonly referred to as hoarseness.Intra-operative Nerve Monitoringwas introduced about 50 years ago and various neuromonitoring methods (glottis pressure method, glottic monitoring method, insertion of needle electrodes invocal cords endoscopically or through cricothyroid membrane, laryngeal palpationmethod, and monitoring via endotracheal tube with surface electrodes) have been utilized. We present a retrospective cohort study to surmise the effect of the use of Intraoperative nerve monitoring devices during Thyroid surgery and compare the clinical outcome in two cohorts. First, the study group where the nerve monitoring was used intraoperatively and the Second, where no intraoperative nerve monitoring was used. All the Patients included in the study underwent Thyroid surgery in the Department of Otorhinolaryngology-Head and Neck Surgery, MBS Hospital, Kota.

Methods: This retrospective cohort study includes 100 patients as per the inclusion criteria specified in this article and all the included patients were studied after dividing them into two groups with one group where intraoperative nerve monitoring was used and the other group where no nerve monitoring was used. Each group had 50 patients each. All the patients are regularly documented for with Video

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Laryngoscopic Examination as a standard. All the data collected from the archives and put to statistical evaluation to analyse the data Age wise, Sex wise, Residential address wise, according to mean Thyroid volume, according to presenting complaints, according to history, according to mean operative time, according to the type of Nerve Injury, according to duration of hospital stay and other parameters as followed in the study.

Results: On appropriate statistical analysis of the data, it was seen that there were no demographic variables within groups that ensured statistical similarity in the groups, there was also no statistical correlation of functional preservation attributable to mean Thyroid volume. The incidence of nerve injury was higher in the patients who got themselves operated for the malignancy of thyroid and the revision surgeries. The patients being operated for controlled toxic goitre reported ni nerve injury in the post operative period. The intraoperative nerve monitoring reported lower mean time required to do the surgery. There was a similar incidence of permanent and transient nerve injury in both the cohort groups.

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Introduction:-

Thyroid surgery has evolved from the horrid butcheries to the era of minimal incision endoscopic assisted Thyroidectomies. With the advent of modern technology and better understanding of the disease extent the Thyroid Surgery today is focussed at both anatomical and functional preservation as well as adequate surgical resection of the disease. The use of intraoperative nerve monitoring has almost become a standard in most medical centres today. It provides accurate and instantaneous assessment of the functioning of Recurrent Laryngeal Nerve and the mobility of Vocal Cord. It greatly improves and guides the dissection of the surgeon and provides functional preservation of the Nerve as well. The gold standard of protecting the nerve is the careful dissection and identification before proceeding with resection of the thyroid Gland.The recurrent Laryngeal Nerve is a nerve of 6^{th} pharyngeal arch and curves under the Arch of Aorta on the left and from under the Subclavian artery on the right because of degeneration of 4^{th} and 5^{th} arches on the right. The existence of the Recurrent Laryngeal Nerve was documented by the Physician Galen. The Recurrent Laryngeal Nerves are the branches of Vagusnerve, and they are called recurrent as they travel in the opposite direction from their parent nerve of origin.

Materials and Methods:-

Study Population

To carry out this retrospective study a total of 100 patients were chosen who underwent Thyroid Surgery in the Department of Otorhinolaryngology, MBS Hospital, Kota. Only the patients qualifying in the inclusion criteria were included in the study.

Study Design

A retrospective study was designed for the above-mentioned population. A preoperative Video Laryngoscopy was performed routinely in all patients and normal mobility of Vocal Cords was confirmed. All the patients undergoing surgery were intubated with NIM 3.0 contact endotracheal tube and MEDTRONIC NIM 3.0 monitoring system was used to identify, test the functioning of the Recurrent Laryngeal Nerve in the surgery. After confirming the adequate position of the endotracheal tube by the means of direct laryngoscopy by the Anaesthetist and the surgeon the Electrodes were placed at the level of true vocal cords. The nerve stimulator was set at 0.5 mA and whenthe RLN was visually identified, it was stimulated with 0.5mA to confirm identification and machine function. In somecases, if there was no response, 1.0-mA and then 2.0-mAstimuli was used.

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

Once thespecimen was removed and haemostasiswas obtained, eachnerve was stimulated at the cricoarytenoid joint at 0.25 mAand if there was no response, the stimulus was increasedsuccessively to 0.35, 0.5, 1.0, and 2.0 mA until a

positiveNIM 3.0 response was achieved. Nerve testing was repeated atthe most distal location of RLN dissection from the cricoarytenoidjoint and the smallest stimulus to generate aresponse 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 postoperativeappointment, 1 to 2 weeks after surgery, flexible laryngoscopy was performed in all cases.

Pathology reports and information regarding patients' preoperativeand postoperative vocal cord mobility was reviewedand 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 continuousdata. Statistical significance was set at P^{L} .05.M

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 vocalcord adductor function by using surface electrodes on the ET tube. NIM-Response3.0 System (Medtronic Xomed, Jacksonville, Florida, USA) is the most widely useddevice for RLN monitoring. It transforms laryngeal muscle activity intoaudible and visual EMG signals whenever the RLN or vagus nerve is stimulatedintraoperatively.

This system basically consists of the combination of two electricalcircuits: stimulation and recording sides. The stimulation side consists of a stimulatorprobe (nerve stimulator probe, continuous vagus nerve stimulator probe) which transmits electric current to the nerve and a grounding electrode. The nervestimulation probe can be monopolar or bipolar while the continuous monitoringprobes applied to the vagus nerve can be monopolar, bipolar, or tripolar. Therecording side consists of the ET tube with surface electrodeswhichareplaced at the level of the vocal cords and their ground electrode. Thesetwo main systems combine on the interconnection box through whichET tube with surface electrodes and grounding electrodes (white: stimulation side, green: recording side).

Stimulation and recording sides are combined on the interconnect boxthrough which they connect to themonitor.

Knowledges on Thyroid Cancer is connected to the monitor. The monitoring systems can be with 2, 4, 8 or 16 channels.

The number of channels indicates the number of nerves that can be monitored.

A separate EMG screen appears for each nerve on the monitor.

In thyroid surgery,two channels for the right and left vocal cords are sufficient and two EMG screensappear on the monitor. In case of continuous vagus nerve stimulation,instead, two EMG screens for intermittent monitoring appear on the left side of themonitorand another EMG screen for continuous vagus nerve stimulation appearson the right side.

