Blood Supply to the Head and Neck

The nutrients and oxygen necessary to sustain life are carried to all the cells of all of the tissues by the arteries. Veins and lymphatics pick up the waste products of cell metabolism and, together with deoxygenated red blood cells, return them to various areas. The blood is then rejuvenated and returns to the tissues for continued cell nutrition. The details of the cell physiology involved are not within the scope of this text. However, a basic knowledge of the general mechanics of systemic and pulmonary circulation is important. The circulation of the head and neck can only be understood if one grasps the concept of the "to-and-fro" system of the closed arteriovenous mechanism found in the human.

Circulatory Concepts

Blood is propelled through the body by the heart, which is a hollow muscular organ containing four compartments or chambers. The heart is situated behind the sternum and somewhat to the left. It is about the size of a fist and rests on the diaphragm. The heart is cone-shaped with the apex pointing downward, forward, and to the left.

The four chambers are the right and left atria and the right and left ventricles. The atria are located superior to their respective ventricles. The right and left ventricles and atria are separated from one another by a fibrous septum which extends from the apex to the base of the heart. Blood returning from the tissues passes into the right atrium. It then flows into the right ventricle through the right atrioventricular valve. Blood is then pumped out of the right ventricle into the lungs where it is oxygenated. The oxygenated blood returns to the left atrium of the heart and then passes through the left atrioventricular valve into the left ventricle. From the left ventricle, oxygenated blood is pumped into the body tissues.

It is necessary to understand an important concept here, that is, the cardiopulmonary relationship. Blood going to the lungs from the right ventricle is being sent to the lungs to rid the system of carbon dioxide and to pick up a fresh supply of oxygen. Blood rich in oxygen and other nutrients to supply the cells of the lungs with metabolic needs reaches the cells of the lungs, not from the right ventricle, but from the left ventricle via the bronchial branches of the aorta.

End products of metabolism (except carbon dioxide) are still in the blood, returning from the lungs to the heart at the left atrium. The blood carrying these end products is then sent to the liver and kidneys from the left ventricle. The blood has only been oxygenated and cleared of carbon dioxide in the lungs.

The other end products must be carried in the blood until they reach the kidneys and liver, where the blood is further detoxified. It then returns to the right atrium, via the venous system. One can deduce, therefore, that blood entering the right atrium is a mixture of detoxified blood from the kidneys and liver and blood in need of detoxification from other parts of the body. Also, blood returning from the lungs is rich in oxygen but still contains the percentage of other end products of metabolism found in blood returning to the right atrium.
In addition, nutrients enter the blood from the intestine and return to the right atrium, ultimately reaching the cells after leaving the left ventricle.

In summary, blood returning to the right atrium is a mixture of blood containing end products of metabolism as well as more nutrients. It is, however, poor in oxygen. The same blood returns from the lungs, to the left ventricle, via the left atrium, rich in oxygen, having lost carbon dioxide. It is now ready to be sent to the entire body (1) to bring oxygen to the tissues, (2) to bring other nutrients to the tissues, and (3) to be detoxified in the kidneys and liver.

Blood is carried to the various parts of the body via the arterial tree which ultimately ends in arterial capillaries. Blood returns to the heart via the venous system which begins as venous capillaries.

Except for the pulmonary arteries leaving the right atrium, arteries carry oxygenated blood which is bright red. Except for the pulmonary veins, veins carry oxygen-poor blood, which is dark red. Arteries carry blood away from the heart, and veins carry blood toward the heart. For the most part, arteries and veins travel together to and from the various parts of the body. The walls of veins are less muscular than those of arteries, and the pressure therein is also less.

The arteries and veins are distributed to all parts of the body like branches of a greatly ramified tree. Although the branches of a vessel is smaller than its trunk, the combined cross section of the resulting vessels is greater than that of the trunk. Branches of vessels sometimes open into branches of other vessels of similar size. This junction of two vessels is known as an anastomosis. Anastomoses usually occur in smaller vessels of 0.1 millimeter or less in diameter. When several vessels supply the same area, the area is said to be served by collateral circulation.

