Development of the Pharyngeal Arches
Part II
Competencies: Upon completion of this section of the course, the student must be able to:

1. Recall the embryonic precursors that give rise to the adult structures of the head and neck.
2. Describe how these precursors, especially the pharyngeal arches, form the different structures in the head and neck.
3. Determine how the congenital abnormalities thyroglossal duct cysts, and cervical fistulas would occur.
4. Compare and contrast the development of the different pharyngeal pouches, clefts, arches, mesoderm, nerves, and connective tissues.
5. Use this information to figure out the cause of other congenital defects that you might see clinically.
• The stomadeum ends at the pharynx.
• The pharynx is the first part of the foregut.
• The pharynx is surrounded by the pharyngeal arches.
Pharyngeal Arches

As you look at the stomadeum from the front at an inferior angle you can see the opening surrounded by the first arch and the frontal prominence.
Pharyngeal Arches

- At 5 weeks:
  - Stomadeum (S) is present
  - Surrounded by the 1st arch.
  - Ectoderm surrounds the stomodeum.
  - Ectoderm is found anterior to the tonsillar fossa
27 days
Neural crest cells

• migrate into:
  • Pharyngeal arches - from midbrain and hindbrain
  • Form pharyngeal arch skeletal structures
• form bones of the face and the skull
• form hyoid cartilage (from 2nd and 3rd arches)
• plus cartilage, bone, dentin, tendon, dermis, meninges, sensory neurons and glandular stroma
Development of the Face
End of week 4

Frontonasal Prominence

Maxillary Prominence

Mandibular Prominence

Stomodeum

Cardiac Region
Development of the Face

- By week 5 the face has:
  - 5 facial prominences plus
  - 2 nasal placodes
- Nasal placodes are ectoderm induced by ventral forebrain.
Development of the Face

• During week 5:
  • Nasal placodes invaginate and form nasal pits.
  • Two new prominences appear:
    • lateral nasal prominence
    • medial nasal prominence
• By 34 days the nasal placodes have become nasal pits surrounded by:
  • Medial nasal process.
  • Lateral nasal process.
Development of the Face

• Over the next 2 weeks
  • maxillary processes increase in size
  • maxillary processes grow to midline
  • medial nasal prominences grow to midline
As the maxillary and nasal processes grow, they become separated by grooves:
- Bucconasal groove
- Naso-optic groove.
Development of the Face

- Medial nasal processes fuse in the midline.
Development of the Face

- Maxillary processes fuse with medial nasal processes.
Development of the Upper lip

- Two medial nasal prominences
- Two maxillary prominences
Development of the Face

- Maxillary and lateral nasal prominences separated by
  - Nasolacrimal groove
Development of the Face

- Nasolacrimal groove.
  - invaginates to form the nasolacrimal duct
  - upper end becomes lacrimal sac
**Development of the Lower Lip**

- Mandibular prominences merge in the midline.
Development of the Lower Lip

• Mandibular prominences merge in the midline.
Development of the Cheeks

• Cheeks develop from the maxillary prominences.

Maxillary prominences
Development of the Maxillae

- Develop from maxillary prominences.
Development of the Nose

- The nose is formed from:
  - frontal prominence: bridge
  - medial nasal prominences: crest and tip
  - lateral nasal prominences: alae
Development of the Palate

• By taking a section in the plane of the red line and then looking down on it you would see the following.
Intermaxillary Segment

Primary palate

Maxillary process

Nasomedial process

Palatine shelf
Intermaxillary Segment

- 2 medial nasal prominences
- labial component - philtrum of upper lip
- upper jaw component - 4 incisor teeth
- palatal component - primary palate
- fuses with nasal septum from frontal prominence
The medial nasal processes have formed the primary palate as they fuse. The maxillary processes migrate toward the medial nasal processes to fuse. In the midline posteriorly the maxillary processes develop palatine shelves which fuse.
Secondary Palate

- forms from two outgrowths of the maxillary processes
- palatine shelves

Diagram:
- Primary palate
- Maxillary process
- Nasomedial process
- Palatine shelf
Initially the palatine shelves grow downward on either side of the tongue.
Secondary Palate

- forms from two outgrowths of the maxillary processes
- palatine shelves
**Secondary Palate**

- forms from two outgrowths of the maxillary processes
- palatine shelves

Diagram:
- Primary palate
- Maxillary process
- Nasomedial process
- Palatine shelf
Secondary Palate

- A sagittal view

- Frontonasal prominence
- Olfactory epithelium
- Nasal septum
- Medial nasal prominence
- Tongue
- Mandibular prominence
Secondary Palate

- A sagittal view

- Frontonasal prominence
- Olfactory epithelium
- Nasal septum
- Medial nasal prominence
- Tongue
- Mandibular prominence
Secondary Palate

- A sagittal view

- Frontonasal prominence
- Olfactory epithelium
- Nasal septum
- Medial nasal prominence
- Tongue
- Mandibular prominence
Development of the Palate

- A coronal view

- Developing brain
- Nasal septum
- Palatine shelves
- Tongue
As the tongue develops it moves downward and the palatine shelves move toward each other toward the midline.
Development of the Palate

- Palatine shelves
- Intermaxillary segment
- Junction between two is incisive foramen
Development of the Palate

• As the palatine shelves fuse . . .
• Nasal septum fuses with primary and secondary palate.

Nasal septum
Palatine shelves
• The palatine shelves fuse in the midline and also fuse with the nasal septum
• Note the developing teeth, maxillary bone, and the palatine shelves.