The anaesthetist plays a key role in IONM procedure, particularly aboutthe type of drugs used to induce anaesthesia and to the positioning of the ET tube.

After these steps, anaesthesia can be obtained by inhaler or intravenous anaesthetics. These agents do not have significant effects on EMG signal, providing an adequatedepth of anaesthesia. Differently, neuromuscular blocking agents (NMBAs) interferewith monitoring, reducing EMG amplitude and the optimal laryngeal response,thus making neuromonitoring less effective. For this reason, after induction, NMBAshould be avoided for the rest of the operation. Small doses of a non-depolarizingmuscle relaxant (usually rocuronium and atracurium) are used at time of intubation.

Doses used are- Inj. Midazolam 0.02 mg/kg plus Inj. Glycopyrrolate 0.004 mg/kg and Inj. Fentanyl 2micro gram/ Kg with Pre oxygenation with oxygen @ 10lt/min. by simple face mask for 3mins.

Then induction by Inj. Propofol 2mg/Kg muscle relaxant Inj. Succinyl Choline 2mg/kg then infusion with intraoperative propofol is started @ 100-200 µg/kg/min. Infusion of fentanyl started @1-2µg/kg/min, inhalational sevoflurane @1.2% +O2 @ µLit/ min. allow the restoration of basic physiological functions, such as spontaneousrespiration and normal muscle twitch activity, within a few minutes.

Endotracheal tubes are available in sizes 6.0, 6.5, 7.0, 7.5, and 8.0. The largesttube which can pass between the patient's vocal cords is used.

ET tube is placed under direct laryngoscopy with the middle of the blue markedregion (the exposed electrodes) in contact with the true vocal cords. The tube must be placed in the right position to obtain adequate functioning of the system. After the tube is inserted, thepatient is given the operating position, with hyperextended neck by applyinga pillow under the shoulders.

During positioning, the anaesthetist must protectthe ET tube to keep its position unchanged. If the tube is fixed to the rim of thepatient's mouth before the patient is correctly positioned, the position of the tubein the airway can change. This can lead to a disruption of the relationship betweenthe surface electrodes of the ET tube and the vocal cords. Thus, the tube must besecured to the rim of the lip after the patient is correctly positioned.

Once the patient is positioned, the grounding electrode of the recording sideand the grounding electrode of the stimulation side are sub-dermally applied tothe pre-sternal region or to the shoulder at the side of the monitor. The second oneshould be placed 1–2 cm below the first one.

After all connections are made, the correct positioning of the ET tube must bechecked. This can be done from the monitor by verifying the impedance value of the electrodes.

For each electrode, it must be less than 5 kΩ. Moreover,the impedance difference between positive and negative electrodes of each channelshould be less than 1 kΩ. Values above these thresholds indicate that the contactbetween the patient's vocal cords and the ET tube electrodes is not adequate.

Othertests to verify the correct location of the ET tube includes the evaluation of respiratorychanges or a further laryngoscopy. After the first method, in the short-termwindow period between the loss of the effect of short-acting NMBA and thedeepening of anaesthesia following intubation, spontaneous respiratory movementsshould result in waveforms with an amplitude of 30–70 µV on the monitor. Theserespiratory changes should be detected for both vocal cords.

At this point, the monitor should be set as follows: a threshold value of 100 µV,an excitation electrode stimulation level of 0.5–2 mA (mean: 1 mA), a stimulationperiod of 100 µs, and a stimulation frequency of 4 stimuli per second.

At the beginning of the operation, the stimulator probe should be tested directlyon the infrahyoid or sternocleidomastoid muscle to confirm the presence of anappropriate muscle twitching. This confirms that the nerve stimulation probe isworking properly and the absence of ongoing paralytic agent. Moreover, to confirmthe overall system function, before the identification of RLN, an EMG signalshould initially be obtained from the vagus nerve. This step is crucial to assess thatIONM system is functioning correctly and that the normal pathway of RLN signalis elicited.

The vagus nerve can be directly stimulated after dissection of the carotidsheath, or its stimulation can be performed simply by increasing the stimulationlevel up to 2–3 mA with the probe on the carotid sheath without dissecting it.

TheRLN is situated at the tracheoesophageal groove in proximity to the inferior thyroidartery. It can be initially searched with a stimulation level of 2 mA and fully mappedout; then, it can be isolated and visually confirmed.

Once the nerve is visualized,the stimulation level can be turned down to 1 mA. It is important to keep in mindthat RLN has an extra-laryngeal branch that can be found in about 30–40% of patients,particularly at the level of Berry's ligament. Thus, it is necessary to dissect the RLNfrom the lower neck up to the nerve entrance into the larynx. In case of branchedRLN, each branch should be stimulated separately by using a stimulation current of0.4–0.5 mA.

EMG signal of these individual branches should be assessed to allow areliable evaluation of the distribution of the motor and sensory fibres.

After removingthe surgical specimen and ensuring a complete haemostasis, the final testing ofRLN and vagus nerve is performed.

Results:-

Study was conducted on patients with mobile vocal cord and confirmed by I L & VLS examinations.

Table 1:- Age Wise Distribution.

Age group (years)	Group A (with Nerve monitor)		Group B (without Nerve monitor)	
	No.	%	No.	%
21-30	18	36.00	20	40.00
31-40	16	32.00	14	28.00
41-50	14	28.00	12	24.00
51-60	2	4.00	4	8.00
Total	50	100.00	50	100.00
Mean ± SD	25.40±3.42		24.84±3.01	
Result (P value)	0.386 (NS)			

S = Significant; NS = Non-Significant

This table shows that-

Most of the subjects in both Group A (36%) and Group B (40%) were in the age group of 21 – 30 years.

Mean age of subjects in Group A was 25.40±3.42, while that of Group B was 24.84±3.01 years.

No significant difference was seen in age distribution of study groups.