Arterioles is the term applied to arteries of less than 0.1 millimeter in diameter. They are the smallest arteries. The smallest veins are venules.

Capillaries connect the arterioles and venules. They are microscopic in size and their walls are usually only one cell thick.

Multiple small arterioles or venules supplying a highly vascularized area are referred to as venous or arterial plexuses. Of importance in the dental profession is the pterygoid plexus, a large network of veins located in the retromaxillary, pterygoid plate region between the pterygoid and temporal muscles. Injections of local anesthesia often encounter this plexus, and retrograde dental infection here can be quite hazardous.

Arteries of the Head and Neck

A large artery exits from the left ventricle, carrying all the blood to the systemic circulation. This artery is the aorta. Immediately after its exit from the heart, it gives off the right and left coronary arteries which supply blood to the musculature of the heart. The aorta then passes upward about 4.0 centimeters, where it curves in a large arch about the level of
the first rib and begins to descent in the thorax. Three large vessels arise from the aortic arch: (1) the brachiocephalic artery, (2) the left common carotid artery, and (3) the left subclavian artery. The brachiocephalic artery branches into the right subclavian artery and the right common carotid artery. Both the subclavian arteries are destined for the arms and the thorax. They also give rise to a few arteries to the neck. The vertebral arteries, which are branches of the subclavian arteries, ascend in the posterior part of the neck through the foramina in the transverse processes of the upper six cervical vertebrae. They enter the skull through the foramen magnum and contribute to the blood supply of the brain (see also circle of Willis).

The Common Carotid Arteries

The common carotid arteries supply almost all the blood to the head and neck. These arteries ascend on the lateral aspect of the neck, deep to the sternocleidomastoid muscle. As the common carotid artery reaches the level of the thyroid cartilage, it divides (bifurcates) into the internal and external carotid arteries.

Internal Carotid Artery

The internal carotid artery has no branches in the neck. After it enters the brain case at the carotid canal, located in the petrous portion of the temporal bone, the internal carotid gives off several branches, eleven in number. These branches supply various vital structures, including the brain and the eye. Only the major vessels will be discussed.

Ophthalmic Artery. This vessel supplies the muscles and tissues associated with the eye. It is the first of the three major intracranial branches of the internal carotid artery. Along with the optic nerve, it enters the orbit through the optic foramen. It supplies the muscles and globe of the eye via various branches. In general, the ocular branches are destined for the globe while the orbital branches supply the orbit and surrounding parts.

Ocular Branches. (See also chapter on The Organs of Special Senses.)

1. Central artery of the retina. This artery passes within the sheath of the optic nerve for a short distance and finally pierces the nerve and runs forward in the center of the nerve to the retina.

2. Ciliary branches. About 8 to 14 small branches leave the ophthalmic artery and pierce the sclera. They supply the choroid and ciliary process. Moreover, some of these arteries branch from the ophthalmic artery to pierce the sclera and form a circular plexus around the iris. Additional branches arise from the muscular group.

3. Muscular Branches. These vessels arise from the ophthalmic artery to supply extraocular muscles of the eye.

Orbital Branches. The supraorbital artery is a branch of the ophthalmic artery in the orbit. It exits from the orbit at the supraorbital notch and supplies the associated area of the forehead and scalp. The ophthalmic artery also gives off the ethmoidal arteries to the ethmoid air cells, the lateral wall of the nose, and the nasal septum. The ophthalmic artery terminates
as a frontal artery, exiting from the orbit at the medial angle of the supraorbital ridge, and the dorsal nasal artery, which supplies the root and dorsum of the nose. The lacrimal gland is supplied by the lacrimal artery, another intraorbital branch of the ophthalmic artery.

**Cerebral Branches.** The cerebral branches terminate the internal carotid artery after the ophthalmic artery is given off. Two branches, the anterior cerebral and posterior communicating arteries, supply the circle of Willis. The middle cerebral artery continues up along the side of the brain.

