

Intraoperative monitoring of the recurrent laryngeal nerve in thyroid gland surgery

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Abstract: In Thyroid surgery, the two novel approaches are the trans-axillary Robotic thyroidectomy and the trans-oral and sub-chin techniques.

During these surgical approaches is mandatory to recognise the Anatomy. The lower laryngeal nerves originate from the X cranial nerve (vagus nerve) and innervate all the intrinsic muscles of the larynx except for the cricothyroid muscles (which are innervated by the superior laryngeal nerve instead). The "recurring" name is due to the course in the opposite direction to the nerve of origin.

Neuro-monitoring of recurrent laryngeal nerves is the most important of the recent technological innovations. However it is of fundamental importance for the operator to remember that this method does not prevent recurrent nerve injury. On the other hand a two stage thyroidectomy can avoid a tracheostomy thanks to neuro-monitoring.

Keywords: Recurrent Laryngeal Nerves, Neuro-monitoring, Thyroid Surgery

Introduction

Thyroid surgery has a complex and constantly evolving history. In the commonly used "open" approach, the intra-operative steps have improved constantly to provide a correct and clean dissection that is increasingly minimally invasive and free of post-surgical complications. During its history, innovative approaches and strategies have emerged as alternatives with advantages and disadvantages to be considered and tailored to the individual patient. These may differ from open surgery at various steps,

from the indication to surgery up to clinical decision-making, which is evidence-based and ultimately finds its root in the current international guidelines. Two novel approaches worth mentioning are the trans-axillary Robotic thyroidectomy and the most recent trans-oral and sub-chin techniques, in which the setting of the patient and the layout of the operating room are also changed in addition to the instrumentation used by the operator and the surgical technique.

The indications, which are at the base of this type of surgery, are essentially three:

- complicated or unmanageable forms of hyperthyroidism through long-term medical therapy.
- indeterminate or malignant cytology nodules.
- toxic or non-toxic multi-nodular goitre that generates compressive symptoms in the patient due to the correlation between anatomical relationships and volumetric increase in the gland (es. dysphonia, dyspnea, dysphagia).

In the development of the operative decision and strategy, the specialist has increasingly innovative tools, the use of which implies the integration of technical knowledge relating to the instrument itself, but also of knowledge of clinical anatomy and neurophysiology, surgical technique, and clinical management of the patient.

All this affects the operator's learning curve, the intra and post-operative safety profile as well as one of the most serious complications, recurrent laryngeal nerve injury.

Clinical-functional anatomy of the recurrent laryngeal nerve

The thyroid is in close anatomical relationship with some nervous structures of great functional importance.

The lower laryngeal nerves originate from the X cranial nerve (vagus nerve) and innervate all the intrinsic muscles of the larynx except for the cricothyroid muscles (which are innervated by the superior laryngeal nerve instead). The "recurring" name is due to the course in the opposite direction to the nerve of origin.

The vagus nerve emerges from the base of the neurocranium through the jugular foramen (or posterior lacerate hole, which arises between the rear portion of the petrous rock of the temporal bone and the anterior edge of the occipital bone). Through its anteromedial portion, the X cranial nerve emerges together with the IX and XI cranial nerve, while in the jugular portion proper (posterolateral portion) the sigmoid sinus can be found, which becomes the internal jugular vein just below the foramen.

The vagus nerve runs downwards within the carotid sheath that wraps the vascular-nerve bundle, which includes the internal jugular vein and internal carotid vein as well as the vagus nerve itself along its entire course up to the base of the neck. The right vagus nerve continues adhering to the anonymous artery, while the left vagus nerve runs in front of the aortic arch. This

is where the recurrent laryngeal nerve originates, meaning that the two recurrent laryngeal nerves will be characterized by an asymmetry in their course and length (i.e. the right one surrounds the subclavian artery, while the second one runs over the aortic arch).

