CHAPTER 1

Anatomy of the Larynx

The larynx is found in vertebrates that breathe through the lungs. It is located in the middle of the anterior neck and below the hyoid bone. It opens into the laryngopharynx and continues into the trachea. The upper end of the larynx is the upper edge of the epiglottis, the lower end is the lower border of the cricoid cartilage, the anterior is the infrahyoid strap muscles, the posterior is the pharynx and the cervical vertebrae, and it projects ventrally between the great neurovascular bundles of the neck and the lateral lobes of the thyroid gland. The larynx is a conical lumen organ formed by a series of cartilages as the skeletal framework, interconnected by ligaments, fibrous membranes, and a few muscles. The larynx lies opposite the third to sixth cervical vertebrae in adult males, about 8 cm high, and it is somewhat higher in children and adult females.

COPYRIGHTED MATERIAL

1.1 Laryngeal Muscles

The muscles of the larynx are striated muscles, which are divided into extrinsic and intrinsic laryngeal muscles. Except for the single transverse arytenoid muscle, they all exist in pairs (Sataloff 2017).

The role of the extrinsic laryngeal muscles is to elevate or lower the larynx, as well as to fix the larynx and to assist swallowing and phonation. Suprahyoid muscles, such as the middle pharyngeal constrictor muscles, allow the larynx to rise with the hyoid bone. During phonation, under the combined action of the sternothyroid muscle, the hyoid bone is fixed, and the thyroid cartilage is tilted forward and downward, increasing the tension of the vocal folds (Sataloff 2017).

The intrinsic laryngeal muscles originate and terminate in the larynx and may be divided into four groups based on their main actions (Figure 1.1).

1.1.1 Glottic Dilator Muscles (Muscles That Abduct the Vocal Folds)

The posterior cricoarytenoid (PCA) muscles are the only abductor muscles of the larynx, located on the posterior surface of the cricoid lamina. The contraction of the PCA muscles pulls the muscular processes of the arytenoid cartilages inward and downward, causing the arytenoid cartilages to

Principles and Practices of Laryngeal Electromyography, First Edition. Wen Xu.
© 2026 People's Medical Publishing House Co. Ltd. All rights reserved. Published 2026 by John Wiley & Sons Ltd.

move, slide, and rotate outward, and then the vocal processes to rotate posteriorly, upward, and outward, assisting the abduction of vocal folds, enlargement of glottis, and tensing of vocal folds (Sataloff 2017).

1.1.2 Muscles That Adduct the Vocal Folds

The laryngeal muscles that adduct the vocal folds consist of the lateral cricoarytenoid (LCA) and interarytenoid (IA) muscles.

