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Embryology of congenital neck masses

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Knowledge of the embryogenesis of the head and neck is essential to the evaluation and management of congenital neck masses. In this article, we describe the embryology of the most common congenital neck masses: branchial apparatus and thyroglossal duct cysts. The anatomy of both branchial clefts and pouches is reviewed along with the histology and descent of the thyroid from its origin at the foramen cecum of the tongue. This article serves as the foundation for understanding the anatomy surrounding surgical resection of these lesions, which will be discussed in later articles.

Introduction

The branchial arches, also known as pharyngeal arches, consist of 5-6 pairs of fingerlike embryonic structures that develop into the face, neck, and pharynx (Figure 1).[1] They are composed of mesenchyme, which is derived from mesoderm, somites, and neural crest cells.[1] Branchial arches appear between the fourth and seventh week of gestation on each side of the pharyngeal foregut.[1] Between each arch is an indentation called a branchial cleft, which is composed of ectoderm. Lateral outpouchings of the foregut oppose the branchial clefts and are known as pharyngeal pouches. These are composed of endoderm. Each branchial derivative is numbered in cranio-caudal succession.

Aside from the fifth branchial arch, which undergoes resorption or never forms, the branchial arches give rise to the structures of the head and neck.[2,3] Each branchial arch receives cranial nerve innervation because of its proximity to the brainstem (Figure 2). The branchial arch couples with the adjacent cranial nerve and retains this innervation regardless of later migration in the developing head and neck. The specific bony, cartilaginous, vascular, and muscular derivatives of each branchial arch are outlined in Table 1. These are different from those of the endodermal pharyngeal pouches, which form glandular tissue and contribute to the upper aerodigestive tract. The derivatives of pharyngeal pouches are listed in Table 2.

Branchial cleft anomalies

Branchial cleft anomalies are the second most common congenital lesions of the head and neck and accounted for one-third of all congenital neck masses in one series.[1,4] They may present as cysts, sinus tracts, fistulae, or cartilaginous remnants.[1] They are bilateral in 2%-3% of cases with a familial component.[5] Although the cause of formation remains unclear, most believe that these anomalies result from remnants of the branchial apparatus, particularly the cleft.[6]

Because of the complex growth and migration pattern of the branchial arches, anomalies can present anywhere from the upper periauricular area to the clavicles (Figure 3).

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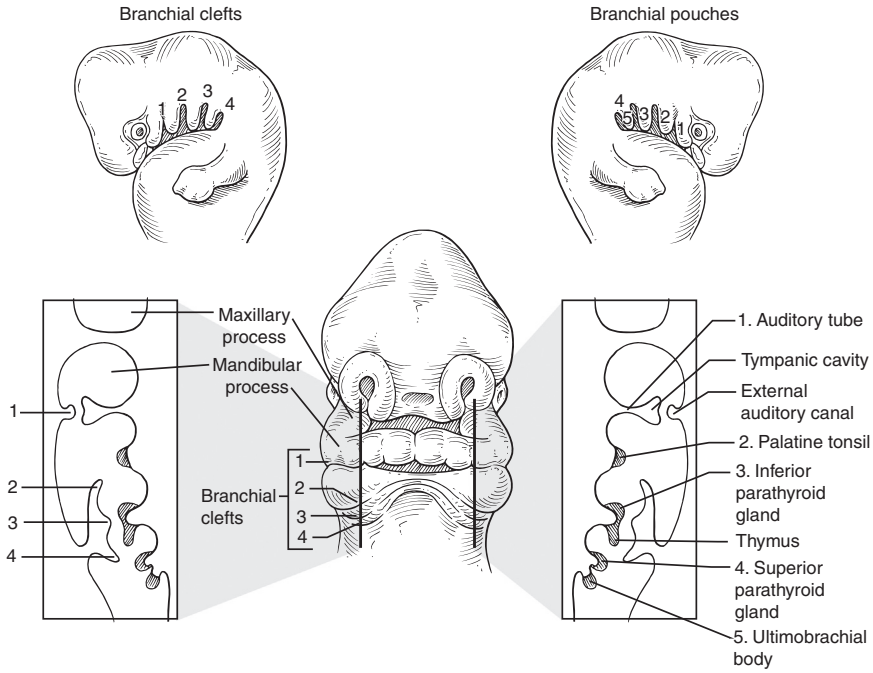

Figure 1 Diagram depicting branchial cleft and pouch derivatives.

