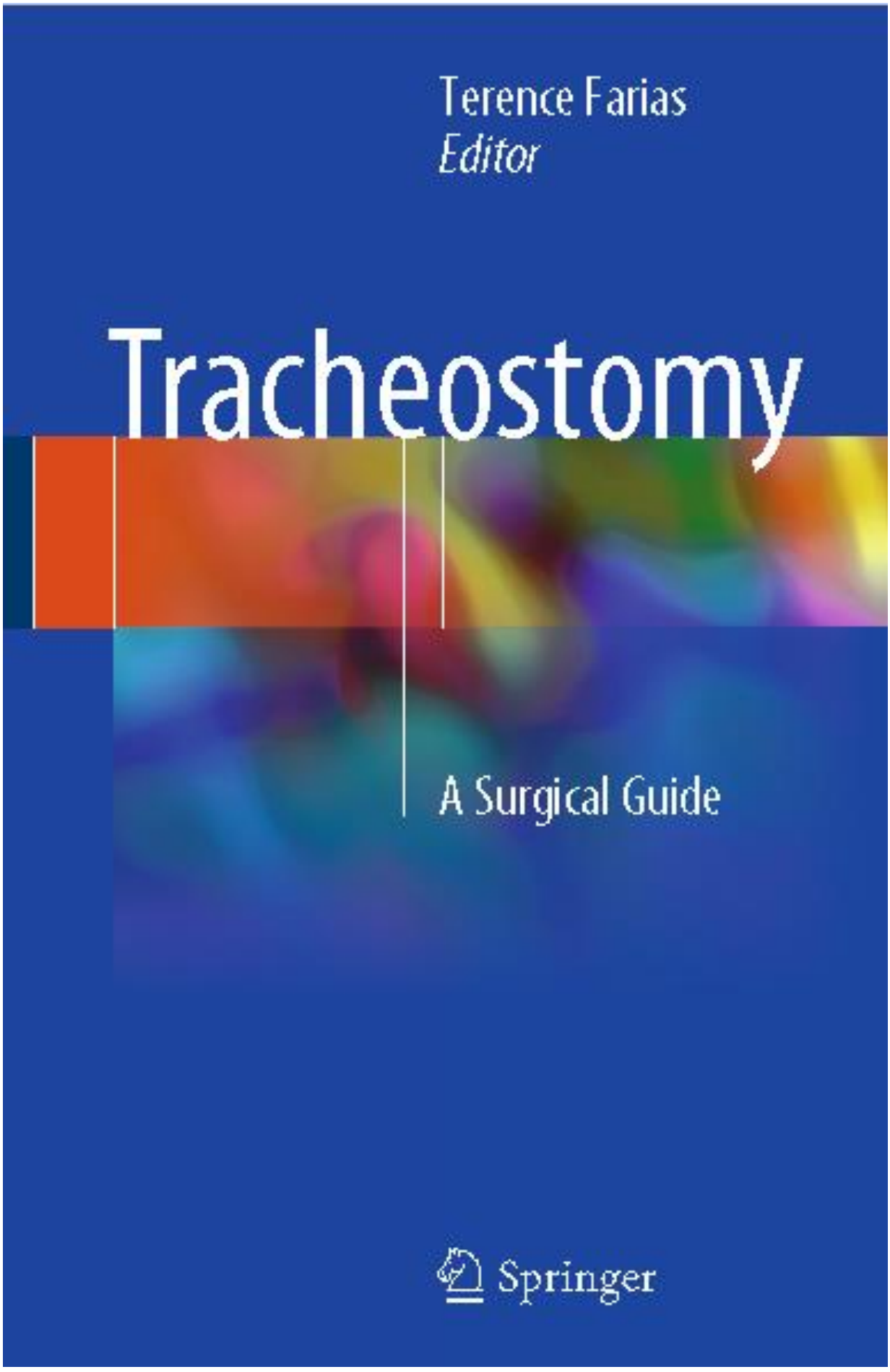
Terence Farias
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Contents

Anatomy of the Trachea

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For practice of any surgery, it is essential to know the anatomy of each structure involved in the technique, as well as the elements that surround it. The trachea is not just a tube that connects the larynx to the bronchi, as well as other organs of the respiratory tree; it has the function of cleaning and heating the air that transits in its lumen. Anatomical variations, whether congenital or acquired, are challenging and should never be overlooked. In this chapter, we will provide an explanation illustrated with a photographic and schematic collection, with emphasis on surgical details.

Macrostructure

The trachea is a tube located in the midline, connecting the cricoid cartilage in the neck to the main bronchi in the thorax. In its cervical portion, it begins at the height of the sixth or seventh vertebra, and is deep to the cervical fascia and infrahyoid muscles (Figs. 1 and 2). It is bordered by the thyroid gland on the anterior face, with lateral recurrent laryngeal nerves. As it progresses caudally, it remains anterior to the esophagus, between the common carotid arteries, internal jugular veins, and vagus nerve (Figs. 3, 4, 5, and 6). The brachiocephalic or innominate artery is the first blood vessel found in pretracheal dissection during airway mobilization, justifying the reason for trachea–innominate fistula

