**THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY CHENNAI, TAMILNADU**

# A CLINICAL STUDY TO ASSESS THE RISK OF RECURRENT LARYNGEAL NERVE INJURY IN THYROID SURGERY

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# CERTIFICATE

This is to certify that the dissertation entitled **"A CLINICAL STUDY TO ASSESS THE RISK OF RECURRENT LARYNGEAL NERVE INJURY IN THYROID SURGERY"** submitted by **Dr. S. VENKATASARAVANAN** to the faculty of General Surgery, Government Rajaji Hospital, Madurai Medical College, Madurai, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, is in partial fulfillment of requirement in the award of M.S. Degree, branch – I (General Surgery) for the September 2006 examination and is a bonafide research work carried out by him under our direct supervision and guidance.

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# DECLARATION

I solemnly declare that this dissertation **"A CLINICAL STUDY TO ASSESS THE RISK OF RECURRENT LARYNGEAL NERVE INJURY IN THYROID SURGERY"** was prepared by me from the Department of General Surgery, Madurai Medical College and Govt Rajaji Hospital , Madurai , under the guidance and supervision of **Prof. Dr.K.V. Maheswaran, M.S., Reader in Surgery, Madurai Medical College , Madurai.**

This dissertation is submitted to the Tamil Nadu Dr.M.G. R. Medical University, Chennai ,in partial fulfillment of the university regulations for the award of the degree of M.S. Branch I General Surgery examinations to be held in September 2006.

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# CONTENTS

# INTRODUCTION

A post – operative bilateral permanent Recurrent Laryngeal Nerve (RLN) Palsy is a surgical tragedy. It is an iatrogenic horror comparable to a surgically induced facial nerve paralysis and possibly more incapacitating and embarrassing than the loss of a lower limb. Further more such a disaster is more than likely to be followed by the misery of litigation. Unfortunately thyroidectomy continues to produce a high rate of complications and damage to the recurrent laryngeal nerve is occasionally an inevitable complication of thyroid surgery. It may be temporary or permanent and/or unilateral or bilateral.

Since the remarkable contributions to thyroidectomy made by Kocher, there have been modification by various surgeons, great surgical pioneers such as Wolf and Blight recognized the risk of injury to the RLN and even today the reported incidence ranges from 0.3- 13.2%.

Opinion as to the advisability of deliberately exposing the nerve during thyroidectomy was sharply divided. Bier and his colleagues in their operations recommended dissection of the RLN at operation in 1914; and this practice was discussed, but considered to be inadvisable in “ A system of operative surgery” edited by Burgher in the same year. In 1918 Judd, New and Mann shows that

the RLN of dogs could be handled without fear of damage. Yet the routine exposure and visualization of the recurrent nerves at thyroidectomy was not undertaken on a large scale until 1935, when surgeons at Lahey clinic began the practice of demonstrating the nerves practically in thyroid operations and showed there by a marked reduction in their figures for nerve injury following throidectomy.

Crile (1929) had stated that, in many, the recurrent nerves were unlike other peripheral nerves in that they were naked and liable to damage by the slightest pressure or by the formation of scar tissue after exposure. This statement was vigorously denied by Berllin (1935) and by Lahey (1938), who claimed that the recurrent nerve was no different from other peripheral nerves, either in histological structure or in behaviour and could be handled with impunity.

The sustained advocacy of the dissection of the nerves at thyoidectomy by Lahey has undoubtedly influenced surgical practice profoundly, but opinion was far from unanimous. Pirelli (1993) condemned nerve dissection out of hand and dogmatically asserted the “ it is an axiom in thyroid surgery that a recurrent laryngeal nerve seen, is injured”. Hertzler (1938) stated that while he recognized that it was a sound surgical practice to safeguard important

structures in or near the operative field by exposing them, he had given up the practice of dissecting the recurrent nerves because he considered it harmful to remove the capsule of the nerve and expose its fibres to the exudates in the wound; he claimed that temporary disturbance of the cord function frequently followed dissection. These views were shared by many American surgeons (Smith 1964). In Britain, Joel (1932) with his unrivaled experience of thyroid surgery, considered it unnecessary provided that a wedge of the Posteromedial portion of the gland was left in situ. Pierce (1950) drawing from the experience of the New England Thyroid clinic, considered that isolation of the nerve in every partial thyroidectomy was a dangerous teaching, which could lead more to damage than to safety of the nerve. On the other hand Riddell, in a discussion at the Royal society of Medicine (1949) stated that he had adopted nerve dissection and strongly condemned what he termed 'blind' thyroidectomy. To hold the view that a recurrent nerve seen is a recurrent nerve injured is to adopt the naïve philosophy of the ostrich (Riddell 1970). Russell (1951) also recommended routine dissection and identification of the recurrent nerves as a standard technique of thyroidectomy.

In 1977 Holt has examined the problem again and emphasized the importance of nerve identification. In 1983 Farrar WB et al and in 1985 Martensson et al favoured identification and preservation of the RLN.

In 1991 Greatorex et al showed the importance of the RLN identification in thyroid surgery.

In this new era of thyroid surgery most authors agree with the principles proposed by Lahey in 1944 and favour routine systematic exposure of the nerves, that not only safeguard the nerves, but that the careful dissection entailed ensures that adequate thyroid tissue is excised, that homeostasis is more easily and certainly secured and that the parathyroid glands are less likely to be removed.

# AIM OF THE STUDY

The primary purpose of this study is to assess the risk of damage to the RLN during thyroidectomy. Secondly, it is hoped to obtain information as to whether or not impairment of nerve function follows adequate dissection of the nerve at operation.

# REVIEW OF LITERATURE

## INCIDENCE OF INJURY:

The rate of RLN palsy after thyroid gland surgery varies from 0.3% to 13.27%, although in experienced hands the rate of injury should be quite low from 0.3-2%. Ideally it should be below 1%. Statistical differences exist at least in part because injury rates are sometimes reported per number of operations and sometimes per number of nerves at risk.

The rate of RLN injury is clearly related to several factors, including surgeon' s experience, difficulty of operation, anatomical variations, benign versus malignant etc. Martensson and Terins reported a 5.8% injury rate per number of operations and a 3.6% injury rate per number of nerves at risk in primary operations. However they showed a 14% injury rate per number of operations or 9.2% of nerves at risk in secondary and cancer operations.

According to Sinclair IS of Royal infirmary of Edinburgh, (1994) there is a greatly increased risk in retrosternal goiters (17.5%) and in unilateral lobectomy (11.8%) as compared with bilateral resectioning for adenomatous goiter (5.2%)

For wagner (1994) the rate of RLN palsy was 5.9%, with 2.4% being permanent . For subtotal lobectomy it was 1.1% and for total lobectomy the rate was 4% . When the RLN was not exposed the rate increased to 7%.

