

Lesions of the Laryngeal Nerves during Thyroidectomy - What's New?

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Rezumat

Abordări actuale în leziunile recurențiale iatrogene

Leziunile nervilor recurenți constituie în ciuda incidenței scăzute una dintre cele mai severe complicații post-tiroidectomie. Disecția atentă intraoperatorie a nervului recurent este considerată "gold standard" în prevenirea leziunilor acestuia. Evidențierea raporturilor cu tuberculul Zuckerkandl și conștientizarea posibilității existenței mai multor ramuri nervoase prelaringiene facilitează disecția și ajută la prevenirea leziunilor. Sunt subliniate anumite situații de risc chirurgical crescut cum ar fi: nervul laringian nerecurrent cu emergență înaltă și nervul laringian superior tip Cernea 2 precum și soluții chirurgicale de evitare a leziunilor în aceste situații. Studiile neurofiziologice privind procesul de regenerare nervoasă și definirea gradelor de sinchineză orientează clinicianul în privința evoluției și prognosticului acestor pacienți. Evaluarea funcției laringiene pre și post-operator constituie soluția obiectivă de evidențiere a incidenței reale și de stabilire a gradului de severitate al leziunilor nervoase. Fibroscopia și electromiografia evaluează gradul de denervare al corzilor vocale și pot aduce date importante cu privire la recuperarea funcționalității acestora. Cu toate acestea, datorită impredictibilității procesului de sinchineză, prognosticul gradului de recuperare vocală este greu de formulat.

Cuvinte cheie: nerv laringeu recurent (RLN), nerv laringeu superior (SLN), tuberculul Zuckerkandl (TZ), electromiografie laringiană (LEMG)

Abstract

Lesions to the laryngeal nerves, despite their low incidence, are the most severe long term complications after thyroidectomy. Visualization after careful dissection of the recurrent laryngeal nerve (RLN) is now the gold standard among thyroid surgeons. The Zuckerkandl tubercle (TZ) is a constant landmark for the identification of the RLN. Recent studies show the occurrence of two or more branches of RLN before entering the larynx. Knowledge about their existence could prevent lesions. Some high risk surgical situations are evidenced, such as: non-recurrent laryngeal nerve emerging high from the vagus and the superior laryngeal nerve type Cernea 2. Several examination procedures are mandatory for a complete postoperative evaluation: video laryngoscopy and laryngeal electromyography (LEMG) bring valuable objective and prognostic data. However, due to the unpredictability of the synkinesis process, the prognosis of recovery in RLN injuries remains difficult.

Key words: recurrent laryngeal nerve (RLN), superior laryngeal nerve (SLN), tubercle of Zuckerkandl (TZ), laryngeal electromyography (LEMG)

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Anatomic landmarks and surgical approach

One of the most important objectives of thyroidectomy is the prevention of laryngeal nerve damage. Risk factors

for recurrent laryngeal nerve (RLN) injuries are: total thyroidectomy, voluminous goitre and thyroid cancer. Inexperienced surgeons are an important independent risk factor. (1) Dissection of the RLN is essential in the prevention of injuries. However, the lesion may occur even when nerve monitoring is used during surgery. (2) The section of the Berry ligament is a high risk moment because the nerve is very near to the gland, and often covered by conjunctive tissue. Sometimes, in the attempt to stop bleeding from an inferior thyroid artery branch, the nerve can be caught in ligation or even burned by nearby cautery.

The nerve usually divides in branches inside the larynx. Sometimes, the branches occur before entering the larynx, most frequently between 10 and 18 mm. [Ardito (3) 3-45 mm, Beneragama (4) 5-35 mm, Yalçin (5) 4-32 mm, Casella (6) 0-25 mm].

Most studies investigate the way the RLN splits into branches before entering the larynx, but there are important contradictions between them. Page (7) and Casella (6) found a single trunk in 91% of cases, and two branches in 19% and 17% respectively, opposed to Yalçin (5) who found single trunk in only 7.3% of patients, and two branches in 85%.