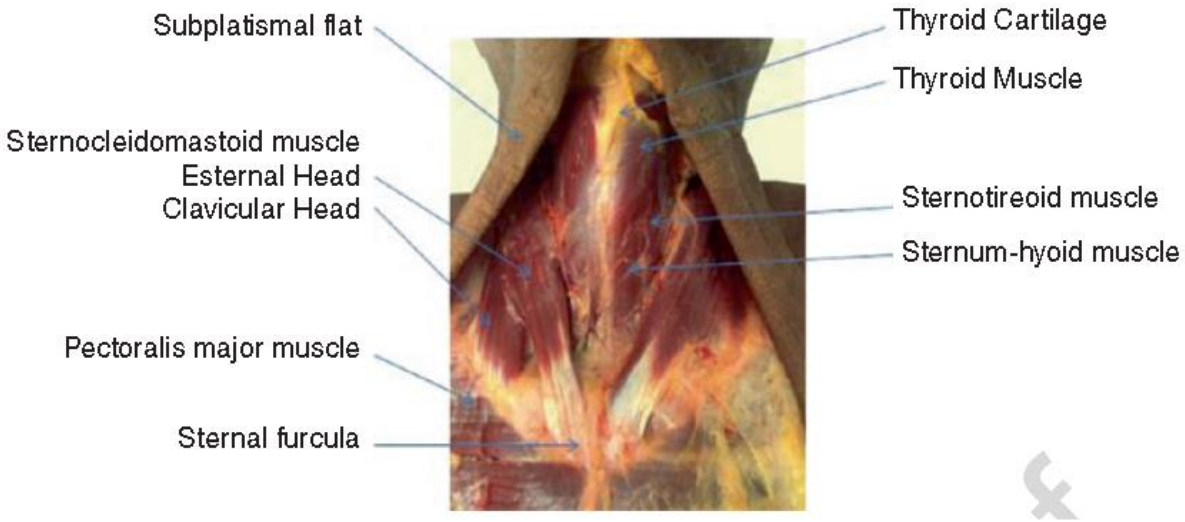

Fig. 1 Cervical region with the subplatysmal myocutaneous flap highlighted. Infrahyoid muscles arise medially and the sternocleidomastoid laterally

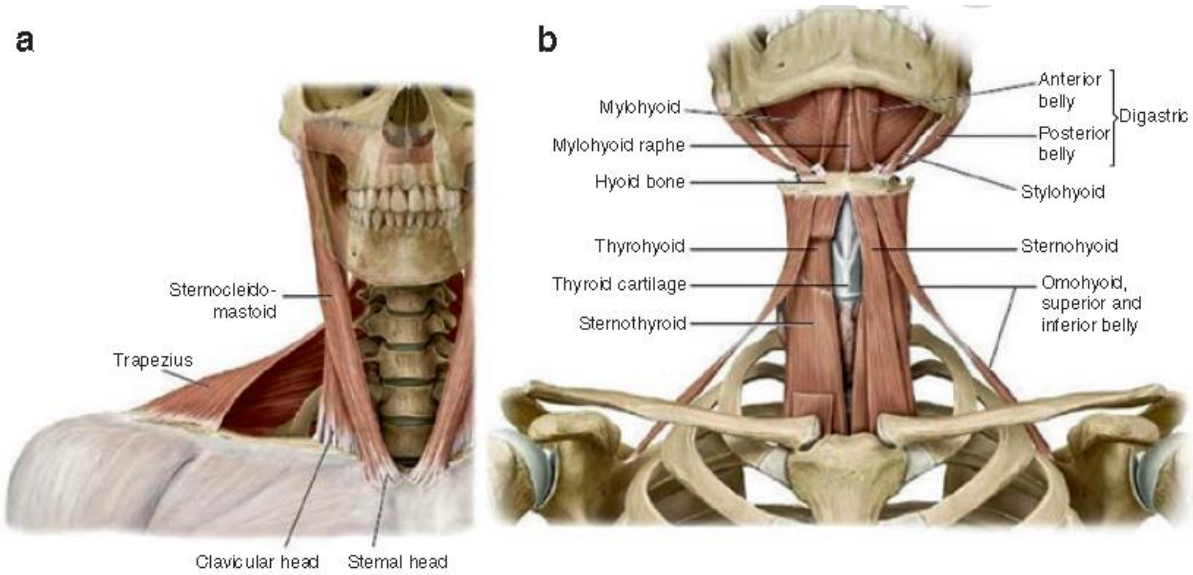

Fig. 2 Individualized neck muscles . (**a**) Anterior view. (**b**) Anterior view.The sternohyoid has been cut (right)

infrahyoid muscles (Figs. 1 and 2). It is bordered by the thyroid gland on the anterior face, with lateral recurrent laryngeal nerves. As it progresses caudally, it remains anterior to the esophagus, between the common carotid arteries, internal jugular veins, and vagus nerve (Figs. 3, 4, 5, and 6). The brachiocephalic or innominate artery is the first blood vessel found in pretracheal dissection during airway mobilization, justifying the reason for trachea–innominate fistula.