Sinuses and fistualae often present as chronic draining lesions whereas cysts present as soft, compressible masses that may become inflamed or form an abscess during an upper respiratory tract infection.[7] In addition, many craniofacial syndromes can result from abnormalities in the branchial arches and pharyngeal pouches during embryonic development, including Treacher Collins syndrome, Goldenhar syndrome, branchio-oto-renal syndrome, Pierre Robin sequence, and DiGeorge sequence.

First branchial cleft anomalies

Anomalies of the first branchial cleft are rare, accounting for only 1%-4% of all branchial cleft anomalies.[8] They often include cysts or sinuses around the ear or near the angle of the mandible. However, they may be located anywhere along the tract, which begins in the submandibular triangle, rises to the parotid salivary gland, and ends in the external auditory canal.[7,9]

Because the first branchial cleft forms the external auditory canal, stenosis, atresia, and duplication of the canal may result. There are two types of first branchial cleft anomalies based on pathogenesis.[10]

(1) Type I anomalies consist of only ectodermal tissue. They involve duplication of the membranous ectodermal external auditory canal, which results in cystic masses adjacent to the canal.
(2) Type II anomalies are comprised of ectodermal and mesodermal portions of the canal. They may present as cysts, sinuses, or fistulae near the angle of the mandible.

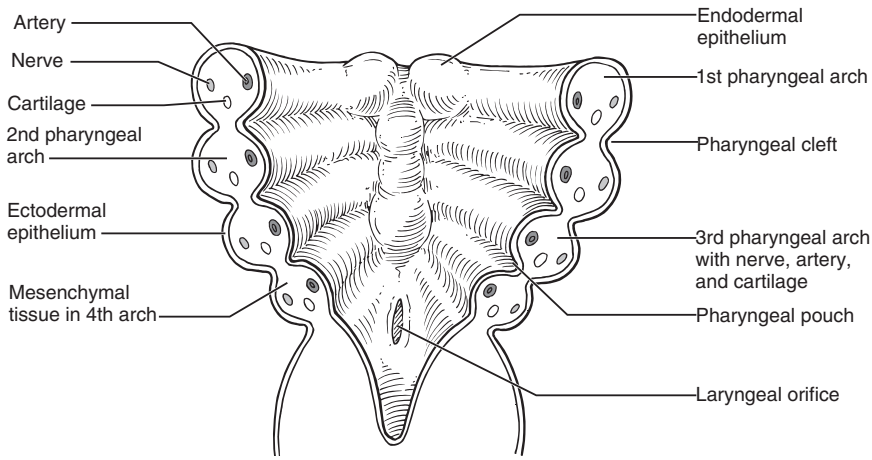

Figure 2 Branchial arches with their corresponding arteries, nerves, and cartilage embedded within mesenchyme. Note the location of ectoderm and endoderm germ layers and their relationships to branchial clefts and pouches, respectively.

Table 1 Derivatives of branchial arches

Branchial arch	Bony/cartilaginous derivatives	Vascular derivatives	Muscular derivatives	Associated cranial nerve
First	Meckel's cartilage forms mandibular ramus, body of mandible, sphenomandibular ligament, anterior malleolar ligament, malleus (except manubrium), incus (except long process) Maxillary process forms premaxilla, maxilla, zygoma, part of temporal bone	Internal maxillary artery	Muscles of mastication: temporalis, masseter, medial, and lateral pterygoid Tensor tympani, tensor veli palatini, anterior belly of the digastric, mylohyoid muscle	V (trigeminal nerve)
Second	Reichert's cartilage Proximal → styloid process, manubrium of malleus, long process of incus, and stapes suprastructure Central → stylohyoid ligament Distal → superior portion of body and lesser cornu of hyoid bone	Stapedial artery	All muscles of facial expression Posterior belly of digastric, stylohyoid, auricularis, and stapedius	VII (facial nerve)
Third	Inferior body and greater cornu of hyoid bone	Common carotid artery Proximal internal carotid artery	Stylopharyngeus	IX (glossopharyngeal)
Fourth	Thyroid and cuneiform laryngeal cartilages	Aortic arch between common carotid and subclavian arteries Right proximal subclavian artery	Pharyngeal muscles: leavator veli palatine, pharyngeal constrictor muscles	X (superior laryngeal branch of vagus nerve)
Sixth	Cricoid, arytenoid, and corniculate cartilages	Ductus arteriosus Proximal right pulmonary artery	Striated muscle in upper half of esophagus Laryngeal muscles: thyroepiglottic, aryepiglottic, cricothyroid, posterior cricoarytenoid, lateral cricoarytenoid, transverse arytenoid, and oblique arytenoid muscles	X (recurrent laryngeal branch of vagus nerve)

Type II anomalies are more likely to involve the parotid gland and facial nerve. They may present as cystic masses or sinus tracts inferior to the ear or in the superior neck, and also as inflammatory lesions in the external auditory canal or around the ear.

