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**VEINS OF THE SYSTEMIC
CIRCULATION**

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**ВЕНЫ БОЛЬШОГО КРУГА
КРОВООБРАЩЕНИЯ
VEINS OF THE SYSTEMIC
CIRCULATION**

Учебно-методическое пособие



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INTRODUCTION

The cardiovascular system consists of the heart and numerous blood and lymphatic vessels carrying blood and lymph. The major types of the **blood vessels** are arteries, veins, and capillaries. The **arteries** conduct blood away from the heart; they branch into smaller arteries and, finally, into their smallest branches — **arterioles**, which give rise to capillaries. The **capillaries** are the smallest vessels that serve for exchange of gases, nutrients and wastes between blood and tissues. The **veins** carry blood towards the heart; the blood from capillaries is collected to the **venules**, then small veins that merge to form bigger veins. The smaller veins emptying into the larger veins are usually called “tributaries” (rarely “inflows”) but can also be called “branches” by analogy with arterial vessels. The **lymphatic vessels** conduct lymph in one direction - from the peripheral tissues to the great veins; thus, they supplement venous system in returning tissue fluid to the heart.

All blood vessels are subdivided into 3 groups: **pulmonary, systemic, and cardiac vessels**. They form vessel circuits that arise and end in the heart.

The **pulmonary circulation** starts in the right ventricle of the heart. Deoxygenated blood is carried to the lungs through the pulmonary trunk dividing into the right and left pulmonary arteries. The pulmonary veins (two from each lung) bring oxygenated blood to the left atrium.

The **systemic circulation** starts in the left ventricle of the heart. Oxygenated blood passes through the aorta and its branches to supply all parts of the body. Deoxygenated blood is returned into the right atrium through the veins eventually draining into the superior vena cava (SVC) and the inferior vena cava (IVC).

The cardiac vessels being part of the systemic circulation form their own **cardiac circuit** for supply of the heart itself. It comprises two coronary arteries arising from the aortic root and the cardiac veins draining blood directly to the chambers of the heart (predominantly to the right atrium).

The **systemic veins** are the most numerous group of vessels. They have much more capacity than corresponding arteries and contain 50-60% of the circulating blood. Among them several types of veins can be distinguished:

- **Cutaneous veins** lie in the skin and collect blood from skin capillaries; they empty into superficial or deep veins.
- **Superficial (subcutaneous) veins** course in the subcutaneous tissue and eventually empty into the large deep veins; they usually do not accompany arteries and are more prominent in the limbs.
- **Deep veins** lie internal to the deep fascia and accompany arteries sharing their names. The smaller deep veins are generally paired, especially in the limbs. They pass on either side of the artery and are called **venae comitantes** (*Latin* for accompanying veins). The larger veins are usually single.

- **Perforating veins** perforate the deep fascia to connect the superficial veins with the deep veins where they drain. In greater number they are found in the lower limbs.

SYSTEM OF THE SUPERIOR VENA CAVA

SUPERIOR VENA CAVA

The **superior vena cava (SVC)** is one of the two big systemic veins, which returns blood and lymph to the heart. It drains the venous blood from the upper half of the body above the diaphragm - head, neck, upper limbs, and chest (except for the heart wall and most of the lungs).

The SVC is a short (about 7 cm long) and large-diameter (24 mm) vein. It is formed by the union of the two **brachiocephalic veins** behind the 1st right costal cartilage (Fig. 1). The SVC passes from the superior mediastinum downwards along the right border of the sternum, enters the pericardial cavity and ends in the right atrium at the upper border of the 3rd costal cartilage. The **azygos vein** joins the SVC just above the pericardium.

VEINS OF THE THORAX

Blood from the thorax is returned into the superior vena cava through the brachiocephalic veins and the azygos vein. The **brachiocephalic veins** drain the veins of the anterior thoracic wall, anterior portion of the diaphragm, and upper posterior intercostal spaces. The **azygos vein** drains the veins of the posterior thoracic wall and posterior portion of the diaphragm. The veins of most thoracic viscera are tributaries of both the brachiocephalic veins and the veins of the azygos venous system.

BRACHIOCEPHALIC VEINS

The **right and left brachiocephalic (innominate) veins** are formed posterior to the right and left sternoclavicular joints by the union of the **internal jugular** and **subclavian veins** of the respective side (Fig. 1). This union is called the **right and left venous angles**. (The right lymphatic duct opens to the right angle, while the thoracic duct opens to the left angle). The left brachiocephalic vein is more than twice as long as the right one. It passes behind the manubrium of sternum, anterior to the roots of the three major branches of the aortic arch, and joins with the right brachiocephalic vein at the right border of the sternum.

The brachiocephalic veins receive **tributaries** from the neck, the thoracic viscera and thoracic walls (*the areas drained generally correspond to those supplied by the 1st and 2nd parts of the subclavian artery*):

- From the **neck**:

1. The **inferior thyroid vein(s)** empties into the **left** brachiocephalic vein; it drains the **unpaired thyroid venous plexus** collecting blood from the larynx and lower pharynx.

