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Surgical anatomy of the larynx

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This article provides a review of the surgical anatomy of the larynx. The external cartilaginous and bony framework of the larynx are described in relation to how these structures can be used as landmarks to identify internal features of the larynx. The overlying musculature of the larynx is also detailed. The spaces of the internal larynx are explained including the pre-epiglottic, paraglottic, and cricoid area by their borders and contents to assist in orienting the surgeon. The course of vasculature and nerves within the larynx is described in detail. This includes the anatomical variants of the External Branch of the Superior Laryngeal nerve described by both Cernea and Friedman as well as variations in the Recurrent Laryngeal nerve. Finally, the musculature, mucosa, and cartilaginous structures of the internal larynx are described.

Introduction

The larynx functions to protect the airway during swallowing and also allows phonation from the vocal ligaments contained within the larynx. Surgical intervention within the larynx requires a detailed knowledge of the structure and the relationships between all components in order to avoid complications that may impair proper functioning of the larynx.

Exterior/superficial larynx

The larynx is built upon a framework made up of the hyoid bone at the superior boundary of the larynx, the cricoid cartilage inferior, and the thyroid cartilage spanning and connecting these 2 structures. The hyoid bone is a horseshoe shaped bone located at the level of C3.The inferior edge of the hyoid bone is connected to the superior border of the thyroid cartilage by the thyrohyoid membrane and the median and lateral thyrohyoid ligaments.[1,2] The thyroid cartilage is formed from 2 quadrilateral laminae which are fused medially forming the laryngeal prominence.[2] The posterolateral edge of the thyroid cartilage terminates in superior and inferior horns bilaterally. Inferior to the thyroid cartilage is the cricoid cartilage. The 2 structures are connected via a direct articulation between the inferior horn of the thyroid cartilage and the lateral facet of the cricoid cartilage. The cricothyroid ligament connects the anteromedial edge of the thyroid and cricoid cartilages.[1]

The strap muscles exist as bilateral pairs which run anteriorly and superficial to the laryngeal framework allowing movement of the larynx. The sternohyoid is the most medial travelling from the hyoid to the manubrium. Lateral to the sternohyoid is the omohyoid which travels inferiorly down the neck. Deep to the omohyoid and ster-

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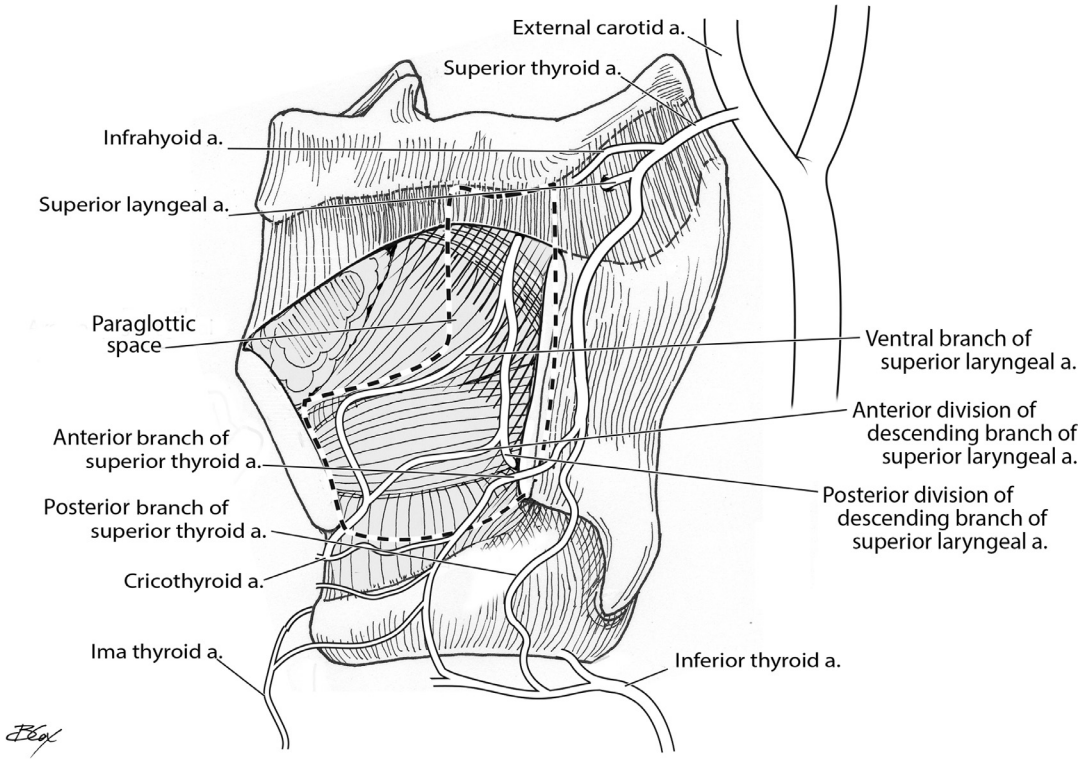