Harris SC (1992) reported a nerve injury rate of 1%

According to Victor Riddell (1970) the RLN injury in a non – thyroid clinic may be as high as 10%.

Also it has been the experience of most authors that the right recurrent nerve shows a greater incidence of injury than the left nerve (Coller, 1938) (Wade 1955).

**RLN PALSY:**

It can be permanent or transient. Fortunately, nature is on the side of the patient (and surgeon) and the majority recover. While the transient injury rate is of interest, it is the permanent injury rate that is of real importance in recording the true damage rate to the recurrent laryngeal nerve. The transient injury rate is a warning only and not a conclusion. A warning in the sense that all palsies should be followed up post operatively, when we will be surprised to find a recovery in many. A palsy that remains after 12 months which is considered as permanent (Riddell 1970), although recovery has been reported after 3yrs.

According to Malcolm H Wheeler et al, the cut off line is 18 months after which a nerve regeneration and recovery can't be expected.

## SURGICAL ANATOMY OF RLN:

RLNs were probably first described by Galen as early as 2nd century, but the relevance to the operation of thyroidectomy remains hidden until Kocher's remarkable contributions rendered this procedure safe. The RLN differs, as to its origin and course on the two sides of the body. On the right side it arises from the vagus nerve in front of the subclavian artery. Near the lower pole of the lobe of the thyroid gland the nerve is always intimately related to the inferior thyroid artery. The relations of the RLN to the inferior thyroid artery are highly variable and will be described later.

On the left side it arises form the vagus nerve on the left of the arch of the aorta and winds below the arch immediately behind the attachment of the legmentum arteriosum to the concavity of the arch and then ascends to the side of the trachea.

The nerve on each side ascends in or nearer the groove between the trachea and oesophagus, near the 2nd/ 3rd tracheal ring it passes behind the thyroid gland under the lower border of the inferior constrictor and enters the

larynx behind the articulation of the inferior cornu of the thyroid with the cricoid cartilage. RLN is a branch of vagus and RLN runs against the course of vagus (below upwards) to supply various organs this is why it is called as recurrent nerve. It gives branches to all the muscles of the larynx excepting the cricothyroid. At or near the level of the inferior border of the thyroid cartilage, the RLN gives off the tiny abductor branch posteriorly and medially to the posterior cricoarytenoid muscle and the purely sensory Galen's anastomossi posterolaterally. The remaining portion of the RLN passes to the inter arytenoids, thyroarytenoid and the lateral cricoarytenoid muscles. This trifurcation is approximately lcm above the lower most corner of the thyroid cartilage in most humans. It communicates with the internal laryngeal nerve above, and supplies sensory filaments to the mucous membrane of the larynx below the level of the vocal folds. As it curves round the subclavian artery or the arch of aorta, it gives several cardiac filaments . As it ascends in the neck it gives branches , more numerous on the left than on the right side, to the oesophagus and to the trachea.

# ANATOMICAL VARIATIONS OF RLN OF SURGICAL IMPORTANCE :

## INTRANEURAL TOPOGRAPHY:

Richard R. Gacek et al (1977) reports that the laryngeal motor neurons can be separated in to abductor and adductor group in the brain stem nuclei, but the axons of these two groups of motor neurons are mixed throughout the central and peripheral course of the vagus nerve . The motor fibres collect into abductor and adductor halves of the RLN before entering the larynx. The implication of this arrangement is that theories based on a vulnerable position of a particular group of motor neurons are not tenable in the vagus nerve, but may be in the RLN.

If this were so, according to Sunderlond and Swaney, the abductor fibres could be selectively injured , but it would still be difficult to explain how the abductor branch should be the one more prone to injury. They found that in 70% of their dissections the nerve divided in to its 2 terminal divisions before reaching the inferior constrictor, but they did not find that the extralaryngeal division represented a separation of the nerve fibers in to two system, one innervating the abductors and the other the adductors. More usually they found

a wide variation in the pattern of the two terminal branches, with each carrying both abductor and adductor fibres.

Study of the internal structures of RLN showed that the nerve bundles were not arranged as segregated parallel strands. In stead they formed repeated plexuses leading to such an intertwining and frequent redistribution of the fibres that no constant anatomical arrangement of fibres within the main trunk could be maintained or become separated to subserve the function of any particular group of muscles.

## EXTRALARYNGEAL BRANCHING :

Extralaryngeal branching is not an anatomical rarity. There are wide variations in the reported frequency of occurrence of extralaryngeal divisions ranging at any point peripheral to the origin of the main trunk of the nerve form the vagus, but branching is uncommon below the level of the inferior thyroid artery. Majority of the nerves with branching did so within 0.6 to 3.5 cm from the inferior border of cricoid certilage in the tracheo oesophageal groove with an average of 1.96cm. the branches many number two (usually) to six (Bowden 1955).

## RLN AND INFERIOR THYROID ARTERY :

The anatomy of the RLN with special reference to their relation with the inferior thyroid arteries has been extensively reviewed by Fowler and Hanson (1929), Reed (1943) Bowden (1955) and Wade (1955). The inferior thyroid arterial pattern shows gross variation and that the recurrent laryngeal nerve lying within this vascular network also shows gross variations in its relation to the arterial trunks. The inferior thyroid artery reaches the junction of the lower and middle third of the lateral lobe of the thyroid gland where it breaks up in to glandular branches. Of these terminal branches there is a constant ascending branch and a descending branch. These again break up into smaller branches. The artery may be absent sometimes. Also anomalous RLN can occur on right side. Almost all authors agree that the nerve most commonly lies deep to the artery. There is a marginal variation in the percentages quoted of those lying superficial or between the branches (Riddell). According to Wade, the RLN lay deep to the inferior thyroid artery and all its branches in 46% of cases, superficial to it in 10% and between the terminal branches in 3.5%.

According to Bowden, when right and left sides were analysed, it was found that on the right side there is almost equal chances of finding the nerve anterior, posterior or intermingled with the branches of the artery. On the left

side the nerve is most likely to be posterior to the artery and least likely to be anterior. A bilaterally symmetrical relation can be noted in 33% of cases.

The exact relationship between the terminal branches of the nerve and of the artery are extremely difficult to follow since the artery may be absent, may divide in to two main branches well lateral to the gland, or may have as many as 4-6 terminal branches while the nerve itself may be undivided as it enters into the larynx or it may have as many as six branches. Thus considering these different patterns, Reed described 28 different types of relations and Bowden described 60 different types of relations.

But for convenience , we will consider 8 main variations of surgical significance (Wade 1957).