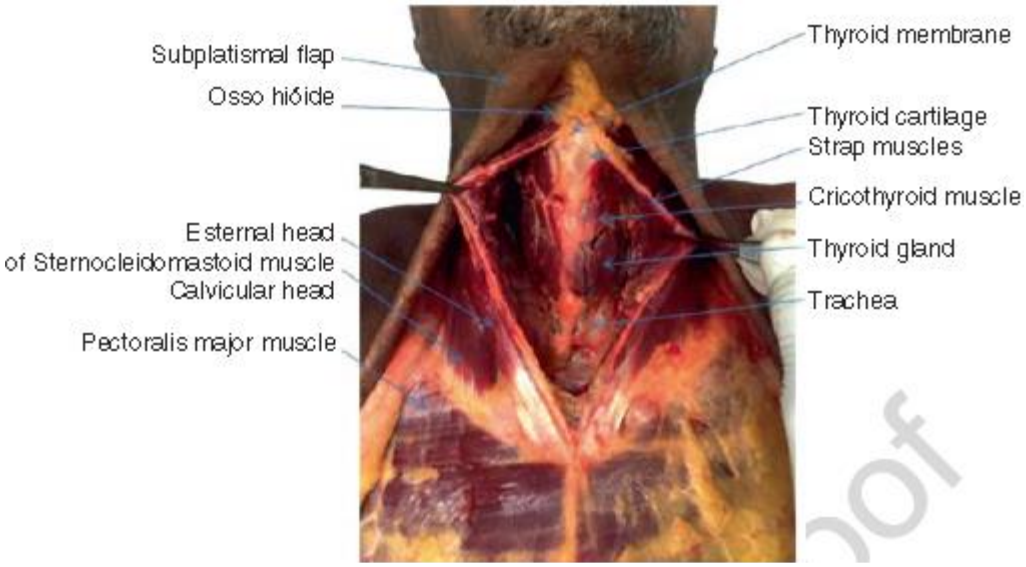

Fig. 3 Dissection through the pretracheal visceral fascia exposing the midline organs

occurrence. The brachiocephalic vein crosses the front of the innominate in a plane even more anterior to the trachea. The carina is the lower border of the trachea, where the two primary bronchi originate, at the height of the fourth or fifth thoracic vertebra (Figs. 7 and 8) [1].

The trachea surfaces with cervical extension allowing half of it to be accessible by this route, facilitating most surgical procedures. Maximal flexion leads to cricoid cartilage at the level of the sternum, minimizing the tension of anastomoses after resection of the tracheal segment. With current anatomical knowledge and blood supply, good mobilization promotes greater safety for resection and reconstruction of half the length of the trachea [2].

The trachea has an incomplete cartilaginous ring structure, the posterior face filled by smooth muscle with longitudinal (external) and transverse fibers (internal tracheal muscle). The annular ligament is found between the tracheal rings and it is composed of two layers of fibrous membrane: an external layer, covering the surface of each ring; and another internal layer. In the intervals of the cartilage, these membranes meet, conferring both flexibility and fixation to the respiratory tract.

The external diameter of the trachea measures approximately 2.3 cm in the coronal cut, and 1.8 cm in the sagittal cut in men, forming a U-like structure. In females these dimensions are 2.0 cm and 1.4 cm, respectively, forming an elliptical framework in the axial section. The length in the adult phase is, on average, 11.8 cm and