**The Circle of Willis.** The circle of Willis, an arterial anastomosis of great importance, lies at the base of the brain and is composed of branches of the internal carotid and vertebral arteries.

The right and left vertebral arteries join one another at the base of the brain, posteriorly. The resultant artery from this junction is the basilar artery. The basilar artery passes forward and divides into two posterior cerebral arteries. The posterior communicating artery of the internal carotid artery, passing posteriorly, enters the posterior cerebral artery. The anterior cerebral arteries of the internal carotid pass anteriorly and anastomose with one another by way of a short anterior communicating artery. Thus an elaborate, anastomotic, well-designed network of arterial supply is available to the brain.

**The External Carotid Artery**

The external carotid is the branch of the common carotid artery that supplies the face, jaws, and scalp. It passes superiorly, but is more superficial than the internal carotid. It parallels the internal carotid artery somewhat and enters the parotid gland with its terminal branch, the superficial temporal artery. It gives off this branch about the level of the condylar neck. Here it lies deep to the condyle and turns medially and anteriorly and is known as the maxillary artery.

The eight branches of the external carotid artery begin near the bifurcation of the common carotid artery.

**Ascending Pharyngeal Artery.** This usually arises immediately above the bifurcation of the common carotid artery. It ascends along the lateral pharyngeal wall to the skull. The blood supply to the pharynx and adjacent muscles is provided, in part, by this vessel. It is small and anastomoses with pharyngeal branches of other arteries.

**Superior Thyroid Artery.** The bifurcation of the common carotid is also the location for the origin of the superior thyroid artery. It curves anteriorly and downward to supply the thyroid gland. The mucous membrane and muscles of the larynx also receive blood from the superior thyroid artery. It dispenses some blood via a small branch to the hyoid region.

**Lingual Artery.** Destined for the tip of the tongue via a tortuous course, the lingual artery arises from the external carotid artery at the level of the hyoid bone. Often it arises in common with the facial artery via the lingual-facial trunk. From its origin, the lingual artery courses anteriorly to the posterior border of the hyoglossus muscle. It passes deep to this
muscle and turns upward to the mouth, where it enters the base of the tongue. It terminates at the tip of the tongue.

The lingual artery gives off the sublingual artery to the floor of the mouth, prior to entering the substance of the tongue. The sublingual artery supplies the sublingual gland, mucosa of the floor of the mouth, the mylohyoid muscle, and the lingual gingiva. It anastomoses with the submental branch of the facial artery. After giving off the sublingual artery, the lingual artery, now in the body of the tongue, is termed the deep lingual artery.

The Facial Artery (External Maxillary Artery). The facial artery supplies, for the most part, the superficial structures of the face. It arises from the external carotid artery just above the origin of the lingual artery at about the level of the angle of the mandible. It may arise from the lingual-facial trunk. Passing forward and upward, it passes deep to the digastric muscle and enters the submandibular triangle. It then enters the substance of the submandibular salivary gland or it may pass deep to the gland. After it reaches the superior border of the gland, it arches upward toward the floor of the mouth and then turns downward and laterally to pass below the inferior border of the mandible. The artery then turns sharply upward on the lateral surface of the mandible and crosses in front of the anterior border of the masseter muscle. It is then directed toward the angle of the mouth, deep to the muscles of facial expression, but lateral to the buccinator. After passing under the zygomaticus major muscle, it usually lies superficial to the infraorbital muscles. At the corner of the mouth, it turns upward along the lateral border of the nose to the inner corner (canthus) of the eye. Here it anastomoses with the terminal branches of the ophthalmic branch of the internal carotid artery.

The two most important branches of the facial artery under the jaw are the ascending palatine and the submental arteries. The ascending palatine arises close to the origin of the facial artery and supplies the soft palate, pharynx, and tonsils with the ascending pharyngeal artery. The submental artery originates from the facial artery before the facial artery turns onto the face. It supplies the submandibular region and anastomoses with the sublingual artery.

