TRACHEA AND BRONCHI

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I - INTRODUCTION:

The trachea and bronchi are cartilaginous and membranous airways designed to convey respiratory and phonatory airflow.

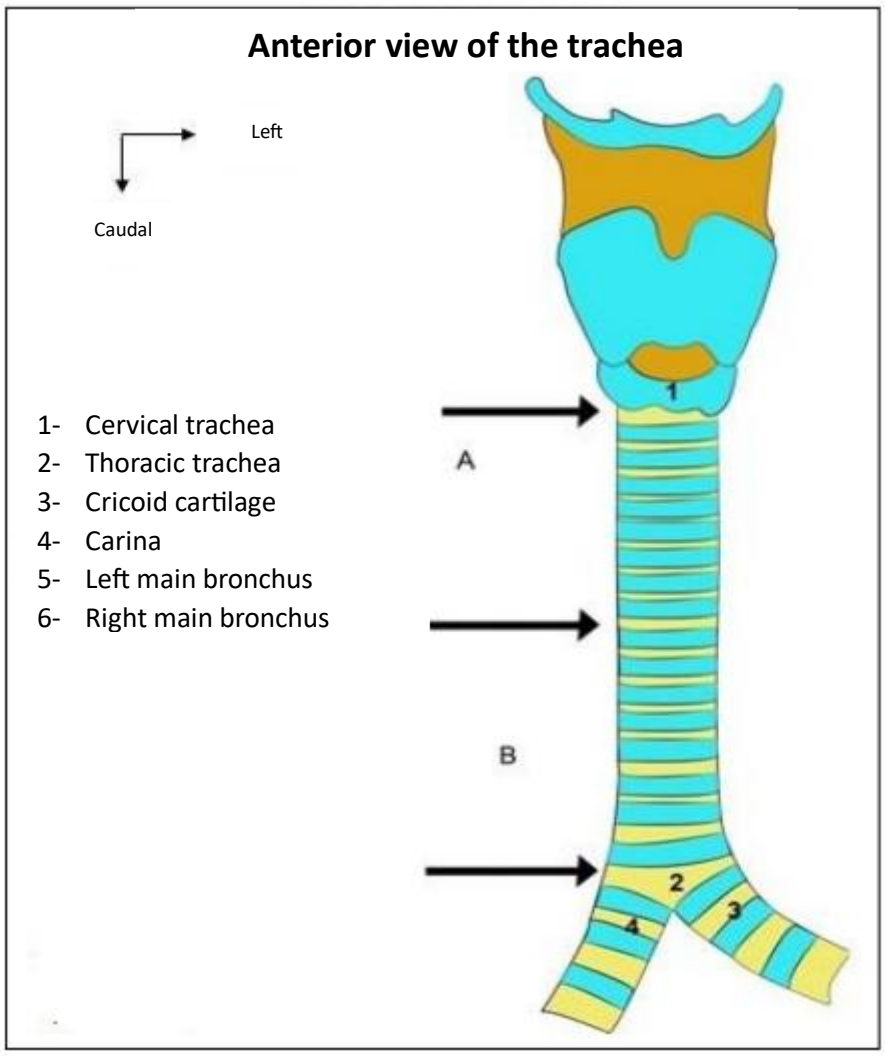
II - TRACHEA:

1. Descriptive anatomy:

a. Origin – course – termination:

The trachea has two segments:

- A **cervical segment**: it follows the larynx, extending from the lower border of the cricoid cartilage, contained within the visceral sheath of the neck, and moves obliquely downward and backward in the subhyoid region, ending at the upper border of the manubrium sternum (the base of the neck).
- A **thoracic segment**: it occupies the upper part of the middle mediastinum, extending from T2 to T4, where it terminates by bifurcating into the two mainstem bronchi.



b. External configuration:

The trachea has the shape of a cylindrical tube flattened on its posterior surface.

- The **anterior part** is made up of overlapping, prominent cartilaginous rings, separated by inter-ring depressions.
- The **posterior part** consists of a flat, flexible membrane.

c. Dimensions:

- The length is between **12 and 14 cm**: **6 to 7 cm** for the **cervical segment**, and **6 to 7 cm** for the **thoracic segment**.

***Note**: In fact, its structure allows for elongation during inspiration.*

- The **diameter** is between **12 and 16 mm**, but variable.
- Two **depressions** are visible on the left side of the trachea: the **thyroid imprint** at the top, and the **aortic imprint** at the bottom.

d. Internal configuration:

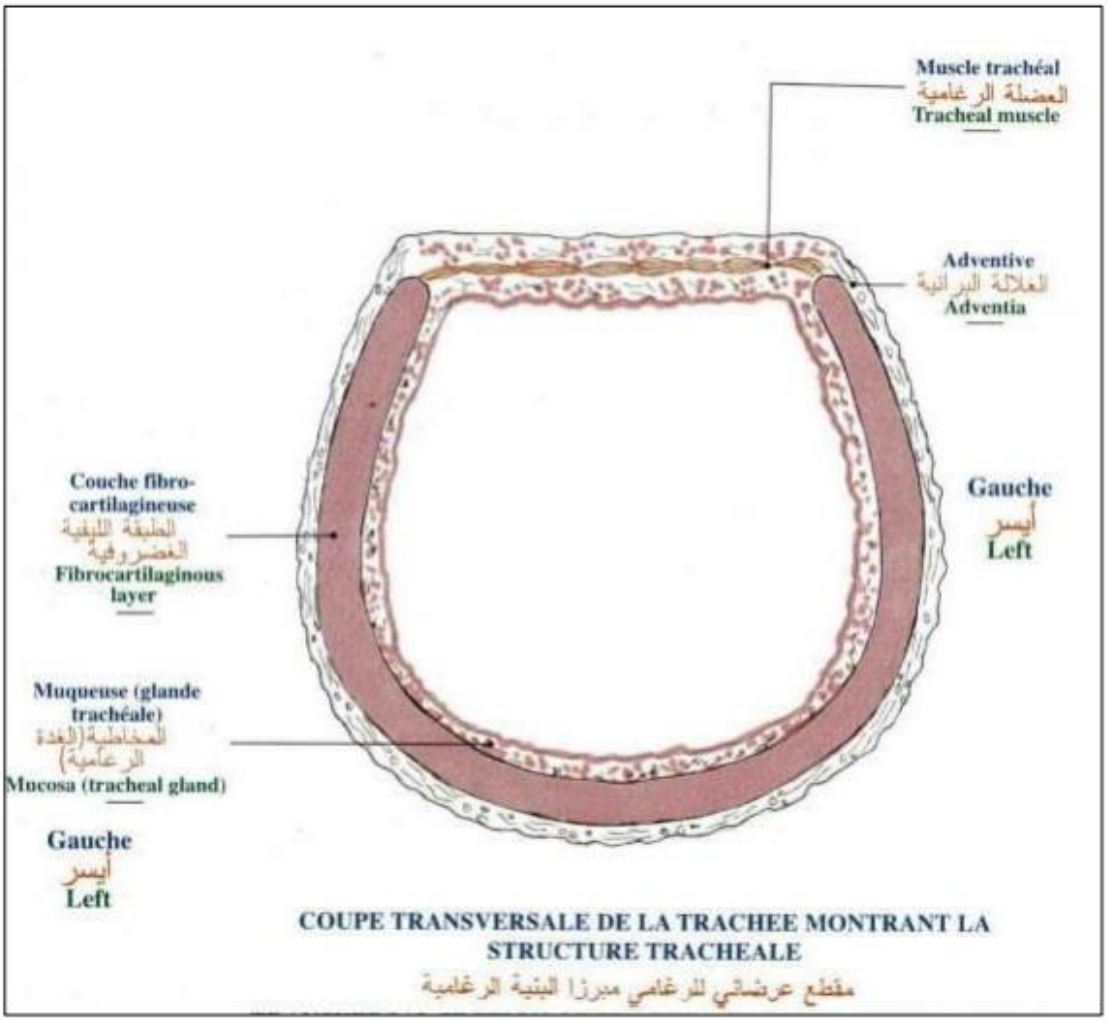
- The tracheal mucosa is white-pink in color, raised in the front by a series of folds corresponding to the tracheal cartilages.
- At the lower end of the trachea, the two bronchial orifices, right and left, are separated by an anteroposterior prominence, almost median (slightly displaced to the right): the Carina, or tracheal spur.

***Note**: Endoscopy (tracheobronchoscopy) allows for visualization of the internal tracheal configuration.*

e. Structure:

The trachea, like the bronchi, is made up of two essential layers:

- **An external layer**: It is fibro-musculo-cartilaginous, formed by the stacking of 15 to 20 cartilaginous pieces in the shape of a horseshoe, separated by interannular ligaments and joined at the back by a fibrous lamina; this is the membranous layer. This external layer is covered by an adventitia.
- **An internal layer**: It is a mucosal layer consisting of a chorion that contains mucous glands and a characteristic epithelium.



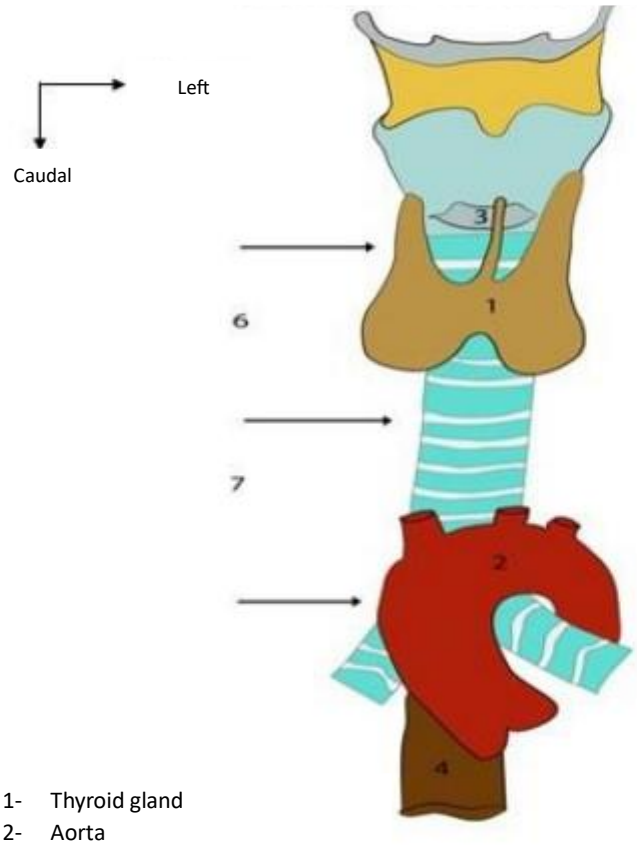
Transverse section of the trachea showing its structure

e. Means of fixation:

- **Cervical portion:**
  The cervical trachea is held in place by its continuity with the larynx and its adhesion to the esophagus and the thyroid gland.
- **Thoracic portion:**
  The thoracic trachea is held in place by its continuity with the cervical trachea, the larynx, and its adhesion to the esophagus and the aortic arch.

Note: *The trachea is relatively mobile, descending during inspiration and rising during expiration.*

Overview of the trachea



1- Thyroid gland
2- Aorta
3- Larynx
4- Esophagus
5- Cervical segment
6- Thoracic segment

2. Anatomical relations:

a. Cervical trachea:

The **cervical trachea** is related:

- **Anteriorly:** to the thyroid isthmus, and further down, to the superior thyroid arteries, inferior thyroid veins, brachiocephalic trunk, and the thymus. Superficially, the trachea is covered by the sternothyroid muscles, sternohyoid muscles, and the pretracheal lamina of the cervical fascia.

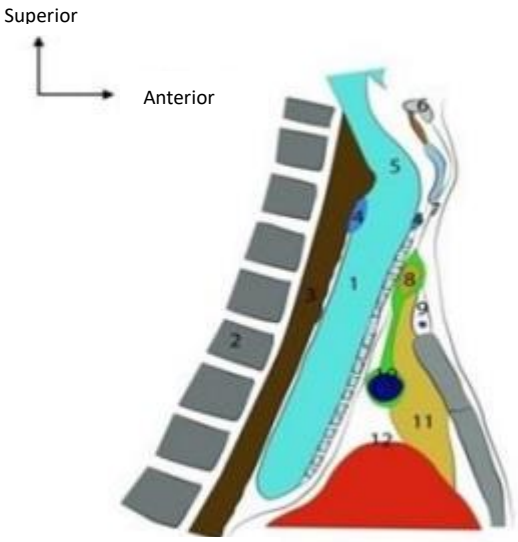
Note: *At this level, the trachea is deeper, and its numerous venous relations make the supraisthmic tracheotomy preferable.*

- **Posteriorly:** to the anterior surface of the esophagus.

Note: *This explains the frequency of tracheoesophageal fistulas.*

- **Laterally:** to the thyroid lobes, common carotid arteries, and inferior thyroid arteries.

Sagittal section of the neck and upper part of the thorax



1- Trachea
2- Vertebral column
3- Esophagus
4- Cricoid cartilage
5- Larynx
6- Hyoid bone
7- Cervical linea alba
8- Thyroid isthmus
9- Supra sternal space
10- Left brachiocephalic trunk
11- Thymic compartement
12- Pericardium

b. Thoracic trachea:

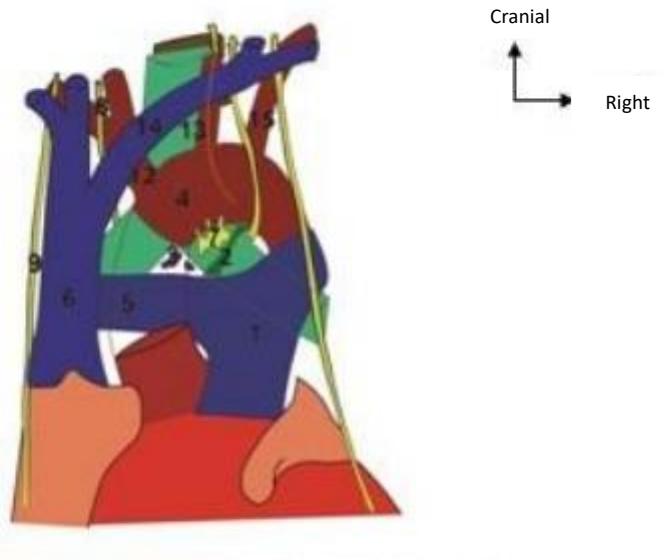
The **thoracic trachea** is in relation with:

- **Anteriorly:** The aortic arch, brachiocephalic artery, left common carotid artery, tracheobronchial lymph nodes, cardiac plexus nerves, and the left brachiocephalic vein. Further anteriorly, it is related to the thymus and superficially to the manubrium sterni.
- **Posteriorly:** It is related to the esophagus.
- **Laterally:**