Group 1- Nerve superficial to the trunk or to the two divisions

Group 2- Nerve deep to the trunk or to the two divisions

Group 3 - Nerve between the two divisions

Group 4 - Nerve between the glandular branches of the inferior division

Group 5- Nerve between the glandular branches of the superior division

Group 6 - Nerve between the glandular branches of the superior and inferior division.

Group 7 - No inferior thyroid artery present

Group 8 - Anomalous nerve

## THE COURSE AND FASCIAL RELATIONS OF THE RLN IN THE NECK :

The fascial envelop of the thyroid glands formed by the pretracheal fascia, and it is this layer which forms the important fascial relations of the RLNs. The anatomy of this layer appears to be variable, so that descriptions of it often differ markedly from each other. This is particularly so in regard to that portion which ensheathes the Posteromedial aspect of the thyroid gland, even in the case of special studies of the fascial arrangement in this region (Pool and Falk 1916, Fowler and Harison 1929, Thocck 1949). In the presence of a goiter the arrangement and relationships of the fascia may be grossly distorted, especially in the important area lying between the surface of the thyroid gland and the trachea.

In the lower third of its course the nerve passes upwards and forwards, covered by a fascial layer of varying thickness, which also encloses the trachea and the inferior thyroid veins. It is surrounded by areolar tissue which is particularly marked on the right side, where the nerve lies further from the trachea and oesophagus and it is unusual to find it running horizontally in the groove between them. In the middle and upper third of its course the nerve runs parallel and closely related to the trachea, before arching gently backwards to enter the larynx immediately behind the inferior cornu of thyroid cartilage.

In the upper third of its course the nerve invariably lies medial to a well developed layer of fascia, the suspensory ligament of the thyroid gland, which attaches the middle part of the thyroid lobe to the cricoid and upper tracheal cartilages . In the middle third, the fasical relations are less constant; the nerve may be between the suspensory ligament and the trachea, within the suspensory ligament itself, or lateral to the suspensory ligament and intimately related to the thyroid lobe. Berlin (1935) in an analysis of his dissections , in the mid-thyroid area gave 65% of nerves as lying medial to the ligament, 25% within the ligament, and 10% in close relationship to the thyroid tissue lateral to the ligament.

Certain practical points suggested by Wade (1955) include (a) in the lower third of the course of the nerve the fascial layer is usually thin enough to enable the surgeon to palpate the nerve as a tight strand or roll it against the tracheal ring. (b) in the upper third, where the nerve normally lies medial to the tough suspensory ligament, exposure is more difficult than in the middle and lower thirds .

(c) in the lower and upper thirds of its course the nerve is usually bound to the trachea and oesophagus by a fascial layer, Fasical fixation to the goiter the these sites is therefore uncommon, as compared with the middle third of its course, where fascial fixation could occur in about 35% of cases (Berlin 1935) .

**ANOMALOUS RLN:**

A non recurrent laryngeal nerve was first descried over 160 years ago by Stedman. Its incidence ranges form 0.3-0.8% . A non- recurrent nerve is most often seen on the right side. If the embryonic fourth aortic arch on the right side disappears, so that the right subclavian artery arises directly form the descending aorta, no artery remains to hold down the recurrent nerve in the thorax. As a result the right inferior laryngeal nerve arises directly from the vagus trunk, at the level of the cricoid, passes behind the common carotid artery to enter the larynx behind the inferior cornu. Lahey (1944, 1947) described two courses for anomalous nerves . In the first, the nerve looped downwards to hook around inferior thyroid artery, and in the second, the nerve ran directly into the larynx.

A non- recurrent inferior laryngeal nerve on the left side is a great rarity This can occur in situs inversus. But the chances of encountering this anomaly the thyroidectomy can surely be disregarded.

Very rarely a right non- recurrent nerve may be associated with an additional recurrent branch. The operating surgeon if unaware of these possibilities he may inadvertently injure the inferior laryngeal nerves.

## MODES OF DAMAGE :

The RLN may conceivably be damaged during thyroidectomy in several ways.

1. Crushing
2. Compression in a ligature
3. Division by a sharp instrument
4. Stretching (neuropraxia)
5. Ischaemia following nerve exposure
6. Involvement in fibrous tissue following nerve exposure
7. Compression by a haematoma
8. Oedema
9. Heat by diathermy
10. Post – op neuritis of the nerve
11. Post- op suction damage by suction drains

## 1. CRUSHING

Crushing by a haemostatic forceps is a common cause of injury. Haemostats placed along the proposed line of resection of the thyroid lobe or picking up small bleeding points on the lateral aspect of trachea, particularly on the medial aspect of the superior pole of the gland can cause damage even in

experienced hands. Animal experiments of Judd et al (1918) says that majority of the pure crushing injuries are temporary. However as it is usual to tie a ligature about the points of a haemostat or to underrun it with a suture , it seems probable that the majority of nerve injuries due to crushing at thyroidectomy do in fact result in permanent damage.

**2. COMPRESSION IN A LIGATURE:**

Commonest mode of injury whether this occurs through ligating a bleeding point or through suturing the gland tissue depends largely upon the technique of the surgeon .

**3. DIVISION BY A SHARP INSTRUMENT:**

While crushing and compression of the nerve in a ligature are the common mechanisms, the nerve may less frequently be divided by the scalpel, either during resection of the gland, or more rarely when the inferior thyroid veins are divided . This mode usually results in a permanent damage.

**4. STRETCHING:**

Stretching of the recurrent nerve to a major degree must be a common occurrence , while the goiter is displaced forwards prior to resection .

However, if the nerve is tethered to a large substernal goiter stretching will be much more severe enough to cause a permanent nerve damage. Judd (1918) opined that the nerve will tolerate quite severe stretching, and that paralysis from this cause is relatively uncommon.

## 5.6 ISCHAEMIA AND FIBROSIS FOLLOWING EXPOSURE OF THE NERVE :

The RLN is accompanied into the larynx by the inferior laryngeal branch of the inferior thyroid artery and an unnamed artery form the thorax. Damage to these vessels during rough exposure of the nerve is quite possible . In the same way, involvement in fibrous tissue following mobilization of the nerve is possible, although histological examination leads,, no support in this views. (Berlin – 1995) . Many authors suggest strongly that nerve damage following exposure is more exceptional , provided that the nerve is not roughly handled.