Figure 1 Vascular supply to the larynx.

nohyoid lies the thyrohyoid spanning between the thyroid cartilage and hyoid bone. Inferior to the lower attachment of the thyrohyoid is the sternothyroid which travels deep to the sternohyoid thereby connecting the thyroid cartilage to the sternum.

Spaces of the larynx

The interior larynx houses 3 spaces, the pre-epiglottic (PES), paraglottic (PGS), and cricoid area (CA). The boundaries of the laryngeal spaces have been discussed extensively in the literature however no absolute consensus has been reached.[3-7] Despite the lack of consensus, a summary of findings has been outlined. The PES straddles the epiglottis anteriorly and laterally near the upper edge of the thyroid lamina. The PES inferior edge terminates superior to the glottic level. The PGS is medial to the lower 2/3 of the thyroid cartilage lamina along the entire length. The medial edge of the PGS consists of the thyroepiglottic ligament and aryepiglottic muscle at the supraglottic level. At the glottic level the medial edge is the thyroarytenoid muscle. The medial border of the PGS at the subglottic level consists of the thyroarytenoid muscle, lateral cricoarytenoid muscle, and conus elasticus. The CA is medial to the internal perichondrium of cricoid within the subglottic area. The CA is fused above to the conus elasticus and to the first tracheal ligament inferiorly, travelling in an oblique direction posterosuperior from cricothyroid joint to an anteroinferior connection.[1]

Neurovasculature

Blood supply to the larynx is provided by branches of the superior and inferior laryngeal arteries. The arteries of the larynx run in the paraglottic space between the laryngeal muscles and thyroid cartilage.[1]

The superior laryngeal artery (SLA) divides off of the superior thyroid artery and enters the PGS space superiorly by piercing the lateral thyrohyoid membrane accompanied by the internal branch of the superior laryngeal nerve. The SLA then descends in the posterior portion of the paraglottic space. Within the supraglottic portion of the paraglottic space the ventral branch travels anteriorly off the descending SLA until anastomosing with the ascending branch of the cricothyroid branch of the superior thyroid artery. Once reaching the glottic level, the SLA divides again into anterior and posterior divisions. The anterior division anastomoses with the cricothyroid branch of the superior thyroid artery within the paraglottic space. The posterior division continues inferiorly until anastomosing with the inferior laryngeal artery in the posterior portion of the paraglottic space (Figure 1).

The cricothyroid branch of the superior thyroid artery enters the paraglottic space through the cricothyroid ligament before dividing, with 1 branch continuing through the paraglottic space until anastomosing with the anterior division of the descending branch of the SLA and an ascending branch traveling anteriorly within the PSGS before anastomosing with the ventral branch of the SLA.

The inferior laryngeal artery travels up the trachea in the tracheoesophageal groove deep to the inferior constrictor muscle with the recurrent laryngeal nerve before anastomosing with the posterior division of the descending branch of the SLA as well as with the branch from the opposite side.