Second branchial cleft

Ninety-five percent of branchial cleft anomalies arise from the second branchial cleft, and most present as cysts.[1] This is because of ectoderm becoming trapped between the second branchial arch and the epicardial ridge as the cervical sinus closes. This may result in an inclusion cyst with or without a sinus tract. Most appear in the submandibular region but can occur anywhere along the branchial arch tract from the supraclavicular region to the palatine tonsil bed.[11] The complicated route of the tract—through the platysma muscle, in between the internal and external carotid arteries, and over cranial nerves IX and XII—can make surgical excision challenging.

Third and fourth branchial clefts

Cysts arising from the third branchial cleft present near the upper pole of the thyroid gland.[1] Sinus tracts or fistulae of the third branchial cleft generally begin medial to the sternocleidomastoid muscle and terminate in the piriform sinus below the hyoid bone. Anomalies of the fourth branchial cleft take a similar route, arising from the same location and ending in the apex of the piriform sinus. They are commonly left-sided and can cause recurrent suppurative thyroidits or a recurrent abscess in the low anterior neck.[1] From an anatomical perspective, third and fourth branchial cleft anomalies are distinguished by their position relative to

Table 2 Derivatives of pharyngeal pouches

Pharyngeal pouch	Derivative
First	Mastoid antrum Tubotympanic recess → middle ear and Eustachian tube Inner layer of tympanic membrane
Second	Epithelial lining of tonsillar fossa and palatine tonsil, lymphoid tissue of tonsil
Third—superior portion	Inferior parathyroid glands
Third—inferior portion	Thymic tissue (which eventually forms thymus gland)
Fourth through sixth	Superior parathyroid glands and ultimobranchial body (calcitonin-producing cells (parafollicular/C cells) of thyroid gland)

the superior laryngeal nerve. Third branchial cleft anomalies lie above this nerve, whereas fourth branchial cleft anomalies lie below.

Thyroglossal duct cysts

In the embryo, the thyroid gland is the first endocrine organ to develop.[12] At the fourth week of gestation, it begins as a small mass of endoderm between the first and second pharyngeal grooves. This area is called the foramen cecum and lies at the junction of the anterior two-thirds and posterior third of the tongue (Figure 4). As the lateral lingual swellings fuse to form the tongue, the primordial thyroid tissue mass invaginates to form the thyroglossal duct. This extends inferiorly from the foramen cecum toward the anterior neck.[2,12] Most commonly, the duct extends anterior to the laryngeal cartilages while adhering to the hyoid bone. However, the duct has been shown to develop posterior to the hyoid in 30% of cases.[13-16]

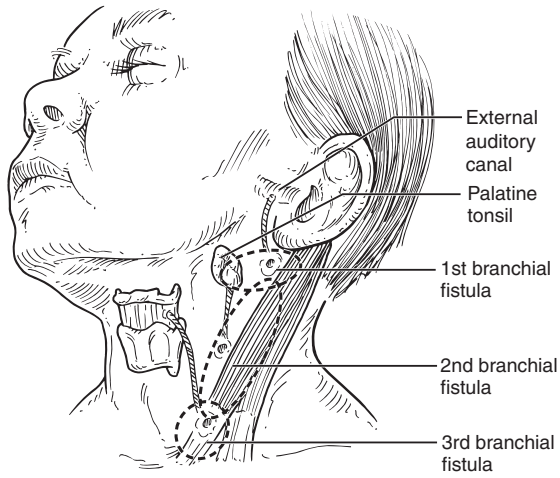

Figure 3 Illustration depicting the locations of cervical skin openings and their potential fistula tracts for first to third branchial anomalies.