## THE CAUSES OF VULNERABILITY / DAMAGE :

The nerve becomes vulnerable if it is displaced from its expected anatomical course to such an extent that is liable to damage during resection of the thyroid lobe. Thus, during the increase in size of the thyroid gland in goiter formation, any factor which tends to tether the nerve to the gland tissue may

cause it to be displaced and if there is gross and asymmetrical growth of the gland, as occurs particularly in nodular goiter, the nerve may be displaced to an extraordinary degree. The various causes are:

## 1. ARTERIAL FIXATION:

The nerve may be fixed to the goiter by the fork formed by a dividing artery. This is the commonest cause of displacement. Gross displacement, however is not essential in order to render the nerve vulnerable in this case. A nerve running a comparatively normal course may be picked up in a haemostatic forceps if it lies between the branches (main/glandular) of the inferior thyroid artery and particularly so if the goiter is a vascular one and the branches bleed after section, despite ligature of both superior and inferior pole vessels . If there is arterial fixation, the closer the arterial trunk approaches the gland before it divides, the greater is the danger to the nerve, however small goiter is.

## 2. FASCIAL FIXATION :

Fascial fixation is another important cause of vulnerability particularly in the middle third where the fascia is notably thickened and will tend to bind the nerve firmly to the developing goiter. In the middle third the nerve may pass

deep to or through the ligament or even superficial to the ligament. In the lower third of its course the nerve, does not normally come into direct relationship with the gland and the nerve is covered by a fairly thin fascia and areolar tissue which constitutes no particular problem.

Almost invariably the nerve in its upper third passes deep to the fascial structure and is vulnerable.

**3. TUNNELING:**

Although the recurrent laryngeal nerve actually pierces the true thyroid, capsule, the normal lobulation of the thyroid gland can form a crevice in which the nerve may run; (Flower an Hanson 1929), but borrowing or tunneling of the nerve through the thyroid tissue is the result of its enclosure by abnormal accentuations and lobulations of the goiter or by irregular growth of nodules. Similar tunneling and fixation is often seen in malignancy as a result of enlarged metastatic nodes and in multi nodular goiter. The recurrent nerve may of course be directly involved in the primary tumour mass. It is wise to remember that tunneling is rarely a primary cause of fixation of the nerve to the gland, but that it occurs later, as the goiter increases in size. The nerve being already fixed to the gland by an arterial fork or by fascia.

## 4. DISPLACEMENT OF THE NERVE FOR NO APPARENT REASON:

In the normal course, the recurrent nerve in the lower third inclines obliquely forwards across the line of the trachea and oesophagus until it levels out along the trachea at the junction of the middle and lower thirds of its course in the neck. Very occasionally this forward inclination is exaggerated for no apparent reason (Fowler & Hanson 1929), so that the nerve lies on a plane anterior to the trachea, and in such intimate relationship to the inferior thyroid veins, putting it in grave danger of being ligated and divided with the veins. This accident can happen readily, particularly if a mass ligature is used for securing the veins. For this reason, the nerve should be found first and the vein tied afterwards (Riddell 1970), if this is not possible , individual ligation of the veins may be performed (Wade 1955).

## 5. THE TYPE OF GOITER:

Vulnerability is more with large nodular goiters. Diffuse toxic goiters are some what more frequently associated with vulnerable nerves than were nodular goiters . Retrosternal goiter is a high risk factor for vulnerability.

## 6. SIZE OF THE GOITER:

If the recurrent nerve is tethered to the thyroid gland, the larger the goiter, the greater must be the liability of the nerve to displacement from its course and hence greater the vulnerability, particularly in the middle and lower thirds of its course.

## 7. TYPE OF SURGERY:

Greater risk for second or third operations. Total lobectomy is associated with increased damage when compared to subtotal lobectomy. Also operations for malignancies show greater incidence of nerve damage .

## 8. DIFFERENCE IN VULNERABILITY BETWEEN LEFT AND RIGHT NEVES:

It has been the experience of most observes that the right recurrent nerve is more often damaged than the left (Coller 1938, Wade 1995, Riddell 1970). This may be because of the obliquity of the nerve's course in the lower third and its distance from the trachea compared with the course of the left nerve. Also because the anatomical variations and anomalies are more often encountered on the right side than on the left.

## 9. ANOMALOUS RECURRENT LARYNGEAL NERVES:

The anomalous nerve in its distal part runs exactly the same risk as does the ordinary recurrent nerve in the upper third of its course. In the lower part of the neck it is absent and there fore at no risk. The hazard is due to failure to recognize the high origin of the nerve and its sweeping course medially, so that a ligature could be placed around the inferior thyroid artery and include the nerve. Provided the surgeon is alive to the possibility of encountering an anomalous nerve the risks of ligature in its proximal part are less than those run by a normal nerve in the lower two thirds of the operative field (Wade 1955).

10. Haemorrhage is the agent which prepares the conditions most favourable to injury at all sites. (Riddell 1970)

12. A poor surgical technique is a very important cause of injury.
13. Another cause of vocal cord paralysis during thyroid surgery is the damage inflicted by endotracheal intubation for anaesthesia.

## SITES OF VULNERABILITY:

The recurrent nerve is fixed to the enlarging goitre may be displaced either anteriorly to lie between is medial surface and the trachea, or laterally to lie under its posterior surface. In the later position the displacement from the

anatomical course is exaggerated during thyroidectomy when the lateral lobe is mobilized and turned forward, so that the liability to damage is increased.

## 1. VULNERABILITY AT THE UPPER THIRD:

RLN is most vulnerable at the upper third. It is particularly to occur when small glandular branches of the superior division of the inferior thyroid artery are picked up close to the trachea, if the nerve is lying amongst them. The course of the nerve in the upper third is far more difficult to demonstrate than in the lower two thirds, because the fascia is usually much tougher and the goiter more difficult to dislocate forwards. The temptation to dispense with this part of the discussion is often very great, but it should be absolutely resisted unless the surgeon be quite certain that the nerve is lying deep to the branches of the artery and passing well clear of the thyroid tissue towards the inferior cornu of the thyroid cartilage.

It has been suggested that the recurrent nerve in the upper third can be embraced in a ligature of the superior thyroid pedicle (Luchetti, 1944) It occasionally happens that a goiter lies much lower in the neck than is normally the case, and the superior pole lies at or below the cricothyroid articulation . In this event the nerve may be extremely vulnerable, and it is always advisable to palpate the inferior cornu of the thyroid cartilage when passing a ligature

around the superior thyroid vessels, it is felt that discussion of the nerve in the upper third of its course is particularly essential if the goiter lies low in the neck.

## 2. VULNERABILITY AT THE MIDDLE THIRD:

In the middle third of its course, when arterial fixation is the cause of nerve vulnerability, the nerve is usually displaced laterally and caught in the fork of the arterial division Moreover, it is in the midthyroid region that the nerve is liable to come into intimate relationship with the thyroid tissues and to be bound to it by fascia forming the strong suspensory ligament; so that fascial fixation and tunneling are more commonly found at this site than at the upper or lower poles of the gland.

