Lecture #2

Respiratory system. Development
Respiratory system - is a biological system consisting of specific organs and structures used for the process of respiration in an organism.
Breathing and Respiration

**Breathing** is the mechanical action of getting air in and out of the lungs.

**Respiration** is the chemical reaction that provides the energy that makes the organism function. It occurs in the cells, more precisely in the mitochondria (the powerplant of the cell).
Systema respiratoria

The Respiratory System

- Nasal Cavity
- Oral Cavity
- Tongue
- Larynx
- Trachea
- Bronchus
- Left Lung
- Diaphragm
- Right Lung
- Pleura
- Epiglottis
- Pharynx
Gastrulation – formation of germ layers (4th week)

- Ectoderm
- Mesoderm
- Endoderm
Intraembryonic mesoderm plates:

- **Paraxial (dorsal) mesoderm** – axial skeleton (somites)
- **Intermediate mesoderm** – urogenital apparatus
- **Lateral mesoderm (somatic and splanchnic)** – appendicular skeleton and internal organs
With lateral folding, mesoderm is recruited to gut wall.

- Lateral folding of the embryo completes the gut tube.
- Mesodermal layer of the gut tube is called splanchnic (visceral) mesoderm - derived from lateral plate mesoderm.
- Somatic mesoderm lines body cavity.
Primary gut (foregut) → Hollow organs (trachea, bronchi)
Intraembryonic cavity → Pleural cavity
Diagram showing the segmentation of the gut into foregut, midgut, and hindgut. The foregut includes the stomach and liver bud, the midgut includes the vitelline duct and allantois, and the hindgut includes the cloacal membrane.
From foregut develop:
- Esophagus
- Stomach
- Duodenum (proximal part)
- Liver, pancreas, gall bladder
- **Respiratory tube**

Blood supply – *truncus coeliacus*
Sympathetic innervation – *n. splanchnicus major*
Parasympathetic innervation – *n.vagus*
**Tubular organ layers development**

- **Mucosa**
  - Epithelial lining and glands
  - Lamina propria
  - Muscularis mucosae
  - Derived from **endoderm**

- **Submucosa**

- **Muscularis externa/cartilages**

- **Adventitia/Serosa**

  Derived from **visceral mesoderm**
Development of the upper respiratory system:
- nose, nasopharynx, oropharynx
Development of the face
(from 4\textsuperscript{th} to 8\textsuperscript{th} weeks)

1. Development of the primitive mouth – \textit{stomodeum} (beginning of the 4\textsuperscript{th} week)
2. Rupture of oropharyngeal membrane (the 24\textsuperscript{th} day)
3. Development of the nasal cavity (from the end of the 4\textsuperscript{th} week)
4. Rupture of oronasal membrane (the 6\textsuperscript{th} week)
5. Development of \textit{paranasal air sinuses} from diverticuli of nasal walls during late fetal life & after birth
Cranial end of the foregut

Ratke's pouch

Buccopharyngeal membrane ruptures at 24 to 26 days

Sagittal section through a 25-day embryo

Figure from Ten Cate’s Oral Histology, Ed., Antonio Nanci, 6th edition
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Rupture of buccopharyngeal membrane

- Stomodeum
- Buccopharyngeal/oropharyngeal membrane
- Ectoderm
- Epithelial lining of oral cavity, teeth
- Parotid and submandibular salivary glands
- Endoderm (foregut)
- Epithelial lining of pharynx
- Endoderm (foregut)
- Sublingual salivary gland
- Ratke`s pouch
- Adenohypophysis

Fauces

Oral cavity

Epithelial lining of oral cavity, teeth

Parotid and submandibular salivary glands

Epithelial lining of pharynx

Sublingual salivary gland

Adenohypophysis
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Development of the primitive mouth 
(Stomodeum)

It develops from five facial primordia:

– Frontonasal prominence
– Paired maxillary prominences
– Paired mandibular prominences

Medial and Lateral Nasal Prominences form a boundary of Naris
Stomodeum and nasal placodes

- Bilateral right and left oval thickenings of surface ectoderm, the end of the 4th week.