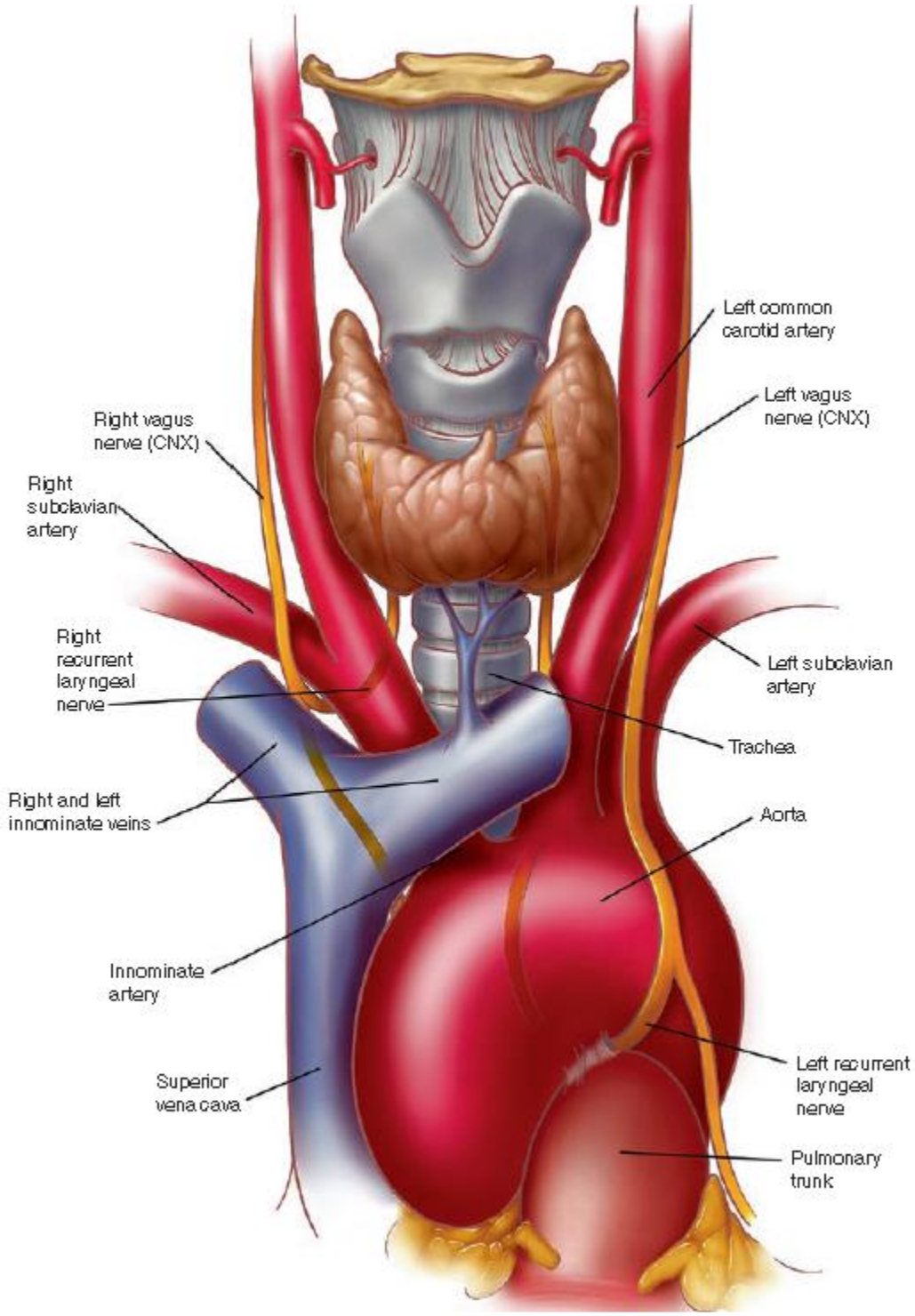

Fig. 4 Relationships of trachea to surrounding structures. Anterior view. Note the tight packing of major mediastinal vessels adjacent to the trachea

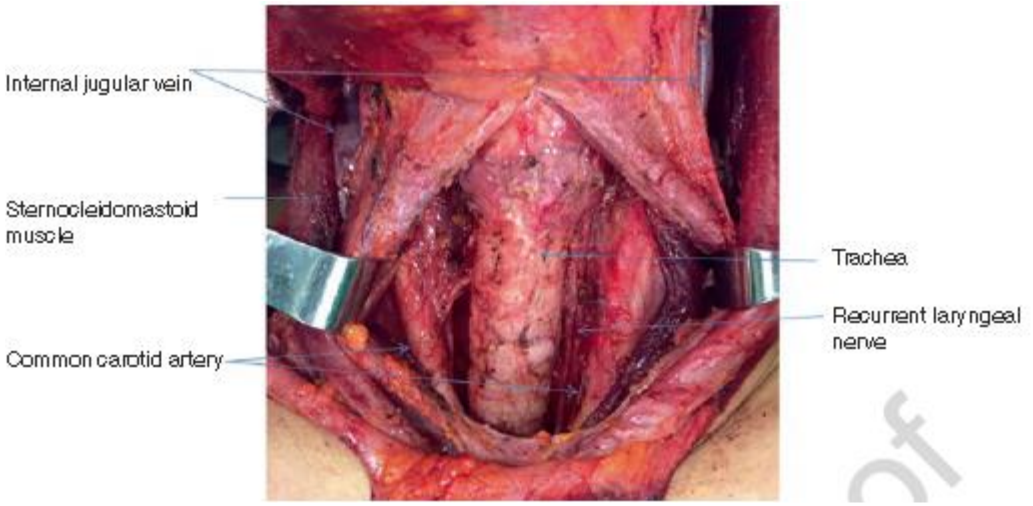

Fig. 5 Vessels and nerves lateral to the tracheal compartment

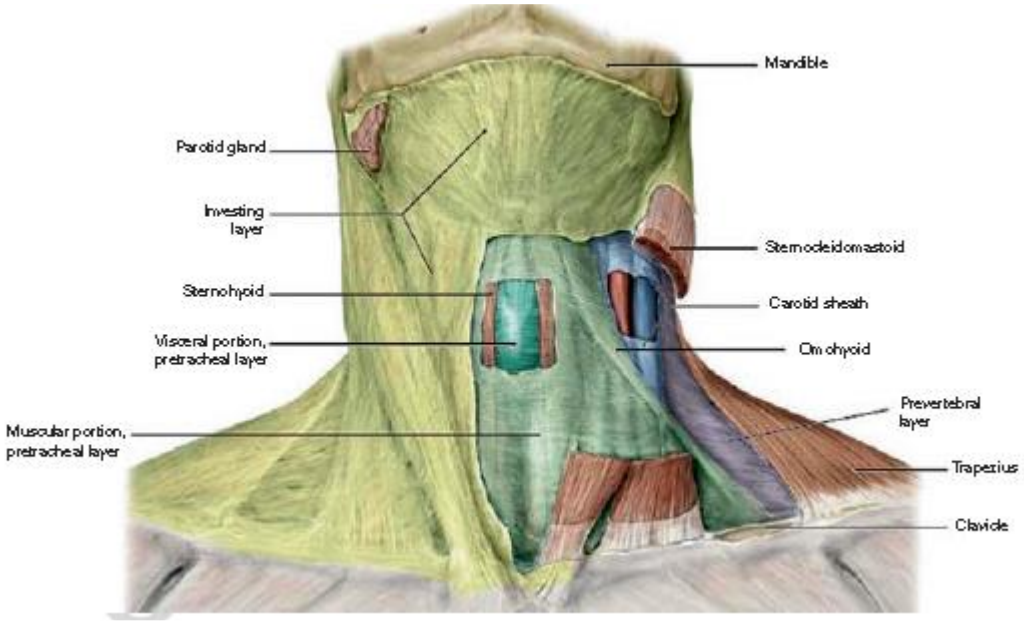

Fig. 6 Cervical fascia and neck muscles illustrating the planes until identification of the trachea