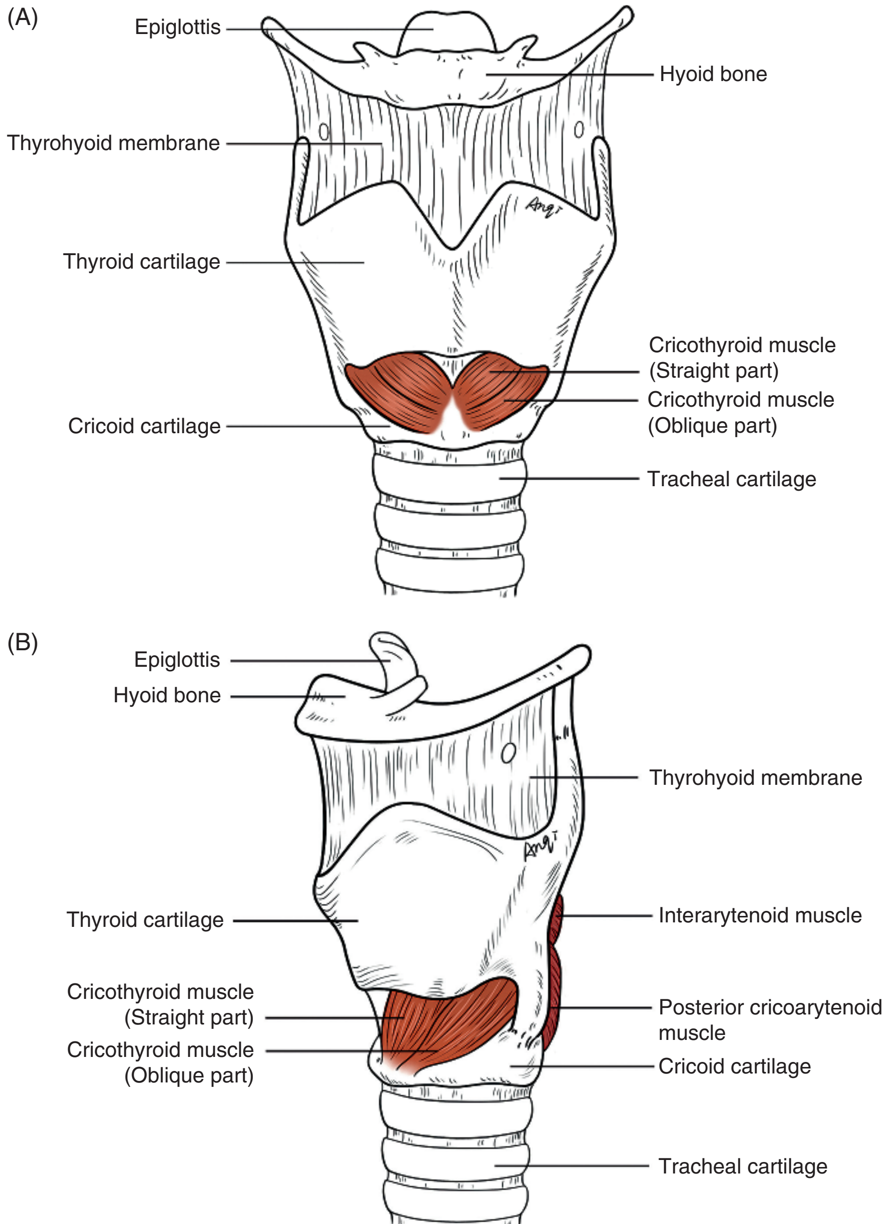

FIGURE 1.1 Diagram of the laryngeal muscles. (A) Anterior view. (B) Left lateral view. (C) Posterior view. (D) Sectional view

