Respiratory system

Anatomy

sheet | handout | slides

Number	Embryo#1
Doctor	Mohammad Hisham Al-Mohtaseb
Done by	باشق جهاد
corrected by	

Before you start, it is important to link what you learn in gross anatomy with developmental stages discussed in embryology.

Cells that form organs of the embryo originate from three layers:
Ectoderm: cells covering the surfaces.
Endoderm: cells lining the inner surfaces of a tubes or hollow organs.
Mesoderm: cells forming connective tissues.

The mesenchyme originates from the mesoderm and it develops into the tissues of the lymphatic and circulatory systems, as well as the musculoskeletal system.

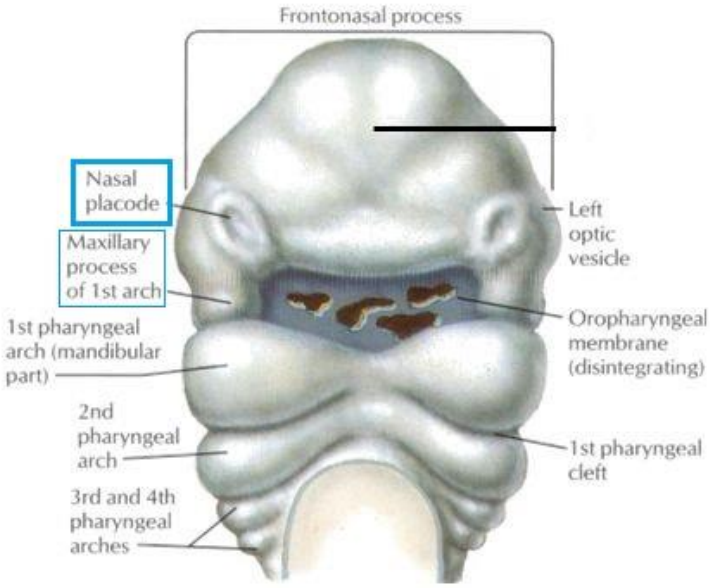
Development of the nose and Palate:

As you know, the nose contains two cavities separated by a septum and surrounded by lateral walls. It also has two openings anteriorly called nostrils (also called nares) and two openings posteriorly called choana.
The hard palate separates the nasal cavity from the oral cavity.

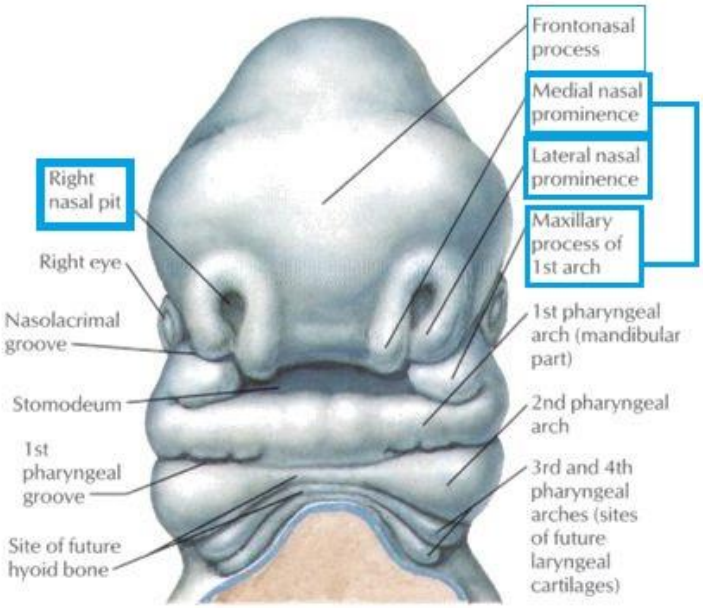
At the end of the fourth week, **facial prominences** consisting primarily of neural crest-derived mesenchyme and formed mainly by the first pair of pharyngeal arches appear.
A prominence is an elevation caused by proliferation of some cells more than others, it participates in formation and development of certain structures in the embryo.
Facial prominences include:

- **Maxillary prominence:**
  It develops into the maxilla and participates in formation of the upper lip and philtrum.
- **Mandibular prominence:**
  It develops into the mandible and lower lip.
- **Frontonasal prominence:**
  It's a bony prominence that starts from the forehead (in front of the brain) and continues downward to from the septum of the nose, it also forms the frontal bone. Since it is bony, it originates from mesoderm.
  On both sides of the frontonasal prominence, surface **ectoderm** cells proliferate locally under inductive influence of the ventral portion of the forebrain producing thickenings called the **nasal (olfactory) placodes**.