The facial artery gives off the inferior labial and superior labial arteries at the corner of the mouth. The inferior labial artery anastomoses with the mental artery to supply the chin and lower lip. The superior labial artery anastomoses with the terminal nasal branches of the ophthalmic artery and with the infraorbital arteries. The facial artery then courses superiorly, giving branches to the side of the nose and cheek to end at the medial canthus of the eye as the angular artery.

Occipital Artery. The occipital artery arises close to the origin of the facial artery. It, however, runs upward and backward toward the occipital area of the scalp. After it crosses the mastoid process in the occipital groove of the temporal bone, it becomes more superficial. It supplies the scalp.

Posterior Auricular Artery. The posterior auricular artery originates from the external carotid artery at a level just opposite the lobe of the ear. It then passes laterally and posteriorly to supply the outer ear and adjacent scalp behind the ear. The superficial temporal
artery and occipital artery both give branches that anastomose with the posterior auricular artery.

**Superficial Temporal Artery.** The superficial temporal artery is anatomically, but not embryologically, the continuation of the external carotid artery. It ascends vertically in front of the ear to the temporal region of the scalp. It passes through the substance of the parotid gland in the retromandibular fossa, releasing the *transverse facial artery*, which passes horizontally and ends near the lateral canthus of the eye. Also, it sends branches to the outer ear and a *middle temporal* branch to the temporalis muscle. In the scalp, the branches of the superficial temporal artery anastomose with branches of the occipital artery, posterior auricular artery, frontal artery, supraorbital artery, and across the midline with arteries of the opposite side.

**Maxillary (Internal Maxillary) Artery.** This complex and most interesting vessel supplies the deep tissues of the face. It originates at the condylar neck and passes deep. The course is horizontal and anterior as it heads for the pterygopalatine fossa. It is close to the medial surface of the condylar neck when it first originates, and as it passes deeply, it runs between the condylar neck and the *sphenomandibular ligament*. There, it lies either lateral or medial to the external pterygoid muscle. If it lies lateral, it must reach the pterygopalatine fossa by turning medially between the two heads of origin of the external pterygoid muscle.

It is easy to understand the divisions of the maxillary artery if one classifies it into sections and organizes its distribution. For the purpose of study, the artery is divided into four sections: mandibular, muscular, maxillary, and sphenopalatine.

**Muscular Section.** This part supplies the muscles of mastication and the buccinator muscle. The temporalis receives the *posterior* and *anterior deep temporal arteries*. The *masseteric artery* passes laterally through the condylar notch to supply the masseter muscle. A variable number of small *pterygoid branches* are released to the pterygoid muscles. The last branch of this section is the *buccal artery*, which crosses the anterior border of the ascending mandibular ramus at the level of the occlusal plane. It is sometimes encountered during surgery of this area and can be quite troublesome.

**Maxillary Section.** In the maxillary section the *posterior superior alveolar artery* crosses the maxillary tuberosity and here gives off *posterior superior arteries*, which enter the posterior superior alveolar foramina and supply the maxillary posterior teeth and bone. It continues on as the *gingival artery* and supplies the alveolar process and gingiva.

The *infraorbital artery* is next released by the maxillary artery. This vessel enters the orbit through the inferior orbital fissure and lies in the infraorbital sulcus and then the infraorbital canal. In the orbit, it supplies contiguous structures and releases the *anterior superior alveolar artery* to the anterior teeth, bone, and gingiva. The infraorbital foramen is its exist. It thus supplies the anterior part of the cheek and upper lip, anastomosing with the superior labial and angular arteries.

