Vascular anatomy of the head and neck region, pictorial assay.

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Learning objectives

To review vascular anatomy (arterial and venous) of the head and neck (H&N) region. Learn and understand main divisions, landmarks, common variants and relevant nearby structures.

CT images (MPR, 3DVR) comparison with drawings and pictures of anatomical models will be used to describe vessels from the aortic arch to the cranial base.

Images for this section:

![MR-angiography of the aortic arch and head&neck arterial vessels overview.](image)

**Fig. 1:** MR-angiography of the aortic arch and head&neck arterial vessels overview.
Background

Normal vascular anatomy of the head and neck is rich and highly detailed, precise knowledge has use in reporting vascular pathology but also in defining conditions that secondarily affects or displace arteries and veins.

Imaging findings OR Procedure details

Aortic arch: begins at the level of the upper border of the second sternocostal articulation on the right, runs upward, backward and ends to the left from the trachea; then downward on the left side of T4 vertebral body (from here starts the descending aorta).

From the aortic arch originate:

• innominate artery: right subclavian artery, right carotid artery
• left carotid artery
• left subclavian artery

Superior vena cava, formed by the left and the right brachiocephalic veins, is located right from the ascending aorta.

Normal anatomy on axial CT scans shows the three arterial vessels (innominate, left carotid, left subclavian) in a row from right to left Fig.2. Rightmost is the superior vena cava, and anterior is the left innominate veins.

The configuration here described is the most common (~80%) but variants are frequent: common origin of innominate and left carotid artery <3% (so called "bovine arch"), variants of origin of the vertebral artery (most often left vertebral artery from the aortic arch)~4%, thyroid ima artery, aberrant right subclavian artery~1% (it is the last branch of the aortic arch and crosses behind the esophagus most often), so called "arteria lusoria". Many, less common, variants exist.

Clinical interest for aortic arch anatomy in H&N, beside being the origin of the main neck arterial vessels is related to the path of recurrent (inferior) laryngeal nerve, branch of the X c.n., vagus nerve. It is so called "recurren" because it descends into the thorax before rising up between trachea and esophagus. The right nerve loops around the right subclavian artery, while he left has a longer course as it hooks the aortic arch Fig.3. The recurrent (inferior) laryngeal nerve is responsible for supplying all laryngeal muscles (except the cricothyroid, which is innervated by the superior laryngeal nerve). Damage to recurrent laryngeal nerve results in ipsilateral vocal cord paralysis. Left recurrent laryngeal nerve damage can result from enlarged thoracic lymphnodes, direct tumoral
invasion, aortic aneurysm. Higher in the neck both recurrent laryngeal nerve are at risk of injury during neck/thyroid surgery as they run immediately posterior to this gland.

**Subclavian artery**: is located between the anterior scalene muscle and the medius scalene muscle *Fig.4*, while the **subclavian vein** is located anterior to the anterior scalene muscle. Both are deep to the sternocleidomastoid muscle.

The **subclavian artery** can be divided into three segments *Fig.3a*:

- **1st segment, from the origin to the medial border of anterior scalene muscle.** Branches: vertebral artery, internal mammary artery (runs downward posterior to the ribs), thyrocervical trunk: inferior thyroid artery, ascending cervical artery, transverse cervical artery) *Fig.5*.
- **2nd segment, posterior to the anterior scalene muscle.** Branches: costocervical trunk, gives off intercostal arteries, and deep cervical artery which can give anastomosis with the vertebral circulation *Fig.6*.
- **3rd segment, from the lateral border of the anterior scalene muscle to the external border of the 1st rib** (from here it becomes axillary artery). Branches: dorsal artery of the scapula *Fig.7*.

**Vertebral arteries**: arise from the subclavian artery (1st segment) then move medially to the transverse process at the level of C6 (variant 8% at C7) and start to move upward crossing multiple transverse foramina of each vertebrae until C1. At the level of the atlas bone vertebral arteries travel across the posterior arch entering the foramen magnum *Fig.8*.

- V1: from the origin to the transverse foramen.
- V2: from the lowest transverse foramen to C2.
- V3: from C2 to the dura, crossing the foramen magnum *Fig.9*.
- V4: from dura to basilar artery.

The vertebral arteries are commonly of unequal caliber, typically the left is larger (dominant left).

Vertebral arteries do not give relevant branches is the H&N region (except potential anastomoses).

**Carotid arteries**:

- Common carotid artery (CC)
- Internal carotid artery (ICA)
- External carotid artery (ECA)
Common carotid artery (CC)

CC runs behind sternocleidomastoid muscle paired with the internal jugular vein which is located laterally, c.n. X (vagus nerve) stays between them Fig.10. The structures are contained in a sheath known as the carotid sheath, which is derived from the deep cervical fascia.