Usually the branches are of the same size but sometimes one of them is bigger and can easily be misjudged as single trunk. Symmetry is not mandatory. We can find a single trunk on one side and two or more branches on the other. (8)

The most important landmarks for RLN dissection are: the Zuckerkandl tubercle, the Berry ligament and the inferior thyroid artery. (2)

The Zuckerkandl tubercle is an embryological remnant of the primordial thyroid that is present in 60% to 90% of adult glands. (9) Pelizzo in 1998 was first to show the importance of TZ as landmark for RLN dissection (10). (Fig. 1)

The constant proximity between RLN and TZ is useful for the surgeon especially in voluminous goitre when the position and the direction of the RLN may change. If the nerve passes between the branches of the inferior thyroid artery the hypertrophy of the gland "pulls" the nerve from the esophageal groove and conveys a curve trajectory to it. (Fig. 2)

Pelizzo's classification of TZ has 4 degrees: 0 degree when TZ is absent, first degree when tubercle is less than 5 mm, second degree when it is between 5 mm and 1 cm, third degree when it is bigger than 1 cm. (10).

Yalçin thinks that the size of the tubercle is not so important and proposes the term of recognizable tubercle for second and third degree of Pelizzo classification (11-13).

The TZ is mostly placed in the medium third of the thyroid lobe (82.8%); however it can be found in the lower part (12%) or the superior one (5.2%) (12). TZ reveals the RLN or its branches like an arrow pointed to the nerve. (10)

In 91.9% of cases the nerve passes beneath the TZ. In 7.7% the nerve may be found lateral to the tubercle. When TZ is recognizable (second and third degree) the nerve is almost always beneath the tubercle (96.9%).

The dissection of RLN is usually performed by lateral approach because it is quite easy and may preserve the vessels

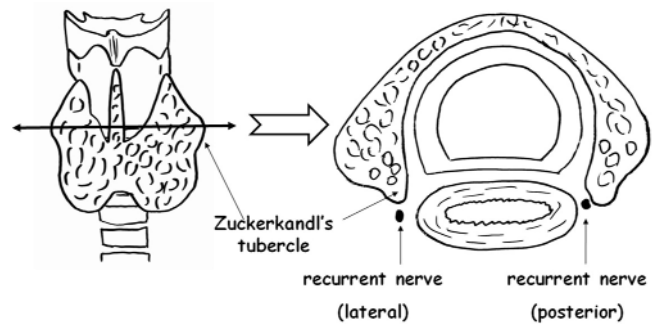


Figure 1. The relationship between Zuckerkandl's tubercle and recurrent nerve

of the superior parathyroid gland. (2) After the ligation of the medium thyroid vein and superior vessels the thyroid lobe can be pulled to the median line. Dissection goes near the thyroid capsule as the TZ is revealed. The nerve is usually posterior or lateral, adherent to the tubercle. The branches of the inferior thyroid artery pass inside the lobe, although the nerve or its branches never enter inside the thyroid capsule. We have to pay attention to the next situation: when the nerve is thin it could be just the posterior branch in a lower ramification. The anterior branch, carrying the most important motor fibres is stuck on the posterior side of the thyroid lobe.

RLN can be covered at the level of the Berry ligament by an extension of conjunctive tissue. This is the place where injuries occur most often. (2) We have to dissect along the fibres of the already revealed nerve, at the point of entry in the larynx. When there is a suspicion of ramification at the level of the Berry ligament it is better to make the resection inside the thyroid capsule to prevent lesions. The residual tissue is less than one cube millimetre big and can be destroyed using radioiodine in case of thyroid cancer.

The inferior laryngeal nerve may be, in very rare situations, non-recurrent. It is an abnormality that shows only in the right side in less than 1% of the cases and it is due to an embryo-logical disorder. When it occurs on the left side it is associated with situs inversus (14). Despite low incidence, the surgical risk of lesions is seven times higher (12.9%) than in

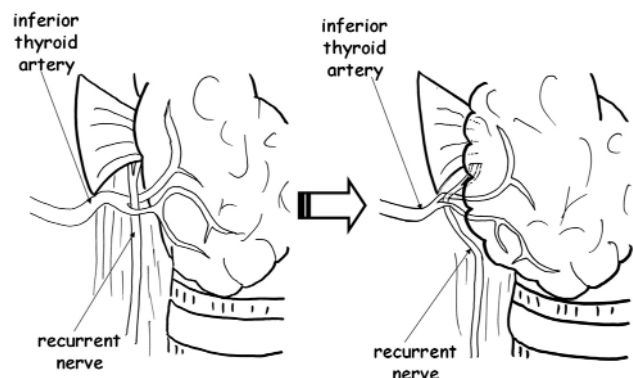


Figure 2. Displacement of recurrent nerve in voluminous goiter

recurrent situations (15). There are 3 types of non-recurrent laryngeal nerve:

- type 1 the nerve emerges high from the vagus and goes down close to the superior thyroid vessels, risk of lesion being very high;
- type 2A the nerve emerges low and has a cross trajectory;
- type 2B the nerve emerges low and has an ascendant trajectory near the inferior thyroid artery; it is difficult to differentiate from normal RLN (15,16).