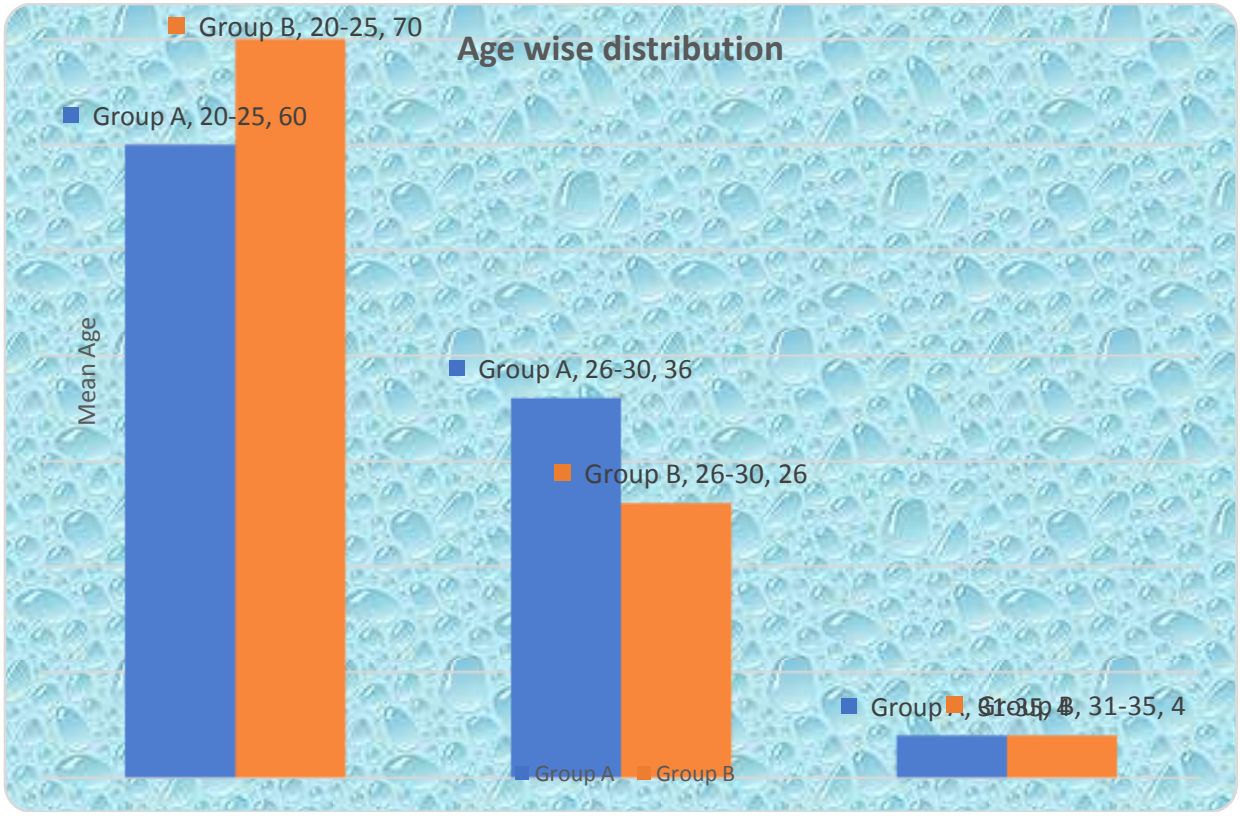


Table 2:- Sex Wise Distribution.

	Group A (with Nerve monitor)		Group B (without Nerve monitor)	
	No.	%	No.	%
Male	**2**	**4.00**	**4**	**8.00**
Female	**48**	**96.00**	**46**	**92.00**
Total	**50**	**100.00**	**50**	**100.00**
Result (P value)	**0.674 (NS)**			

S = Significant; NS = non-Significant

Above table depicts the sex wise distribution of study groups.

Most of the subjects in both Group A (96%) and Group B (92%) were females.

No significant difference was seen in Sex wise distribution of study groups (p=0.674).

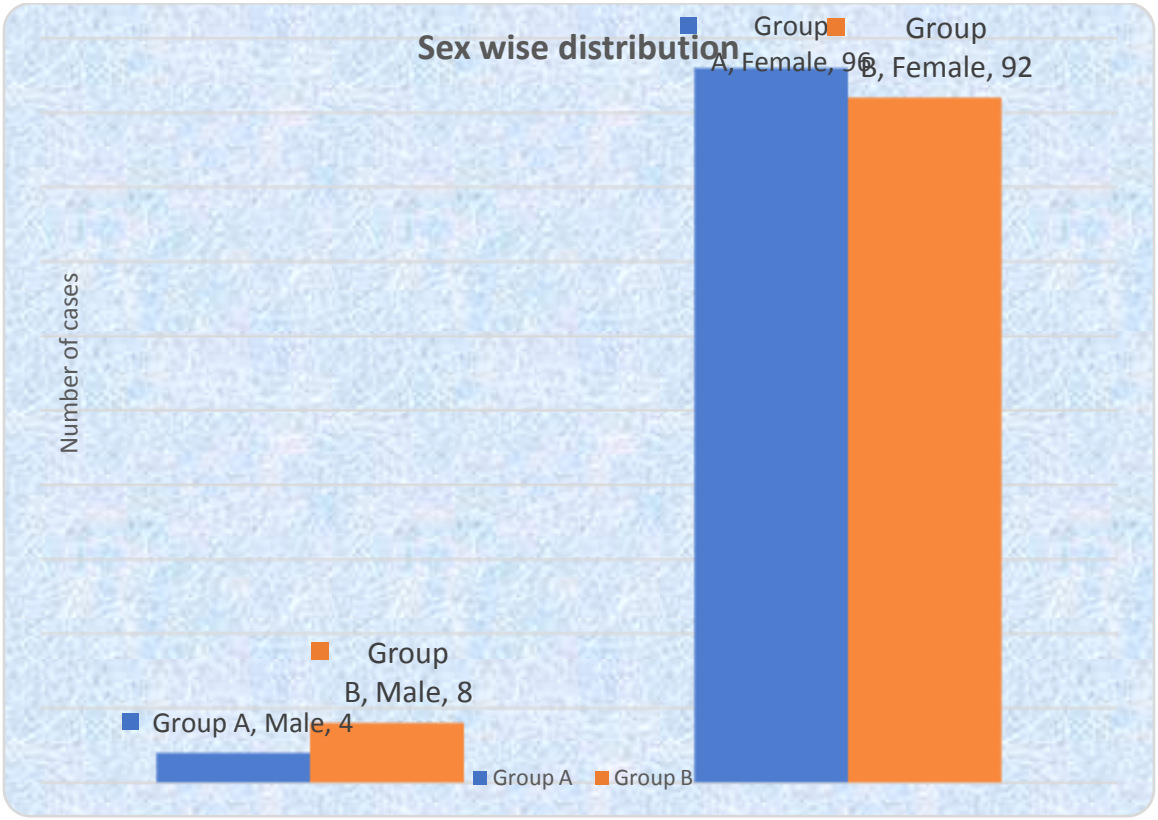


Table 3:- Distribution Of Study Subjects According To Their Residence.