CC divides in two terminal branches the ECA and ICA: ECA is usually medial and anterior to the ICA at the bifurcation, congenital or age induced alterations are common variants to this configuration. As we move with CT axial scans cranially ECA and ICA exchange their position as a final position ICA reaches the carotid foramen in the skull base and ECA reaches the parotid gland Fig.11.

At the bifurcation: the carotid bulb represent a normal increase of caliber compared to the CC. At this level, at the angle of the bifurcation: the carotid sinus (baroceptor) and carotid glomus (chemoceptor) are located.

Carotid bifurcation occurs most commonly at C3-C4 (34%) or C4-C5 (46%) level, nevertheless it can also bifurcate higher (more common) or lower (less common). The landmark is the superior margin of the thyroid cartilage Fig.12.

Vessels normally originating from ECA can instead branch from CC: like lingual artery, ascending pharyngeal artery.

Internal carotid artery (ICA)

ICA does not gives relevant branches in the H&N region (except potential anastomoses), small branches for the petrosal and cavernous tract. There is a relevant anastomosis with the ECA trough the ophtalmic artery.

It enters in the base of the skull trough the carotid foramen Fig.13.

External carotid artery (ECA)

ECA is the major artery of H&N and begins at the level of the upper border of thyroid cartilage, taking a slightly curved course, passes upward and forward, and then inclines backward to the space behind the neck of the mandible, where it divides into the superficial temporal and maxillary artery within the parotid gland Fig.14.

Eight branches feed the scalp, face and deep structures, and can be divided into 4 groups:

Anterior

• lingual artery
- superior thyroid artery
- facial artery

Middle
- ascending pharyngeal artery

Posterior
- occipital artery
- deep auricular artery

Terminal
- internal maxillary artery
- superficial temporal artery

Many mnemonic tricks exist to remember the ECA's branching order, one is: "she always likes friends over Papa, Sister, and Mamma": superior thyroid artery, ascending pharyngeal artery, lingual artery, facial artery, occipital artery, auricular artery, superficial temporal artery and internal maxillary artery.

Frequent variants include common trunks among the anterior branches as: thyrolingual trunk (4%), linguofacial trunk (23%) and thyrolingual facial trunk (1%). Ascending pharyngeal artery often can arise from occipital artery (20%), occasionally from ICA or ECA/ICA bifurcation.

**Superior thyroid artery**: arises from the external carotid artery just below the level of the greater cornu of the hyoid bone and ends in the thyroid gland *Fig. 15*. Branches: infrahyoid artery, sternocleidomastoid artery, superior laryngeal artery, cricothyroid artery. Superior laryngeal artery travels together with the superior laryngeal nerve and can be identified as it pierces the thyrohyoid membrane *Fig. 16*.

**Lingual artery**: it first runs obliquely upward and medialward to the greater cornu of the hyoid bone *Fig. 17*. It then curves downward and forward, forming a loop which is crossed by the hypoglossal nerve, and passing beneath the digastic muscle and stylohyoideus muscle it runs horizontally forward, beneath the hyoglossus muscle, and finally, ascending almost perpendicularly to the tongue, turns forward on its lower surface as far as the tip, under the name of the deep lingual artery. Branches: suprhyoid branch of lingual artery, dorsal lingual branches of lingual artery, deep lingual artery, sublingual artery. Hyoglossus muscle is located between lingual artery and lingual vein *Fig. 18*.

**Facial artery**: branches distal to lingual artery ascends along the lateral aspect of the pharynx close to the superior constrictor muscle, crosses the submandibular gland and
circles the lower margin of the mandible *Fig.19*. In the facial region direct towards the buccal commissure, nasolabial sulcus terminal branches for the alae nasi. The branches of the facial artery are: ascending palatine artery, tonsillar branch, submental artery, glandular branches, inferior labial artery, superior labial artery, lateral nasal branch, and angular artery. Facial artery is thinner and more superficial than the **facial vein**, the zygomatic muscle is interposed between them. Deep, crossing the facial vein, the parotid duct can be localized *Fig.20*.

**Ascending pharyngeal artery**: the smallest branch of the external carotid, is a long, slender vessel, deeply seated in the neck, beneath the other branches of the external carotid and under the stylopharyngeus muscle. It feeds pharyngeal tissues, and the posterior branch is important as it provides vascularization to IX c.n, X c.n., XI c.n. and XII c.n. *Fig.21*.

**Occipital artery**: the occipital artery arises from the external carotid artery opposite the facial artery, its path is below the posterior belly of digastric to the occipital region.

