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INTERNATIONAL

ORIGINAL ARTICLE

Impact of the laryngeal nerves anatomy on the intraoperative neuromonitoring results in surgery of thyroid gland and functional results after partial laryngectomies

Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

Greta Berger[1ADEF], Bożena Kosztyła-Hojna[1D], Lech Chyczewski[2D]

[1]Department of Clinical Phonoaudiology and Speech Therapy, Bialystok, Poland; Head: Ph MD Bożena Kosztyła Hojna
[2]Medical University of Bialystok, Poland; Head: Ph MD Lech Chyczewski

Article history: Received: 08.06.2018 Accepted: 26.06.2018 Published: 06.08.2018

ABSTRACT: Goal of this work was to describe, interpret and highlight the impact of neuroanatomy in the region of the larynx on the intraoperative neuromonitoring (IONM) during thyroidectomy. Rich anastomoses network of the recurrent laryngeal nerve (RLN) and superior laryngeal nerve (SLN) may have impact on results of thyroidectomy and partial laryngectomy. Intraoperative neuromonitoring is a useful tool in the armamentarium of the Head and Neck surgeon but it will never replace deep knowledge of surgical anatomy and good surgical technique.

KEYWORDS: recurrent laryngeal nerve (RLN), superior laryngeal nerve (SLN), thyroidectomy, partial laryngectomy, neuromonitoring

INTRODUCTION

Injury of the inferior laryngeal nerve (ILN), a branch of recurrent laryngeal nerve (RLN), is considered to be the cause of voice disorders after thyroid surgery [23]. Prevention of voice disorders is therefore a priority in thyroid surgery. Damage to the external branch of the superior laryngeal nerve (EBSLN) also has a negative impact on voice quality of professional voice users. The superior laryngeal nerve is also called the "nerve of Amelita Galli Curci" after a legendary operatic soprano who suffered injury to her superior laryngeal nerve after total thyroidectomy. As a result, she lost the high upper extension of her voice and ended her spectacular career. Injury of the superior laryngeal nerve (SLN) is also the cause of sensory laryngeal dysfunction, which can result in aspiration of food into the respiratory tract and dysphagia. Moreover, Pereira et al. [19] reported that 30% of patients with unilateral inferior laryngeal nerve damage have inadequate swallow with aspiration of food into the respiratory tract. Most patients undergoing thyroidectomy do not experience such complications. There is, however, a group of patients who, despite the normal course of the procedure and with normal function of inferior and superior laryngeal nerves, experience temporary phonation and swallowing problems in the postoperative period.

Temporary dysphagia usually lasts longer than dysphonia and reduces the quality of life of patients, despite the fact that laryngeal nerves are not damaged. The main complaint reported by patients is the difficulty in swallowing large tablets that require drinking more water. Lombardy et al. [14] analyzed vocal and swallowing disorders in patients without laryngeal nerve damage after total thyroidectomy. They noticed that temporary swallowing problems and voice dysfunctions are associated with healing process and with the incidence of rare postoperative hematoma, which was also confirmed by Pereira et al. [19]. In addition, pre-laryngeal muscles are the only mechanical support for the segment between the larynx and trachea after total thyroidectomy. When postoperative scar is being formed, the laryngeal-tracheal section becomes permanently immobilized so that all vertical movements are ceased. Each cut of the muscles covering the larynx is associated with the formation of permanent scar, which additionally intensifies the above problem. For this reason, the most important element of the surgical technique is to split and retract strap muscles without their mechanical damage. Scar formation is not the only cause of dysphagia, as it may also result from the damage of thin nerve branches, called anastomoses, connecting recurrent laryngeal nerve (RLN) branches with the external branch of the superior laryngeal nerve (EBSLN), and thin nerve branches of cricopharyngeal muscle. Many centers do not routinely practice superior laryngeal nerve (SLN) exposure and intraoperative nerve monitoring, therefore it is important to ligate the superior thyroid artery and vein on the capsule of the thyroid gland to reduce the risk of SLN damage. In addition, mechanical damage and coagulation should be avoided in the area of cricothyroid muscle (CTM), through which the external branch of the superior laryngeal nerve passes. Voice dysfunction after total thyroid gland removal without damage to the laryngeal nerves, if occurs at all, is usually transient and gradually disappears. Other reasons of post-operative dysphonia include mechanical damage of the vocal folds during intubation, dislocation of cricoarytenoid articulation, transient changes in the blood flow in the larynx area, dysfunction of cricothyroid articulation, immobilization of the laryngeal-tracheal section with vertical movements restriction, weakness of pre-laryngeal muscles and psychological reaction of the patient to the new situation after the procedure.