The larynx is innervated by the recurrent laryngeal nerves (RLN) and the superior laryngeal nerves (SLN). On each side of the neck the SLN originates from the ganglion nodosum to descend alongside the pharynx posterior and then medial to the internal carotid artery before dividing into internal and external branches.[8,9] The internal branch pierces the thyrohyoid membrane with the SLA before dividing into the upper and lower branches. The external branch travels inferiorly until terminating in the cricothyroid muscle. Descent of the external branch has been described in the literature extensively, notably by Cernea and Friedman. The criteria outlined by Cernea categorizes variations of the external branch of the superior laryngeal nerve (EBSLN) in relation to the superior thyroid vessels, classifying 3 distinct types.[10] Type I EBSLN crosses the vessels at least 1 cm above the plane horizontal to the upper edge of the superior thyroid pole, Type IIa crosses less than 1 cm but above the plane, IIb less than 1 cm but below the plane. An alternative classification designed to increase identification in previously "unidentifiable" EBSLN has been described by Friedman.[11] Under the Friedman criteria Type I travels superficial or lateral to the inferior constrictor with the superior thyroid vessels until terminating in the cricothyroid muscle. Type II penetrates the lower portion of the inferior constrictor and terminates in the cricothyroid muscle. Type III penetrates the superior portion of the inferior constrictor until terminating in the cricothyroid muscle. Type II and type III offer protection to the external branch of the SLN though make identification difficult visually. Friedman did not offer data on percentages of nerves which are Type II/III but others