**Sphenopalatine Section.** This section is short and it is from here that the terminal branches occur. The ramifications occur in the pterygopalatine fossa.
The descending palatine artery arises in the pterygopalatine fossa and passes inferiorly to enter the oral cavity through the greater (major) palatine foramen. In the pterygopalatine canal, it may give off some small nasal branches to the lateral wall of the nasal cavity. Also it gives off lesser palatine branches which exit from the lesser palatine foramina and supply the soft palate and tonsil. Once it exits from the greater palatine foramen, the descending palatine artery is known as the anterior (greater) palatine artery, which turns forward in the substance of the palatal mucosa and passes anteriorly to the nasopalatine foramen. In its course it gives branches to the associated bone, glands, and mucosa. Once it reaches the nasopalatine foramen, it turns upward and passes through the nasopalatine canal into the nose and anastomoses with the sphenopalatine artery on the septum.

The sphenopalatine artery also arises in the pterygopalatine fossa. It leaves the fossa via the same foramen and it enters the nasal cavity through the sphenopalatine foramen. Here it divides into branches supplying the lateral wall of the nasal cavity and septum. On the septum it anastomoses with the septal branch of the anterior palatine artery.

Veins of the Head and Neck

The venous blood of the head and neck is drained almost entirely by the internal jugular vein. Veins usually accompany arteries and carry the same or similar names. The venous network is more variable than the arterial tree, but a definite pattern still exists. Deep veins are united with superficial veins by several anastomoses. These multiple anastomoses present a potential danger by increasing the number and availability of pathways for spread of infection. In addition, because the veins of the face have few, if any, valves, backflow of blood can easily occur. Thus, bacteria can readily flow from superficial to deep veins. Prior to the advent of antibiotics, brain infection, secondary to facial or dental infection, was not uncommon.

Once blood reaches the internal jugular vein, it drains inferiorly to the brachiocephalic vein. The brachiocephalic vein is formed by the confluence of the internal jugular vein and the subclavian vein, which drains the upper extremity. The right and left brachiocephalic veins then joint to form the superior vena cava. The inferior vena cava, draining the lower portion of the body, joins the superior vena cava in an area known as the confluence of the cava, located at the right atrium.

Venous Sinuses

The sinuses of the dura mater in the brain empty their contents into the internal jugular vein which commences at the jugular foramen. Blood from the eye and the brain is collected in the dural sinuses.

Superior Sagittal Sinus

The superior sagittal sinus begins in the area of the cribriform plate of the ethmoid bone and passes posteriorly in the midline along the inner plate of the frontal, parietal, and occipital bones. It drains some of the veins of the brain as it runs posteriorly.
Inferior Sagittal Sinus

The inferior sagittal sinus is enclosed in the lower free border of a vertical fold of dura which separates the two halves of the cerebrum.

Straight Sinus

The straight sinus joins the inferior sagittal sinus and the superior sagittal sinus. It lies in a horizontal fold of dura, separating the cerebrum from the cerebellum.

Transverse Sinus

The transverse sinus begins where the straight sinus and the superior sagittal sinuses join. It passes laterally in a horizontal plane across the inner table of the occipital and temporal bones to become an S-shaped sinus, the sigmoid sinus, and then into the internal jugular vein at the jugular foramen.

Cavernous Sinuses

The cavernous sinuses, which lie on either side of the sella turcica, are pools of venous blood, subdivided internally by thin strands and trabeculae of connective tissue. The right and left cavernous sinuses communicate with one another via anterior and posterior chambers known as intercavernous sinuses. The cavernous sinuses drain associated portions of the brain. Also, the ophthalmic veins draining the eye empty posteriorly into the cavernous sinus. Clinically, it is of great importance to know that the internal carotid artery, the first two divisions of the trigeminal nerve, the abducens nerve, the oculomotor nerve and the trochlear nerve all pass through the cavernous sinus. Retrograde infection into this sinus can lead to a grave clinical problem.

Petrosal Sinuses

The blood in the trabeculated cavernous sinus is drained posteriorly into the superior and inferior petrosal sinuses. The superior petrosal sinus ends in the sigmoid sinus. The inferior petrosal sinus empties more inferiorly, directly into the jugular vein near the foramen.

Internal Jugular Vein

The blood from the brain empties into the internal jugular vein which is formed by the confluence of various sinuses discussed above and which exits the brain case through the jugular foramen. The vein descends in the neck to the brachiocephalic vein.