THE ROLE OF INTRAOPERATIVE NEUROMONITORING

American Academy of the Head and Neck Surgery has published guidelines in order to optimize voice outcomes in patients qualified for thyroidectomy [5]. Intraoperative neuromonitoring of the recurrent laryngeal nerve (RLN) and vagus nerve (X) enables pre-

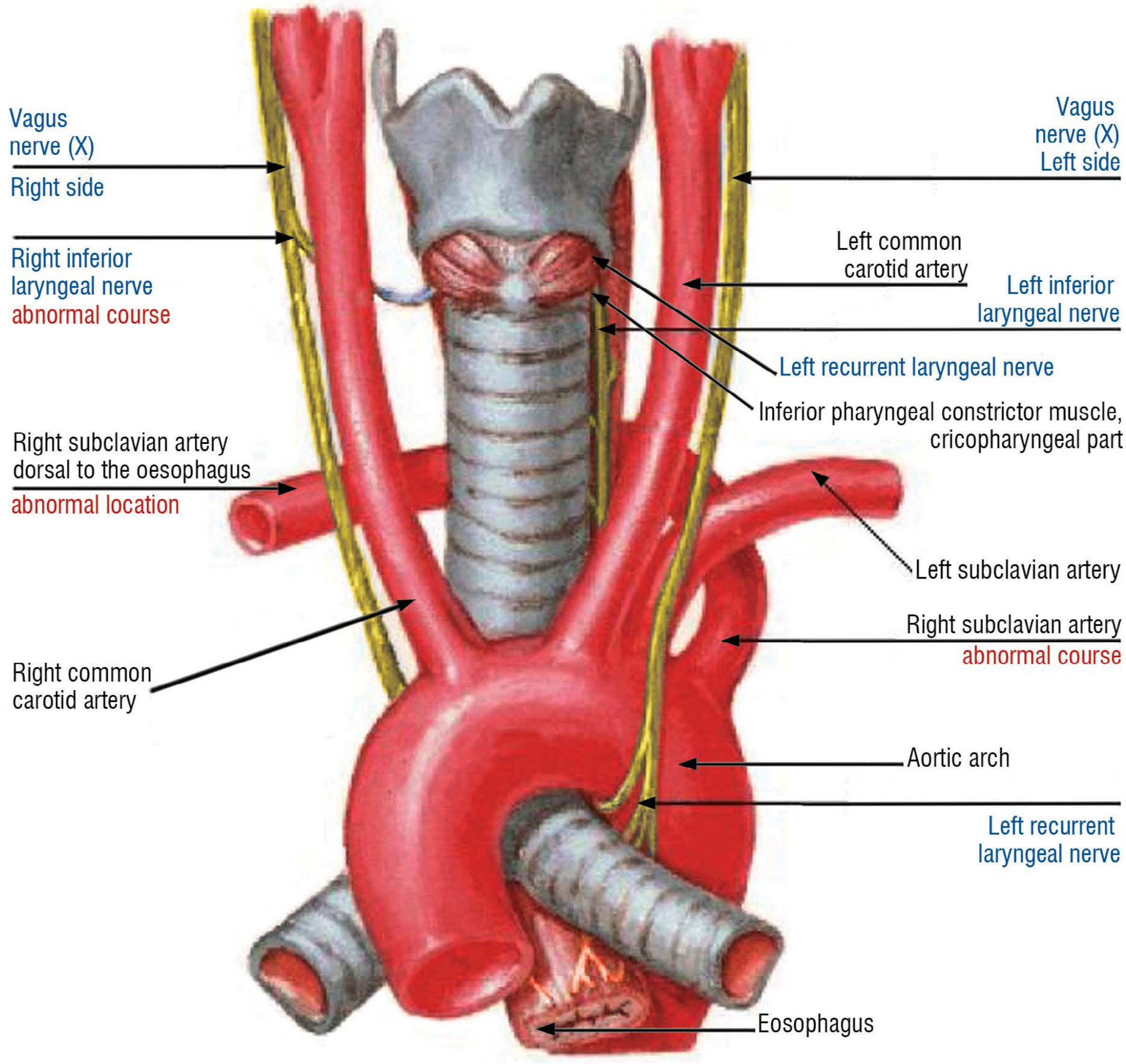

Fig. 1. Non-recurrent inferior laryngeal nerve, right side.

