Development of the Pharyngeal Arches
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.
Introduction

- The origin of tissues that will give rise to head structures.
- Introduce pharyngeal or branchial arches.
Pharyngeal Arches

- Appear at 4 - 5 weeks.
- Play important role in the formation of the face and neck structures.
Pharyngeal Arches

27 days, 29 days, 35 days
1st arch
2nd arch
3rd arch
4th arch

1st pouch

artery

nerve

cartilage

1st cleft
• Arches have:
  • Ectoderm externally
  • Mesenchymal core
  • Endoderm internally
**Primitive Pharynx**

- Each arch consists of:
  - cartilage
  - aortic arch
  - cranial nerve
  - mesenchyme

- Each arch separated by:
  - a Pharyngeal Cleft (Groove) on the outside
  - a Pharyngeal Pouch on the inside
  - together they can make up a Pharyngeal Membrane
Pharyngeal Arches

- Each arch has its own blood supply.
- These are the aortic arches.
<table>
<thead>
<tr>
<th>ARCH</th>
<th>BLOOD VESSEL</th>
<th>NERVE</th>
</tr>
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<tbody>
<tr>
<td>First</td>
<td>First aortic arch</td>
<td>Mandibular (and maxillary) division of the trigeminal nerve (cranial nerve V)</td>
</tr>
<tr>
<td>Second</td>
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Neural crest cells

- migrate into:
  - pharyngeal arches - from midbrain, hindbrain
  - Form pharyngeal arch skeletal structures
- form bones of the face and the skull
- form hyoid cartilage (from 2nd arch)
- plus cartilage, bone, dentin, tendon, dermis, meninges, sensory neurons and glandular stroma
• The early brain has three segments
  • Forebrain
  • Midbrain
  • Hindbrain
• On either side are somatomeres rather than somites.
Rhombomeres

- The hindbrain can be further subdivided into rhombomeres
1. Neural crest cells from different regions of the brain stem migrate into the different pharyngeal arches.

(1) rhombomeres.
   (1) R1 and R2 to Arch 1
   (2) R4 to Arch 2
   (3) R6 and R7 to Arch 3
   (4) R8 to Arch 4

(2) Midbrain
   (1) Face
• Neural crest cells migrate into the head region and the pharyngeal arches.
• Hox genes are not expressed anterior to rhombomere 3.
• Otx2, Msx, Dlx, Barx are expressed during development of cephalic structures
Neural crest cells and head development

- Epithelial mesenchymal interactions important.
  - Sonic Hedgehog
  - Fibroblast growth factor
  - Bone morphogenetic proteins

- Chemoattraction factors
  - TBX1
  - Twist
  - Vegf
  - FGF receptor 1

- Inhibitory factors

- Cilia and ciliary proteins are important
  - Ciliary dysfunction is present in some syndromes
  - Kinesin–like protein implicated in the dysfunction of cilia
  - This affects polarized growth and cell shape
  - Shortened mandibles end up being present
Ectodermal Placodes & Neural Crest

- Ectodermal Placodes & Neural Crest form neurons of:
  - 5th, 7th, 9th and 10th sensory ganglia
  - Neurons migrate into each arch.
  - Each arch has its own nerve supply.
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• Stomadeum is the future oral cavity.
• Bounded posteriorly by the buccopharyngeal membrane (oral plate).
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
Fate of Pharyngeal Clefts

1st pouch

1st arch
2nd arch
3rd arch
4th arch

artery
nerve
cartilage
1st cleft
First Pharyngeal Arch

- First arch develops into 4 prominences:
  - Two maxillary prominences
  - Two mandibular prominences
- First Cleft
Development of the External Auditory Meatus

- First Pharyngeal Cleft gives rise to the external auditory meatus.
- 1st and 2nd arches give rise to external ear
• The region between the 2nd arch and the 3rd, 4th and 6th arches is called the cervical sinus.
Fate of the Ectoderm

• 1st Arch
  • skin over maxilla, mandible, some around the ear and external auditory meatus
  • salivary glands
  • enamel of teeth
  • epithelium of buccal cavity
  • epithelium over anterior body of the tongue
Ectoderm

• Second Arch
  • epithelium over part of external auditory meatus
  • some epithelium behind the ear
Ectoderm