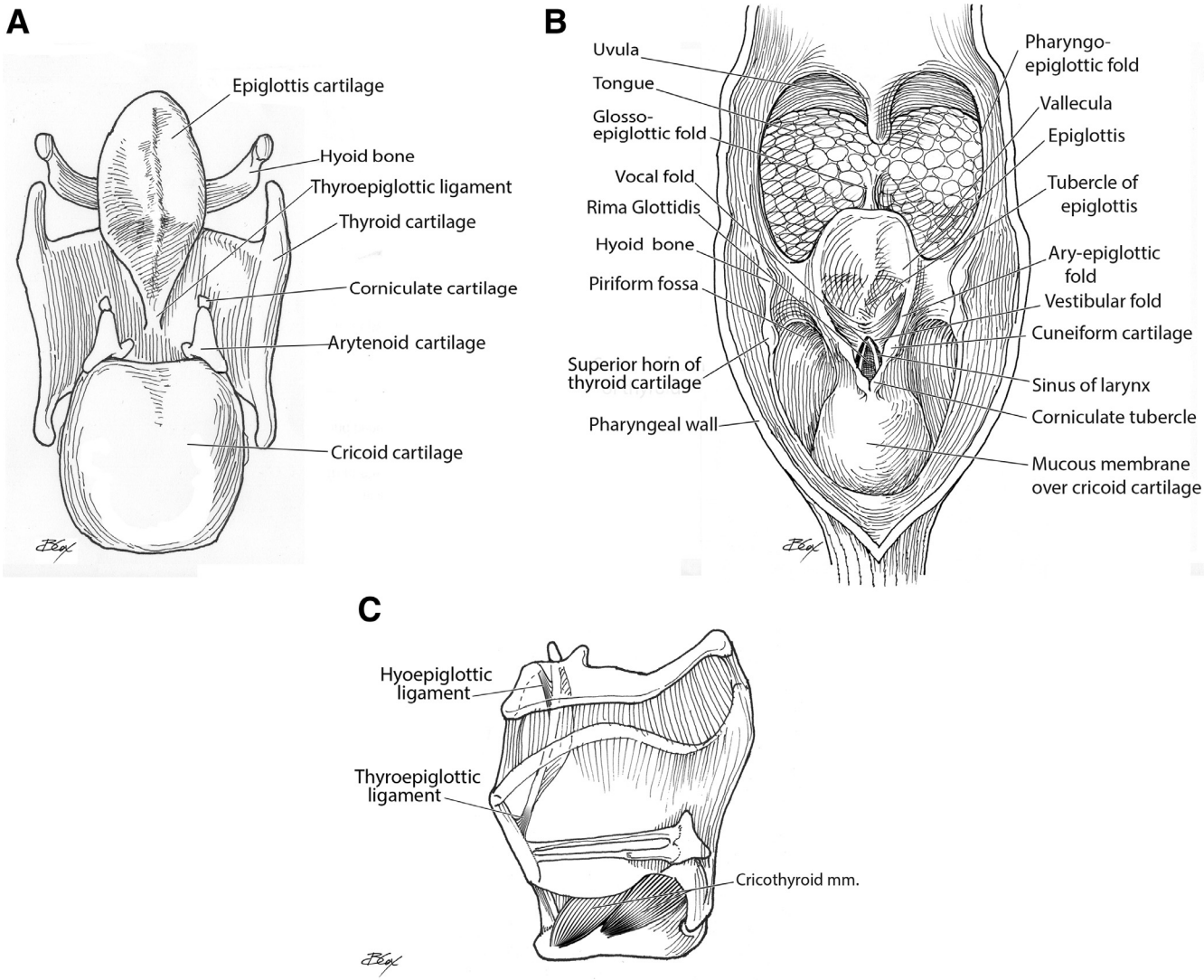

Figure 2 Superior and posterior view of the endolarynx.

have enumerated the finding of these variations at being 34% for type II and 15% for type III.[12]

The RLN are branches of the vagus nerves. The right and left nerves have varying paths down the neck before recurring and terminating posterior and lateral to the cricothyroid articulation. The left RLN branches off the vagus nerve before dipping underneath the aorta and traveling superiorly into the tracheoesophageal groove. The right RLN loops posteriorly around the subclavian artery and rises to the level of the larynx in the tracheoesophageal groove.[13] While traveling superiorly, additional variations between the left and right RLN exist. While the right RLN travels in the tracheoesophageal groove on 65% of cases, the left RLN does so on 77% of cases. The RLN travels lateral to the trachea on 33% of cases on the right, and only on 22% on the left. Rarely, the RLN may be located anterolateral to the trachea which leaves the nerve more vulnerable to surgical injury. Typically, the RLN travels posterior to the inferior thyroid artery on 61% of the cases, but the nerve may also be located between its branches in 6.5% of cases, or anterior to the vessels in 32.5% of cases. Branching of the RLN occurs along its superior travel 40% of the time.[14] Identification of the branching pattern is important for nerve preservation. The anterior branch may be mistaken for a stray posterior branch. Branching may occur between approximately 0.5 cm from the inferior border of the cricoid cartilage.[14] A unique variation that may be encountered is a nonrecurrent RLN in approximately 0.6% of cases, and is more frequent on the right.[14]

Extralaryngeal anatomical landmarks

Anticipating the location of internal laryngeal structures can rely on the presence of exterior landmarks. Using these landmarks to locate important interior structures can be