The lower laryngeal nerves continue going up in the tracheo-esophageal sulcus and anteriorly, taking relation posteriorly to the lobes of the thyroid gland. Finally, their course ends into the larynx in the intercricothyroid space to innervate the vocal cords, determining their movement by controlling the abduction of the posterior cricoarytenoid muscles. In its course, the nerve supplies branches to the deep cardiac plexus, tracheal and esophageal branches and to the inferior constrictor muscle of the pharynx.

The inferior laryngeal nerve is a mixed sensory-motor nerve as it also provides sensitivity to the larynx. This is fundamental in some important reflexes such as the cough reflex, which in this case has the function of maintaining the patency of the upper airways and consequently monitoring the swallowing act in such a way that the latter occurs correctly from a dynamic and motor point of view. An important surgical landmark of this region is Zuckerkandl's lobe or tubercle (i.e. the posterior pyramidal extension of the right and left thyroid lobes), which allows the inferior laryngeal nerve to be identified before it plunges into the larynx.

Usually, the recurrent laryngeal nerve is located in a medio-lateral position with respect to this tubercle, with more frequently horizontal direction to the right and oblique to the left.

The recurrent laryngeal nerve derived embryologically from the sixth pharyngeal arch and was first documented by the ancient roman physician Galen, who also gave the name to the most common of its anatomical variants: the loop of Galen (anastomosis between the inferior and superior laryngeal nerve that occurs in 4/5 of the population).

In about 10% / 20% of cases, however, the right recurrent laryngeal nerve does not recur and branches off from the vagus nerve directly to the level of the cricoid cartilage. Non-recurrence of the left recurrent laryngeal nerve is a rare finding and is usually associated with a complex arterial vascular variant.

Thus, a unilateral lesion of the recurrent laryngeal nerve can lead to a significant

alteration of the voice (dysphonia) and increased vocal fatigue (phonasthenia). A bilateral lesion, on the other hand, leads to a severe alteration of the vocal capacity and to a bilateral paralysis in adduction of the vocal cords with important respiratory distress. This becomes evident through the clinical signs of corneal reflex and tirage up to the more serious phenomenon of abdominal reentry, in which the inspiratory effort is partially compensated not only by the use of the neck muscles but also of the abdominal muscles.

A bilateral lesion is thus usually a very severe occurrence, such as requiring a tracheostomy.^{1,2,3}

The upper laryngeal nerves also innervate the vocal cords; however, they do not determine their movement but rather the degree of muscular tension, thus regulating the high tones of the voice. Their damage determines an inability to use the higher vocal tones, to sing and to use the voice for a long time. Their preservation is important for all patients but especially for those who use their voice for professional purposes