**Deep auricular artery**: it ascends in the substance of the parotid gland, behind the temporomandibular articulation, pierces the cartilaginous or bony wall of the external acoustic meatus, and supplies its cuticular lining and the outer surface of the tympanic membrane.

**Superficial temporal artery**: the superficial temporal artery is the smaller of two terminal branches that bifurcate superiorly from the external carotid. It begins in the substance of the parotid gland, behind the neck of the mandible, and passes superficially over the posterior root of the zygomatic process of the temporal bone *Fig.18a* above this process it divides into two branches, a frontal and a parietal *Fig.22*.

**Internal Maxillary artery**: the maxillary artery, the larger of the two terminal branches of the external carotid artery, arises behind the neck of the mandible, and is at first imbedded in the substance of the parotid gland; it moves medially to the pterygopalatine fossa crossing the infratemporal fossa *Fig.23*.

It can be divided in 3 portions:

- 1<sup>st</sup> portion, **mandibular**
- 2<sup>nd</sup> portion, **pterigoid**
- 3<sup>rd</sup> portion, **pterygopalatine**
1st portion, mandibular: passes horizontally forward, between the neck of the mandible and the sphenomandibular ligament Fig.24, and runs along the lower border of the lateral pterygoid muscle Branches: anterior tympanic artery, inferior alveolar artery Fig.25, middle meningeal artery Fig.26, accessory meningeal artery.

2nd portion, pterigoid: runs obliquely forward and upward under cover of the ramus of the mandible and insertion of the temporalis, on the superficial (very frequently on the deep) surface of the lateral pterygoid muscle; it then passes between the two heads of origin of this muscle and enters the fossa. Branches: masseteric artery, pterygoid branches, deep temporal arteries, buccal artery.

3rd portion, pterygopalatine: lies in the pterygopalatine fossa in relation with the pterygopalatine ganglion. This is considered the terminal branch of the maxillary artery. Branches: sphenopalatine artery, descending palatine artery, infraorbital artery, posterior superior alveolar artery, artery of pterygoid canal, pharyngeal artery, middle superior alveolar (a branch of the infraorbital artery)

anterior superior alveolar arteries Fig.26.

Nasal fossa: rich vascularization with diffuse anastomoses comes from multiple vessels:

- anterior and posterior ethmoidal arteries: from the ophtalmic artery (ICA)
- sphenopalatine artery: from internal maxillary artery
- greater and lesser palatine arteries: from the descending palatine artery (internal maxillary artery).

Orbit:

- optic canal transmits ophthalmic artery and II c.n. only Fig.27;
- superior orbitary fissure connects the middle cranial fossa with the orbit and transmits: superior and inferior ophthalmic veins, and multiple cranial nerves (c.n. III, c.n.IV, c.n.VI and c.n.V1) Fig.28;
- inferior orbitary fissure connects middle cranial fossa with the sphenopalatine fossa, transmits: infraorbitary artery, vein and nerve.

Venous drainage of the H&N
Main system is constituted by the **jugular veins: internal jugular veins, external and anterior jugular veins**, the caliber of the vessels is commonly asymmetric between right and left *Fig.29*.

Internal jugular vein is a direct connection of transverse sinus and drains: (brain, meninges), skull, anterior and lateral face, oral cavity, neck. It is located in the neurovascular space of the neck coverd by the three layers of the deep cervical fascia *Fig.30*.

- facial vein
- retromandibular vein, anterior division
- lingual vein
- superior and middle thyroid vein

External/anterior jugular veins *Fig.31*.

**external jugular veins**: located in the superficial cervical fascia, drains the lateral head

- retromandibular vein, posterior division
- inferior thyroid vein

**anterior jugular veins**: located in the superficial cervical fascia, drains the anterior

**Retromandibular vein**: if formed by the union of superficial temporal vein and maxillary vein and then divides in anterior branch (joins with the anterior facial vein, giving the common facial that will drain in the internal jugular vein), and posterior branch which joins with the posterior auricular giving the external jugular vein.

The retromandibular vein descends in the substance of the parotid gland, superficial to the ECA, but deep to the facial nerve; it is an important landmark *Fig.32*.