Residence	Group A (with Nerve monitor)		Group B (without Nerve monitor)	
	No.	%	No.	%
Rural	**22**	**44.00**	**24**	**48.00**
Urban	**28**	**56.00**	**26**	**52.00**
Total	**50**	**100.00**	**50**	**100.00**
Result (P value)	**0.841 (NS)**			

S = Significant; NS = non-Significant

Present table shows that subjects in Group A were more from urban area (56%) as compared to rural area (44%). Similarly, in Group B, more subjects were from urban area (52%) as compared to rural area (48%).

Hence, both the groups were similar in relation to their residence (p>0.05)

Table 4:- Comparison Of Mean Thyroid Volume Among Study Groups.

	Group A (with Nerve monitor)		Group B (without Nerve monitor)	
	Mean	**SD**	**Mean**	**SD**
Mean Thyroid volume	**56.04**	**4.32**	**56.66**	**4.38**
Range (Min-Max)	**50-62**		**48-65**	
Result (P value)	**0.477 (NS)**			

S = Significant; NS = Non-Significant

This table shows that the 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.

No significant difference was seen in mean thyroid volume between the two groups (p=0.477).

Thyroid volume of each lobe was calculated using the formula width (cm)x length (cm)x depth (cm) x 0.479 for each lobe. (USG Guided).

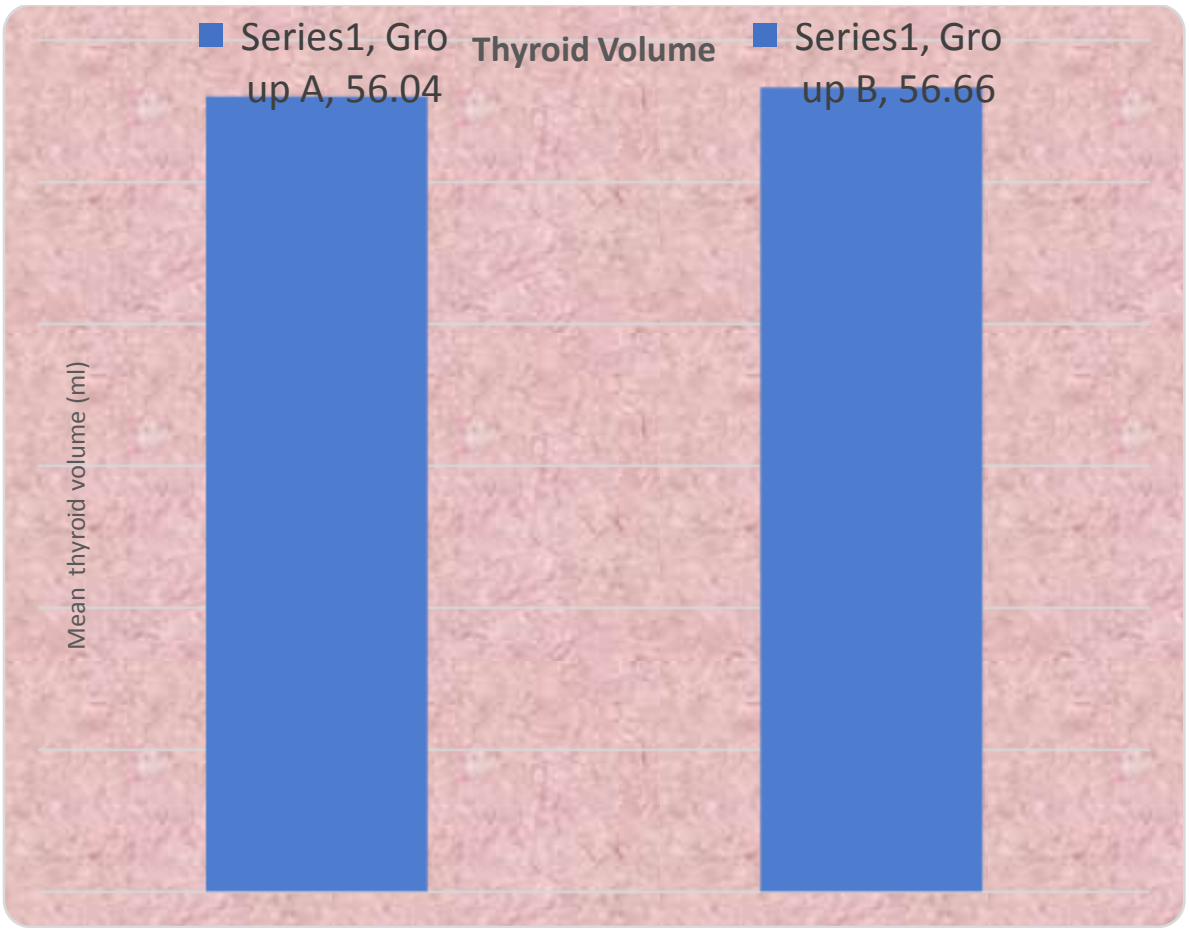


Table 5:- Distribution Of Presenting Complaints Among Study Groups.

Presenting complaints	Group A (with Nerve monitor)		Group B (without Nerve monitor)	
	No.	%	No.	%
Swelling	40	80.00	37	74.00
Difficulty in Swallowing	10	20.00	13	26.00
Total	50	100.00	50	100.00
Result (P value)	0.635 (NS)			

S = Significant; NS = non-Significant

Above table shows that most of the subjects in both Group A (80%) as well as Group B (74%) presented with swelling in neck region. Difficulty in Swallowing was present in only 20% of subjects in Group A and 26% of subjects in Group B. This difference in presenting complaints ws not found to be statistically significant (p=0.635).