cise assessment of inferior laryngeal nerve function, which reduces the risk of transient neuropraxia and eliminates the risk of bilateral paralysis of the recurrent laryngeal nerve. If response from the recurrent laryngeal nerve and the vagus nerve is reduced at the first operated site, the total thyroidectomy is not continued on the other side, but the procedure is limited to unilateral thyroid lobectomy. The next stage of the procedure, also the oncological procedure, is planned taking into consideration the approximate time necessary for the return of the laryngeal nerve function on the already operated side and necessary oncological treatment [11, 31]. Furthermore, indications for use of intraoperative neuromonitoring include pre-operative recurrent laryngeal nerve paralysis, receiving a second thyroid surgery and total thyroidectomy. An important practical element during anesthesia is that muscle relaxants are not used at all and only small amounts of succinylcholine, i.e. 1–2 mg/kg body weight are used for anesthesia induction. The great advantage of intraoperative neuromonitoring is also that it can help to detect anatomical abnormalities such as an abnormal course of the inferior laryngeal nerve (Non-Recurrent Inferior Laryngeal Nerve). The abnormal course of the inferior laryngeal nerve significantly increases the risk of complications during thyroidectomy. This anatomical variant is more common on the right side (0.5%–1%), while it is relatively rare on the left side (0.04%) [11]. According to Kamani et al. [12], neuromonitoring probe should be used to stimulate the vagus nerve (X) low on the neck, i.e. in the area adjacent to the 4th tracheal ring. If there is no muscle response in electromyography, the neuromonitoring probe should be directed higher, i.e. to the area adjacent to the upper edge of the thyroid cartilage. If stimulation of the vagus nerve at this level leads to the muscle response, it indicates the abnormal course of the inferior laryngeal nerve. It is important to take thorough medical history before the procedure since dysphagia is a common symptom in the group of patients with such an anatomical anomaly and it results from the abnormal position of the right subclavian artery, dorsal to the oesophagus [18]. Abnormal course of the inferior laryngeal nerve on the right side is associated with the abnormal course of the right subclavian artery, which origins directly from the aortic arch. Normally, the recurrent laryngeal nerve runs on the right side and loops under the right subclavian artery ~~(Fig. 1).~~

Intraoperative neuromonitoring and EMG results enable the assessment of nerve dysfunction, i.e. when the amplitude of muscle response after stimulation is <100uV and the latency increases by more than 10% [11]. False positive result is characterized by the

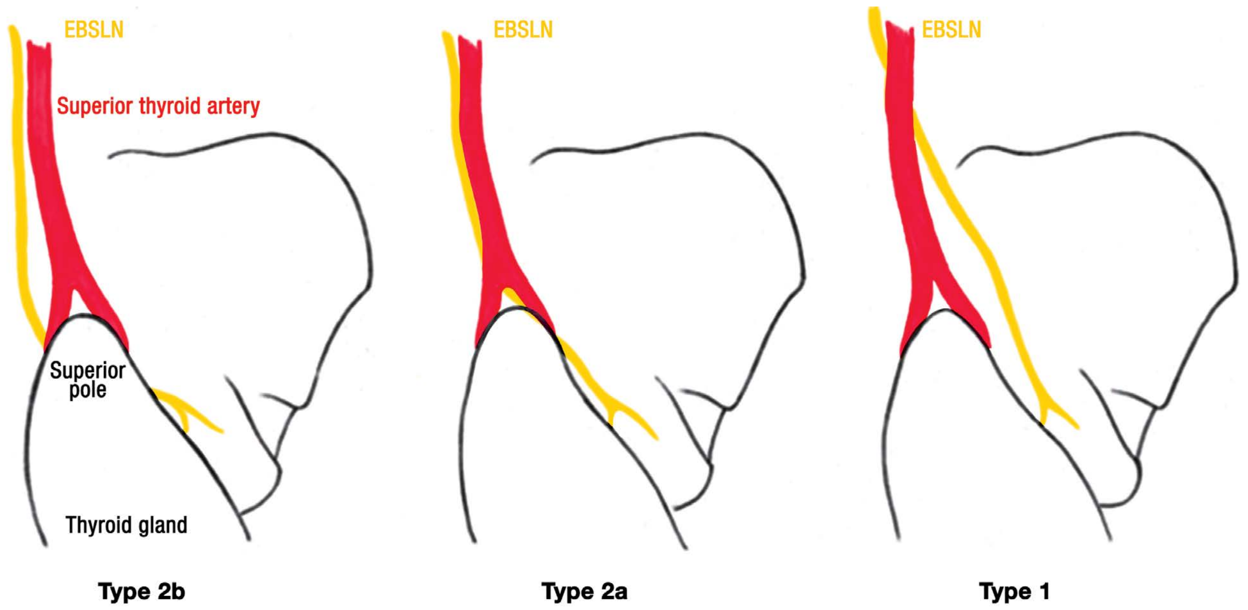

Fig. 2. Superior Laryngeal Nerve (SLN), External Branch (EBSLN) and Internal Branch (INSLN).