Stomodeum

Nasal placodes

Nasal pits

Nasal sacs
- Rupture of oronasal membrane (6th week)
- Development of choana
- Development of primary and secondary palate
Development of nasal cavity and palate

Nasal septum, incisive bone & central part of upper lip develop from merged medial nasal prominences
Development of the palate and palate cleft

- Normal
- Anterior cleft only
- Posterior cleft only
- Compound cleft
Congenital anomalies of middle face

1. **Oblique cleft of the face** (persistent nasolacrimal groove)
   - It connects mouth to medial palpebral angle of the orbit
   - Nasolacrimal duct is present as an open groove
   It results from failure of fusion of lateral nasal and maxillary prominences

2. **Cleft of upper lip, superior alveolar arch and palate**
   - It results from failure of fusion of medial nasal and maxillary prominences
   They could be unilateral or bilateral
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Paranasal air sinuses

- Facial skull bones which contain air spaces lined with mucous membrane
- Make the skull light
- Impart resonance to voice
- Act as conditioning chambers for inspired air
- Sinuses appear on 12th week of gestation
- Rapid growth till 12-years after birth
- Growth together with facial skull bones
- Growth of maxillary sinus stops with eruption of last molars
The 4th week - neural crest cells migrate through the mesenchyme to the future head and neck region, forming elevations of mesoderm on each side of the primitive pharynx.
- a series of mesodermal outpouchings on both sides of the developing pharynx
- covered with:
  - Ectoderm outside – formation of pharyngeal clefts
  - Endoderm inside – formation of pharyngeal pouches
The 1\textsuperscript{st} Pharyngeal arch (mandibular)

Develop:
- masticatory muscles
- m. mylohyoideus, m. digastricus (venter anterior)
- m. tensor veli palatini, m. tensor tympani
- Lips
- Jaws
- Palate
- Anterior 2/3 of the tongue
- Porus accusticus externus
- Membrana tympanica
- Malleus and incus
- External ear (anterior part)

- Innervated by trigeminal nerve (V)
Meckel's cartilage – mandible

NB! Mandible buds are paired!
The 2nd Pharyngeal arch (hyoid)

- Innervated by facial nerve (VII)
- mimic muscles
- m. digastricus (venter posterior)
- m. stylohyoideus
- Stapes and m.stapedius
- Processus styloideus
- Hyoid bone
- Tonsilla palatina
- External ear (posterior part)
The 3rd Pharyngeal arch

- Innervated by glossopharyngeal (IX) nerve
- muscles of the palate
- m. stylopharyngeus
- Hyoid bone
- Thymus
The 4th and the 5th Pharyngeal arches

- Innervated by vagal (X) nerve
- muscles of the palate and pharynx
- Cartilages and muscles of the larynx
- Thymus
## Development of the tongue

### Tongue parts

- **Anterior 2/3 of the tongue**
  - **Tongue buds**
    - Median bud
    - 2 distal buds
  - **Origin of the bud**
    - Pharyngeal arch 1
  - **Fusion**
    - Median sulcus

- **Posterior 1/3 of the tongue**
  - **Tongue buds**
    - Copula
    - Hypobranchial prominence
  - **Origin of the bud**
    - Pharyngeal arches 2,3,4
  - **Fusion**
    - Sulcus terminalis
    - Foramen cecum
Pathology of the tongue development
Development of the lower airway, lungs and pleura
Figure 11-1. Early development of respiratory system. (A) Lateral view of an embryo at day 25, showing the entire primitive gut tube. The area in the rectangle indicates the portion of foregut involved in respiratory development. This area is enlarged in B. (B) Relationship of the laryngotracheal diverticulum and foregut. Curved arrows indicate the movement of the tracheoesophageal folds.

Endoderm ➞ Epithelium and glands of the lower airway
Mesoderm ➞ Connective tissue, cartilage, muscle, vessels and pleurae
Development of the larynx

- the 4th and the 5th Pharyngeal arches
  - Innervated by vagal (X) nerve
  - muscles of the palate and pharynx
  - Cartilages and muscles of the larynx
  - Thymus
Figure 11-3. Drawings illustrating successive stages in the development of the larynx. A, 4 weeks. B, 5 weeks. C, 6 weeks. D, 10 weeks. The epithelium lining the larynx is of endodermal origin. The cartilages and muscles of the larynx arise from mesenchyme in the fourth and sixth pairs of pharyngeal arches. Note that the laryngeal inlet or aditus changes in shape from a slitlike opening to a T-shaped inlet as the mesenchyme surrounding the developing larynx proliferates.
Development of the trachea

Endoderm ➞ Epithelium and glands of the lower airway
Mesoderm ➞ Connective tissue, cartilage, muscle, vessels and adventitia
Congenital anomalies of trachea

1. Tracheoesophageal fistula – communication between trachea and esophagus
Congenital anomalies of trachea

2. Tracheal Stenosis (narrowing) and Atresia (closure)
Congenital anomalies of trachea

3. Tracheal diverticulum
Development of the bronchi

- Lung buds divide into two bronchial buds
- The 5th week bronchial buds enlarge to form primary bronchi
- Primary bronchi further subdivide into secondary bronchi
- Secondary bronchi further subdivide into tertiary (=segmental) bronchi
Development of the bronchi
Bronchopulmonary segments