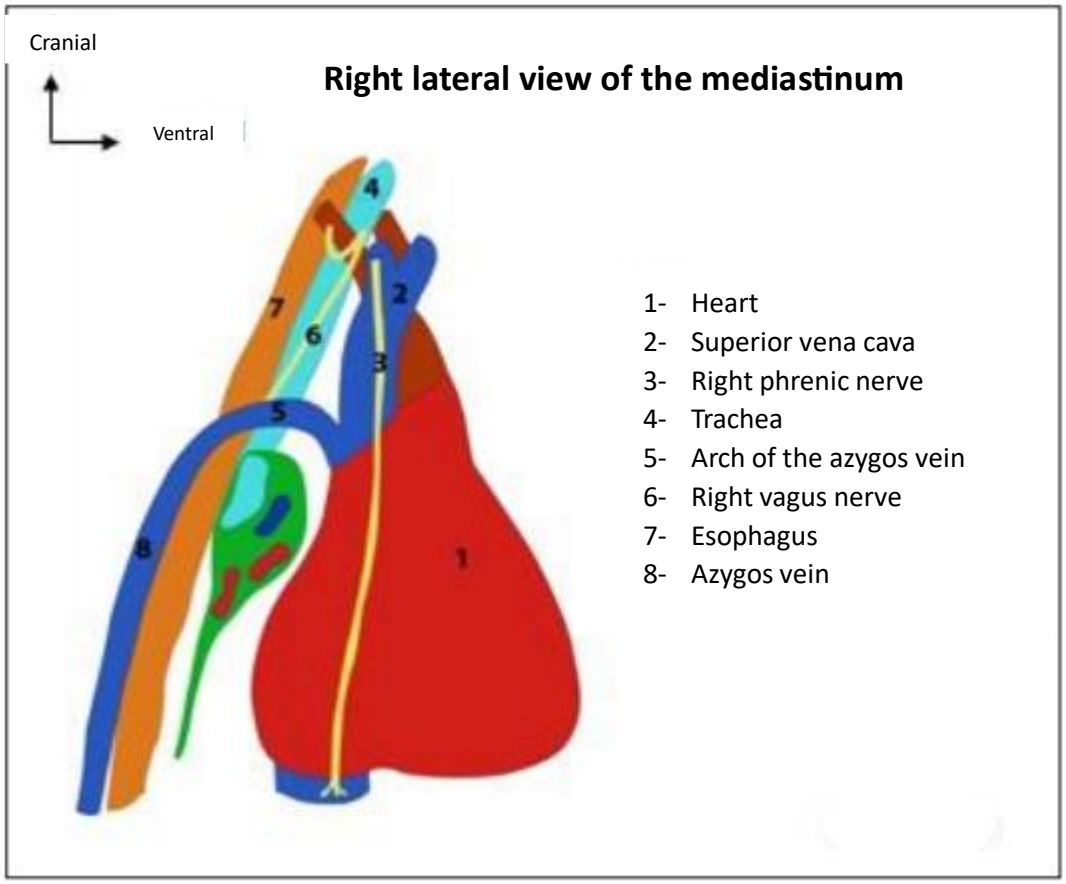
- **On the right:** It is related to the right lung, right pleura, right brachiocephalic vein, superior vena cava, right vagus nerve, and the azygos vein.
- **On the left:** It is related to the aortic arch, left common carotid artery, left subclavian artery, and the left recurrent laryngeal nerve.

Note: *These elements are in close relation to the trachea through the adventitia, which serves as a means of fixation. Therefore, releasing these connections is the first step in tracheal mobilization during a resection-anastomosis procedure.*

Anterior view of the mediastinum showing the anterior and left relations of the trachea



1- Pulmonary artery
2- Ligamentum arteriosum
3- Inferior tracheo-bronchial lymph nodes
4- Aortic arch
5- Right branch of the pulmonary artery
6- Superior vena cava
7- Wrisberg's cardiac ganglia
8- Right vagus nerve
9- Right phrenic nerve
10- Left vagus nerve
11- Left recurrent laryngeal nerve
12- Arterial brachiocephalic trunk
13- Left common carotid artery
14- Left venous brachiocephalic trunk
15- Left subclavian artery



3. Vascularization – innervation – lymphatic drainage system:

a. Arterial vascularization:

The arterial vascularization of the trachea comes from several sources:

- **Inferior thyroid arteries:** These are branches of the thyrocervical trunks, originating from the subclavian arteries. They primarily supply the cervical segment of the trachea.
- **Internal thoracic arteries:** These are branches of the subclavian arteries, and they provide branches to the thoracic segment of the trachea.
- **Bronchial arteries:** These arise from the aortic arch and supply the area around the tracheal bifurcation.
- **Middle thyroid artery** (when it exists).

b. Venous vascularization:

The venules of the trachea drain into the **inferior thyroid veins** and **esophageal veins**, and at

the level of the bifurcation, into the **azygos vein** on the right side and the **superior hemiazygos vein** on the left side.

c. Lymphatic drainage:

The lymphatic vessels from the mucosal and submucosal networks drain into the:

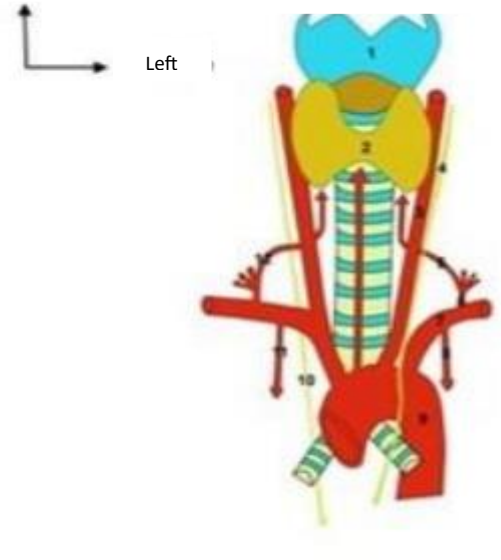
- **Recurrent chain lymph nodes**
- **Peritracheobronchial lymph nodes**

d. Innervation:

The nerve fibers that supply the trachea have two sources:

- **Vagus nerves** (through the **recurrent laryngeal nerves**)
- **Sympathetic nervous system** (through the **cervical ganglia** and the first **thoracic ganglia**)

Anterior view of the trachea showing its arteries and nerves



1- Thyroid cartilage
2- Thyroid gland
3- Common carotid artery
4- Left vagus nerve
5- Left inferior thyroid artery
6- Thyrocervical trunk
7- Subclavian artery
8- Left internal thoracic artery
9- Aorta
10- Right vagus nerve
11- Right internal thoracic artery
12- Right inferior thyroid artery

III – BRONCHI:

1. Descriptive anatomy:

a. Definition and origin:

- The bronchi are the two branches that divide from the trachea, one on the right and one on the left. They are called primary bronchi (or main bronchi).
- The tracheal bifurcation occurs at the level of the 5th thoracic vertebra, but it can occur lower, at the level of the T5-T6 intervertebral disc, in alignment with the sternal angle, about 1 cm from the midline.

b. Arrangement and direction:

The right and left main bronchi have an asymmetrical arrangement in relation to the tracheal bifurcation. They form an angle of 70°.

c. Segments and branches:

The main bronchi present two segments:

- **An extrapulmonary segment**
- **An intrapulmonary segment**

Extrapulmonary segment:

- **Right main bronchus:**
  - It extends from the tracheal bifurcation to the superior lobar bronchus. It is almost vertical (slightly oblique downwards and outwards).
  - Its length is **2 to 3 cm** and its diameter is **12 to 14 mm**.

Note: *It is often the site of foreign body aspiration in the respiratory tract.*

- **Left main bronchus:**
  - It extends from the tracheal bifurcation to the superior lobar bronchus. It is almost horizontal.
  - Its length is **5 to 6 cm** and its diameter is **9 to 11 mm**.

Note: *Its endoscopic exploration can sometimes be difficult.*

Intrapulmonary segment and bronchial segmentation:

- The **intrapulmonary segment** of the main bronchus is part of the lung structure and represents the intrapulmonary part of the bronchial tree. Each main bronchus traverses the lung without discontinuity until its base. From the main bronchial trunk arise the **lobar bronchi**, which further divide into **segmental bronchi**.

  - **Right main bronchus:** It gives rise to:

    - **Superior lobar bronchus (BLS)**: from its lateral surface.
    - **Middle lobar bronchus (BLM)**: from its anterior surface.
    - **Inferior lobar bronchus (BLI)**: from its terminal segment.

- The **superior lobar bronchus** divides into three segmental bronchi for the upper lobe:

  1. Apical segmental bronchus of the upper lobe.
  2. Dorsal segmental bronchus.
  3. Ventral segmental bronchus.

- The **middle lobar bronchus** divides into two segmental bronchi for the middle lobe:

  4. Lateral segmental bronchus.
  5. Medial segmental bronchus.

- The **inferior lobar bronchus** divides into five segmental bronchi for the lower lobe:

  6. Apical segmental bronchus of the lower lobe (or Nelson's apical bronchus).
  7. Medio-basal segmental bronchus (or para-cardiac segmental bronchus).
  8. Ventro-basal segmental bronchus.
  9. Latero-basal segmental bronchus.
  10. Dorso-basal segmental bronchus (or terminal basal bronchus).