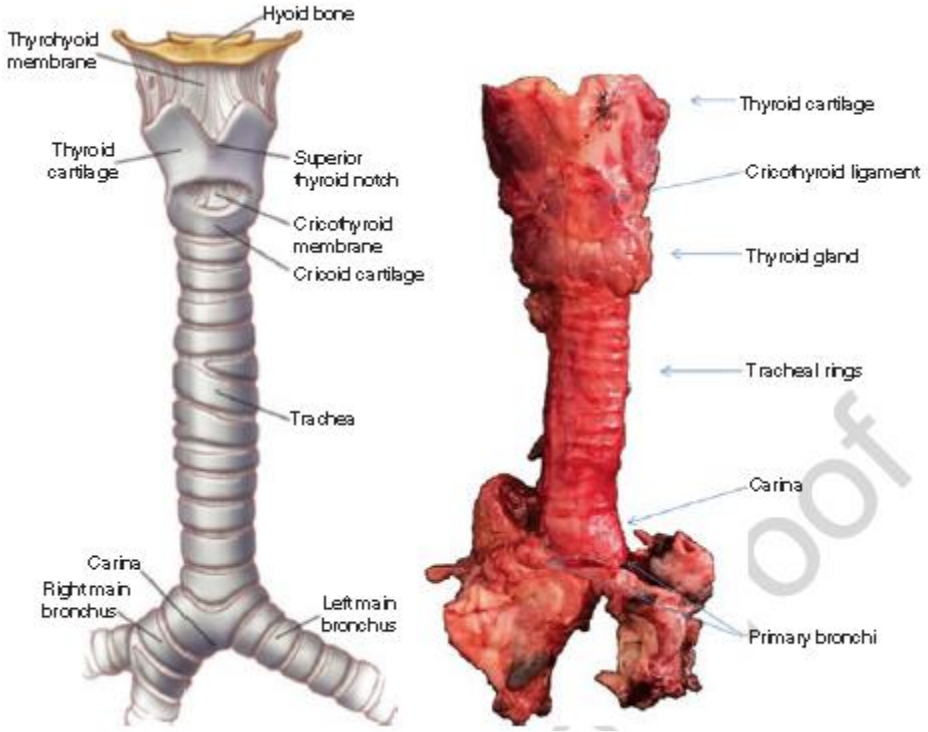

Fig. 7 Laryngeal case and inferior airway. Cricothyroid ligament where access is made for cricostomy. Trachea divided into cervical and thoracic portions. Conventional cervical tracheostomy allows easier and safer organ exposure

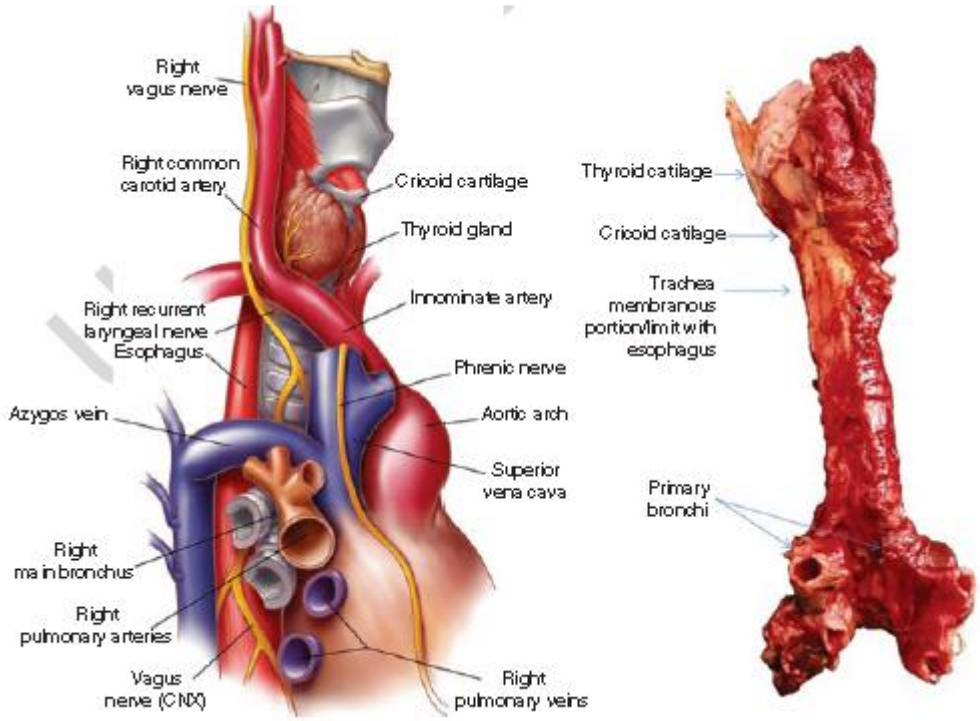

Fig. 8 Right oblique cut shows the posterior area membranous direct limit with the esophagus. In the emergence of the thoracic portion, the innominate artery crosses the trachea, which is accompanied by the vagus nerve until its bifurcation in the source bronchi

can vary, according to sex and height, between 10 and 13 cm, and its thickness is, on average, 3 mm. At each centimeter of extension, there are approximately two rings, and every organ has a total of 18–22 cartilaginous rings [3]. The first tracheal ring has a larger diameter and is connected to the cricoid cartilage cricothyroid ligament, while the last tracheal ring is thicker and broader in the midline, since its lower border extends in a triangular-shaped process, curved down and behind the two bronchi.
These rings prevent the collapse of the tracheal mucosa during inspiration. Airflow depends on the tracheal diameter. The resistance is inversely proportional to the radius to the fourth power. Thus thickening of the mucosa, constriction of muscles, masses/tumors that compress the respiratory tract, and even endotracheal tubes trigger reduction of the lumen and generate turbulent airflow [4].