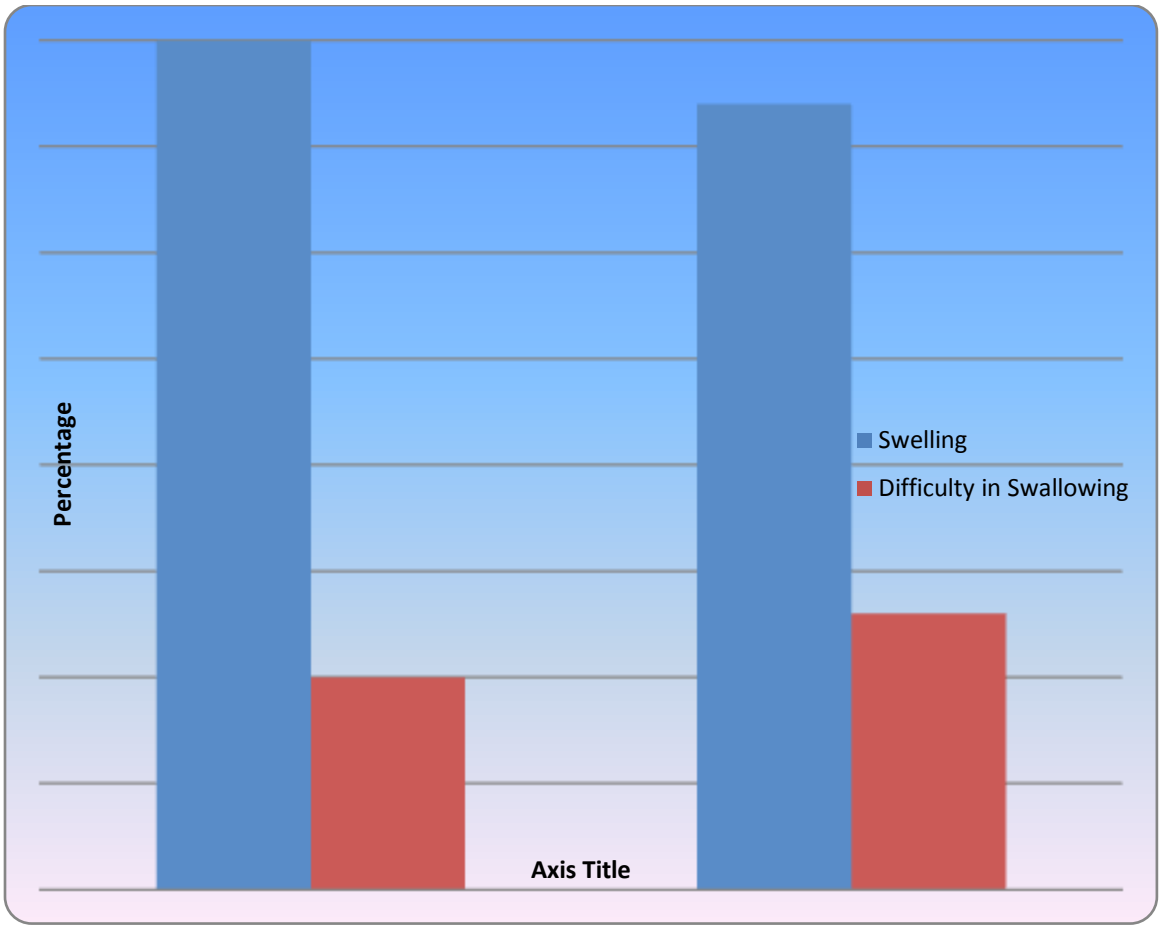


Table 6:- Distribution Of Study Subjects According To Nerve Damaged While Operating For Various Thyroid Diseases.

THYROID DISEASE	Group A (with Nerve monitor)		Group B (without Nerve monitor)	
	No.	%	No.	%
MALIGNANCY THYROID	2	20	5	55.55
CONTROLLED TOXIC NODULAR GOITRE	0	0	1	33.33
REVISION THYROID SURGERY	0	0	1	33.33
EUTHYROID NODULAR GOITRE	0	0	0	0
CONTROLLED GRAVE'S DISEASE	0	0	0	0
Total	50	100	50	100
Result (P value)	0.693 (NS)			

S = Significant; NS = non-Significant

Above table shows that-

Most of the subjects in both Group A (20%) and Group B (55.55%) got nerve injuries while operating for Malignancy thyroid.

Nerve injuries while operating for Controlled toxic nodular goitre was seen in 0% subjects in Group A and 33.33 % subjects in Group B.

In those having Revision thyroid surgery, it was elicited in 0% of subjects in Group A and 33.33% subjects in Group B.

Operating for both Euthyroid nodular and Controlled Graves' disease resulted in nerve injuries to 0% of subjects in both Group A and Group B subjects.

No significant difference was seen in thyroid disease among the two groups (p=0.693).