**Pteriogoid plexus**: is a venous plexus of considerable size, and is situated between the temporalis muscle and lateral pterygoid muscle, and partly between the two pterygoid muscles. This plexus communicates freely with the anterior facial vein; it also communicates with the cavernous sinus, by branches through the foramen Vesali, foramen ovale, and foramen lacerum. Due to its communication with the cavernous sinus, infection of the superficial face may spread to the cavernous sinus, causing cavernous sinus thrombosis.
Fig. 2: Axial image, normal aortic arch configuration from right to left (red lines): innominate artery, left carotid artery, left subclavian artery. On the right (blue lines) superior vena cava and anterior left innominate vein.
Fig. 3: Axial image at the level of T5, shows approximate position of descending and ascending left recurrent laryngeal nerve as it hooks the aortic arch.
**Fig. 4:** Coronal image shows right subclavian artery located between the anterior scalene muscle and the medius scalene muscle. Relationship with the 1st rib is also clear. The mentioned structured are also used to divide the subclavian artery into three segments (see main text).
Fig. 5: Coronal image, shows branches 1st segment of the subclavian artery.
**Fig. 6:** Axial image, shows branches 2nd segment of the subclavian artery.
Fig. 7: Axial image, shows branches 3rd segment of the subclavian artery.
Fig. 8: 3dVR shows path of the vertebral artery getting close to the transverse process and into the transverse foramen (C6 level). At the level of the atlas bone it circles posteriorly and enters the foramen magnum.
**Fig. 9:** Anatomic model and axial CT image: the marker show entry point of the vertebral artery (V3) into the foramen magnum.
**Fig. 10:** Internal jugular vein, common carotid artery and vagus nerve; enclosed in the carotid sheath (green line). The sternocleidomastoid muscle is anterior to it.
**Fig. 11:** axial images, caudal to cranial planes, show variations in relative positions between ICA end ECA; the pink structure represents the parotid gland (see main text).

**Fig. 12:** Schematic showing how CC bifurcations corresponds to superior margin of thyroid cartilage.
Fig. 13: Marker shows the carotid canal in the anatomic model and axial CT of the skull base.
Fig. 14: Schematic showing branching of the ECA and some relevant distal subdivisions (internal maxillary artery).
**Fig. 15:** 3dVR red arrow shows superior thyroid artery, the inset with different color look-up tables demonstrate the relationship with the gland.

**Fig. 16:** Red arrows point superior laryngeal artery as it pierces the thyrohioid membrane (superior laryngeal nerve, not visible, travels with the artery).
**Fig. 17:** MIP image shows lingual artery, relationship with greater cornu of the hyoid bone and then upward directed into the tongue muscles.
**Fig. 18:** The images show relationship between lingual artery and lingual veins and with the muscles forming the floor of the mouth.

**Fig. 19:** 3dVR facial artery path is shown (thin white arrows): it ascends crossing the submandibular gland circling the lower margin of the mandible up toward the nasolabial sulcus.
Fig. 20: Facial artery is small and more superficial than facial vein, they are separated by the zygomatic muscle. Deeper the facial vein is crossed by the parotid duct.

Fig. 21: The slender ascending pharyngeal artery traces a long path to the skull base.
**Fig. 22:** 3dVR shows (white arrow) the superficial temporal artery and the branching in frontal an parietal divisions, better appreciated on axial images.

**Fig. 23:** 3dVR (white arrow) internal maxillary artery from origin to the mandibular portion then moving into the infratemporal fossa (pterigoid portion) and reaching the pterygopalatine fossa.
**Fig. 24:** Internal maxillary artery 1st portion, mandibular (red arrow), runs along the lower border of the lateral pterygoid muscle.
**Fig. 26:** Inferior alveolar artery, branch of the 1st portion of the internal maxillary artery. Distal part runs into the mandibular canal pairing with the mandibular vein and the mandibular nerve.

**Fig. 25:** Middle meningeal artery (red arrow), branch of the 1st part of the internal maxillary artery; passes through the spinous canal, shown on anatomic model and CT of the skull base.
Fig. 27: Axial (left) am Sagittal (right) closeup of the pterigopalatine fossa, inside the path of the 3rd part of the internal maxillary artery is superimposed (red line) as well as the pterigopalatine ganglion and maxillary nerve (yellow).
**Fig. 28:** Optic canal shown on the anatomical and on CT image (red arrow), please note the difference with superior orbital fissure Fig.29. For the structures transmitted see main text,
**Fig. 29:** Superior orbital fissure shown on the anatomical and on CT image (red arrow), please note the difference with optic canal Fig.28. Note that in the picture (not in the CT) inferior orbital fissure is also evident. For the structures transmitted see main text.
Fig. 30: 3dVR show deep and superficial jugular veins and their tributary.
Fig. 31: 3dVR shows superficial jugular and anterior jugular veins and their tributary vessels.
Fig. 32: The images show position of the retromandibular vein, the facial nerve c.n. VII (not visible) is superficial to it, while the ECA is deeper.
Conclusion

Vessel anatomy of the head and neck here described can serve as a framework for describing vascular and non-vascular lesions in reports.

References


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