Microstructure

The cartilaginous arch is covered externally by the adventitial tunica and internally lined by mucosa of ciliated cylindrical pseudostratified epithelium. This is composed of hair cells, goblet cells, basal cells, and neuroendocrine cells. In smokers or in individuals with a chronic irritation process, squamous metaplasia and loss of hair cells may occur. The submucosal layer is composed of a loose connective tissue network, which houses nerves, blood vessels, and mucus-producing glands (Figs. 9 and 10).
The air is heated to about 37 °C and humidified to 100% saturation during inspiration. In case of reduction of the airway—in tracheostomies or

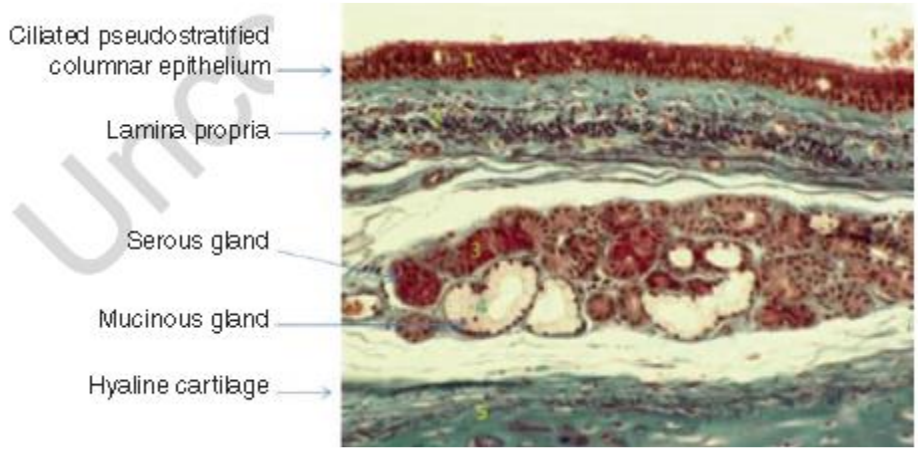

Fig. 9 Tissue layers constituting the tracheal wall: respiratory epithelium, the submucosa filled with glands, and the hyaline cartilage of the rings

Fig. 10 Cross-section in the trachea evidencing the annular shape and structural difference conferred by the cartilage rings

intubations, for example—the air that will reach the lungs will be less hot and humid. This difference in heat loss raises energy consumption to reach temperature homeostasis [4].

Vascularization

The blood supply to the trachea occurs through lateral pedicles. This is important to rule out lateral dissection in tracheal resection, being limited to 1–2 cm to prevent devascularization or anastomosis dehiscence.

The cranial portion of the trachea is supplied by the lower thyroid arteries and their tracheoesophageal branches, while the bronchial arteries nourish the distal portion, carina, and bronchi (Figs. 11 and 12).

Between the rings a submucosal plexus of intercartilaginous arteries is present, filling the tissue and irrigating the cartilaginous portion, while the membranous trachea is nourished by branches from the esophageal arteries (Fig. 13).

The venous drainage converges to the brachiocephalic vein through the plexus of the inferior thyroid vein, while the lymphatic drainage converges to the paratracheal lymph node and deep cervical lymph nodes.

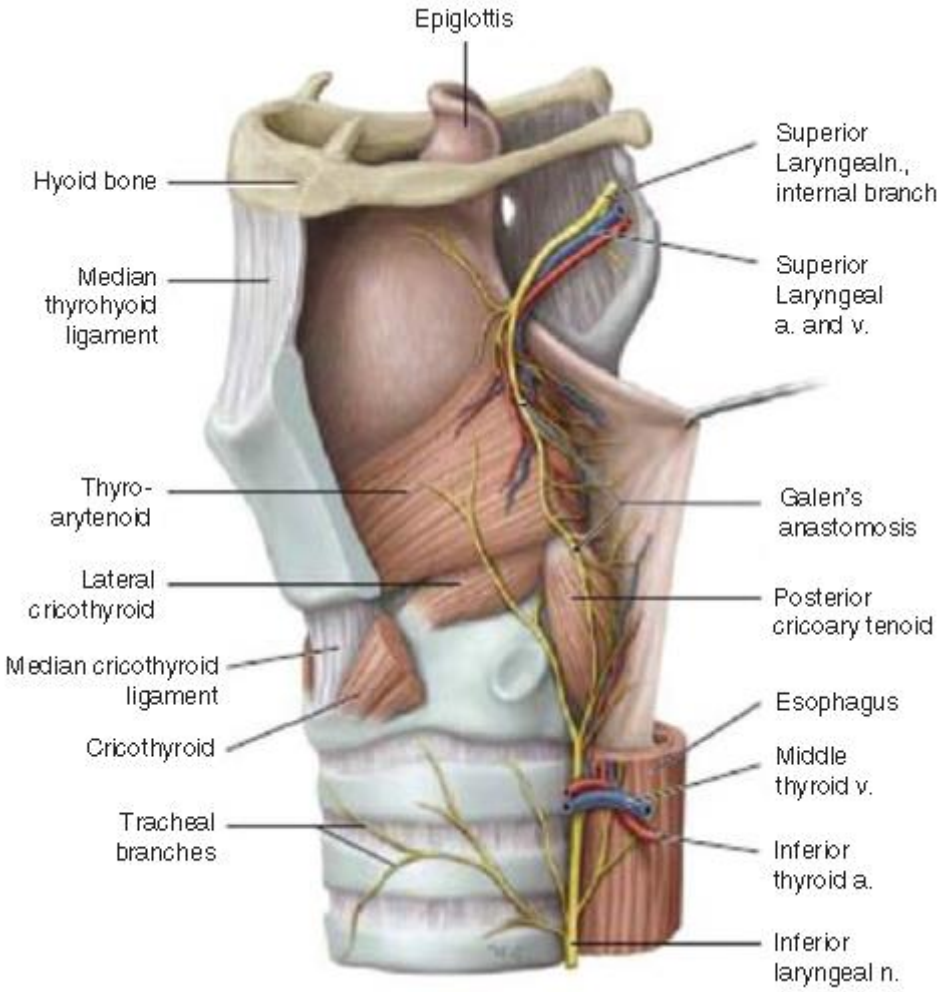

Fig. 11 The cervical portion of the trachea is supplied by the lower thyroid arteries

Innervation

The innervation of the trachea comes from tracheal branches originating from the thoracic sympathetic chain and the inferior ganglion of the vagus nerve (Fig. 14). The former is responsible for tracheobronchial muscle tone, allowing bronchodilation and bronchoconstriction, production of mucoid secretion, and vascular permeability. The vagal innervation in turn is responsible for the reflex of coughing and sternutation.