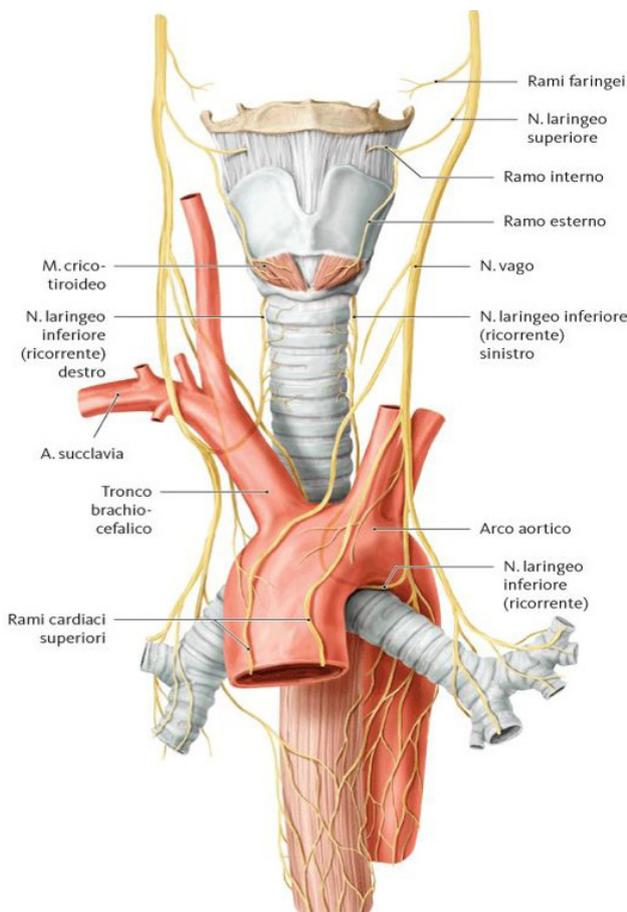


Figure 1: Anatomy and relationships of vagus nerve
M. Schünke, E. Schulte, U. Schumacher
Prometheus - Anatomy Atlas Text - Head, Neck and Neuroanatomy
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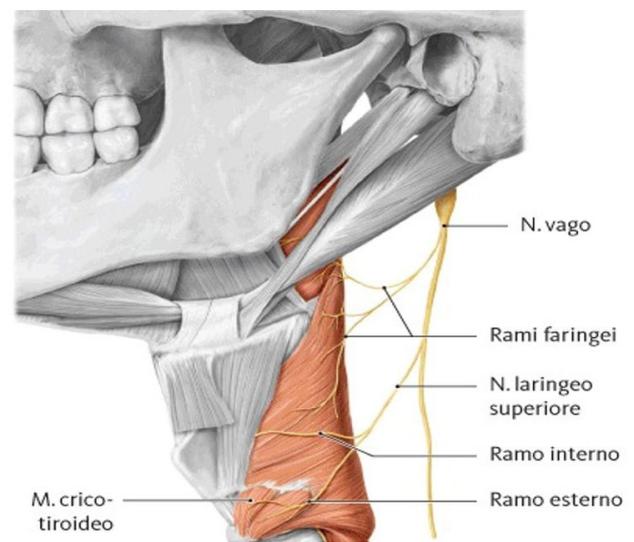