## 3. VULNERABILITY AT THE LOWER THIRD:

In the lower third of its course the nerve may be displaced anteriorly or laterally on the thyroid lobe, and thus endangered by arterial fixation. Also the nerve may be vulnerable because of its proximity to the inferior thyroid veins. To avoid this, identify the nerve before dividing the inferior thyroid veins, or if this cannot be done, identify and ligate the veins individually (Wade 1955) .

## PREVENTION OF DAMAGE:

The essential prerequisite for a safe thyroidectomy procedure, free of any significant risk of damage to the recurrent laryngeal nerve, are a complete awareness by the surgeon of the normal nerve anatomy and its many possible variations and discipline of identifying the nerve throughout its course in the neck. All surgeons will acknowledge the fundamental principle that an important structure liable to injury during an operation should be identified in order to ensure preservation. This is usually accepted. Although some controversy has surrounded the issue of exposure of the RLN it is generally agreed that identifying the course of the recurrent nerve during thyroidectomy is the best way to avoid injury. (Reeve TS 1969).

For majority of the surgeons, if nerve preservation is to be ensured identification is mandatory (Riddell 1970, Wade 1955, Malcolm H Wheeler 1991). They argue that modern anaesthesia and surgical techniques have replaced speed in thyroid surgery with precision and so allow the operator for an unhurried search for the RLN in a field which should be bloodless. If RLN is injured when identified , it is likely to be a transient palsy and recovery will follow;

Visual identification is not enough. Identification and integrity are not the same thing (Riddell 1970) . The assumption that identification ensures integrity can lead to a false belief that the nerve is transmitting impulses normally. This may not be so, as it is so exceedingly sensitive to invisible trauma from stretching and oedema or clot retention postoperatively . The integrity of the nerve can only be established by proving that it transmits nerve impulses . There are several methods to establish the integrity of the nerve.

## EXPOSURE OF THE RECURRENT LARYNGEAL NERVE:

The first step in identifying the nerve is to find and display the inferior thyroid artery. The anatomical details of inferior thyroid artery and RLN have already been described in detail . It was a principle of thyroid surgery to tie the inferior thyroid artery as far out as possible where the ligature is less likely to include the nerve and most likely to catch the main artery before it divides . Now the principle is that, if at all ,there is a need to divide the inferior artery (most often no), the actual division or ligation should not be made until the recurrent nerve has been identified. Initial identification of the RLN should be in the lower third of its course. For convenience various anatomical triangles have been described . In 1957 Simon described a triangle bounded laterally by the common carotid artery , above by the inferior thyroid artery and medially by the recurrent nerve. In 1977 Beahrs described a triangle as – common

carotid artery posteriorly, inferior thyroid artery superiorly and the recurrent nerve anteroinferiorly. In 1977 Lore proposed a different triangle utilizing the carotid artery laterally, the trachea and esophagus medially and lower pole of the thyroid lobe superiorly.

Visual identification is aided by a preliminary search for the nerve by finger tip palpation. In a high proportion of patients, this is a quick guide to its location The nerve feels like a cord like structure which can be rolled against the trachea. Palpation alone is insufficient. The tissues in the abovedescribed triangles are opened with a haemostat, the jaws being opened along the line of the nerve.

The nerve is exposed for 2cm of its length without touching it with an instrument. The nerve is characteristically white and shiny . Scrutiny will confirm the passage of sensory nerve rootlets to each tracheal segment It is also recognized by the minute vein which runs upon its surface (Riddell 1956). Some people use nerve stimulator to confirm its identification. Identification of the recurrent nerve does not require its naked exposure as in an anatomical display specimen. It is wrong and unnecessary to dissect out or strip the nerve of its ensheathing fascia (Riddell 1970). The operation must be done gently, because the nerve is readily damaged by stretching if too much traction is

exerted on the gland : which is particularly liable to occur when the thyroid lobe is unusually mobile . Visualization in the region of the inferior thyroid artery with precise definition of the nerve / artery relationship and any fixation by the arterial branches is then achieved . A potential pitfall for the unwary exists when the RLN appear to pulsate if it passes superficial to the inferior thyroid artery and may therefore be mistaken for a vessel and ligated. In the operation of lobectomy , the small arterial branches must all be individually clipped and tied close to the thyroid gland staying on the thyroid capsule.

To identify the nerve as it passes further towards the larynx through the area of Berry's ligament where it is at greatest risk, this suspensory fascia must be divided . This is most safely accomplished by staying close to the thyroid and picking up superficial layers one at a time with fine haemostats, being absolutely certain at each stage that only fascia and small arterial branches are included. The RLN is soon seen at a deeper level glistening with its fine accompanying arterial blood vessel. Careful scalpel dissection along the thyroid capsule rather than the use of scissors is most effective . The parathyroid glands are teased laterally with their blood supply intact and mobilization of the lateral lobe continued. It will be noted that the main inferior thyroid artery trunk is not ligated.

Sometimes the nerve cannot be found in relation to the inferior thyroid artery. This occurs most commonly when an adenoma displaces the artery downwards. In such cases, before searching for the nerve in the upper part , repalpation with the finger- tip amidst the inferior thyroid veins is advisable. Sometimes it is not an easy exercise. If the nerve has not be found inferiorly it is justifiable to search for it in the upper part of the wound and trace in downwards. The key here is the inferior corn of the thyroid cartilage which can be easily palpated. Here the nerve bears a constant relation to the cricothyroid articulation. It lies behind this articulation before becoming endolaryngeal (Rustad 1954, Disko – Dubienski, 1960)

**OTHER MEASURES TO REDUCE DAMAGE :**

Strict haemostasis must be employed while searching for the recurrent laryngeal nerve. If a bleeder is inadvertently divided, it should be controlled immediately and the blood irrigated away before proceeding further with nerve identification .

Wade drew attention to the possibility of the nerve injury during ligation of the superior thyroid pedicle and has been mentioned previously. In STT the nerve should be identified before the thyroid gland is incised and that any haemostats placed in the remnant of thyroid for haemostasis must be

meticulously inserted to avoid the nerve, and if the technique of suturing the remnant to the larynx is employed, traction of the thyroid tissue and nerve must be avoided.

If the suction drains are used, it is important to avoid placing them in close proximity to an exposed nerve lest it should induce suction damage.

**INTEGRITY OF THE RLN:**

A nerve stimulator is invaluable in determining whether or not an unidentified strand of tissue is RLN. Several techniques have been proposed based on the electrical stimulation of the RLN responds to direct electrical stimulation 1 mA or less and that increasing intensities make the response less selective but can lead to nerve location. D' Ingianni (1956) and Shedd & Burge (1996) described per- op RLN stimulation & endolaryngeal ballon spirography. Most commonly used a sophisticated double – cuffed endotraheal tube that simultaneously occlude the trachea while monitoring pressure change, induced by RLN stimulation , in the second proximal cuff placed between the vocal cords . Electromyography (EMG) has been used by several authors to monitor the function of the laryngeal muscles after stimulation of the RLN.