During the fifth week, the nasal placodes invaginate to form small depressions called nasal pits (the future nostril). During invagination, two nasal prominences originate (from frontonasal prominence) around the each pit:



- **Medial nasal prominence:** Forms the medial septum of the nose and aids the maxillary prominence in formation of the upper lip.
- **Lateral nasal prominence:** Produces the lateral wall and ala of the nose



During the following 2 weeks, the maxillary prominences continue to increase in size. They grow medially compressing the medial nasal prominences toward the midline, the maxillary and medial nasal prominences on each side fuse and the cleft between them is lost.

If fusion failed the result would be a cleft lip (hare lip).

So five embryonic structures participate in formation of the nose:

• Frontonasal prominence gives rise to the bridge and nasal septum.

• The merged medial nasal prominences provide the nasal crest and tip of the nose.

• Lateral nasal prominences form the sides and alae.

• Olfactory pit forms the nostril and then with further invagination it forms a blind sac which is the vestibule.

Prominence	Structures formed
Frontonasal	Forehead, bridge of the nose, nasal septum, **medial and lateral nasal prominences**
Lateral nasal	Alae of the nose
Medial nasal	Nasal crest, tip off the nose, philtrum and *medial* portion of the upper lip
Maxillary	Cheeks, *lateral* portion of upper lip the
Mandibular	Lower lip

Note: all these prominences are paired **except** the frontonasal which is single unpaired**.**

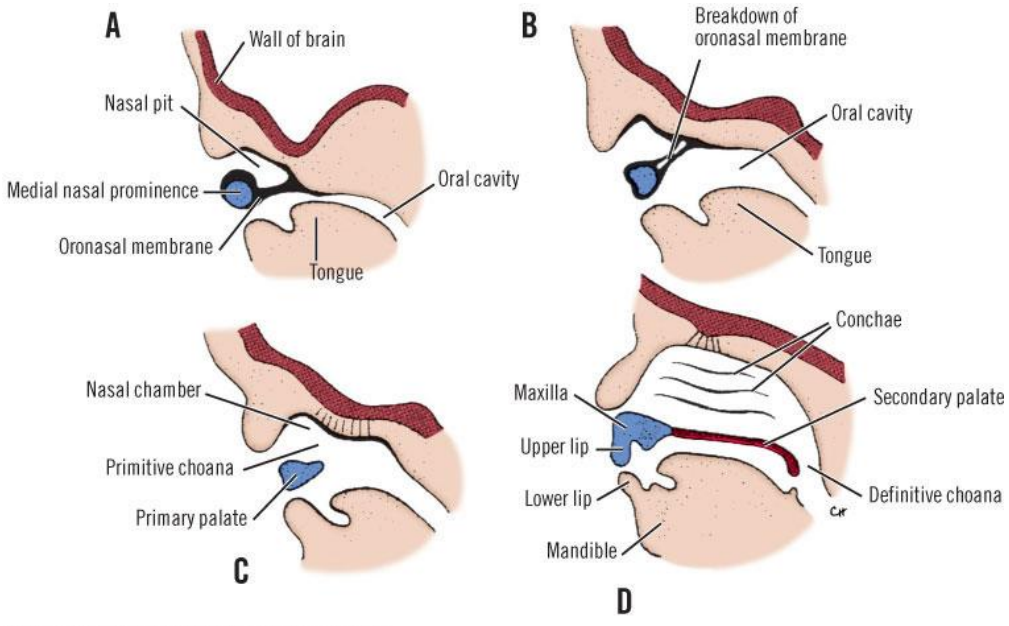
Note: Nasal septum separates the right nasal cavity from the left, while bridge of the nose is the upper part of the roof of the nose and is formed by the junction between the two nasal bones.

Nasal cavities:

During the sixth week, the nasal pits deepen considerably, partly because of growth of the surrounding nasal prominences and partly because of their penetration into the underlying mesenchyme, the cavities formed are still separated from the primitive oral cavity by oronasal membrane.

This membrane will eventually rupture and disappear, and two new structures emerge:

- Primary palate, anteriorly and below
- Primitive choana, posteriorly and above



Later on, secondary palate is formed further separating the nasal cavity from the oral cavity, and the definitive choanae will lie at the junction of the nasal cavity and the pharynx (opens into the nasopharynx).
At this moment walls of the nasal cavity are taking their final shape and choncae appear at the medial (septal) wall.