During surgery we have to consider the possibility of a non-recurrent laryngeal nerve if normal RLN cannot be identified using common anatomic criteria. To avoid lesions, the dissection has to go near the thyroid capsule including the vessels of the upper pole because a type 1 non-recurrent laryngeal nerve descends very close to the superior pedicel.

The lesion of the external branch of the superior laryngeal nerve (SLN) leads to less important voice modifications. In SLN paralysis a loss of head register and reduction of voice bellow one octave can be observed (normal voice has two octaves). However, these modifications are significant for singers and professional speakers. That's why SLN modifications are less frequently evaluated in the postoperative period ("the neglected nerve" during thyroidectomy).

Cernea classification is an anatomic evaluation of SLN risk of lesions based on the reports between the SLN and vessels of the upper pole.

Cernea classification of SLN:

- Type 1: the nerve crosses the superior thyroid artery at more than 1 cm from the upper pole of the thyroid gland;
- Type 2a: the nerve crosses the superior thyroid artery at less than 1 cm from the upper pole of the thyroid gland;
- Type 2b: the nerve goes between the branches of the thyroid artery in close contact with the superior upper pole.

Cernea 2a - 2b types have a high risk of lesion. This is even more important considering their relatively high incidence between 10 - 22%. (16)

To prevent lesions of SLN there are two kinds of attitudes: dissecting and highlighting the nerve during surgery and "avoiding the encounter" attitude.

The dissection of the SLN is usually practiced for scientific purposes or by a surgeon using intraoperative monitoring of the nerves. (2)

Thyroid surgeons do not usually dissect the SLN. To prevent SLN lesions they ligate the superior thyroid vessels one by one, very close to the thyroid parenchyma, avoiding "en block" ligation. (2) If the dissection goes in the avascular space between the superior thyroid pole and the cricothyroid muscle, a 2b type SLN nerve can be highlighted and preserved. (17)

Pathology

The mechanism and the degree of nerve damage are important factors for prognosis and functional recovery of the vocal folds

after nerve lesion. RLN may be injured by scissors action, crushed by forceps, tractioned by misplaced ligation or thermal lesions. 30% of RLN injuries are caused by thermal lesions due to improper use of cautery.

Sunderland Classification (18,19) is a system based on RLN degree of lesions.

- First degree means neuropraxia. It is usually followed by full recovery.
- Second degree means Wallerian degeneration occurred distal to the injury site. The usual mechanism for this type of injury is by crushing. The endoneural shield remains intact and synkinesis does not occur. Consequently, the recovery is in most cases complete.
- Third degree lesion means misdirect regeneration of axons caused by endoneural scarring.
- Fourth degree injury implies scarring, which blocks regenerating axons.
- Fifth degree lesion means complete transection.

Reinervation is a process of regeneration that occurs at the level of nerves fibres after injury. The sources of regeneration are fibres from resected RLN, cervical plexus, branches for pharyngeal constrictors. Some studies show occurrence of anastomotic branches between SLN and transected RLN. Reinervation may be observed only four months after injury (20), sometimes even when the nerve is transected completely. Unfortunately, when the regeneration process occurs it is usually synkinetic. Synkinesis is a phenomenon that leads to a non-selective innervation of adductor and abductor muscles, with the absence of favorable movements of vocal folds. This is due to misguided peripheral motor axons which reinnervate inappropriate muscle fibres. As a result opposite muscle fibres contract simultaneously. EMG tests show loss of control and strength of contraction due to the synkinetic processes. (1) Clinical features depend on the proportion of adductor or abductor fibres involved in synkinesis. In the larynx there are four times more adductor than abductor fibres. As a result, after reinervation the adductor muscle pulls the vocal fold from lateral to a more medial position. (1)

Crumley Classification (21) describes five types of laryngeal synkinesis.

- Type 1 means favourable synkinesis. The voice and breathing are almost normal.
- Type 2 synkinesis leads to spastic vocal fold. The voice quality is poor.
- Type 3 synkinesis leads to tonic adduction of the vocal fold. Voice is good, but breathing is affected. This type of synkinesis causes a more important reinervation of the lateral cricoarytenoidian muscle compared with the posterior cricoarytenoidian muscle, whereas in type 4 the opposite is likely to occur.
- Type 4 synkinesis causes a tonic adduction of vocal folds. The voice is breathy and there is a great risk of aspiration.