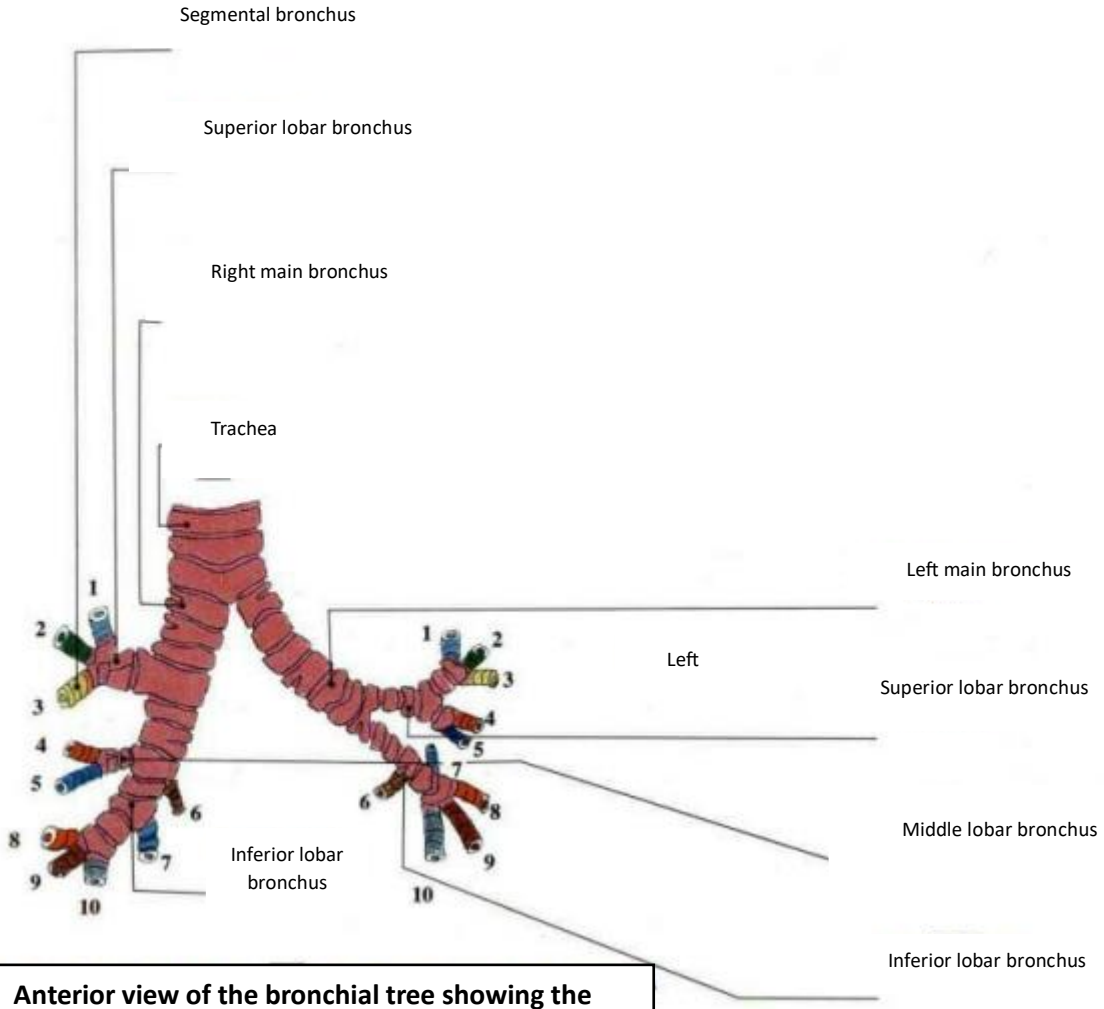
  - **Left main bronchus:** It gives rise to the **superior lobar bronchus (BLS)** from its anterolateral face and ends with the **inferior lobar bronchus (BLI)** from its terminal segment.

- **Left superior lobar bronchus**: First divides into two bronchi—**superior (culminal)** and **inferior (lingular)**—which further divide into five segmental bronchi:
    - ✓ **Culminal (superior) bronchus (BC)**: Divides into three segmental bronchi:
        1. Apical segmental bronchus of the upper lobe.
        2. Dorsal segmental bronchus.
        3. Ventral segmental bronchus.
    - ✓ **Lingular (inferior) bronchus (BL)**: Divides into two segmental bronchi:
        4. Cranial lingular segmental bronchus.
        5. Caudal lingular segmental bronchus.

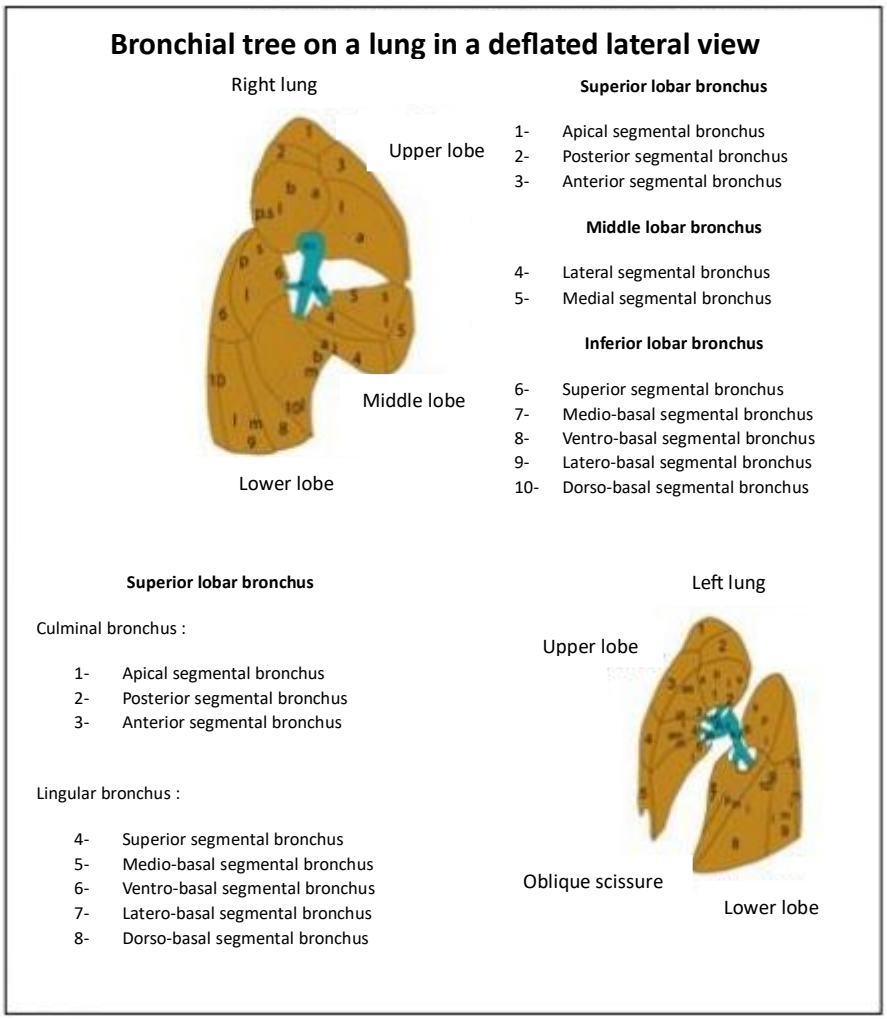
- **Left inferior lobar bronchus**: Has the same segments as the **right inferior lobar bronchus** (segments 6 to 10).