• At the arrows the rests of epithelial tissues can be seen along the fusion line.
• Histological sections showing the development of the palate and its fusion with the nasal septum.
Development of the Tongue

- Tongue develops where the stomodeum and pharynx meet.
Development of the Tongue

- Lingual swellings and tuberculum impar develop from the first arch.
Development of the Tongue

• The hypobranchial eminence or copula develops at the level of the 2, 3, and 4 arches.
Development of the Tongue

- Epiglottic swellings develop at the level of the 4th arch.
Lateral lingual swellings from first arch give rise to mucosa of anterior 2/3 of the tongue.
Development of the Tongue

- Hypobranchial eminence mostly from 3rd arch gives rise to the posterior 1/3 of the tongue.
Development of the Tongue

- The epiglottis and the most posterior part of the tongue are derived from the 4th arch.
Development of the Tongue

• Note that there is little if any contribution from the 2nd arch.
Tongue Musculature

- Myoblasts from occipital somites give rise to most of the tongue muscles and are innervated by the hypoglossal nerve.
# Development of Tongue Summary

<table>
<thead>
<tr>
<th>Embryonic Tissue</th>
<th>Developmental Intermediate</th>
<th>Adult Organ</th>
<th>Nerve</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Arch</td>
<td>Lingual swellings</td>
<td>Mucosa of Anterior 2/3 of Tongue</td>
<td>CN V</td>
</tr>
<tr>
<td>Second Arch</td>
<td>Hypobranchial Eminence</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Third Arch</td>
<td>Hypobranchial Eminence</td>
<td>Mucosa of Posterior 1/3 of Tongue</td>
<td>CN IX</td>
</tr>
<tr>
<td>Fourth Arch</td>
<td>Hypobranchial Eminence</td>
<td>Mucosa of the most posterior tongue and epiglottis</td>
<td>CN X</td>
</tr>
<tr>
<td>Occipital Somites</td>
<td></td>
<td>Tongue Muscles</td>
<td>CN XII</td>
</tr>
</tbody>
</table>
Development of the Nasal Cavities

• As nasal pits invaginate . . .
• Nasal cavity is separated from oral cavity by oronasal membrane.

Oronasal membrane
Development of the Nasal Cavities

- with breakdown of oronasal membrane:
  - primitive choanae
Development of the Nasal Cavities

- with formation of secondary palate
  - definitive choanae
Development of the Pituitary

- Rathke’s Pouch - invagination of ectoderm
- Infundibulum - diverticulum from forebrain
Development of the Pituitary

- Infundibulum - infundibular stalk and the pars nervosa
- Rathke’s Pouch - pars intermedia, pars distalis and pars tuberalis
Primordial Stem cell

Committed pituitary cell

Lineage precursors

GATA-2

Prop-1

Pit-1

Gonadotropes
FSH & LH

Thryotropes
TSH

Lactotropes
Prolactin

Somatomammotropes

Somatotrops
GH

Corticotrops
ACTH
Pituitary

From: Rathke’s Pouch
Basophils: TSH, LH, FSH and ACTH
Acidophils: Prolactin and GH

From: infundibulum of diencephalon
Oxytocin & ADH neurons
Development of the Adrenal Glands

- Coelomic epithelial cells migrate into the intermediate mesoderm.
- Neural crest cells migrate from the sympathetic chain.
- 6 weeks of development.
Development of the Adrenal Glands

• Coelomic epithelial cells become adrenal cortex
• Neural crest cells become adrenal medulla.
• 8 weeks of development
Pathway for the formation of adrenal medulla chromaffin cells

Neural Crest cell

- Leukocyte Inducing Factor
- FGF2
- Stem Cell Factor

Sensory Neuron

Sympathetic neuron

Melanocyte

Chromaffin Cell Progenitor

Glucocorticoids

- NGF
- Ciliary Neurotrophic Factor

Adrenergic Neuron

Cholinergic Neuron

Chromaffin Cell

Glucocorticoids
Adrenal Gland

• Fetal Adrenal
  • Capsule
  • Definitive zone
  • Transition zone
  • Fetal zone.
  • Medulla.

• Functions
  • Maturation of:
    • Lungs
    • Liver
    • GI epithelium
Fetal adrenal blastema

Expresses SF1 and DAX (both transcription factors)

Organized into a Inner Fetal Zone (large eosinophilic cells)
Involutes at birth.

Outer Definitive zone (small densely packed basophilic cells)
Outer definitive zone gives rise to the postnatal adrenal cortex

Mutations
X-linked adrenal hypoplasia congenita
Leads to adrenal insufficiency
• Cortisol secretion is thought to begin during early pregnancy.

• At seven weeks of gestation the following are present in the fetal zone:
  • steroid acute regulatory protein (StAR),
  • cytochrome P450 cholesterol side-chain cleavage (CYP11A),
  • 17α-hydroxylase/17,20-lyase (CYP17),
  • CYP21,
  • 11β-hydroxylase (CYP11B1)/aldosterone synthase (CYP11B2)

• Early cortisol secretion inhibits excess ACTH secretion

• This minimizes androgen secretion during development of the fetus especially the female.
Schematic representation of hypothetical model describing endocrine cascades in human feto-placental unit. Near term, placenta-derived CRH increases and directly stimulates HFA production of DHEA/DHEAS and cortisol. Increased cortisol, in turn, stimulates production of placental CRH. CRH also up-regulates expression of the ACTHR, thereby increasing HFA responsiveness to ACTH, the level in fetal circulation of which may be constant or decrease near term. HFA and placental CRH constitute positive feedback cascade. DHEA/DHEAS is converted by placenta to estrogen, promoting initiation of parturition partly through up-regulation of contraction-associated proteins. Cortisol also promotes maturation of fetal organs (e.g., the lung) and stimulates production of prostaglandins, uterotonins necessary for parturitional processes. CRH also directly promotes initiation of parturition in part by increasing prostaglandins. When “functional withdrawal” of progesterone occurs, coupled with these changes, parturition is initiated.