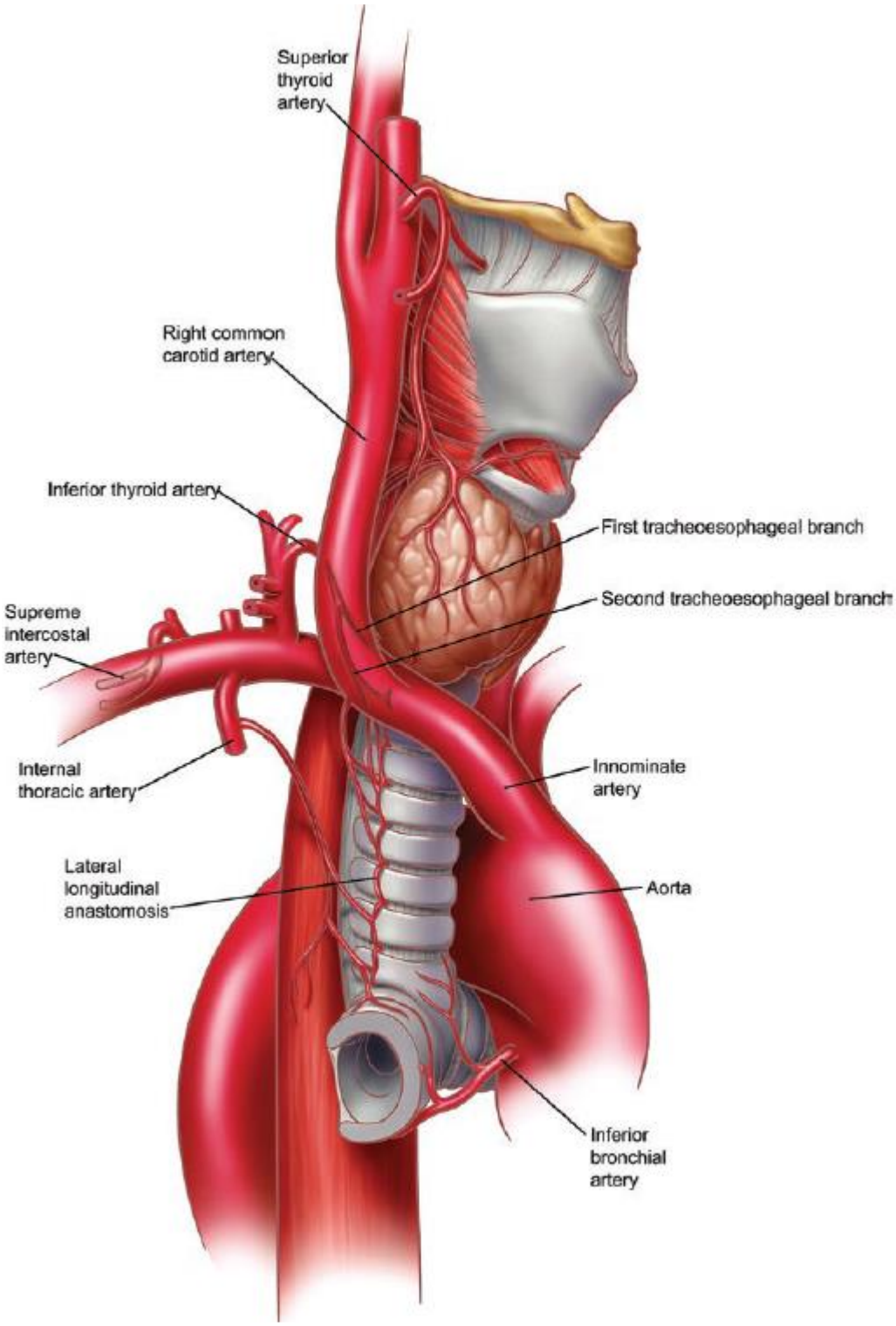

Fig. 12 The thyrocervical trunk, a direct branch of the aorta, emits the inferior thyroid artery, and this originates tracheoesophageal branches nourishing the cranial portion. The internal thoracic artery also gives branches to the caudal portion, which anastomoses to the bronchial arteries