Figure 2: Anatomy and relationships of vagus nerve
M. Schünke, E. Schulte, U. Schumacher
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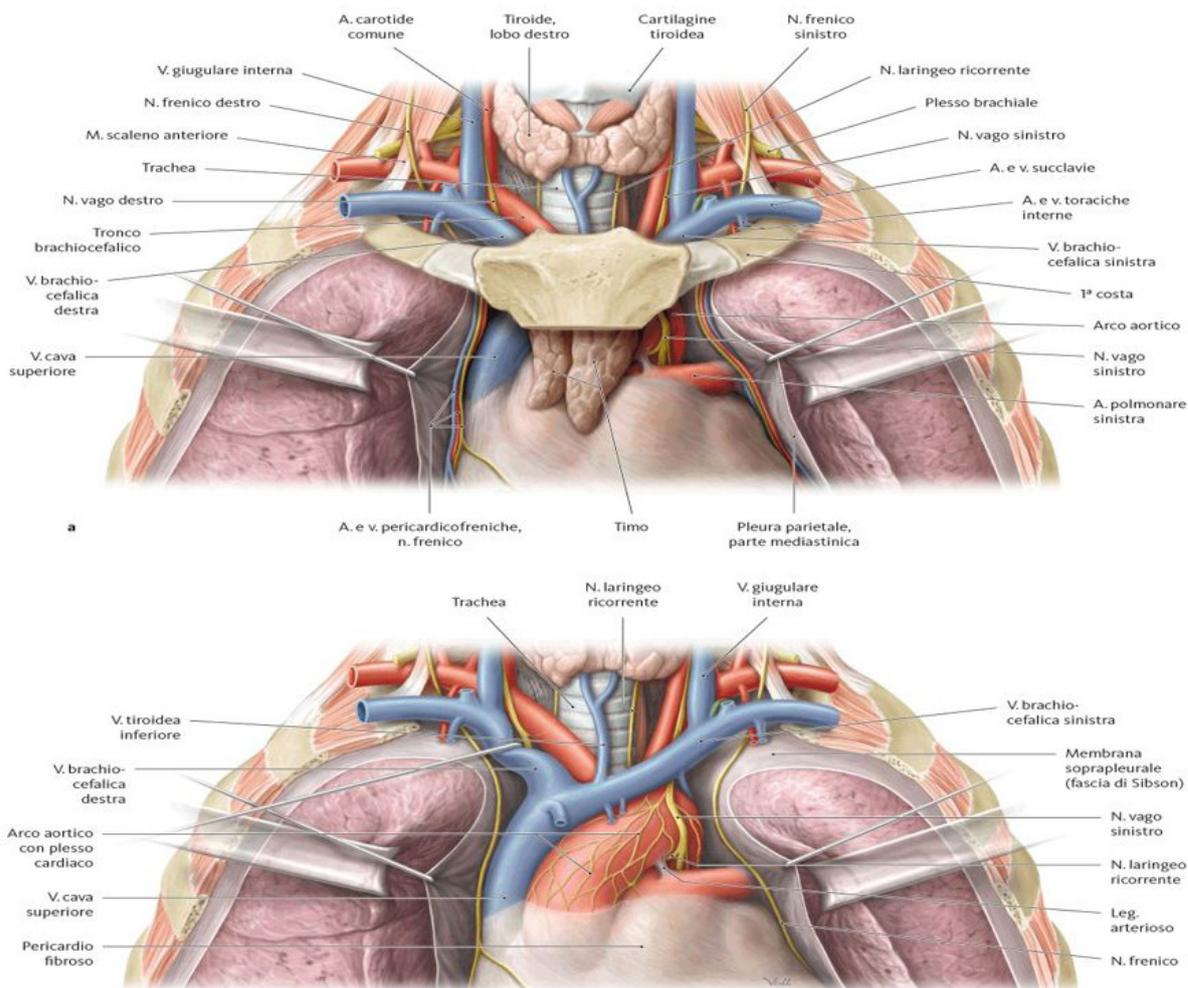


Figure 3: Anatomy and relationships of vagus nerve
 M. Schünke, E. Schulte, U. Schumacher
 Prometheus – Anatomy Atlas Text – Internal Organs, II Ed.
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Neuro-monitoring

Neuro-monitoring of recurrent laryngeal nerves is maybe the most important of the recent technological innovations. It is of fundamental importance for the operator to remember that this method does not prevent recurrent nerve injury. In fact, this may still occur, most often due to the stretching of this nerve or the heat of thermal instruments rather than the accidental cutting of the structure. Neuro-monitoring can, however assist the operator in the surgical phases and times, thus allowing him to change the operative strategy during surgery if needed, even following the unilateral nerve injury and consequently reducing the need for tracheostomy to almost zero per cent.

Another important warning concerns young operators, who must keep in mind that this

method must not be substituted for anatomical and surgical knowledge in the search for the recurrent nerve, as the instrument is created precisely for the purpose of monitoring and can replace neither the surgical competence of the operator nor his intuition and knowledge.

In this type of surgery, the tube used for endotracheal intubation is equipped with two special electrodes that are positioned, under the vision of the optical fibre laryngoscope, precisely in contact with the vocal cords in a type of classic oro-tracheal intubation approach.

The operator uses a thin electromyographic probe that selectively stimulates each structure before it is sectioned. The electrodes record the transmitted impulses, and the surgeon can analyze the amplitude of the recorded stimulus on the monitor, thus deciding whether to proceed safely with the dissection. The common scheme

used always provides for selective stimulation before and after nerve dissection so as to identify any lesions early as well as reassure the operator on the correct position of the tube and the closure of the electrical circuit. The vagus nerve is stimulated first, which gives us an indication of the correct positioning of the tube. Then, after identifying the ipsilateral recurrent, it is stimulated before proceeding to the lobectomy of the same side. After the dissection, another stimulation of the recurrent nerve is performed. Finally, the vagus nerve is stimulated again after dissection to ensure the absence of damage and the correct positioning. The same process can now be repeated on the contralateral side.