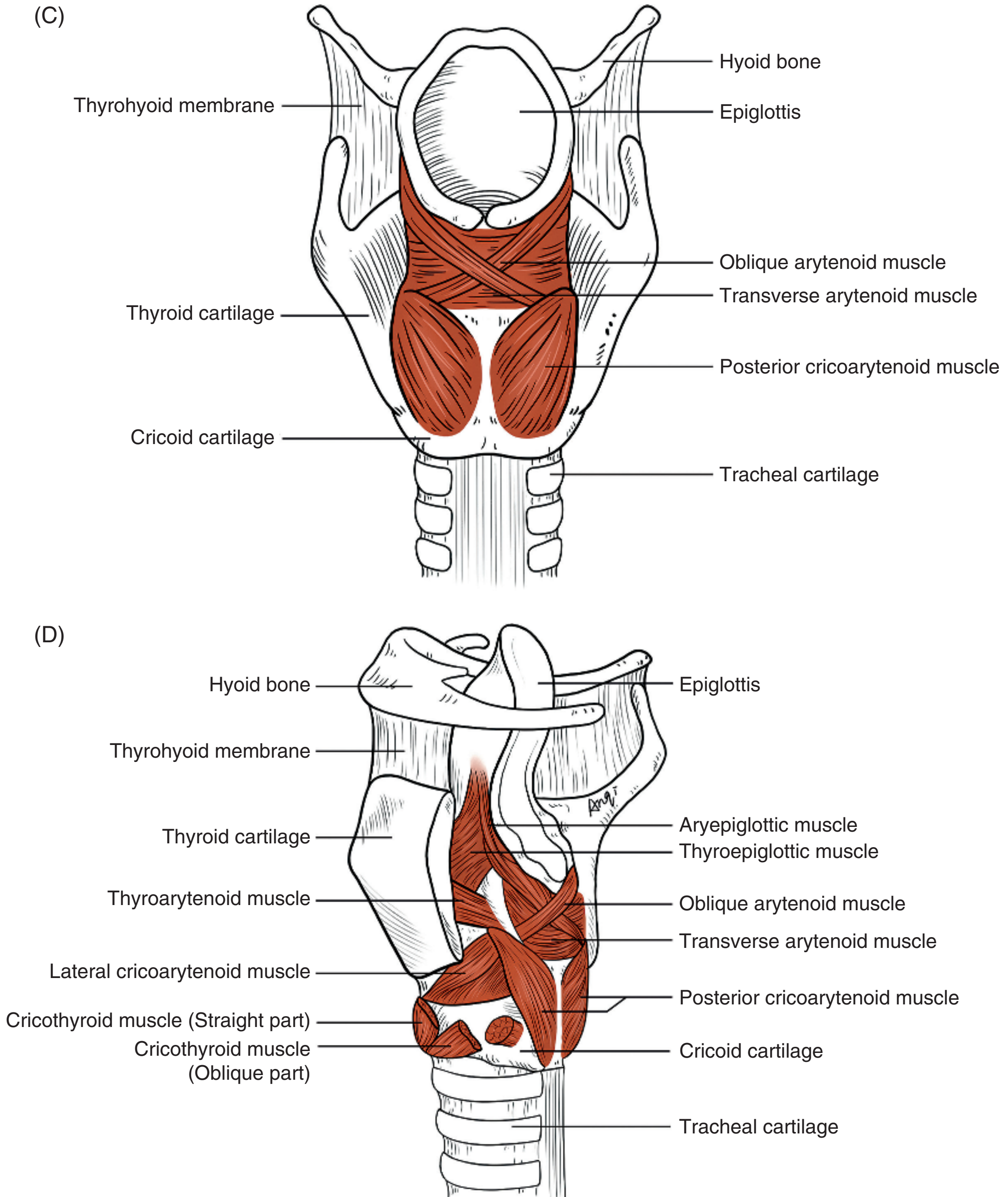

FIGURE 1.1 *(continued)*

Lateral Cricoarytenoid Muscle

When the LCA muscles contract, they rotate the arytenoid cartilages and thus medially swing the vocal process onto which the vocal ligaments are attached. This brings the tips of the vocal processes together, resulting in adduction of the vocal folds, closure of the ligamentous part of the rima glottidis, and opening of the posterior intercartilaginous part in a triangular shape.

Interarytenoid Muscle

The arytenoid muscles, also known as the interarytenoid (IA) muscle, include the transverse arytenoid muscle and the oblique arytenoid muscle. Contraction of the IA muscle brings bilateral arytenoid cartilages together to close the posterior of the rima glottidis.

1.1.3 Vocal Fold Tension/Relaxation Muscles

The muscles that tense or relax the vocal folds consist of the cricothyroid (CT) and thyroarytenoid (TA) muscles.

Cricothyroid Muscle The CT muscle is divided into two parts – straight and oblique parts. The former lies in front, while the latter lies to the outside of it. When the CT muscle contracts, the thyroid cartilage and the arch of the cricoid cartilage approach each other. The distance between the arytenoid cartilage and thyroid cartilage increases, which tightens the TA muscles, increases the tension of the vocal folds, raises the pitch, and then causes slight adduction of the vocal folds. It has also been suggested that during phonation, the cricopharyngeal muscle contracts so that the cricoid cartilage is fixed in front of the spine, while the lower edge of the thyroid cartilage approaches the arch of the cricoid cartilage. During swallowing, the arch of cricoid cartilage approaches the lower edge of the thyroid cartilage.