Subsegmental bronchi:

The **segmental bronchi** divide into **subsegmental bronchi** about ten times, eventually leading to the **terminal bronchioles**, which end in the **alveolar ducts** (alveolar sac).



Anterior view of the bronchial tree showing the correspondence of the bronchial segments



d. External configuration:

- The **extra-pulmonary bronchi** have an external configuration similar to that of the trachea (a cylindrical conduit flattened at the back).
- Inside the lung, the bronchi become circular in cross-section, with the cartilaginous rings being replaced by cartilaginous plates, which eventually disappear in bronchi of 1 mm in diameter.

e. Structure:

The bronchi are composed of two layers, similar to the trachea:

- An **internal layer**: mucous.
- An **external layer**: fibro-musculo-cartilaginous.

2. Anatomical relations:

a. Relations of the tracheal bifurcation:

The tracheal bifurcation is in relation with:

- **Inferiorly:**
    - The bifurcation of the pulmonary artery.
    - The inter-tracheo-bronchial lymph nodes.
    - The left atrium, covered by the oblique sinus of the pericardium.

Note: *The two main bronchi may be displaced upwards in cases of large left atrial dilatation.*

- **Anteriorly:**
    - The aortic arch.
    - The right branch of the pulmonary artery.
    - The superior vena cava, more to the right.
    - The cardiac ganglia of Wrisberg, more to the left.
    - The thymus, more anteriorly.
- **Posteriorly:**
    - The esophagus.
    - The thoracic duct, more posteriorly.
- **Superiorly:** Two sides:
    - The right side: with the arch of the azygos vein.
    - The left side: with the aortic arch (crossing over the left pulmonary pedicle).

Note: *This makes surgical access to the trachea very difficult on this side.*

- **To the right:**
    - The right vagus nerve.
    - The right lateral tracheo-bronchial lymph nodes.
- **On the left:**
    - The left vagus nerve.

b. Relations of the main bronchi with elements of the nourishing pulmonary pedicle:

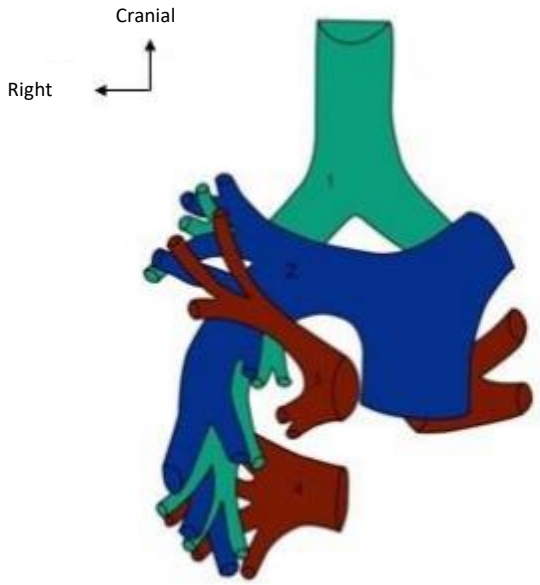
- **On the right:**
    - The **right bronchial artery**: travels along the posterior surface of the right main bronchus.
    - The **bronchial veins**: arise from the posterior surface of the right main bronchus.
    - The **lymphatics**: The right main bronchus is in relation to the lymph nodes that receive lymphatics from the right lung:
        - The interlobar peri-bronchial nodes.
        - The inter-tracheo-bronchial nodes.
        - The paratracheal nodes.
    - The **bronchial nerves**: have a dual origin:
        - **Sympathetic**.
        - Pneumogastric (**vagus nerve**): through nerve fibers from the trunk of the vagus nerve, behind the right main bronchus.
- **On the left:**
    - **The bronchial arteries**: they travel along the posterior surface of the left main bronchus.
    - **The left bronchial veins:** they arise from the posterior surface of the left main bronchus.
    - **The lymphatics**: The left main bronchus is in relation to the lymph nodes that receive lymphatics from the left lung:
        - The interlobar peri-bronchial nodes.
        - The inter-tracheal bronchial nodes and left paratracheal nodes.
        - The prevascular nodes.
    - **The bronchial nerves** have a dual origin:
        - **Sympathetic**.
        - **Vagus** (pneumogastric): through nerve fibers from the trunk of the vagus nerve, behind the left main bronchus.

c. Relations of the main bronchi with the functional pedicle elements:

The main bronchi are part of the functional pulmonary pedicle. They have close relations with the other elements of the pedicle, particularly the pulmonary arteries and veins.