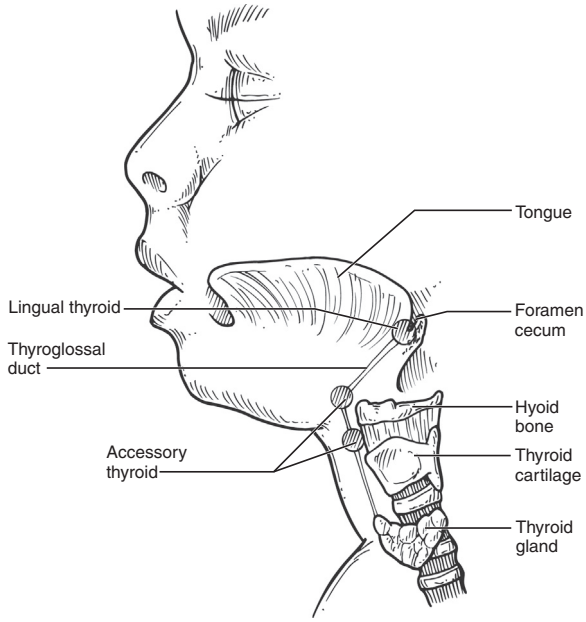

Figure 4 Diagram depicting the descent of the thyroid gland from the foramen cecum to the central neck during embryogenesis. Note that ectopic thyroid tissue can occur anywhere along this tract.

The distal end of the duct forms the developing thyroid. It divides at around the fifth week of development, forming 2 lateral lobes joined by an isthmus that differentiate into the thyroid gland.[2,12] By the end of the fifth week, the thyroglossal duct begins to atrophy. The thyroid reaches its final destination just inferior to the cricoid cartilage by the seventh week of gestation. Between weeks 7 and 10, the thyroglossal duct completely involutes.[2,12,17] However, parts of the duct may fail to degenerate. Remnants often present as a superiorly projecting pyramidal lobe of the thyroid gland, which occurs in 50% of individuals.[12] However, this lobe and the foramen cecum are considered normal vestigial remains of the duct. Any remaining patent portion of the duct between the foramen cecum and the thyroid gland may become a thyroglossal duct cyst (TGDC).[18-20]

The histology of TGDC is related to its location in the neck. The epithelial tissue encapsulating the cyst is likely to consist of stratified squamous epithelium when the cyst is located near the foramen cecum. Cysts that are more proximal to the thyroid gland are likely to be lined with thyroidal acinar epithelium.[21] Repeated infection or inflammation allows secretions from this epithelial tissue to accumulate, which contributes to cyst formation and growth.[22,23]

In children, TGDC comprises approximately 70% of all congenital neck lesions, making it the most common congenital abnormality of the neck.[24,25] The cyst presents as a midline neck mass; fewer than 1% of cases are not located on the midline.[18-20] The cyst commonly develops just below the hyoid, though there are four locations where

TGDC can be found: (1) intralingual, (2) suprahyoid or submental, (3) thyrohyoid, and (4) suprasternal. It may appear to elevate with swallowing or tongue protrusion.[26-28] Most cysts are asymptomatic, but may enlarge, become erythematous, or begin draining during an upper respiratory infection. Additionally, an intralingual TGDC may cause stridor, airway obstruction, and dysphagia.[28-30]

Evaluation of TGDC typically involves ultrasonography to confirm that the suspected lesion is cystic rather than solid and also to confirm that there is a normal thyroid gland. Surgical excision is the treatment of choice for both diagnostic and therapeutic purposes. Excision is most commonly performed via a Sistrunk procedure, involving excision of the duct, cyst, and midportion of the hyoid bone. The thick cyst fluid may contain cholesterol and often appears yellowish-white to dark brown in color.[23] In all, 45% of excised cysts have included thyroid tissue.[31] Thyroglossal duct carcinomas have rarely been reported.[23,32-34] Recurrence after uncomplicated Sistrunk procedures is reported to be 10% in children.[4] This is believed to be a result of the extensive branching of the suprahyoid duct, making complete duct excision a priority.[14]

Conclusion

Knowledge of the embryology of the head and neck is essential to understand the pathogenesis of congenital neck lesions. The branchial apparatus differentiates into all important head and neck structures between the fourth and tenth weeks of gestation. TGDC and branchial anomalies are the most common congenital neck lesions and result from errors during embryogenesis. Surgical excision is the treatment of choice for most congenital neck lesions and the specifics of resection will be discussed in greater detail in the ensuing articles.

Disclosure

The authors reported no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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