Stimulation is displayed on the monitor and changes according to the voltage selected for stimulation, which in turn depends on the type of nerve being tested and its action potential. The potential itself is thus displayed on the monitor if the nerve is functioning correctly. Here it is also possible to visualize the feedback on the laryngeal muscle contraction that occurs at the time of stimulation of the recurrent nerve.

Furthermore, if at the end of the dissection of the first half of the thyroid gland a nerve damage is detected (it is impossible to establish whether temporary or permanent, even with a macroscopically intact nerve), the surgeon can interrupt the operation, postponing its completion to a later time (i.e. “two-stage thyroidectomy”). When nerve function is resumed, in the event of a temporary injury, and after an accurate fibro-laryngoscopic study, which allows verifying the correct chord motility and morphology, it will be possible to reschedule the completion of the surgery. This conduct eliminates the risk of having to subject the patient to a tracheostomy. The discomfort of having to undergo two surgeries is thus counterbalanced by the undisputed advantage of safely avoiding a tracheostomy, either definitive or temporary.^{4,5,6}

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References

1. Yalcin B, Poyrazoglu Y. Recurrent laryngeal nerve. *Surg Radiol Anat.* 2012 Aug;34(6):571. doi: 10.1007/s00276-012-0969-0. Epub 2012 Apr 5. PMID: 22476859.
2. Haller JM, Iwanik M, Shen FH. Clinically relevant anatomy of recurrent laryngeal nerve. *Spine (Phila Pa 1976).* 2012 Jan 15;37(2):97-100. doi: 10.1097/BRS.0b013e31821f3e86. PMID: 21540775.
3. Pei MW, Chen WB, Hu MR. Study progress of intraoperative neuro-monitoring of recurrent laryngeal nerve in thyroidectomy. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi.* 2018 Jun 7;53(6):474-478. Chinese. doi: 10.3760/cma.j.issn.1673-0860.2018.06.021. PMID: 29902860.
4. Tewari A, Samy RN, Castle J, Frye TM, Habeych ME, Mohamed M. Intraoperative Neurophysiological Monitoring of the Laryngeal Nerves During Anterior Neck Surgery: A Review. *Ann Otol Rhinol Laryngol.* 2017 Jan;126(1):67-72. doi: 10.1177/0003489416675354. Epub 2016 Nov 1. PMID: 27803238.
5. Moroni E, Jonas J, Cavallaro A, Sapienza P, M C, Bahr R. Intraoperative neuro-monitoring of the recurrent laryngeal nerve. Experience of 1000 consecutive patients. *G Chir.* 2007 Jan-Feb;28(1-2):29-34. Italian. PMID: 17313730.
6. Liddy W, Wu CW, Dionigi G, Donatini G, Giles Senyurek Y, Kamani D, Iwata A, Wang B, Okose O, Cheung A, Saito Y, Casella C, Aygun N, Uludag M, Brauckhoff K, Carnaille B, Tunca F, Barczyński M, Kim HY, Favero E, Innaro N, Vamvakidis K, Serpell J, Romanchishen AF, Takami H, Chiang FY, Schneider R, Dralle H, Shin JJ, Abdelhamid Ahmed AH, Randolph GW. Varied Recurrent Laryngeal Nerve Course Is Associated with Increased Risk of Nerve Dysfunction During Thyroidectomy: Results of the Surgical Anatomy of the Recurrent Laryngeal Nerve in Thyroid Surgery Study, an International Multicenter Prospective Anatomic and Electrophysiologic Study of 1000 Monitored Nerves at Risk from the International Neural Monitoring Study Group. *Thyroid.* 2021 Nov;31(11):1730-1740. doi: 10.1089/thy.2021.0155. PMID: 34541890.