reduced amplitude of muscle response (<100uV) without postoperative restricted mobility of the vocal fold. The same false positive result may occur with transient neuropraxia that may last from several days to several months after surgery. False negative result is characterized by intra-operative signal and amplitude of muscle response of appropriate value and post-operative paralysis of the vocal fold. False negative result is caused by the stimulation of the inferior laryngeal nerve in the area of the damaged nerve segment. In order to eliminate false negative results, the amplitude of the muscular response (EMG) from the vagus nerve should be assessed after lobectomy. The positive result is characterized by a reduced amplitude (<100uV) of the response in electromyography (EMG) and limited mobility of the vocal fold found after the surgery. The negative result is characterized by the correct amplitude of muscle response after stimulation and maintaining the normal function of vocal folds after surgery. Julien et al. [11] reported that response from the vagus nerve before (Vagal – V1) and after lobectomy (Vagal – V2) and response from the recurrent laryngeal nerve before (RLN – R1) and after lobectomy (RLN – R2) with the same stimulation with a 1 mA current, correlated with the normal postoperative function of vocal folds. The amplitude of muscle response was above 100 uV but significantly higher values were not a better prognostic factor. The best location for stimulation of the recurrent laryngeal nerve (RLN) is the lower edge of the thyroid lobe, where inferior laryngeal nerve diverges from the recurrent laryngeal nerve. Dissecting tissues surrounding Berry's ligament and Zuckerkandl's tubercle helps to locate the laryngeal nerve since the inferior laryngeal nerve runs here close to the thyroid gland [11].

ANATOMY AND IMPORTANCE OF THE UPPER LARYNGEAL NERVE (SLN)

The upper laryngeal nerve diverges from the lower part of the inferior ganglion of the vagus nerve (X) at the level of cervical vertebra 2 (C2), 4 cm away from the bifurcation of the common carotid artery in cranial direction [7, 32]. At the height of the greater horn of hyoid bone, about 1.5 cm in the caudal direction, superior laryngeal nerve diverges into a thin external branch (External Branch Superior Laryngeal Nerve EBSLN) with sensory and motor fibers and a thicker inner branch (Inferior Branch Superior Laryngeal Nerve IBSLN) which is exclusively sensory [7, 32]. The external branch of superior laryngeal nerve (EBSLN) runs on the surface of the inferior pharyngeal constrictor and innervates the cricothyroid muscle (CTM). The stimulation of CTM causes the thyroid cartilage to slide forward on the cricoid cartilage, thus it is responsible for the tension and elongation of vocal folds. Damage to the CTM muscle and external branch of the superior laryngeal nerve (EBSLN) leads to decrease in the fundamental frequency of laryngeal tone (Fundamental Frequency F0) and voice and limits the patient's ability to produce high-frequency sounds. This type of dysphonia is particularly evident in patients with high-pitched voices (soprano), whereas in people who are not professional voice users, this can be unnoticed. Symptoms reported by patients may include vocal fatigue, effortful phonation and puffing voice [3, 24]. When superior laryngeal nerve is damaged, laryngoscopy enables to see the shift of the stalk of epiglottis to the side of the damaged nerve, asymmetrical mucosal wave and rotation of the back of the glottis to the side of the damaged superior laryngeal nerve [3, 25]. EBSLN also plays an important role in the act of swallowing due to sensory nerve fibers, the damage of which leads to sensory laryngeal dysfunction. It is a priority in all conservative (partial) laryngectomies performed in patients with laryngeal cancer to maintain the act of swallowing, reconstruct the continuity of alimentary and respira tory tract and to form a new glottis, so called neoglottis. The maintenance of the superior laryngeal nerve (SLN) function is also important during thyroidectomy. The best proof of the normal SLN function is the intraoperative comparison of the nerve activity with the amplitude and latency of the evoked response in EMG of the cricothyroid muscle (CTM). Darr et al. [7] used intraoperative neuromonitoring to assess the SLN activity and they detected response from the cricothyroid muscle (CTM) in EMG in 100%, i.e. in all patients examined. The significance of the use of superior laryngeal nerve neuromonitoring (SLN) in thyroidectomy is also emphasized by Friedman et al. [9] who remark