Contributing veins include the inferior petrosal sinus, communications from the pharynx and tongue, common facial vein, veins of the larynx and the thyroid gland, the external jugular vein, and the anterior jugular veins.
**Common Facial Vein**

The common facial vein is a short, thick vessel resulting from a merger of the *anterior facial vein* and the *retromandibular vein*. It enters the internal jugular vein at the level of the hyoid bone.

**Anterior Facial Vein**

The anterior facial vein follows a course similar to that of the facial artery. It originates from the veins of the forehead and nose. The *frontal vein*, *supraorbital vein*, and veins from the lids and nose all contribute to the first part of the facial vein, the *angular vein*. The angular vein then becomes the facial vein as it drains inferiorly. A wide anastomosis takes place between the angular vein and the *superior and inferior ophthalmic veins*. As the facial vein descends, it picks up communicating branches from the associated area. An anastomotic branch to the *pterygoid plexus* is released from the facial vein at the level of the upper lip. This communicating vein is the *deep facial vein*. Once the facial vein has picked up the *superior and inferior labial veins*, it reaches the inferior border of the mandible where it turns posteriorly and deep. Here it receives the *submental* and *palatine veins* and enters the common facial vein.

**Ophthalmic Veins**

The *inferior ophthalmic vein* drains the floor and medial wall of the orbit and associated soft tissue. It empties into either the pterygoid plexus, the cavernous sinus, the superior ophthalmic vein, or any combination of the three. The *superior ophthalmic vein* drains the areas supplied by the ophthalmic artery and empties into the cavernous sinus after passing through the superior portion of the orbit.

**Retromandibular Vein**

The areas supplied by the maxillary artery and the superficial temporal artery are drained by the retromandibular vein. This vessel is sometimes called the *posterior facial vein*. It is formed by the union of the *superficial temporal vein* with the deep veins of the maxilla. It emerges from the substance of the parotid salivary gland and courses vertically down to the common facial vein.

**Lingual Veins**

The lingual veins, three or four in number, accompany the lingual arteries. They drain the tongue and floor of the mouth and empty into the anterior facial vein, common facial vein, or retromandibular vein.

**Pterygoid Plexus**

The venous network known as the pterygoid plexus lies between the temporal and pterygoid muscles. It drains the muscles of mastication, the nasal cavity, the temporomandibular joint, the external ear, and a small portion of the dura. It communicates
with the facial vein by way of the deep facial vein. Also, it drains the maxillae and the palate and communicates with the cavernous sinus. It empties posteroinferiorly, joining the superficial temporal vein to form the retromandibular vein.

**External Jugular Vein**

The external jugular vein is formed by the junction of the posterior auricular vein with the occipital vein. It passes across the sternocleidomastoideus, superficially, and then passes deep to enter the internal jugular vein low in the neck near the junction of the internal jugular vein with the subclavian vein. It often anastomoses with the common facial vein or retromandibular vein.

**Anterior Jugular Vein**

Often absent, the anterior jugular vein may be a single midline vein or two midline veins. It empties into the internal jugular vein near the junction of the internal jugular vein with the subclavian vein. The suprasternal space of Burns, above the superior border of the sternum, is where profuse anastomoses of the two anterior jugular veins often take place.

**Variations in Venous Drainage**

As noted earlier, many variations in the venous drainage are common. Some of the most common variations, as listed by Sicher, are:

1. The common facial vein may not exist. The retromandibular vein empties into the external jugular vein and the facial vein opens into the internal jugular vein.

2. The common facial vein opens into the external jugular vein.

3. The facial vein empties into the anterior jugular vein, and the retromandibular vein empties into the external jugular vein or the internal jugular vein.

**Vertebral Vein**

The vertebral vein begins in the suboccipital region. It descends in the vertebral foramina and empties into the back of the ipsilateral brachiocephalic vein. It arises from multiple tributaries and plexuses, draining deep muscles and structures of the cervico-occipital region.