Some authors presented a microlaryngeal electrode for EMG monitoring, Two fine needle electrodes are placed on the vocal cord, endoscopically and the electromyographic activity on RLN stimulation is registered using a nerve integrity monitor . Certain monitors provide the capability for monitoring the vocalis muscle electromyogram by means of visual and auditory display. It also provides the capability of performing evoked electromyogrpahic tests of nerve integrity.

In 1973 Kratz proposed the use of the surgical microscope and facial nerve stimulator to accurately locate the RLN during surgery. The stimulation of the RLN cause a downward and lateral movement of the larynx that can be felt with a finger placed on the thyroid gland and mobilize the trachea and larynx form the thyroid gland prior to RLN stimulation to detect the laryngeal movement produced by stimulation . It is also possible that the larynx may fail to move leading the surgeon to a false conclusion.

Based on similar principles James et al, stimulating the RLN detected the movement produced in the cricothyroid muscle . This has no anatomical basis and hence not recommended .

In 1986 Gavilan and Gavilan described another simple method, based on direct electrical stimulation of the RLN with a disposable nerve stimulator and palpation of the response of the posterior criocoarytenod muscle (posticus).

Riddell recommends direct stimulation of the RLN and the anaesthetist observing the movement of the vocal cord by a direct laryngoscopy . For technical reasons if the preoperative laryngoscopy is difficult he recommends another technique . Feel the inferior horn of the thyroid cartilage and slide finger up to the outer side of the ala and feel the vibratory movement , if the vocal cord is functioning .

Lastly, if the thyroidectomy is performed under local anaesthesia , it is said that the voice can be tested during the operation and thus the integrity of the RLN can be ensured . But some times the altered quality of voice can be misleading. Hager (1934) considers this method as one lacking precision.

## LARYNGOSCOPY:

### Preoperative:

Preoperative indirect laryngoscopy should always be performed by an independent otorhinolaryngolgist as the occasional patient will already have asymptomatic laryngeal nerve palsy, unsuspected owing to some unrelated cause. Also the thyroid pathology itself can cause recurrent nerve paralysis. Such preoperative information is vitally important and will often influence the precise surgical procedure to be performed , it being necessary for the surgeon to take even more than the usual care to avoid damaging the opposite nerve. It may influence the surgeon's decision to operate if the normal nerve is on the side of the lesion. It may also exonerate him in the medicolegal sense if a complaint is raised about a paralysed cord postoperatively in a patient who has undergone preoperative laryngoscopy. If this preoperative precaution is omitted, a laryngeal palsy not unnaturally is likely to be attributed to the thyoidectomy . Also it is important in patients who have had a previous operation on the thyroid gland.

## OPERATIVE:

By laryngoscopy during operation and simultaneously stimulating the exposed recurrent nerve, we can observe the presence or absence of vocal cord

movement. The true cords should be looked for beyond the aryepiglottic folds as the latter are bilaterally innervated and both folds will move normally despite one nerve being nonconductive. If laryngocopy is carried out during the operation and impaired movement is found, which persists after stimulating the nerve, a palsy should be assumed until proved otherwise by subsequent recovery. To ignore this finding makes a mockery of the endoscopy. If this is detected, extra care can be taken to avoid damage to the recurrent nerve of the opposite side.

## POSTOPERATIVE LARYNGOSCOPY:

Post – op laryngoscopy is essential for a true estimate of the frequency of vocal cord damage due to thyroidectomy. A cord paralysis following throidectomy is commoner than is supposed. Some existing statistics tend to tbe based on the selective postoperative examination of patients who have some obvious symptoms of damage, for example a hoarse voice (Cattell 1948). An assessment on the basis of audible phonation is unlikely to be reliable. A hoarse voice is very common after any surgical procedure involving endotracheal intubation. Also this method does not reveal those instances where rapid compensatory readjustment of the unparalysed cord has produced a normal speaking voice at conversational distance.

Post-operative laryngoscopy depending on the findings may be required at three different intervals of time.

## I. IMMEDIATE (OPERATING THEATRE):

Laryngoscopy immediately after thyroidecotmy while the patient is still anaesthetized or at the time of extubation by the anaesthetist may be helpful, but is less reliable. Because, pressure on the vocal cords by an endotracheal tube may temporarily limit adduction or abduction and also the depth of anaesthesia or the use of a relaxant may prevent normal movement. In the post op period the paralyzed cord lies in the paramedian position. Over the next several weeks the vocal cord may lateralise slightly.

## 2) CONVALESCENCE (WARD):

Usually done on the fourth or fifth day of surgery. This is usually indicated if the laryngoscopy in the theatre was equivocal or cord was not moving.

## 3) FOLLOW – UP (OUT PATIENTS):

A palsy still present on discharge from the ward must be followed up at reasonable intervals for at least 1 year, before finally being declared permanent.

## RECURRENT LARYNGEAL NERVE REGENERATION:

The injured recurrent laryngeal nerve has marked regenerative potential and capability. Nerve transection or ligation does not always result in total RLN paralysis. Patients with spastic dysphonia treated with section and ligation have been reported to demonstrate nerve regeneration with medial vocal cord bulging and glottic compromise. In an animal study of RLN regeneration it was found that nine of ten dogs demonstrated regeneration after 1 inch segment of the RLN was removed and the proximal and distal stumps ligated. The dog's larynges had random adductor and abductor reinnervaiton (Laryngeal synkinesis). Since the injured RLN is likely to regenerate, it is probable that degree of laryngeal reinnervation results whenever the nerve is partially clamped, minimally cauterized or otherwise sub totally injured . If the desired amount of regeneration occurs, that is , just enough to achieve muscle tone in the vocal cord adductors and abductor muscle, the vocal function of the larynx may be satisfactory or even normal. However, if the nerve regenerates a large number of healthy axons back to the larynx from the site of injury laryngeal synkinesis will most likely result, with medial vocal cord bulging that may cause glottic compromise and with spasm of the adductor muscles producing vocal spasticity.

# MATERIAL AND METHODS OF THE STUDY

A prospective study involving 100 RLNs in 70 surgical patients at Govt. Rajaji Hospital Madurai was performed over a period of two and a half years. Patients were selected preoperatively from different surgical units on a random basis. The patients ranged in age form 15 to 70 yrs and majority were in the 20-45 yrs group. Of these patients 13 were males and 57were females. All were scheduled for thyroidecotmy – total / near total, subtotal or lobectomy. Disease entities were both benign and malignant including thyroid cancer, thyroid adenomas, multinodular goitre and grave's disease.