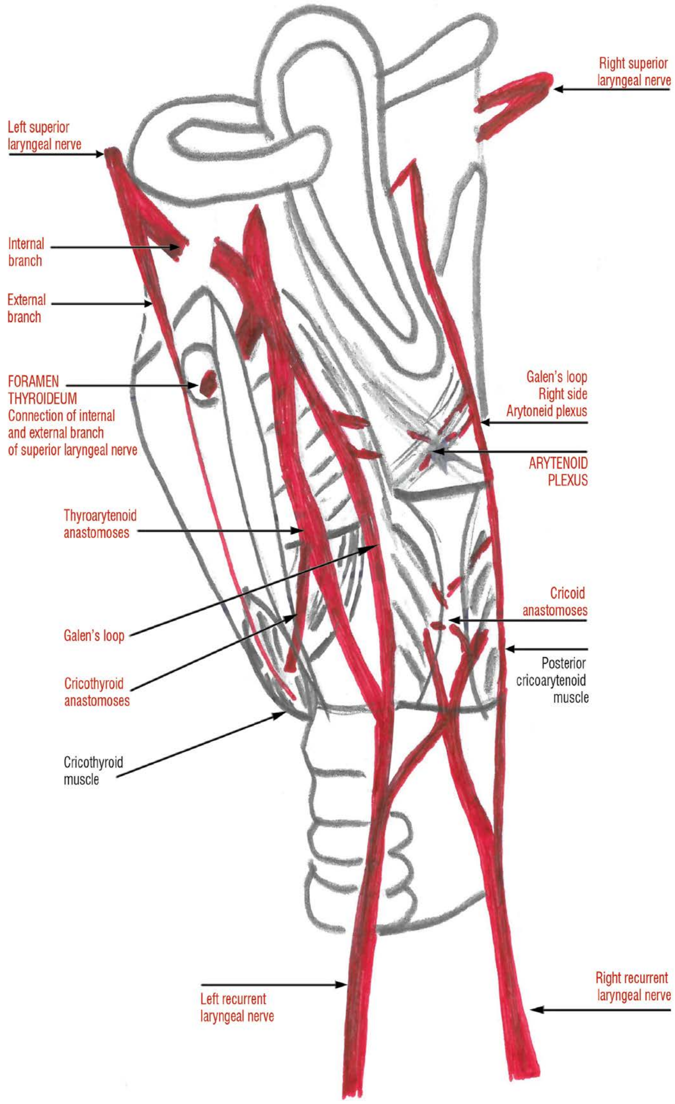

Fig. 3. Neural anastomoses coming from recurrent laryngeal nerve (RLN) and superior laryngeal nerve (SLN).

that visual identification of the external branch of the superior laryngeal nerve (EBSLN) is not always possible, as in 20% of cases the nerve runs under the fascia, in the deep layers of the inferior pharyngeal constrictor. In addition, the possibility of false positive results in visual identification of the nerve should be kept in mind. Tendinous fibers running through the cricothyroid muscle (CTM) may imitate real nerve fibers, resulting in a false positive result in the visual assessment. It should be noted that intact structure of the nerve in the macroscopic evaluation does not necessarily reflect its normal function. In neuromonitoring, EBSLN is found in the sterno-thyroid-laryngeal triangle, and the recurrent laryngeal nerve (RLN) is identified in the area from the lower edge to the half to the thyroid lobe and upwards until the point where the nerve enters the larynx [7]. At this point, it is also important to pay attention to the type of intraoperative neuromonitoring, because the monopolar probe, characterized by high sensitivity to depolarization of the nerve, can be effectively used at some distance from the nerve, also through the fascia covering the nerve. According to Che – Wei Wu et al. [6] bipolar probes, which are the most specific to the nervous tissue, are important in reducing false positive results. The probe, however, must be used close to the nervous tissue and requires the use of a larger current stream (> 1–2 mA) than when using a monopolar probe. It should be noted that bipolar probes have to be used directly on the tissue of the superior laryngeal nerve as it has to be precisely identified. When the nerve runs in the cricothyroid muscle, the dissection of nerve branches is associated with increased risk of nerve damage. It is worth to cite the results of the research performed by Barczyński et al. [1], who in the electromyography (EMG) with neuromonitoring during the procedure of thyroidectomy correctly recognized the nerve among 210 external branches (EBSLN) of the superior laryngeal nerve in 73.9% using electric stimulation (1mA) and mean amplitude of the response from EBSLN was significantly lower compared to the amplitude of the response from the recurrent laryngeal nerve (RLN). The above results are confirmed by the study by Potenza et al. [20], who during 72 thyroidectomies with simultaneous neuromonitoring confirmed the response from the external branches of the superior laryngeal nerve (EBSLN) in 57 cases. The average amplitude of the EBSLN response was 269+ _ 178 uV and for RLN 782 + _178uV when stimulated by the current stream of 1–2 mA. Therefore, the mean amplitude of the response from the superior laryngeal nerve constitutes on average 1/3 of the amplitude of the response from the recurrent laryngeal nerve. The above arguments support the use of neuromonitoring also in the assessment of the superior laryngeal nerve. According to the recommendations of The International Neural Monitoring Study Group (INMSG) from 2013, intraoperative neuromonitoring should be used not only for the identification of the vagus nerve and both recurrent laryngeal nerves, but also for both superior laryngeal nerves [2, 13]. Anatomic variants of the location of the external branch of the superior laryngeal nerve (EBSLN) in relation to the upper pole of the thyroid gland are described in the Cernea classification. Types 2a and 2b mean that the branch runs, respectively, in the caudal direction in close proximity of the vein and artery of the upper thyroid pole, and forward from the surface of the thyroid gland, thus complicating the identification of the nerve. According to Cernea et al. [4], such a course of the external branch of the superior laryngeal nerve is found in about 24% of cases and is associated with the highest risk of nerve damage during thyroidectomy ~~(Fig. 2).~~