Thyroarytenoid Muscle The main role of the TA muscle is to regulate the tension of the vocal folds. Contraction of the TA muscles causes the arytenoid cartilages to rotate inward to shorten and relax the vocal folds and narrow the rima glottidis. Some researchers believe that the vocal fold muscle fibers are divided into longitudinal, transverse, and oblique fibers, which can regulate muscle tension in segments, allowing the vocal folds to vibrate as a whole or partially.

1.1.4 Epiglottis Movement Muscles

The muscle group that activates the epiglottis mainly consists of the aryepiglottic and thyroepiglottic muscles.

The role of the internal laryngeal muscles varies, but it is a coordinated and unified entity in the physiological activities of the larynx. For example, the PCA muscle is mainly related to respiration. It contracts during inspiration to abduct the vocal folds. In recent years, it has been found that the PCA muscle is also involved in phonatory activities. During phonation, the slight contraction of the PCA muscle can stabilize the arytenoid cartilages and maintain the vocal folds in the phonatory position, resulting in stable and strong adduction of the vocal folds, which is conducive to sustained phonation. The PCA muscle also plays a role in increasing the tension in the vocal folds and regulating the pitch and intensity of the voice.

1.1.5 Classification of Laryngeal Muscle Fibers

Human muscle fibers are divided into two types according to their histochemical reaction: type I and type II fibers. Type I fibers (also known as slow muscle fibers) are more reactive to oxidative enzymes and less reactive to both phosphatases and ATPases. Type II fibers (also known as fast muscle fibers), on the other hand, can be divided into three subcategories based on their response to ATPase-IIA, IIB, and IIC. IIC fibers are primarily fetal progenitor cells and are rarely seen in adults. Slow fibers with high oxidative activity tolerate fatigue, whereas fast fibers with high glycolytic activity and low oxidative enzymes tend to be fatigued. The number of mitochondria in the muscle represents the level of aerobic metabolism in the cell. Berendes found that the order of mitochondria in the intrinsic laryngeal muscles was as follows: IA > PCA > TA > CT > LCA.

Among the intrinsic laryngeal muscles innervated by the unilateral recurrent laryngeal nerve (RLN), the TA muscle contains the most type II fibers associated with rapid contraction (up to 65%) and fewer fatigue-resistant type I fibers (35%), making the TA muscle more capable of rapid contraction. The PCA muscle has the most type I fibers (up to 67%) and the least type II fibers (33%). The PCA muscle contains more mitochondria, as well as a high capillary blood flow. Therefore, the PCA muscle has a

strong ability to contract slowly and continuously. The structure of the IA muscle is different from other intrinsic laryngeal muscles and has a typical muscle spindle structure, in which the type of extrafusal muscle fibers is similar to that of normal trunk muscles. Due to the specificity of function, the IA muscle can contract rapidly during activities such as breathing, coughing, and phonation. In a resting state, some muscle fibers also keep tension to maintain the position of the larynx and the tension in the vocal folds. Since the IA muscle is innervated by the bilateral RLNs and is not easily injured, it plays an important compensatory role in unilateral laryngeal nerve paralysis, laryngeal joint fixation, and other conditions, which facilitates glottic closure.

1.2 Laryngeal Nerves

The laryngeal nerves mainly include the superior laryngeal nerve (SLN) and the RLN, which are branches of the vagus nerve, as well as the sympathetic nerves.

The vagus nerve originates from the medulla oblongata and exits the skull through the jugular foramen anterior to the jugular vein, with the posteromedial part close to the vein. The nerve descends to the nodose ganglion (inferior ganglion) located below the jugular foramen, from which it branches off the pharyngeal plexus and the SLN (Xu 2019; Dilworth 1921).