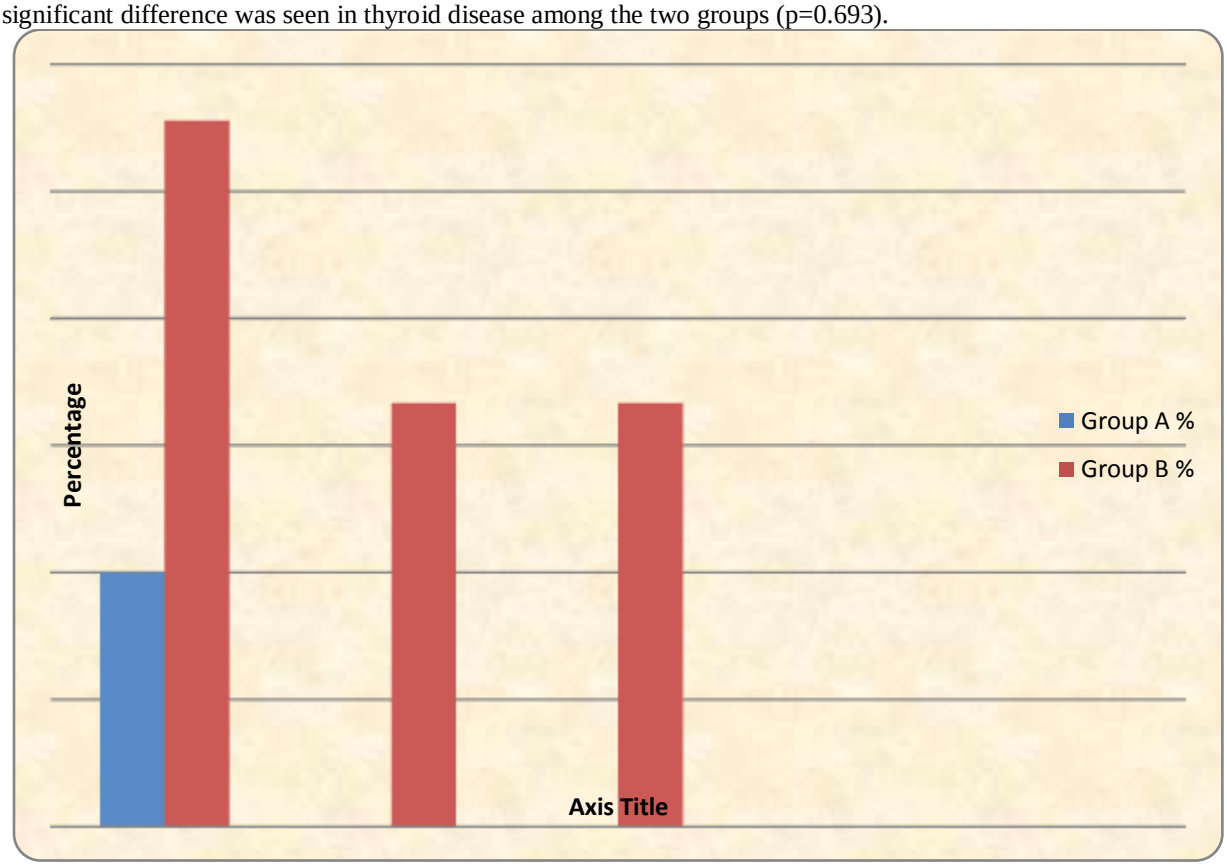


Table 8:- Distribution Of Study Subjects According To Past History Of Thyroid Disease.

	Group A (with Nerve monitor)		Group B (without Nerve monitor)	
	No.	%	No.	%
Present	**9**	**18.00**	**8**	**16.00**
Absent	**41**	**82.00**	**42**	**84.00**
Total	**50**	**100.00**	**50**	**100.00**
Result (P value)	**1.00 (NS)**			

S = Significant; NS = Non-Significant

Above table depicts that past history of thyroid disease which was seen in only 9 (18%) subjects in Group A and 8 (16%) subjects in Group B.

No significant difference was seen in past history of thyroid disease among the two groups. (p=1.000)

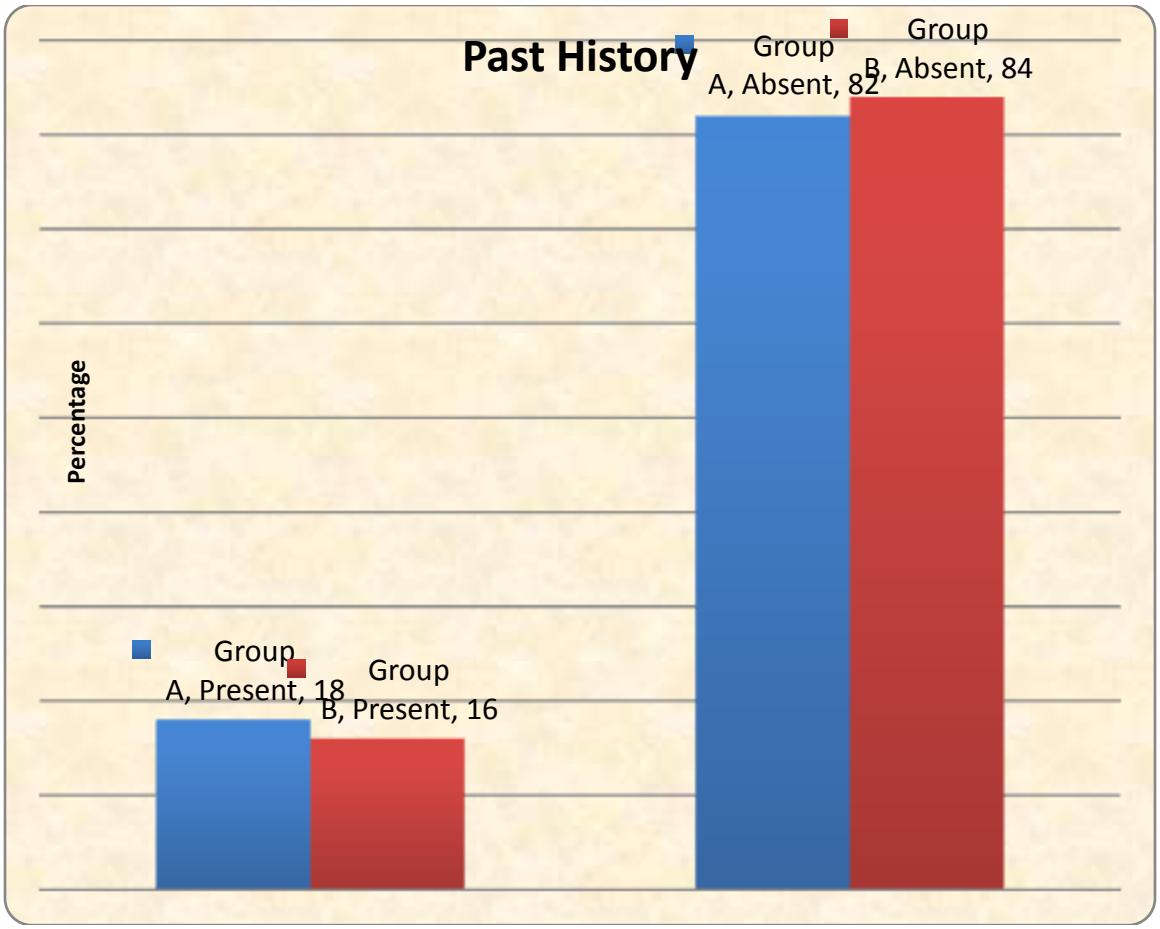


Table 9:- Comparison Of Mean Operative Time Among Study Groups.

	Group A (with Nerve monitor)		Group B (without Nerve monitor)	
	Mean	**SD**	**Mean**	**SD**
Mean operative time	**79.24**	**3.62**	**82.18**	**2.16**
Range (Min-Max)	**75-85**		**80-86**	
Result (P value)	**p<0.001 (S)**			

S = Significant; NS = non-Significant

This table shows that the 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.