Primary and secondary palate:

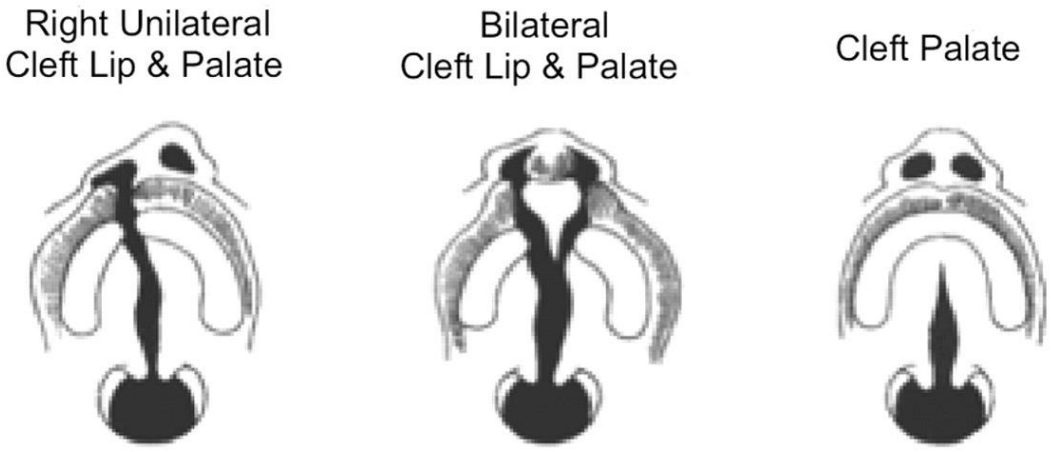
As a result of medial growth of the maxillary prominences, the two medial nasal prominences merge not only at the surface but also at a deeper level. The structure formed by the two merged prominences is the **intermaxillary segment**, it's contains:

A. Labial component, which forms the philtrum of the upper lip
B. Upper jaw component, which carries the four incisor teeth
C. Palatal component, which forms the triangular primary palate

The intermaxillary segment is continuous with the antero-inferior (rostral) portion of the nasal septum, which is formed by the frontonasal prominence.
The main part of the definitive palate is formed by two shelf-like outgrowths from the maxillary prominences called palatine shelves; they appear in the sixth week and grow anteriorly, inferiorly, and toward the midline on each side of the tongue.

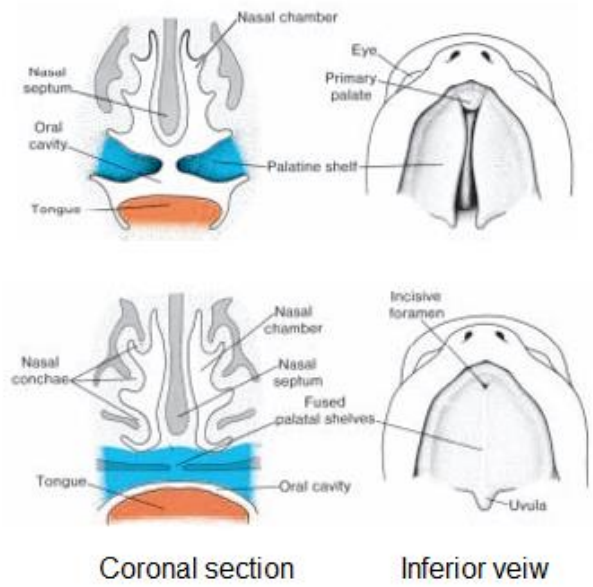
In the seventh week, the palatine shelves ascend to attain a horizontal position above the tongue and a group of fusions occur:
- The two shelves meet medially and fuse **together** forming the secondary palate
- At the same time as the palatine shelves fuse, **the nasal septum** grows down and joins with the cephalic aspect of the newly formed palate
- Anteriorly, the shelves fuse **with the triangular primary palate**, and the incisive foramen is the midline landmark between the primary and secondary palates.

A defect in fusion of palatine shelves can produce cleft palate:
- It could be unilateral or bilateral (this applies to cleft lip as well)
- Unilateral cleft lip and palate can extend to the nose
- In cleft soft palate we can see cleft uvula as well



Cleft lip and palate is dangerous in babies because it makes it hard for them to be fed because feeding material could pass to the respiratory system and suffocates the baby. Doctors may have to place nasogastric tube until surgery takes place.