1.2.1 Superior Laryngeal Nerve

The SLN emanates from the nodose ganglion, receives sympathetic fibers, and descends between the posterior carotid artery and the pharyngeal wall, dividing into internal and external branches at the greater horn of the hyoid bone and 2 cm from the nodose ganglion (Figure 1.2). The external branch of the SLN is mainly a motor nerve, innervating the CT and inferior pharyngeal constrictor muscles, but there are also sensory branches that pass through the CT membrane to the vocal folds and the mucosa anterior to the subglottic region. The internal branch of the SLN is mainly a sensory nerve that passes through the thyroglossal membrane posterior to the superior laryngeal artery and distributes to the mucosa of the epiglottic vallecula, the epiglottis, the posterior glottis above and below the rima glottidis, the oropharynx, a small part of the hypopharynx, and the anterior arytenoid cartilage. There may also be motor nerve fibers innervating the IA muscle. The anatomical group of the Beijing Institute of Otolaryngology (1971) observed the laryngeal nerves in 100 cases and found that all the posterior branches of the internal branch of the SLN had small branches to the deep of the IA muscle and the internal branch shared a number of communicating branches with the posterior branch of the RLN (Xu 2019; Dilworth 1921).

1.2.2 Recurrent Laryngeal Nerve

The RLN arises from the thoracic segment of the vagus nerve trunk. After the vagus nerve descends, it branches out into the RLN. The courses on both sides of the RLN are different: the right RLN branches out at the point where the right vagus nerve passes anterior to the right subclavian artery, curves downward and posteriorly around the right subclavian artery, then ascends along the anterior aspect of the right tracheoesophageal groove, and enters the larynx below the inferior pharyngeal constrictor muscle and behind the CT joint. The left RLN branches out at the point where the left vagus nerve crosses the left anterior aspect of the aortic arch, curves downward and backward the aortic arch, ascends along the tracheoesophageal groove, and then follows a similar course to that of the right side to enter the larynx. The left RLN is about 12 cm long (from the aortic arch to the CT joint), while the right