NERVE ANASTOMOSES AS A SOURCE OF DOUBT IN THE INTERPRETATION OF THE RESULTS OF INTRAOPERATIVE NEUROMONITORING

Anatomy has a direct impact on the interpretation of the results of intraoperative neuromonitoring and allows a visual assessment of the contraction of selected muscles, e.g. unilateral contraction of the vocal muscle can be observed in the laryngoscopic intraoperative assessment during vagal nerve/recurrent laryngeal nerve stimulation on the same side. If the contraction of the vocal muscle in direct laryngoscopy cannot be assessed, the posterior cricoarytenoid muscle (PCA) can be used for evaluation, which is also innervated by the recurrent laryngeal nerve. This possibility was used in research performed by Liddy et al. [13]. The visual assessment of the posterior cricoarytenoid muscle (PCA) contraction can be confirmed by palpation, that is by feeling the muscle contraction in the back of the larynx, while, at the same time, high amplitude of response from the muscle is observed in electromyography (EMG). Similarly, when stimulating the external branch of the superior laryngeal nerve (EBSLN), the contraction of the crico-thyroid muscle (CTM) is observed on the same side. When interpreting the results, doubts may arise when the stimulation of external branch of the superior laryngeal nerve (EBSLN) leads to the contraction of the vocal muscle at 1/3 of the vocal fold length (presence of motor nerve fibers from the recurrent laryngeal nerve) on the same side. Liddy et al. [13] conclude that in such a situation one should pay attention to the value of the amplitude of muscle response in EMG after stimulation of EBSLN, which is significantly lower than the amplitude caused by stimulation of the recurrent laryngeal nerve (RLN) or vagus nerve (VN – X). This situation is explained by Liddy et al. [13] with the presence of Human Communicating Nerve (HCN), i.e. a neural connection, called cricothyroid anastomosis. The cricothyroid connection transfers the stimulation from the external branch of the superior laryngeal nerve (EBSLN) through the nerve fibers running in the cricothyroid muscle, under the mucous membrane of the lower throat, up to the cricoarytenoid muscle at around 1/3 of the vocal fold on the same side. The presence of cricothyroid anastomosis has been confirmed in the examination of human and dog larynges [13, 27, 28]. The theory was confirmed in a clinical assessment by Potenza et al. [20] and Darr et al. [7]. Darr et al. [7] obtained a response in EMG from the vocal muscle in patients after stimulation of the external branch of the superior laryngeal nerve (EBSLN). The amplitude of the response, however, was much lower than the amplitude induced by stimulation of the vagus nerve and recurrent laryngeal nerve on the same side. The mean amplitude after stimulation of EBSLN was approximately ¼ of the amplitude after stimulation of the recurrent laryngeal nerve (RLN). Potenza et al. [20] obtained a response from the anterior 1/3 of the vocal muscle in EMG after stimulation of the external branch of the superior laryngeal nerve (EBSLN) in 80% of patients. The amplitude after EBSLN stimulation was 1/3 of the amplitude obtained after stimulation of RLN. In both studies, the stimulation with the same current (1–2 mA) was used. It should be noted that the cricothyroid muscle (CTM) is not innervated directly by the vagus nerve or recurrent laryngeal nerve and it does not cause vocal folds to adduct. The task of the muscle is to tighten and lengthen the vocal folds, so the observed contraction of the vocal muscle in the front part cannot be caused by stimulation of CTM. Nerve connections, cricothyroid anastomoses, only run motor fibers to the thyroarytenoid muscle (TAM) on the same side, which tightens the vocal folds and narrows the rima glottidis. This explains the possibility of observing the movement of the vocal fold muscle after stimulation of an external branch of the superior laryngeal nerve (EBSLN). It should be noted, however, that during muscle contraction, the amplitude values are low. Detailed knowledge about the presence of nerve anastomoses between the external branch of the superior laryngeal nerve (EBSLN) and recurrent laryngeal nerve (RLN), correct intraoperative interpretation of electromyography (EMG) and reading the appropriate amplitude induced, helps the surgeon to establish accurate diagnosis and assess the laryngeal nerves function.