Two folds grow posteriorly from the edge of the palatine process to form the soft palate and the uvula, the union of the two folds of the soft palate occurs during the eighth week, while the two parts of the uvula fuse in the midline during the eleventh week.



Paranasal sinuses:

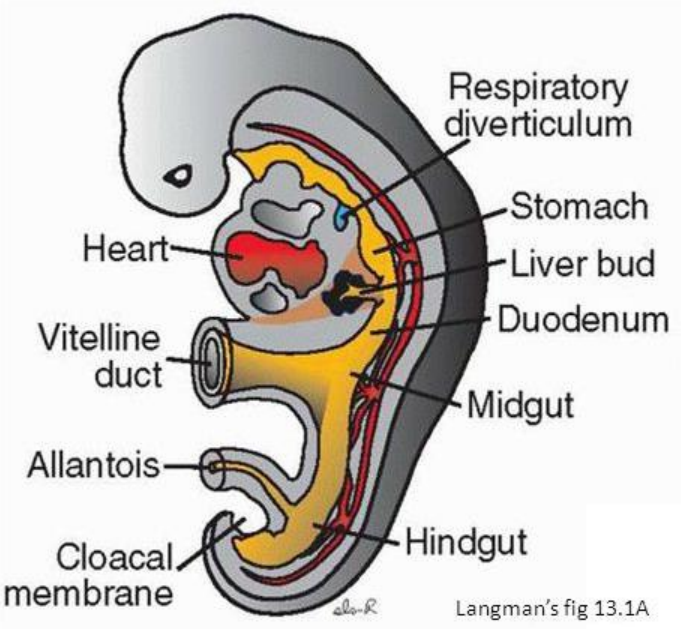
Paranasal air sinuses develop as diverticula of the lateral nasal wall and extend into the corresponding bones (maxilla, ethmoid, frontal, and sphenoid bones).
They start as small cavities and reach their maximal size at puberty when facial bones grow and the face takes its definitive shape.

Respiratory tract development:

Remember: the primitive gut and its derivatives develop into four sections:
- The **pharyngeal gut, or pharynx**, extends from the buccopharyngeal membrane to the tracheobronchial diverticulum
- The **foregut** lies caudal to the pharyngeal tube and extends as far caudally as the liver outgrowth (or middle of the duodenum).
- The **midgut** begins caudal to the liver bud (or middle of the duodenum) and extends to the junction of the right (proximal) two-thirds and left (distal) third of the transverse colon in the adult
- The **hindgut** extends from the left third of the transverse colon to the cloacal membrane.

When the embryo is approximately four weeks old, the respiratory diverticulum (lung bud) appears as an outgrowth from the ventral wall of the foregut. This happens under the influence of **fibroblast growth factors (FGFs)**, which is secreted at a specific time inducing growth of lung bud at a certain spot on the foregut.

This is how the whole embryo thing is going, it's like there's a gene box that causes secretion of certain growth factors at certain times.

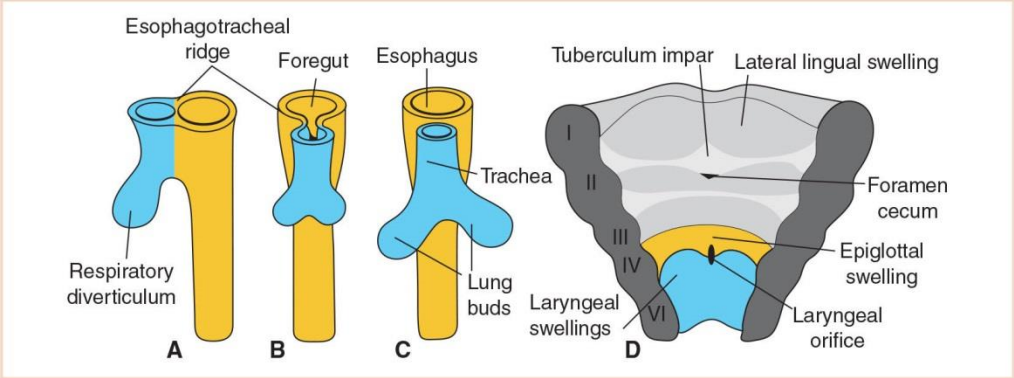


Langman's fig 13.1A

- The lining epithelium for the whole respiratory system is endodermal in origin
- All cartilage, muscle, connective tissue from **splanchnic** mesoderm
- The surface is ectodermal

Initially the lung bud is in open communication with the foregut

When the diverticulum expands caudally, two longitudinal ridges appear at the beginning of the diverticulum called **the tracheoesophageal ridges**, constricting its connection with the foregut.
Subsequently, when these ridges **fuse** to form the tracheoesophageal **septum**, the foregut is divided into a dorsal portion (the esophagus) and a ventral portion (the trachea and lung buds).