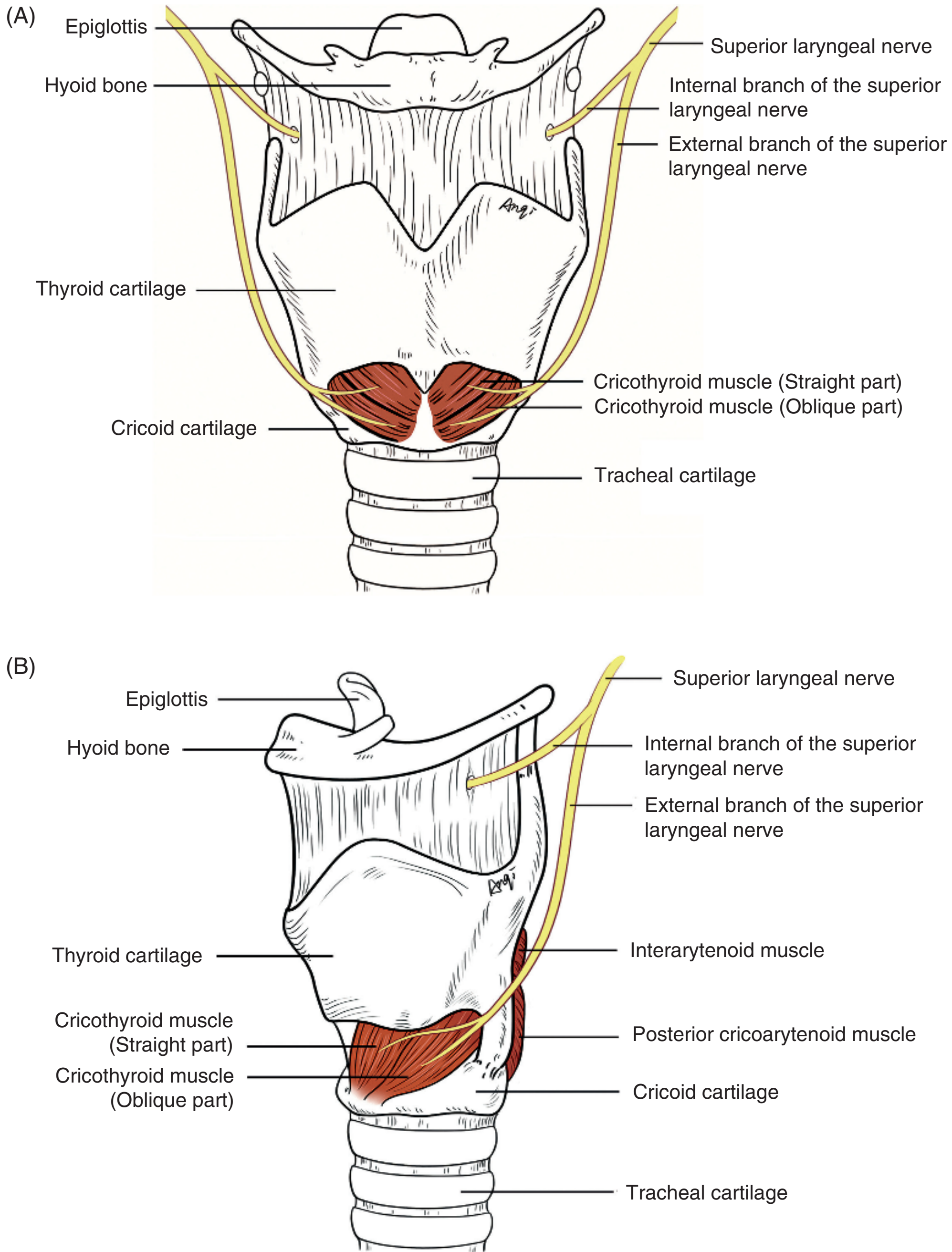

FIGURE 1.2 A schematic diagram of superior laryngeal nerves and their branches. (A) Anterior view. (B) Left lateral view

side is 5–6 cm long (from the subclavian artery to the CT joint). The left RLN course is longer than that of the right side, thus increasing the probability of injury (Figure 1.3) (Dilworth 1921; Sun et al. 2001).

The RLN is mainly a motor nerve (including anterior and posterior branches) and supplies innervation to all muscles in the larynx except the CT muscles. However, it also contains sensory branches distributed in the mucosa of the infraglottis, trachea, esophagus, and part of the hypopharynx. Some fibers of the RLN anastomose with the internal branch of the SLN to form the Galen's anastomosis, which is responsible for the sensation of the infraglottic mucosa (Dilworth 1921; Sun et al. 2001).

The branches of the RLN are highly variable, usually divided into anterior and posterior branches behind or on the inner surface of the CT joint, or branching under the cricoid cartilage. According to the observations of the anatomy group of the Beijing Institute of Otolaryngology, the majority of the RLN starts to branch outside the larynx, and after entering the larynx, it divides into two branches.