Patients were selected preoperatively on a random basis, from different surgical units. All the patients selected for the study were subjected to preoperative indirect laryngoscopic examination to assess the status of the vocal cords. Only patients with bilaterally normal vocal cords were included. Operations on patients with evidence of existing nerve lesions and operations patients, in whom, for any reason both vocal cords were not visualized on indirect laryngoscopy have been rejected. All patients were subjected to thryoidectomy under general anaesthesia with endotracheal intubation. There were two groups, one group of patients undergoing thyroidectomy without identifying the RLN and the other group only after identification of the course

of the RLN. All the operations were carried out by qualified surgeons in accordance with the standard surgical techniques for thyroid operations.

At the time of extubation a note of the vocal cord position was made by the anaesthetist by a laryngoscopy. Subsequently these patients were subjected to indirect laryngoscopic examination at following intervals – 5 days , 3 weeks, 6 months and 1 year after surgery. Thus every patient was followed up for a period of 12 months after surgery. In case of vocal cord paralysis, If the vocal cord movement improved to normal status in this 1 year follow up, these were considered as temporary paralysis, and if the paralysis persisted after 1 year, they were declared as cases of permanent paralysis.

# RESULTS

The results of the study are analysed with references to the number of RLNs encountered during operations, and not in relation to the number of operations performed.

A total of 100 nerves were observed. Of these 53 nerves were exposed and 47 nerves were not identified. Right recurrent laryngeal nerves numbered 57 and left 43. No single case of bilateral paralysis was encountered in this study. Out of the 100 nerves, 8 were found to be primarily injured in the immediate post operative period . Among the 8 nerves injured 4 cases recovered in the 1 year follow up; first 2 within 21 days after surgery and the remaining 2 cases recovered before the end of 1 year.

In the remaining 4 cases damage (all unilateral) was permanent, putting the overall incidence of permanent recurrent laryngeal nerve injury to around 4%.

## TABLE I

## RLN PARALYSIS BASED ON THE NUMBER OF NERVES

| | No. of nerves | Total No. of palsy | Tem. Paresis | Perm. Paralysis |
|---|---|---|---|---|
| Total | 100 | 8(8%) | 4(4%) | 4(4%) |
| Dissected | 53 | 4(7.54%) | 3(5.66%) | 1(1.88%) |
| Not dissected | 47 | 4 (8.52%) | 1(2.13%) | 3(6.39%) |

There were two groups based on the exposure or nonexposure of the RLN during surgery. Of the 100 nerves 53 were identified during surgery and the remaining 47 were not dissected out. In 53 dissected nerves, a total initial injury was observed in 4 cases (7.54%), 3 (5.66%) being temporary and 1(1.88%) being permanent. Majority of the paralysis in the dissected group was temporary. In the nondissected 47 nerves the incidence was higher. 4 nerves (8.52%) showed an initial injury. Majority of the injuries were permanent; that is 3 nerves (6.39%) showing no signs of recovery. In the remaining one (2.13%) the paralysis was temporary making good recovery in the stipulated period of follow up.

A difference in the rate of injury could be noticed between right side and left side.

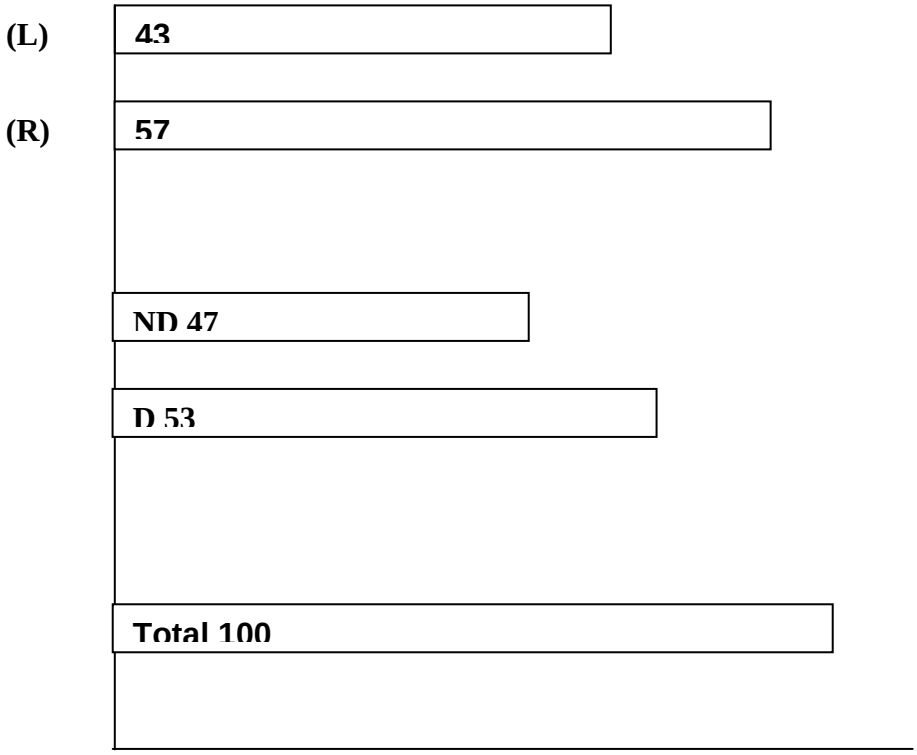
## TABLE II

## RLN VULNERABILITY BASED ON THE SIDE

| | No. of nerves | Initial total No. of palsy | Tem. Paresis | Perm. Paralysis |
|---|---|---|---|---|
| Right | 57 | 5(8.75%) | 2(3.50%) | 3(5.25%) |
| Left | 43 | 3 (6.97%) | 2(4.65%) | 1 (2.32%) |

Table II provides a summary of the nerves on each side and the incidence of injury on either side. In none of the cases a bilateral paralysis was observed . On the right side permanent injury in 3 cases (5.25%) against one case (2.32%) on the left side.

# DISCUSSION




Details of Nerves encountered in this study.

D- Dissected Nd – Not dissected , L- left , R- Right .

This prospective study was undertaken to find out the magnitude of thyroidectomy related damage to the RLN and it proved significant .A total of 100 nerves were subjected to study with 53 nerves being exposed and the remaining 47 were not exposed during thyroidectomy. This study concentrates mainly on the permanent damage suffered because both the patients and the surgeons are scared of the permanent palsy of the vocal cord. The results can be analysed in two ways. (a) number of paralysis may be expressed in relation to the number of patients operated (b) second method is correlating the number of paralysis to the total number of nerves at risk, which is opted by most of the authors. Hence to avoid disparity we preferred the latter method . All the results were analysed statistically to find out the significance (Z test). A comparison of our results with the prevalence is standard institutions at various parts of the world is given in table III. The extremely low result observed by Riddell may be due to the technical expertise.