However, even synkinetic reinervation of the larynx improves voice due to an increase of vocal fold muscle bulk and the tonus of the laryngeal muscle.

Evaluation of the larynx function

Despite low incidence, laryngeal nerve paresis and paralysis have to be quickly recognized. The thyroid surgeon has to evaluate the modifications of voice and swallowing before and after surgery. Any suspicion of vocal fold paresis or paralysis has to be sent immediately to an ENT specialist. Some authors (20) recommend routine laryngoscopy for all patients before thyroid surgery. However, preoperative laryngoscopy is mandatory if the patient has previous cervical surgery like: hemithyroidectomy, carotid surgery, cervical disc hernia. The preoperative identification of a hypomobile vocal fold can raise suspicion of thyroid cancer or voluminous goitre. In both situations the nerve is likely to have been displaced from its normal position and could be at risk. If a patient is submitted for total thyroidectomy and he has had previous unilateral fold paresis he has to be informed about the risks of bilateral paresis and the possible necessity of tracheostomy.

Rubin and colleagues (20) consider that preoperative documentation of vocal fold hypomobility can spare the surgeon of medical-legal problems after thyroidectomy. More than that, an ENT specialist can highlight other causes of voice modification like thyroid nodules, chronic laryngitis, etc. The treatment of these conditions may improve voice and swallowing after surgery.

Symptoms like dysphonia, dysphagia, dyspnoea and aspiration of variable intensity and associations are signs of vocal fold paralysis or paresis. Identification of voice modification in the early postoperative period is very important. Quite usually surgeons overlook these modifications because they know that the nerve was highlighted and preserved during operation. (22) It is important to honestly evaluate the true risks of iatrogenic lesion. This is often difficult. Miller and Spiegel (22) think that the true incidence of RLN lesions is rarely reported because there is a high risk to be biased in any surgical complication, and thyroid surgery is no exception. On the other hand, RLN lesion is quite vaguely defined in literature. Most of the reports are subjective observations of voice modification rather than objective assessment of vocal fold motions. As long as postoperative laryngoscopy is not a routine investigation, the true incidence of RLN lesions remains unknown. Based on literature RLN injury rate is low. Temporary paresis after thyroidectomy ranges between 1 - 6%, while permanent paralysis is between 0.05 - 2.5%. For patients undergoing thyroidectomy for cancer, temporary RLN injury is 0.7 - 4% and permanent paralysis 1.6 - 10%. Reoperative thyroid surgery has a high risk of injury. RLN paresis occurs in 10% of cases, while permanent lesions are reported in up to 8% of patients. (22)

Physical examination of the larynx

Physical examination of the larynx includes vocal tasks and laryngeal visualization. The vocal tasks and the subjective evaluation of the voice usually fail to differentiate between vocal paresis and paralysis. Repeated alternation of "i" vowel and sniff or phonation of "i" with complete stop after each

phonation may show vocal fatigue in RLN paresis. To highlight a SLN injury the patient is asked to raise his/her voice at a higher pitch or for professional speakers and singers to get a sample of their daily demands. (20)

The most important examination is fibroscopy or video-fibroscopy associated with stroboscopy. Fibroscopy could show the position of vocal folds at rest or during different tasks like phonation, breathing, swallowing or single vowel phonation.

RLN paralysis on fibroscopy appears as a vocal fold located away from midline with signs of glottis closure deficit. The most usual position is paramedian (70%). Median position, close to midline, is observed in 20% of cases and in terms of recovery is followed by a better prognosis. Intermediate position between normal adduction and abduction and far from midline is rare (10%) but has the worst prognosis. (23,24) (Fig. 3)

C. Finck (23,25) appreciates as signs of complete denervation of the vocal fold:

- A more lateral position of the vocal fold;
- Reduced length of the paralyzed fold;
- A lower paralyzed fold;
- Emphasis of vertical movement during stroboscopy;
- Atrophic vocal fold.

Signs of partial denervation after C. Finck (23,25) are:

- Persistence of some muscle tone on the paralyzed side;
- Closer position to the midline of the paralyzed vocal fold;
- Better glottic closure;
- No vocal fold atrophy;

Laryngeal electromyography (LEMG) is the most objective method to evaluate the function of the nerves and muscles of the larynx. Usually there are two muscles investigated by percutaneous route using an EMG needle: thyroarytenoid (depending on the RLN) and cricothyroid (depending on the SLN). Signs of denervation (1) are electrical silence during the first days after injury and appearance of sharp waves 10 days after onset of paralysis. Low amplitude and relatively short duration



Figure 3. Right RLN paralysis - image from fibroscopy

polyphasic potentials are recorded 2 months after injury and last for more than a year (1). (Fig. 4) (26)(18)

If the nerve is affected by neuropraxia or its function is partially recovered, LEMG shows normal potentials even if their number is reduced. LEMG is useful for the diagnosis of patients with mild paresis on endoscopic examination. Sometimes LEMG demonstrates bilateral paresis in patients with normal endoscopic examination.