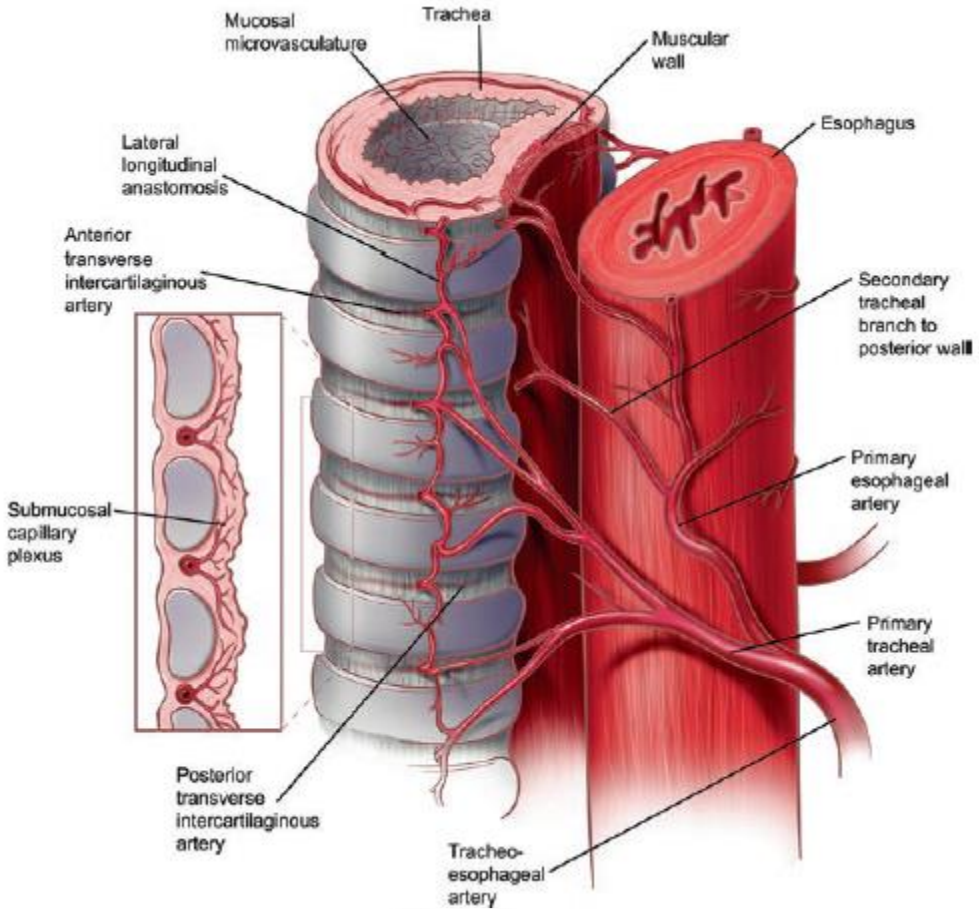

Fig. 13 Submucous capillary plexus formed by the tracheoesophageal branches inserted into the intercartilaginous membranes of the rings

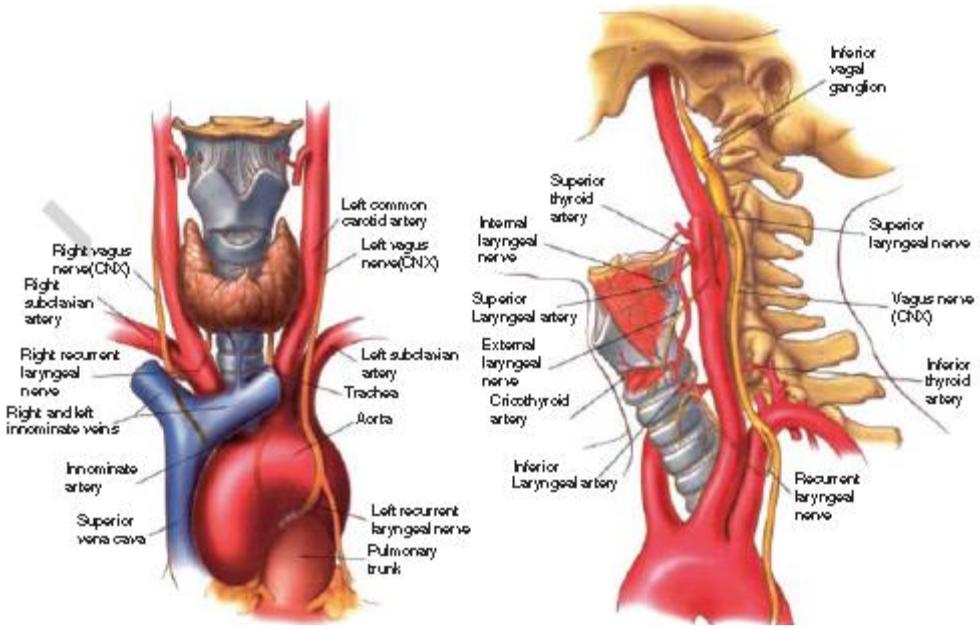

Fig. 14 Vague lateral nerve to the trachea emitting the recurrent laryngeal branch after circumventing the large intrathoracic vessels

Anatomy in Children

In children, the neck and trachea are smaller. The trachea is more elastic and extensible—properties that are reduced with the aging calcification process. It is also deeper and more mobile than in adults; pulmonary reserve is also reduced in cases of apnea, for example. In this way, accidental displacement of the cannula is a high-risk maneuver. Fixing the cannula to the skin through single stitches is an option to prevent this accidental removal.

Anatomical Variations

There is variety in the conformation of the tracheobronchial tree, which can reach an incidence of 1–12% and is usually asymptomatic. When variations are symptomatic, cough, hemoptysis, and recurrent episodes of respiratory infection may occur. The importance of recognition is evident when the patient undergoes procedures such as bronchoscopy, intubation, and pulmonary recruitment. Some variations are accessory bronchi, tracheal diverticulum, and a bronchial bridge [5]. It is suggested that these changes are justified by the theory of selection, in which the bronchial abnormalities result from local morphogenesis disorders. The bronchial mesenchyme itself is able to induce budding if grafted onto the tracheal epithelium [6].

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