• Third Arch
  • epithelium around the ear
• Fourth Arch
  • epithelium around the ear
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<tr>
<th>ARCH</th>
<th>GROOVE</th>
<th>POUCH</th>
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<tbody>
<tr>
<td>First</td>
<td>1. Mandible and maxilla</td>
<td>2. Tympanic membrane</td>
</tr>
<tr>
<td></td>
<td>2. Meckel's cartilage:</td>
<td>3. Tympanic cavity</td>
</tr>
<tr>
<td></td>
<td>a. Incus and malleus of inner ear</td>
<td>4. Mastoid antrum</td>
</tr>
<tr>
<td></td>
<td>b. Sphenomalleolar ligament</td>
<td>5. Eustachian tube</td>
</tr>
<tr>
<td></td>
<td>c. Sphenomandibular ligament</td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>1. Reichert's cartilage:</td>
<td>Obliterated by the down-growth of the second arch</td>
</tr>
<tr>
<td></td>
<td>a. Styloid process of temporal bone</td>
<td>1. Largely obliterated</td>
</tr>
<tr>
<td></td>
<td>b. Stylohyoid ligament</td>
<td>2. Contributes to tonsil</td>
</tr>
<tr>
<td></td>
<td>c. Lesser horns of the hyoid bone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d. Upper part of the body of the hyoid bone</td>
<td></td>
</tr>
<tr>
<td>Third</td>
<td>1. Lower part of the body of the hyoid bone</td>
<td>Inferior parathyroid gland</td>
</tr>
<tr>
<td></td>
<td>2. Greater horns of the hyoid bone</td>
<td>Thymus</td>
</tr>
<tr>
<td>Fourth</td>
<td>1. Cartilages of the larynx</td>
<td>Superior parathyroid gland</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ultimobranchial body</td>
</tr>
<tr>
<td>Fifth</td>
<td>Transient</td>
<td>Transient</td>
</tr>
<tr>
<td>Sixth</td>
<td>Transient</td>
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Fate of Pharyngeal Pouches
Development of the Pharyngeal Pouches

• First pouch gives rise to:
  • middle ear cavity
  • auditory tube
Development of the Tonsils

- Second pouch endoderm and mesoderm gives rise to:
  - Palatine tonsillar fossa.
  - Secondarily lymphatic tissue is incorporated into the pouch.
Development of the Thymus

- Endoderm of the third pouch proliferates and gives rise to the thymus during week 4.
- First start as endodermal tubes.
- This tissue invades the mesoderm.
Development of the Thymus

- Thymic tissue then loses connection with the pharynx.
- Thymus descends during weeks 4 - 7.
The thymus migrates into the superior mediastinum.
**Development of the Thymus**

- Thymus cortical epithelium is derived from ectoderm.
- Thymus medullary epithelium is derived from endoderm.
- Lymphoid tissue infiltrates later.
Development of the Parathyroids

- Inferior parathyroids develop from the third pouch at week 5.
- Detach from pharynx and descend.
Development of the Parathyroids

- End up at the inferior pole of the dorsum of the thyroid by week 7.
Development of the Parathyroids

- Superior parathyroids develop from the fourth pouch at week 5.
- Detach from pharynx and descend.
Development of the Parathyroids

• End up at the superior pole of the dorsum of the thyroid by week 7.
- Chief cells
  - Parathyroid hormone:
    - Increase Calcium concentration in blood
    - Decrease Phosphate concentration in blood

- Oxyphil cells
  - ??
• The thyroid develops as a diverticulum from the foramen cecum.
• Foramen cecum is located between the tuberculum impar and the hypobranchial eminence.
Development of the Thyroid

- The thyroid develops as a diverticulum from the foramen cecum.
- Foramen cecum is located between the tuberculum impar and the hypobranchial eminence.
Development of the Thyroid

• The thyroid develops as a diverticulum from the foramen cecum.
• Foramen cecum is located between the tuberculum impar and the hypobranchial eminence.
Development of the Thyroid

- The thyroid descends in front of the pharynx.

Thyroglossal Duct
Development of the Thyroid

• The thyroid gland remains in contact with the pharynx for a period of time by a narrow duct called the thyroglossal duct.
Development of the Thyroid

- The thyroid gland descends to the region of the junction of the trachea and the larynx.

Tongue

Thryoglossal Duct
Development of the Thyroid

- Path of migration of the thyroid.
  - From base of tongue
  - In front of hyoid
  - In front of thyroid cartilage
Development of the parafollicular cells of the thyroid

- Parafollicular cells of the thyroid are the C cells that produce calcitonin.
- They develop from the 4\(^{th}\) (5\(^{th}\)) Pouch (Ultimobranchial body)
• Thyroid
  • Follicles filled with thyroglobulin
  • Follicle secretes:
    • Thyroxine (T4) and Triiodothyronine (T3)
  • Parafollicular cells of thyroid
    • Calcitonin – protection against excess bone resorption