Anastomoses between the external branch of the superior laryngeal nerve (EBSLN) and the recurrent laryngeal nerve (RLN), so-called crico - thyroid anastomoses, was observed in 68% of larynges studied by Sanudo et al [29]. Morever, Sanudo et al. [29] discovered anastomoses between the internal branch of the superior laryngeal nerve (IBSLN) and the recurrent laryngeal nerve (RLN) and they identified four types of connections. Galen's loop (ANSA GALEANI) was found in all of the laryngeal specimens tested. The Galen's loop was found on the dorsal surface of the posterior cricoarytenoid muscle (PCA) and just below the mucous membrane of the lower throat. The Galen's loop leads the sensory fibers to the laryngeal mucous membrane, below the rima glottides, and to the tracheal mucous membrane, up to the height of 3–4 tracheal cartilage [22, 32]. Additionally, the nerve plexus on the surface of arytenoid cartilages (arytenoid plexus), associated with interarytenoid muscle, was a frequently found nerve connection. Arytenoid plexus was formed by connecting the nerve fibers, that is dorsal branches of the inner branch of the superior laryngeal nerve with the abdominal branch of the laryngeal nerve, which ran upward under the deep layers of posterior cricoarytenoid muscle (PCA). Sanudo et al. [29] also observed nerve connections running from the right to the left side (cross innervation). Clinical significance of the arytenoid plexus is to provide motor nerve fibers to the interarytenoid muscle and sensory fibers to the mucous membrane of the posterior commissure of the larynx. In addition, in partial laryngeal surgery, during which it may be necessary to remove one of the arytenoid cartilages, e.g. in the supracricoid partial laryngectomy, cutting the interarytenoid plexus and interarytenoid muscle may lead to sensory disturbances in the region of posterior commissure. This is important for swallowing and it may be the cause of harmful aspiration of food to the bronchial tree. In larynges examined by Sanudo et al. [29] 14% had thyroarytenoid anastomoses. These connections were formed by a descending branch of the inner branch of the superior laryngeal nerve (IBSLN) and an ascending branch of the recurrent laryngeal nerve (RLN), which is located in the region where the recurrent laryngeal nerve runs near the cricothyroid articulation. This is the place of particular importance, where intraoperative damage of the recurrent laryngeal nerve (RLN) may occur in all surgical techniques requiring the split of cricothyroid articulation. The most rarely observed nerve connection originating from the internal branch of the superior laryngeal nerve (IBSLN) and the recurrent laryngeal nerve (RLN) was the cricoid anastomosis that led the sensory fibers to the subglottic mucosa ~~(Fig. 3).~~