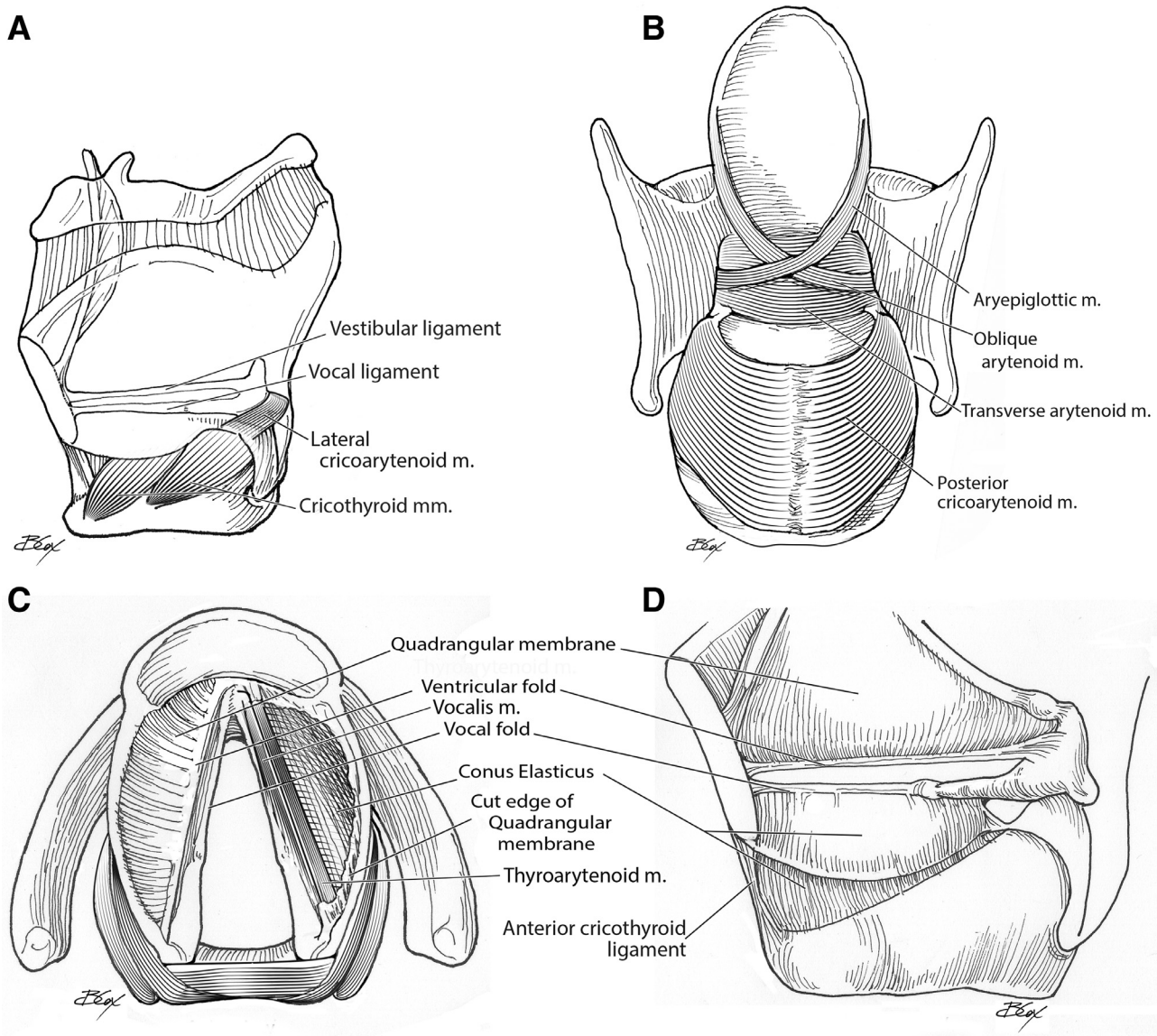

Figure 3 Laryngeal muscles and ligaments.

beneficial for surgical management. The vocal ligament location can be predicted from an anterior view by locating the anterior commissure which is halfway between the superior thyroid notch and inferior border of thyroid cartilage. Looking laterally, the tip of the vocal process is located at the midpoint between the anterior and posterior borders. The vocal ligament travels anteriorly from the vocal process to the thyroid cartilage. The cricoarytenoid joint is also located at the level of the vocal fold. The ventricular fold may be identified by finding the midway point between the superior thyroid notch and anterior commissure.[1]

The endolarynx

The inner structure of the larynx consists of a framework of cartilage and connective tissue (Figure 2A and B). Articulating on top of the lamina of the cricoid cartilage, are the 2 pyramidal shaped arytenoid cartilages which function as a key connection point for muscles and ligaments. Articulating with the summits of the arytenoids, are the corniculate cartilages. The cuneiform cartilages are a bilateral pieces of cartilage which reside within the aryepiglottic fold just anterior to the corniculate cartilages. The epiglottis is attached at its stem, via the thyroepiglottic ligament, to the posterior aspect of the anterior thyroid cartilage. The hyoepiglottic ligament is a fan shaped ligament which further connects the epiglottis to the hyoid bone anteriorly (Figure 2C).[1]

The intrinsic laryngeal muscles (Figure 3A-C) consist of the cricothyroid, thyroarytenoid, the posterior and the lateral cricoarytenoid, the transverse and the oblique arytenoid muscles. These muscles control the shape of the rima glottidis and the tension of the vocal cords. The cricothyroid muscle stretches from the anterolateral aspect of the cricoid cartilage to the inferior horn of the thyroid cartilage. The thyroarytenoid originates from the inferoposterior aspect of the angle of the thyroid cartilage to insert onto the anterolateral arytenoid cartilage. The posterior cricoarytenoid muscle originates from the posterior surface of the cricoid cartilage to insert onto the muscular process of the arytenoid cartilage. The lateral cricoarytenoid originates from the lateral part of the cricoid cartilage to insert onto the muscular process of the arytenoid cartilage. Spanning between the arytenoids are the transverse and oblique arytenoid muscles.

