Fundamental and Practical Aspects of Airway Anatomy

From Glottis to Segmental Bronchus

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KEYWORDS

• Trachea • Airway • Carina • Bronchi

KEY POINTS

- Half of the trachea is in the neck and the other half is in the posterior mediastinum.
- In the neck, the recurrent laryngeal nerves are at risk of injury.
- In the thoracic inlet, contact with the right brachiocephalic artery can lead to erosion if a tracheostomy is placed too low.
- Close contact to the azygos vein can lead to injury during a mediastinoscopy.
- The carina can be exposed via a midline or right thoracotomy approach.

INTRODUCTION

Surgical interventions involving the airways are complex, and complications arising from manipulations of the airways can often be life threatening. Understanding the anatomy is an essential component of a safe surgical outcome. The objective of this article is to review the anatomy of the major airways pertinent to the most common surgical procedures in or around the airways, such as resection of the trachea, mediastinoscopy, and sleeve resections.

FUNDAMENTALS OF TRACHEAL ANATOMY

The human trachea starts from below the vocal cords down to the carina, where it divides itself between 2 mainstem bronchi, which end in the hilum of each lung. The glottis is the space between the vocal cords that allows the passage of air in and out of the trachea via the contractions of the diaphragm and other accessory respiratory muscles.

The length of the trachea is 10 to 13 cm with a diameter of 4 mm at birth to about 23 × 18 mm at full growth. The formula of (age in years +16)/4 is used in the pediatric population to determine the size of the endotracheal tube to be used. In adults, another quick reference is to use the size of the index finger.[1]

The trachea is made of a cartilaginous support frame to prevent collapse during the negative pressures generated during the inspiratory cycle. There are 15 to 22 cartilages, each with a thickness of about 4 mm. The first tracheal cartilage is immediately below the cricoid cartilage, which is the only continuous ring.

The subglottic area is part of the larynx that is formed of the supraglottis, glottis, and subglottis. The subglottis consists of the space immediately below the true vocal cords. Anteriorly, it is bordered by the thyrocricoid membrane and posteriorly by the posterior aspect of the cricoid cartilage. The cricothyroid membrane is the site of insertion of a temporary emergency tracheostomy,

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because it is easily palpable in all individuals and is relatively avascular and wide with the neck in hyperextension. The cricopharyngeous muscle inserts in part to the cricoid cartilage and forms the cricopharyngeal sphincter known also as the Killian sling. Posteriorly, the sling is bordered on its superior aspect by the Killian triangle and inferiorly the Laimer triangle, both sites of the formation of esophageal diverticula.

The recurrent nerve dives below the cricopharyngeus muscle, against the trachea and the cricoid cartilage to innervate the true vocal cords. The intimate anatomic position of the recurrent laryngeal nerves and the trachea must always be remembered during dissection of the trachea in the neck on both sides, and during the dissection of the left border of the trachea in the mediastinum.

The tracheal cartilages are horseshoe shaped. They become circumferential at the level of the segmental bronchi. The vocal cord and the membranous portion of the trachea help with the creation of auto-PEEP during a Valsalva maneuver or coughing.

The cartilages calcify with age, which makes them more friable during the insertion of sutures. Half of the tracheal length is in the neck and starts at the level of C6-7. The other half lies in the posterior mediastinum, where the trachea dives posteriorly in contact with the vertebral bodies down to the level of T4-5. The angle between the sternum and the trachea increases with age as the kyphosis of the thoracic spine becomes more pronounced, making a dissection of the carina in the elderly even more difficult through a midline approach (Fig. 2).

The trachea moves with the position of the neck, and the dissection of any part of the trachea in the neck or the upper thoracic trachea is eased by positioning the head of the patient in hyperextension if safe. The hyperextension is then reversed to remove tension on an anastomosis.

The origin of the blood supply for the cervical trachea is mainly the inferior thyroid artery, and in the chest, the intercostal arteries.[1] The blood supply of the trachea enters the trachea laterally at positions 3 and 9 o'clock. The position of the blood supply must be remembered during the dissection around the trachea. At the carina, the blood supply enters directly into the carina, and it is often injured during the dissection of station 7. That is why this station is always biopsied last, after nodes in stations 4R and 4L are sampled.

Because the blood supply of the trachea is segmental, in order to preserve that blood supply and prevent ischemia, lateral dissection of the trachea below the entry point of the vessels must be avoided. Limiting the dissection anterior to the position of entry of the blood supply during a mediastinoscopy will also limit bleeding during the procedure (Fig. 3).

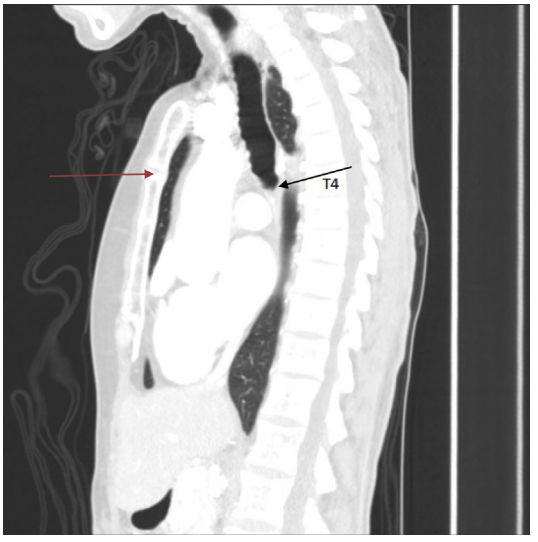

Fig. 1. Coronal view of the computed tomographic (CT) scan of a 40-year-old woman. Note the posterior deflection of the intrathoracic trachea. Note also that the carina (*black arrow*) lies just below the level of the angle of Louis (*red arrow*), the site of insertion of the cartilage of the second rib.

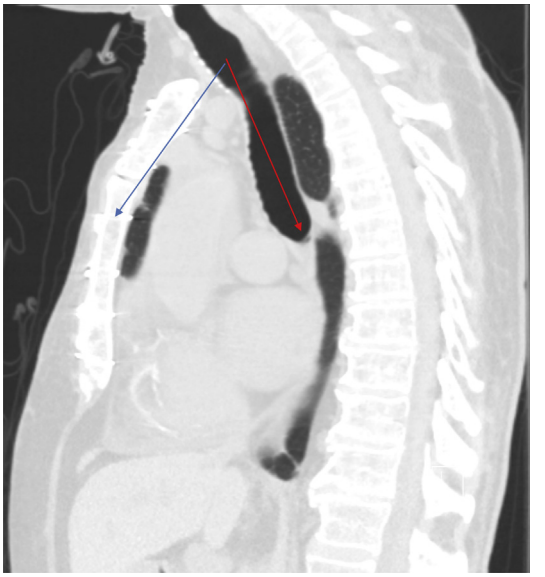

Fig. 2. Coronal CT images of an 82-year-old man. Note that the angle between the trachea (*red arrow*) and the sternum (*blue arrow*) is more pronounced than the younger patient in Fig. 1.