LEMG is used for prognosis purposes in patients with RLN injury, but only in the first 6 months after injury. After this period LEMG has no prognostic value. The most important LEMG prognostic factor after Hirano and colleagues (25) is the presence of action potentials induced by voluntary activity. Their presence is followed by laryngeal function recovery in 60% of cases. Absence of action potentials on LEMG is followed by laryngeal function recovery in only 20% of cases. (25)

Evolution and prognosis

Most of the patients improve spontaneously following the

reinnervation process. Recovery takes place usually in the first 3 months. 6 months after the onset of paralysis most patients recover sufficiently to avoid surgical treatment. The recovery rarely takes place after one year from injury. It is very important for a thyroid surgeon to know that early recognition and treatment may reduce compensatory behaviour. Speech therapy in the first 6 months may improve patient voice and quality of life.

The chances of recovery are hard to tell. Sometimes due to the reinnervation process even a complete paralysis can recover. Even if the vocal fold remains immobile the voice is close to normal due to the recovery of muscle bulk and tonus. (27)

C. Finck (1) considers that in terms of recovery, early signs with a good prognostic value are:

- A more medial position of the vocal fold;
- Absence of denervation signs at LEMG and fibroscopy;
- Presence of normal action potentials at LEMG;
- Residual voluntary movement during laryngeal observation;

Medico-legal implications

Miller and Spiegel (22) appreciated that 30% to 50% of endocrine malpractice litigation involves thyroid and parathyroid surgery. 70% to 90% of these are due to RLN injury with bilateral paresis accounting for nearly 30% of cases. Only one of three rulings is in favor of the defendant. In an era of evidence based medicine the support of RLN monitoring during surgery may be, in the future, the standard of care.

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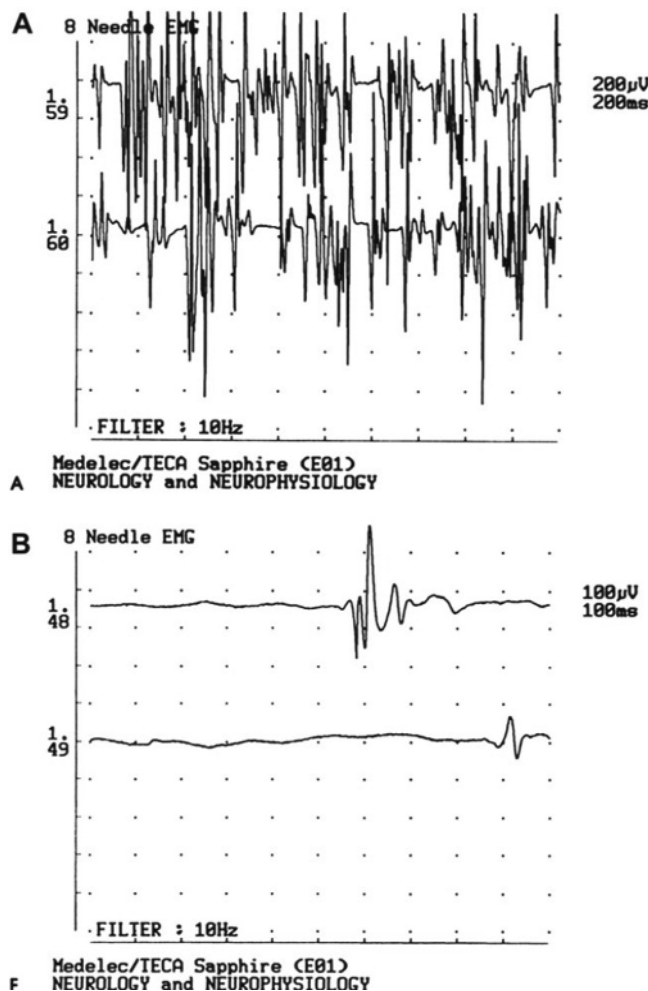


Figure 4. (A) Normal LEMG with maximal contractions. (B) LEMG with maximal contractions 1 year after RLN injury

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