## TABLE III PERM. RLN INJURY DURING THYROID SURGERY

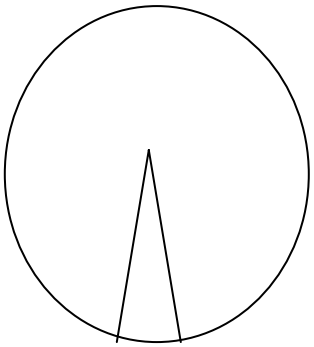
## COMPARISON OF THE RESULT OF THIS STUDY WITH VARIOUS AUTHORS

| S.No | Study | %RLN paralysis (Permanent) | P value |
|---|---|---|---|
| 1. | Sinclair IS | 5.2% | P>0.05 |
| 2. | Balanzoni | 5% | P>0.05 |
| 3. | Riddell | 1.2% | P<0.001 |
| 4. | Svendsen | 2.6% | P>0.05 |
| 5. | Elner A etal | 13.2% | P<0.001 |
| 6. | Thompson | 11.9% | P<0.001 |
| 7. | Grisselson | 3.9% | P>0.05 |
| 8. | deRoy Van Zuideevigan DB | 3.1% | P>0.05 |
| 9. | Merman | 3.2% | P>0.05 |
| 10. | Martensson | 3.6% | P>0.05 |
| 11. | Ladurner | 5.4% | P>0.05 |
| 12. | This study | 4% | |

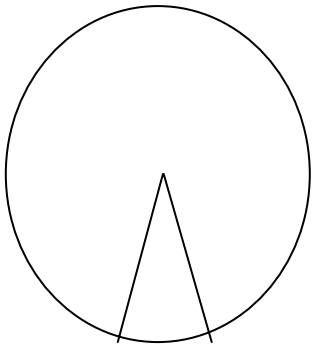
This gives a vivid picture of the facts. The overall incidence of permanent RLN damage of 4% figured in this study is well comparable to those

from various institutions, " It is felt that a figure of about 5% for RLN injuries in general surgical practice is not excessive" (Wade 1955)

Another important aspect of the study was whether unidentified recurrent nerve is in danger during thyroidecotmy. Currently most authors have proved an improvement in the injury rate with RLN identification and hence many prefer this technique to a blind thyroidectomy.



1.88% Permanent paralysis (in this study) RLN identified



6.36% permanent. Paralysis (in this study) RLN not identified

In this study the rate of recurrent nerve injury fell from 6.39% to 1.88% making an obvious difference of 4.51% when RLN was identified. It is comparable to other authors (Table IV). From the surgeon's point, we consider this 4.51% as significant , though statistically this difference failed to show any significance . Lahey & Hoover (1938) noticed a fall form 1.6% to 0.3% when RLN was identified. Similarly Cattell (1948) gave a figure of 3% falling to

0.7% (2.3% diff.). Also Riddell (1969) noted a fall from 2% to 0.6% (1.4% diff.) when RLN was identified. All of them consider this as clinically significant. Hence in spite of the statistically insignificance we strongly support the view that the unidentified RLN is in danger, however careful the surgeon

**TABLE IV**

**SHOWING COMPARISON OF RESULTS WITH RLN IDENTIFICATION**

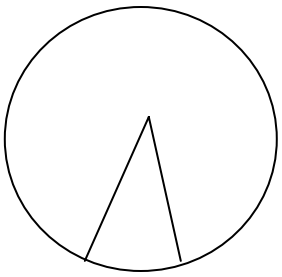
| | **Author** | **%perm** | **P value** |
|---|---|---|---|
| 1. | Hoje J | 4.7% | >0.05 |
| 2. | Riddell | 0.6% | <0.001 |
| 3. | Holt G R | 4.2% | <0.05 |
| 4. | Remacle | 4.5% | >0.05 |
| 5. | This study | 1.88% | |

**TABLE V**

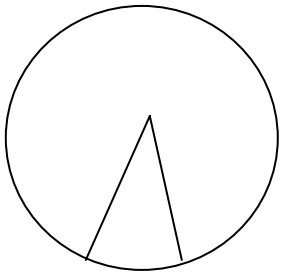
**SHOWS THE RESULT OF THIS STUDYING UNIDENTIFIED (RLN) THYROIDECTOMY & ITS COMPARISON TO OTHER AUTHORS**

| | Author | %perm | P value |
|---|---|---|---|
| 1. | Riddell | 2% | <0.05 |
| 2. | Gisselson | 3.9% | >0.05 |
| 3. | Wagner | 7% | >0.05 |
| 4. | This study | 6.39% | |

Lastly , I will consider the difference in vulnerability between left and right nerves. As previously mentioned it has been experience of most observes that the right recurrent nerve is more often damaged than the left nerve.



(L) 1 Case (2.32%)



(R ) Case (5.25%)

From this study we feel that right sided nerves are more prone for injury even though we could not find out a statistically significant difference. The reasons for the increased vulnerability are already mentioned.

# SUMMARY

## THE FINDINGS OF THIS STUDY CAN BE SUMMARIZED AS

1. A study of 70 thyroidectomies involving 100 RLN is presented ; 53 RLN dissected and 47 not dissected
2. Overall incidence of permanent RLN injury is 4%
3. With RLN identification the permanent injury rate is less – 1.88%
4. Without RLN identification permanent injury rate is more – 6.39%
5. Permanent RLN injury rate on the right side - 3 cases (5.25%)
6. Permanent RLN injury on the left side – 1 case (2.32%)

# CONCLUSION

Identification of the RLN during thyroid operations can reduce the vulnerability to damage.

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# RECURRENT LARYNGEAL NERVE INJURY IN THYROID SURGERY

# PROFORMA

Case No :

Name :

Address :

Age :

Sex :

Ip No :

DOA :

DOD :

Previous neck/ENT Surgery (if any) :

Diagnosis :

Pre-Op I/L :

Surgery underwent :

RLN Dissected /NOT :

Anaesthesia :

Immediate post op Laryngoscopy :

I/L in $5^{th}$ POD :

I/L after 3 weeks :

I/L after 6 months :

I/L after 1 year :

**FINAL CATEGORY**

| A. RLN Dissected | B. RLN Not Dissected |
|---|---|
| I. RLN Not injured | I. RLN Not injured |
| II. RLN injured | II. RLN injured |
| 1. Temporary | 1. Temporary |
| 2. Permanent: Partial | 2. Permanent: Partial |
| Complete | Complete |

**INFERENCE:**