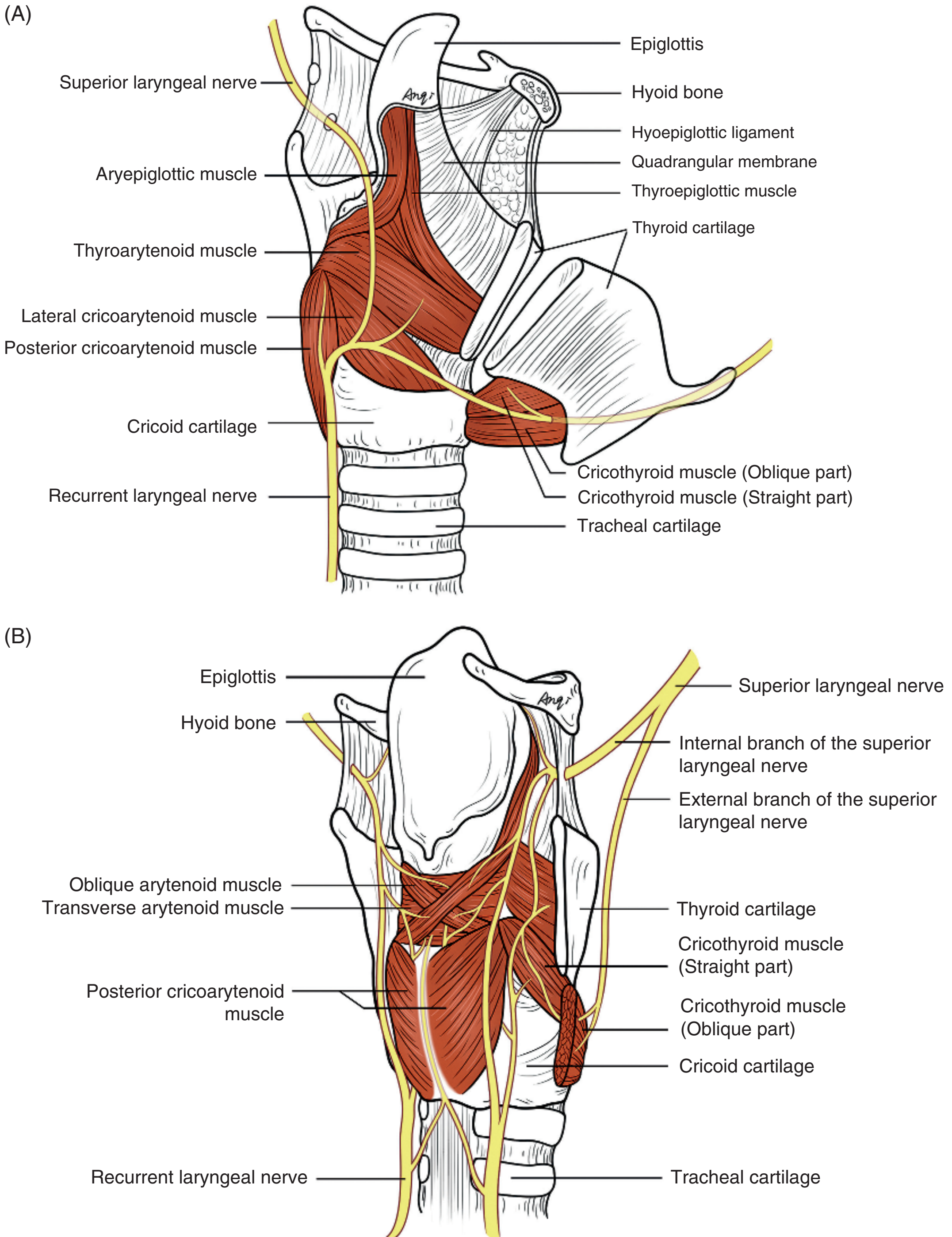

FIGURE 1.3 A schematic diagram of laryngeal nerves and their branches. (A) Sectional view. (B) Lateral posterior view. (C) Superior view