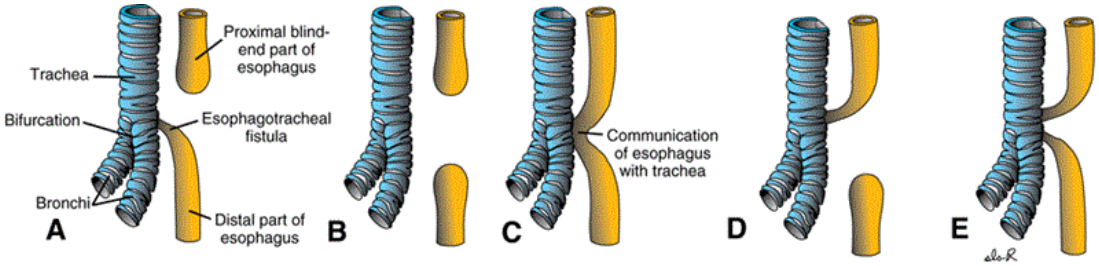
Does that mean that respiratory tract is completely separated from the digestive tract?
No, the respiratory tract maintains its communication with the laryngopharynx through the laryngeal orifice. This communication begins as a slit-like opening, then it develops into T-shape, and finally into laryngeal orifice.

Esophagus:

The esophagus starts short in the chest, but it elongates and descends downwards due to the rapid growth of the heart and lungs, as if they pull it down.
The muscular coat, which is formed by surrounding splanchnic mesenchyme, is striated in its upper two-thirds and innervated by the vagus nerve, while in the lower third the muscle coat is smooth and is innervated by the splanchnic plexus.

Anomalies of the trachea and esophagus:

Esophageal atresia and tracheoesaphageal fistula (TEF)



Atresia: blind-end tube.

These defects result from abnormalities in partitioning of the esophagus and trachea by the tracheoesaphageal septum, they occur in approximately 1/3000 births and affect males more than females.

The most common form (90% of the cases) is *A in the figure*; **proximal esophageal atresia and distal tracheoesaphageal fistula**.

Other defects:

- Double atresia (isolated atresia) accounts for 4% of the cases. (B in the figure)
- H-type tracheoesaphageal fistula without esophageal atresia also accounts for 4% of the cases. (C in the figure)
- Double atresia and double tracheoesaphageal fistula, 1%. (E in the figure)
- Distal esophageal atresia and proximal tracheoesaphageal fistula, 1% (D in the figure)

When infants with common type TEF and esophageal atresia try to swallow milk it rapidly fills the esophageal pouch and is **regurgitated.**

A complication of some TEFs is polyhydramnios (excess amniotic fluid around the baby), since in some types of TEF amniotic fluid **does not pass** to the stomach and intestines as what should normally happen.

Also, gastric contents and/or amniotic fluid may enter the trachea through a fistula, causing pneumonitis and pneumonia.

33% of patients with tracheoesaphageal fistula have cardiac abnormalities like interventricular septal defect or Fallot's tetralogy.

It's also associated with other abnormalities but to a lesser extent like: vertebral anomalies, anal atresia, renal anomalies, and limb defects.

Can the trachea alone (without esophageal involvement) have congenital defects?

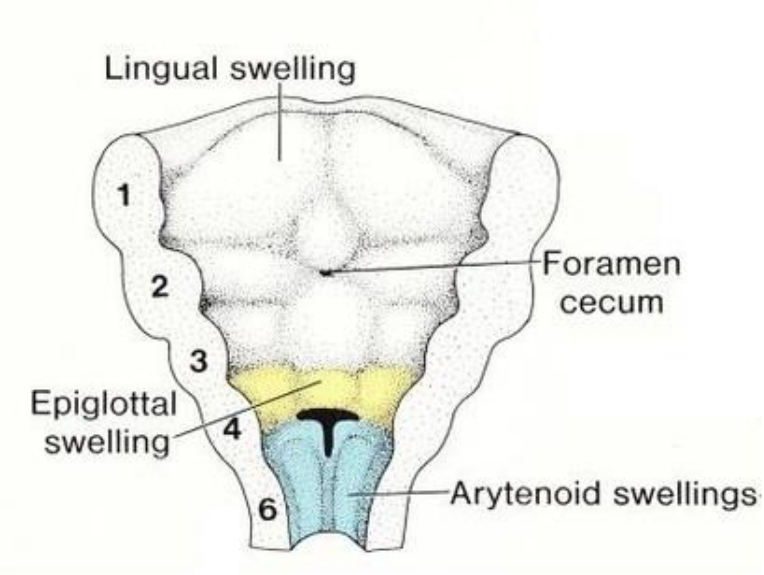
Yes, but this is very rare, these abnormalities include:

- **Tracheal atresia and stenosis**, uncommon anomalies and usually associated with one of the verities of TEF
- In some case a **web tissue** may obstructs the airflow (incomplete tracheal atresia)

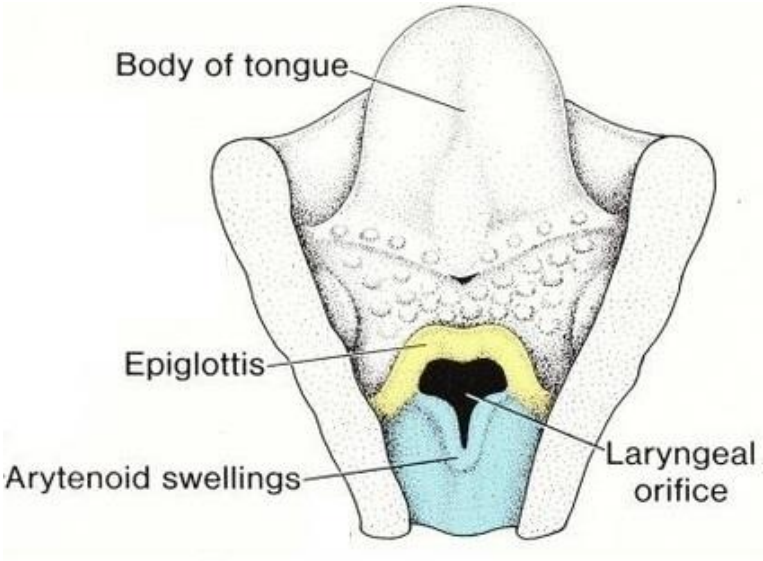
Development of the larynx:

The internal lining of the larynx originates from endoderm, but the cartilages and muscles originate from mesenchyme of the **fourth** and **sixth** pharyngeal **arches.**

*Note in the figure that the opening in the larynx is **T-shaped** (previously it was **slit-like**).*



Subsequently, when mesenchyme of the two arches transforms into the thyroid, cricoid, and arytenoid cartilages, the characteristic adult shape of the **laryngeal orifice** can be recognized, this orifice is bound anteriorly by epiglottis and by aryepiglottic folds on each side.



When the cartilages are formed, the laryngeal epithelium proliferates rapidly resulting in a temporary **occlusion** of the lumen. This is followed by vacuolization and recanalization producing a pair of lateral recesses which are the **laryngeal ventricles** (and saccule at the superior aspect of each ventricle), the folds of tissue around the upper side of the recesses will differentiate into the **false vocal cords** and the ones around the lower side of the recesses will differentiate into **true vocal cords.**

Since musculature of the larynx is derived from mesenchyme of the fourth and sixth pharyngeal arches, all laryngeal muscles are innervated by branches of the tenth cranial nerve, **the vagus nerve**.

The **superior laryngeal** nerve innervates derivatives of the fourth pharyngeal arch (cricothyroid muscle through externa laryngeal branch), and the **recurrent laryngeal** nerve innervates derivatives of the sixth pharyngeal arch (the rest of the muscles of the larynx).

Note: superior laryngeal gives raise to internal and external branches, the internal laryngeal is sensory while the external is motor (to cricothyroid muscle)

Laryngeal anomalies are very rare, one of them is **laryngeal atresia**, also known as congenital high airway obstruction syndrome (**chaos**), it rare as well and it causes obstruction of the upper fetal airways.

Distal to the atresia or stenosis, the lung are enlarged and capable of producing echoes (echogenic). Also the **diaphragm is flattened or inverted** and fetal **ascites** (fluid in the abdominal cavity) and hydrops (accumulation of serous fluid) is present

Prenatal ultra-sonography permits diagnosis of this condition, and it is treated **surgically** by making an opening in the trachea (below the larynx).