- is a segment of lung tissue supplied by a tertiary (segmental) bronchus
Periods of Lung Development:
1. Pseudoglandular period (5 – 17 weeks)
2. Canalicular period (16 – 25 weeks)
3. Terminal sac period (24 weeks to birth)
4. Alveolar period (late fetal period to 8 years after birth)
Development of the human lung

Day 41-44

7 trachea; 1 Left main bronchus; 6 right main bronchus; others lobes

Week 9

Week 10
Type I pneumocytes – thin, flat cells that make up part of the blood-air barrier
Type II pneumocytes – cells, that produce surfactant
Pulmonary surfactant

- a surface-active lipoprotein complex (phospholipoprotein) formed by type II alveolar cells. By adsorbing to the air-water interface of alveoli it reduces surface tension and prevents collapse of the lung (atelectasis) at the end of expiration.
Premature fetuses born between week 25 and 28 can survive with intensive care!

This is the earliest point at which fetus can survive.

Adequate vascularization and surfactant levels are the most important factors for the survival of premature infants!
Development of the pleura and pleural cavities

**Pleura** – serose membrane lining lungs and walls of the thoracic cavity - is derived from *intraembryonic mesoderm*
Lateral mesoderm forms two plates: somatic and splanchnic.

Intraembryonic body cavity (coelom) → Pleural cavity
Somatic mesoderm → Parietal pleura
Splanchnic mesoderm → Visceral pleura

EEM, extraembryonic mesoderm; YS, Yolk sac; NP, neural plate.
Expansion of the lung buds into the pericadioperitoneal canals. At this stage, the canals are in communication with the peritoneal and pericardial cavities.
Development of pleura
Development of the pleura and pleural cavities
Congenital abnormalities (Infant respiratory distress Syndrome (IRDS))

- Also called Hyaline Membrane Disease:
  - Congenital Lung Cysts
  - Agenesis of Lungs or one Lung
  - Lung Hypoplasia
  - Accessory Lung
  - Lobe of Azygos Vein

Lung hypoplasia

Accessory lobe

Agenesis of the right lung
Diaphragm develops from 4 sources:
– 1) Septum Transversum
– 2) Pleuroperitoneal Membranes (folds)
– 3) Dorsal Mesentery of Esophagus
– 4) Body Wall
The trachea is lined with pseudostratified ciliated columnar epithelium with goblet cells. This epithelium is derived from

1) Neuroectoderm
2) Endoderm
3) Ectoderm
4) Visceral mesoderm
5) Mesoderm of 4th and 6th pharyngeal arches
Smooth muscle, connective tissue, and cartilage of primary bronchi are derived from which of the following sources?

1) Neuroectoderm
2) Endoderm
3) Ectoderm
4) Visceral mesoderm
5) Mesoderm of 4th and 6th pharyngeal arches
Components of blood-air barrier in the lungs are derived from which of the following sources?

1) Ectoderm only
2) Visceral mesoderm only
3) Visceral mesoderm and ectoderm
4) Endoderm and ectoderm
5) Visceral mesoderm and endoderm
The laryngotracheal tube initially is an open communication with the primitive foregut. Which of the following embryonic structures is responsible for separating these two structures?

1) Laryngotracheal tube
2) Posterior esophageal folds
3) Laryngoesophageal diverticulum
4) Tracheoesophageal septum
5) Bronchopulmonary segment
After birth, the circulation of fetal blood through the placenta ceases:
- Delivery of oxygenated blood to fetus via umbilical vein ceases—
  **Hypoxia** of all tissues is increasing
- Respiratory centers of the brain stem are stimulated by carbon dioxide
- Inspiratory muscles contract, thoracic cage is expanded
- Expansion of the lungs and **First Breath** takes place
- Inspired air enters respiratory passageways, pushes the contained fluids out of the way and inflates the bronchial and respiratory trees
- Infant’s lungs begin to function and newborn infant utters a **loud cry**
Absence of nasal breathing

Consequences:
- Retarded development of the nose
- Inflammation of the nasal cavity
- Small chin
- Wrong position of the tongue
- Problems with speech and phonation
- Increased salivation
- Anterior position of the head – problems with cervical part of the vertebral column
- Retarded physical development, passive – hypoxia
- Retarded mental development – hypoxia of the brain
- Weak muscles of the lips – changes in teeth position and malocclusion
- Temporomandibular joint disorders, etc.
Thank you for your attention!