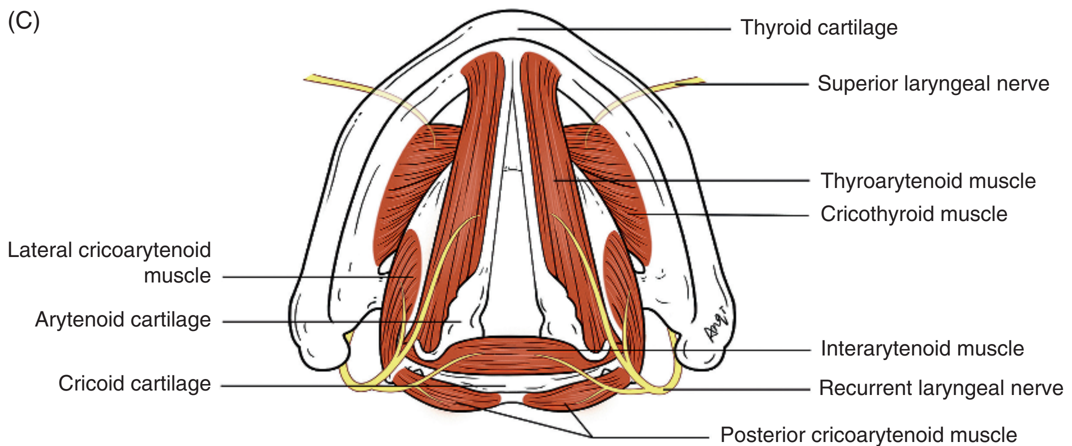

FIGURE 1.3 *(continued)*

The posterior branch enters the PCA muscle and innervates the PCA and the IA muscles, which are anastomosed to the branches of the internal branch of the SLN. The anterior branch ascends behind the cricoarytenoid joint into the LCA muscle and innervates the internal laryngeal muscles except the CT, PCA, and IA muscles. In addition to the IA muscle, the TA, PCA, and LCA muscles are innervated by the ipsilateral RLN. It has been suggested that the CT muscle may also be innervated by motor nerve fibers of the RLN. In rare cases, the right RLN branches out directly from the vagus nerve at the level of the thyroid gland. This variant is called the nonrecurrent nerve and is highly susceptible to being injured during thyroid surgery (Dilworth 1921; Sun et al. 2001).

1.2.3 Sympathetic Nerve

The sympathetic nerve of the larynx comes from the pharyngeal branch of the superior cervical ganglion, passes through the pharyngeal plexus, and is distributed to the glands and blood vessels of the larynx.

1.2.4 Anastomoses

The laryngeal nerve has an abundance of anastomoses. The most common types include the Galen’s anastomosis, the arytenoid plexus, the human communicating nerve, the cricoid communication, and the TA communication, with the first two types being the most common (Henry et al. 2017; Sañudo et al. 1999).

It has been found that these communications can provide additional innervation to the laryngeal muscles and may play a role in the regeneration of the laryngeal nerve after injury. A systematic understanding of these helps to better interpret laryngoscopic findings and to protect them accordingly when performing neck surgery (e.g. thyroid surgery). Current research on the laryngeal anastomoses is mainly based on cadaveric studies. The physiological functions and mechanisms still need to be further investigated (Henry et al. 2017; Miyauchi et al. 2016).

1.2.5 Lower Cranial Nerves

The lower cranial nerves include the glossopharyngeal nerves (CN IX), the vagus nerves (CN X), the accessory nerves (CN XI), and the hypoglossal nerves (CN XII).

References

Dilworth TF. The nerves of the human larynx. J Anat, 1921, 56:48–52.

Henry BM, Pękala PA, Sanna B, et al. The anastomoses of the recurrent laryngeal nerve in the larynx: a meta-analysis and systematic review. J Voice, 2017, 31:495–503.

Miyauchi A, Masuoka H, Nakayama A, et al. Innervation of the cricothyroid muscle by extralaryngeal branches of the recurrent laryngeal nerve. Laryngoscope, 2016, 126:1157–1162.

Sañudo JR, Maranillo E, León X, et al. An anatomical study of anastomoses between the laryngeal nerves. Laryngoscope, 1999, 109:983–987.

Sataloff RT. Professional Voice: The Science and Art of Clinical Care. 4th ed. San Diego: Plural Publishing, 2017.

Sun SQ, Zhao J, Lu H, et al. An anatomical study of the recurrent laryngeal nerve: its branching patterns and relationship to the inferior thyroid artery. Surg Radiol Anat, 2001, 23:363–369.

Xu W. Atlas of Strobolaryngoscopy: Laryngeal Disorders. Springer Nature Singapore Pte Ltd. and Peoples Medical Publishing House, 2019.