- **On the right:**
    - The right pulmonary artery: it runs horizontally to the right and crosses the anterior surface of the right main bronchus.
    - The right pulmonary veins: they are situated in front of and below the right main bronchus.

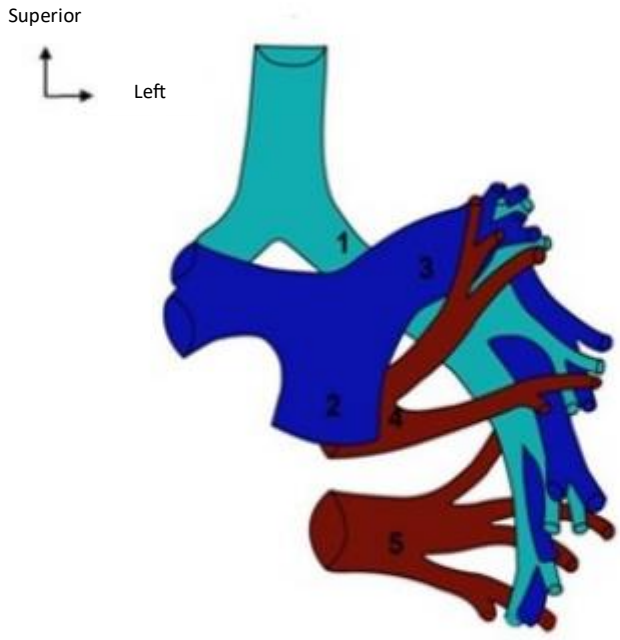
Anterior view of the right pulmonary pedicle



1- Right main bronchus
2- Right pulmonary artery
3- Right superior pulmonary vein
4- Right inferior pulmonary vein

- **On the left**:
    - The left pulmonary artery: it runs obliquely upward and to the left to position itself above the bronchus.
    - The left pulmonary veins: they are located anteriorly and below the main bronchus.

Anterior view of the left pulmonary pedicle



1- Left main bronchus
2- Pulmonary trunk
3- Left pulmonary artery
4- Left superior pulmonary vein
5- Left inferior pulmonary vein

3. Vascularization – innervation – lymphatic drainage system:

a. Arterial vascularization:

The right and left **bronchial arteries** come from the **descending aorta** or sometimes from the **aortic arch**, generally single on the right and double on the left.

b. Venous vascularization:

The **right and left bronchial veins** are **anterior and posterior**, draining into the **pulmonary veins** and the **azygos veins**.

c. Lymphatic drainage:

The **collecting trunks** of the **perilobular network** are adjacent to the vessels and bronchi, draining into the **hilar lymph nodes** located at the bronchial lobar bifurcations.

d. Innervation:

The **nerves** of the bronchi are formed by **branches of the vagus nerve** and the **sympathetic nervous system**, particularly the **cardiac plexus**.

VI – CLINICAL APPLICATIONS:

❖ Bronchial fibroscopy:

The search for a bronchial pathology obstructing the bronchi (such as cancer) involves examining the tracheobronchial mucosa via fibroscopy. This procedure involves introducing a tube containing optical fibers through the mouth into the trachea, allowing progress into the bronchial tree. The carina forms a spur, which is easy to identify, and from there, each main bronchus is explored up to its segmental divisions. A tumor nodule is localized by respecting the bronchial segmentation and can be biopsied for microscopic analysis.

❖ Tracheotomy:

This is an emergency procedure that must be performed when there is an obstruction of the upper airways causing a spasm of the glottis. From a topographical perspective, a tracheotomy is performed at the following points:

- **Lower tracheotomy**: The incision is made below the isthmus of the thyroid gland. It may involve the 4th, 5th, and 6th rings of the trachea.
- **Upper tracheotomy**: The incision may involve the first 3 or 4 rings of the trachea. The isthmus of the thyroid gland is often reclined or sectioned.
- **Crico-thyroidotomy or coniotomy**: Also known as an intercricothyroid laryngotomy, this involves making a transverse incision at the level of the cricothyroid membrane (or elastic cone).

VII - CONCLUSION:

- The trachea and bronchi are part of the lower respiratory tract.
- They allow the passage of oxygen-rich air from the larynx to the lungs, while filtering the air to improve its quality and facilitating the elimination of carbon dioxide-rich air expelled by the lungs.
- Knowledge of their anatomy is essential as it allows for an appropriate diagnostic and therapeutic approach.