Sanudo et al. [29] found connections between the internal and external branches of the superior laryngeal nerve (SLN), which ran through the opening in the thyroid cartilage, at the upper 1/3 of thyroid lamina. Connecting nerve fibers were often accompanied by arterial vessels, that is the upper laryngeal artery or crico-thyroid artery diverging from the upper laryngeal artery [26]. Clinically, such an anatomical connection may be associated with intra-operative bleeding and damage to the superior laryngeal nerve (SLN), both during horizontal supra-glottic laryngectomy and in the classic form described by Alonso. This technique requires removal of the upper one-third or a half of the thyroid cartilage with the hyoid bone (when the tumor spreads to the pre-vocal space). In order to preserve swallowing function in the postoperative period, it is necessary to maintain the intact superior laryngeal nerve (SLN) [17, 33]. Clinical significance of anastomoses between the laryngeal nerves was also emphasized by Sanudo et al. [29], who noted that the position of the vocal fold, its mass and mucosal wave after paralysis of the vocal fold largely depends on the restoration of the innervation influenced by the presence of anastomoses between the laryngeal nerves. Rosenbach [26] and Semon [30] claimed that the vocal fold goes through various stages before it is completely paralyzed. According to the authors, the vocal fold at first lost the ability of abduction and then lost the function of adduction. Grossmann and Wagner were of a different opinion [10, 34]. They claimed that the position of the vocal fold depends on the location of laryngeal nerve damage. With isolated recurrent laryngeal nerve damage (RLN), the vocal fold on the side of the nerve damage takes paramedia position. With the simultaneous damage of the recurrent laryngeal nerve (RLN) and superior laryngeal nerve (SLN), the vocal fold on the side of the nerve damage takes the intermedia position. Sanders et al. [27] indicate the importance of connections between the recurrent laryngeal nerve (RLN) and the superior laryngeal nerve (SLN). The authors point to the two neural networks, that is the area of the interarytenoid muscle, where fibers of all laryngeal nerves connect, and the area of piriform sinuses, where fibers of the external branch of the superior laryngeal nerve (SLN) and recurrent laryngeal nerve (RLN) are combined. Sanders et al. [27] found in 4 out of 10 laryngeal specimens fibers running from the external branch of the superior laryngeal nerve (EBSLN), passing between the bellies of cricothyroid muscle (CTM), running under the mucous membrane of piriform sinuses and ending as motor fibers in the thyroarytenoid muscle (TAM) (where the motor nerve fibers from the recurrent laryngeal nerve RLN also come) and as sensory fibers in the subglottic mucosa. Authors [27] emphasize that the thyroarytenoid muscle (TAM) has the densest network of nerve connections, the most marked on the border of the vocal ligament. The terminal fibers of the recurrent laryngeal nerve (RLN) reach the lateral cricoarytenoid muscle (LCA) and thyroarytenoid muscle (TAM), thus allowing the adduction of vocal folds, and for thyroarytenoid muscle (TAM) they increase tension of the vocal folds. For the functional assessment the innervation of the posterior cricoarytenoid muscle (PCA) is also important, as it abducts vocal folds and opens the glottis, thus having a respiratory function. Sanders et al. [28], who investigated laryngeal specimens from dogs, reported that the muscle is innervated by a single branch of the recurrent laryngeal nerve. The lateral part of the posterior cricoarytenoid muscle (PCA) is responsible for breathing, while the medial part of the muscle reaching the area of arytenoid is associated with voice production. This is confirmed by the innervation of the PCA muscle from two separate branches originating from the recurrent laryngeal nerve observed in humans. According to Sanders et al. [27] innervation of two parts of the same muscle provides more precise phonation control. Nerve anastomoses that connect the laryngeal nerves have been the subject of many studies at the beginning of the 20th century, raising many doubts. In 1921 Dilworth [8] stated: „The vagus nerve enters the network of nerve plexuses in various parts of the body, also in the larynx".

In summary, anastomoses, which are nerve connections between the external branch (EBSLN), the inner branch of superior laryngeal nerve (IBSLN) and the recurrent laryngeal nerve (RLN) of clinical significance, include: 1) Galen's loop (Galens Anastomosis), 2) Plexus on the surface of arytenoid cartilages (Arytenoid Plexus) consisting of sensory nerve fibers that conduct sensory stimuli to many muscles and joints within the larynx and 3) Cricothyroid plexus (Cricothyroid Anastomosis) that conducts mucosal sensory fibers to the subglottic region and motor fibers to the thyroarytenoid muscle (adduction and tightening of vocal folds).

SUMMARY

In order to achieve good functional results after surgical treatment, it is important for a surgeon performing sparing (partial) laryngectomy to know laryngeal neuroanatomy and to correctly interpret intraoperative neuromonitoring when performing thyroidectomy. The internal muscles of the larynx are innervated by the recurrent laryngeal nerve on both sides with the exception of the cricothyroid muscle, which is innervated by the external branch of the superior laryngeal nerve. The presence of anastomoses between recurrent and superior laryngeal nerves affects the clinical assessment of postoperative results and delineates therapeutic and rehabilitative treatment.

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Word count: 5360 Page count: 8 Tables: – Figures: 3 References: 33

DOI: 10.5604/01.3001.0012.1752 Table of content: https://ppch.pl/issue/11867

Competing interests: The authors declare that they have no competing interests.

Corresponding author: Berger Greta; Department of Clinical Phonoaudiology and Speech Therapy, Medical University of Bialystok, Poland;
E-mail: greta.ewa.berger@gmail.com

Cite this article as: Berger G., Kosztyla - Hojna B., Chyczewski L.: Impact of the anatomy of laryngeal nerves on intraoperative neuromonitoring results in surgery of thyroid gland and functional results after partial laryngectomies; Pol Przegl Chir 2019: 91 (2): 29–36; DOI: 10.5604/01.3001.0012.1752