The mean operative time was found to be significantly lower in Group A ($p<0.001$).

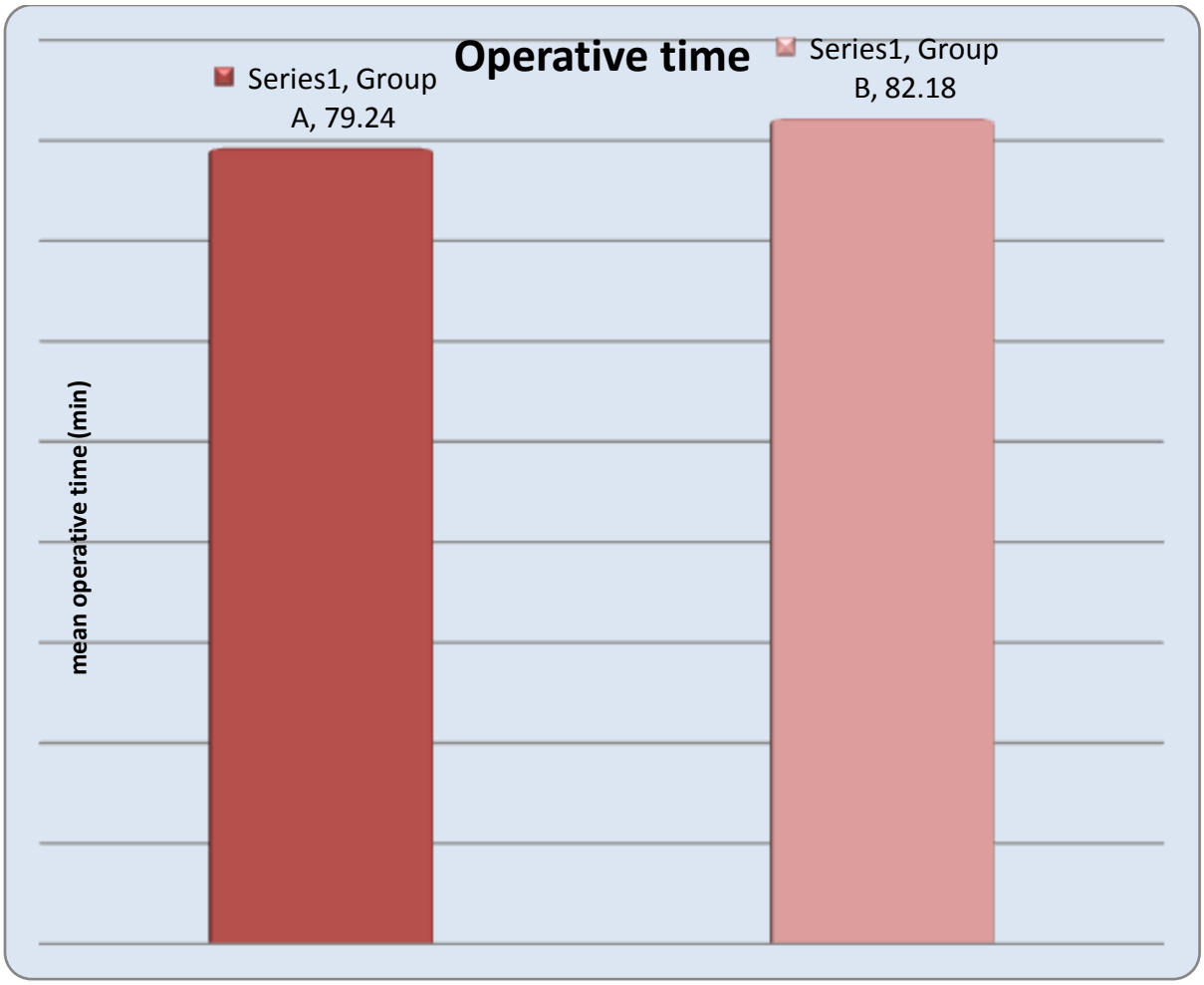


Table 10:- Distribution Of Subjects According To Type Of Nerve Injury.

Nerve injury	Group A (with Nerve monitor)		Group B (without Nerve monitor)	
	No.	%	No.	%
Permanent	5	10.00	5	10.00
Transient	4	8.00	4	8.00
Total	50		50	
Result (P value)	1.00 (NS)			

S = Significant; NS = non-Significant

Present table shows that Permanent nerve injury was seen in 10% of subjects and Transient nerve injury was seen in 8% of subjects in both groups.

No significant difference was seen in nerve injury among the two groups (p=1.000).