The ventricular fold is the thickened inferior edge of the quadrangular membrane that is stretched superior and parallel to the vocal fold, attached anteriorly to the lateral border of the thyroepiglottic ligament and stretching posteriorly to meet the arytenoid cartilage. Inferior to the ventricular fold is the vocal ligament which stretches from the vocal process of the arytenoid cartilage posteriorly, to the anterior commissure tendon anteriorly. The vocal ligament is a thickening of the superior edge of the conus elasticus. The conus elasticus is an elastic membrane that radiates from the superior border of the cricoid cartilage to the vocal ligament. The conus elasticus also fuses with the cricothyroid ligament. Reinke's space (the superficial lamina propria) is a potential space between the vocal cord mucosa and the vocal ligament, and has a key role in the vocal cord vibration pattern.

Conclusion

Knowledge of the laryngeal anatomy is imperative for proper physical examination and surgical management. Understanding the external landmarks can be beneficial in cases of external approach in order to anticipate the location of the endolaryngeal structures.

Disclosure

The authors reported no proprietary or commercial interest in any product mentioned or concept discussed in this article.

References

1. Sato K. Functional Histoanatomy of the Human Larynx. SingaporeSingapore: Springer, 2018.
2. Ekberg O, Nylander G. Anatomy and physiology. In: Ekberg O, editor. Dysphagia: Diagnosis and Treatment. New York, NY: Springer Science & Business Media. 2012, p. 1–18.
3. Dobson J. Anatomical eponyms. 2nd ed. Edinburgh and London: E and S Livingstone, Ltd. 1962, p. 33.
4. Clerf LH: The preepiglottic space. Its relation to carcinoma of the epiglottiss. Arch Otolaryngol 40:177–179, 1944.
5. Tucker GF, Smith HR: A histological demonstration of the development of laryngeal connective tissue compartments. Trans Am Acad Ophthalmol Otolaryngol 66:308–318, 1962.
6. Norris CM, Kuo BF, Tucker GF Jr, et al: A correlation of clinical staging, pathological findings and five year end results in surgically treated cancer of the larynx. Ann Otol Rhinol Laryngol 79:1033–1048, 1970.
7. Maguire A, Dayal VS: Supraglottic anatomy the pre- or the peri-epiglottic space? Can J Otolaryngol 3:432–445, 1974.
8. Pagedar NA, Freeman JL: External branch of the superior laryngeal nerve. Operative Techn Otolaryngol Head Neck Surg 20:35–38, 2009.
9. Hwang S, Lee H, Kim W, et al: The anatomy of the external branch of the superior laryngeal nerve in Koreans. Asian J Surg 36:13–19, 2013.
10. Cernea CR, Ferraz AR, Furlani J, et al: Identification of the external branch of the superior laryngeal nerve during thyroidectomy. Am J Surg 164:634–639, 1992.
11. Friedman M, LoSavio P, Ibrahim H: Superior laryngeal nerve identification and preservation in thyroidectomy. Arch Otolaryngol Head Neck Surg 128:296–303, 2002.
12. Cheruiyot I, Kipkorir V, Henry BM, et al: Surgical anatomy of the external branch of the superior laryngeal nerve: A systematic review and meta-analysis. Langenbecks Arch Surg 403:811, 2018.
13. Henry BM, Sanna B, Graves MJ, et al: The reliability of the tracheoesophageal groove and the ligament of Berry as landmarks for identifying the recurrent laryngeal nerve: A cadaveric study and meta–analysis. Biomed Res Int 2017 4357591, 2017.
14. Ardito G, Ardito F, Revelli L, et al: Revisited anatomy of the recurrent laryngeal nerves. Am J Surg 187:249–253, 2004.