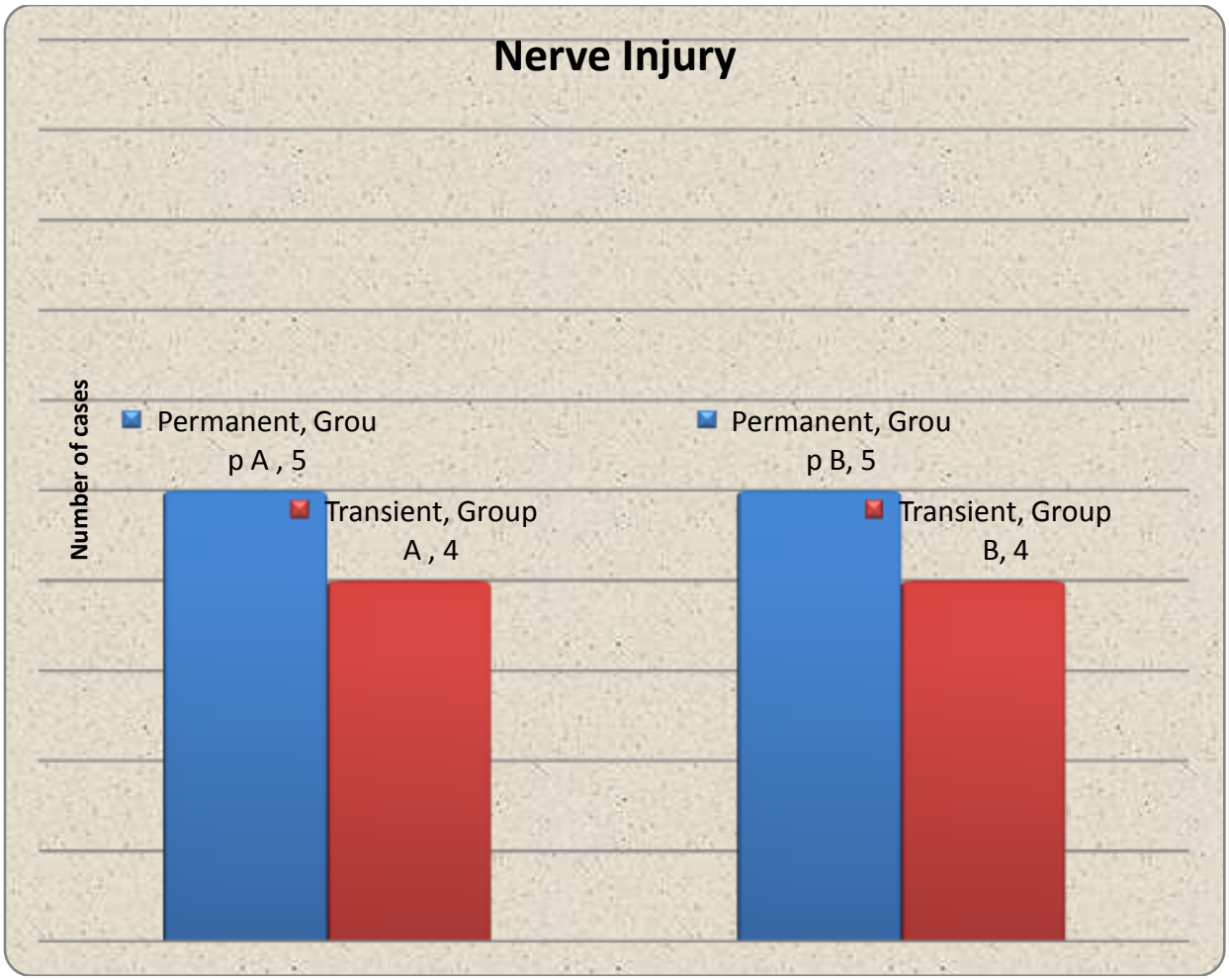


Table 11:- Distribution Of Subjects According To Duration Of Hospital Stay.

Duration of hospital stay (days)	Group A		Group B	
	No.	%	No.	%
3	17	34.00	16	32.00
4	23	46.00	24	48.00
8	10	20.00	10	20.00
Total	50	100.00	50	100.00
Result (P value)	0.975 (NS)			

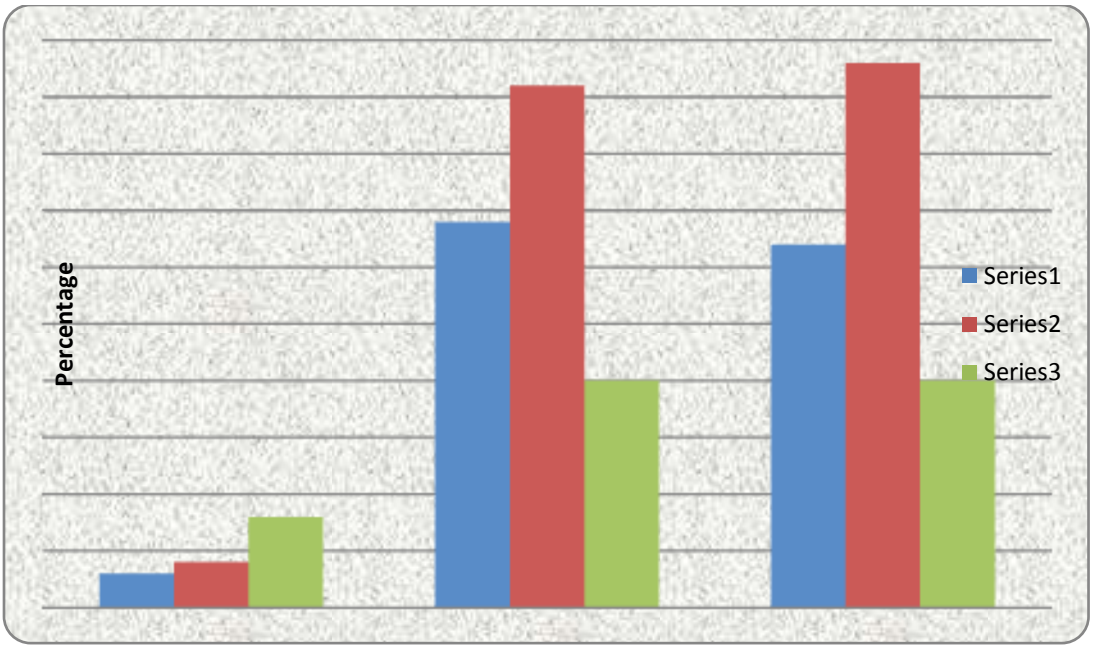
S = Significant; NS = Non-Significant

This table shows that-

Most of the subjects in 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).



Discussion and Conclusion:-

In the present study,

1. 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.
2. Majority of the subjects in both group A (96%) and Group B (92%) were females.
3. According to their residence, urban predominance is noted in both the groups.
4. No statistically significant difference is observed in terms of those demographic variables among both the groups, that ensured baseline similarity among the groups.
5. 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 observedstatistically, there was also, no significant difference between the groups.
6. Looking towards the chief complaints of patients enrolled for thyroid surgery, most of the subjects in both Group A (80%) as well as Group B (74%) presented with swelling in neck region. Difficulty in swallowing was present in only 20% of subjects in Group A and 26% of subjects in Group B and the difference was found to be statistically not significant.
7. 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.Nerve injuries while operating for Controlled toxic nodular goiter was seen in 0% subjects in Group A and 33.33 % subjects in Group B.In those having Revision thyroid surgery, it was elicited in 0% of subjects in Group A and 33.33% subjects in Group B.Operating for both Euthyroid nodular and Controlled Graves' disease resulted in nerve injuries to 0% of subjects in both Group A and Group B subjects.No significant difference was seen in thyroid disease among the two groups (p=0.693).
8. 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.
9. Permanent nerve injury was seen in 10% of subjects in both groups. Transient nerve injury was seen in 8% of subjects in both groups. No significant difference was seen in nerve injury among the two groups.
10. 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.

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