2. The **vertebral vein** arises at the level of the atlas from the **suboccipital venous plexus** (unlike the vertebral artery it does not have a cranial part) and as a venous plexus descends through transverse foramina of the cervical vertebrae. It drains the occipital vein, muscles surrounding the spine, cervical part of the vertebral venous plexuses.
3. The **deep cervical vein** runs in the posterior region of the neck draining the suboccipital area, muscles surrounding the vein, and the cervical spine.
 - From the *thoracic viscera*: **thymic and tracheal veins, bronchial, pericardial, mediastinal, and esophageal tributaries (veins).**
 - From the *thoracic wall*:

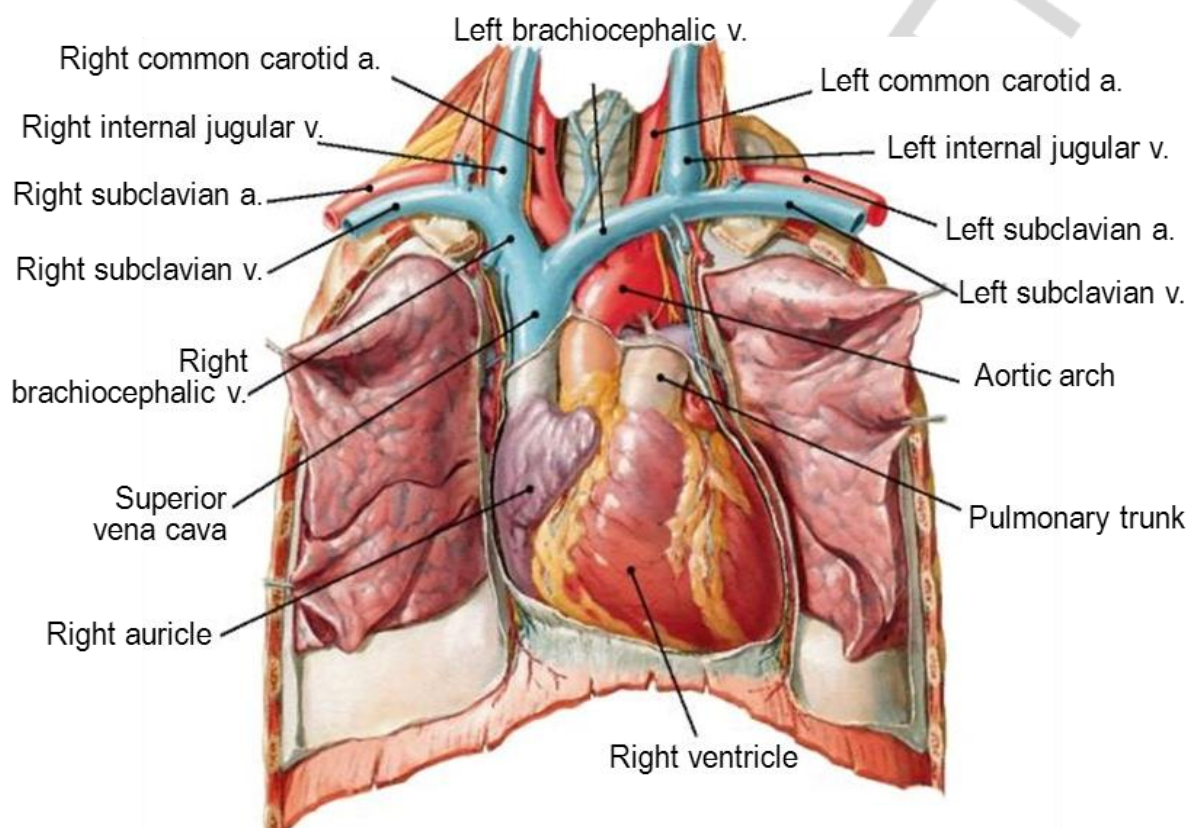


Fig. 1. Superior vena cava with tributaries [11]

1. The **internal thoracic vein** ascends along the border of the sternum as a paired vessel accompanying the artery of the same name and becomes single before emptying into the brachiocephalic vein (Fig. 2). Its tributaries (*mainly correspond to the branches of the internal thoracic artery*) are the **superior epigastric, musculophrenic, anterior intercostal veins**, and the **subcutaneous abdominal veins**. They drain the diaphragm and the anterolateral wall of the thoracic and abdominal cavities.
2. The **pericardiophrenic vein** passes from the diaphragm between the pericardium and pleura.

3. The **supreme intercostal vein** (1st posterior intercostal vein) drains the respective area.
4. The **left superior intercostal vein** drains the superior intercostal spaces (2nd to 4th) to the **left** brachiocephalic vein. (The right superior intercostal vein drains into the azygos vein).

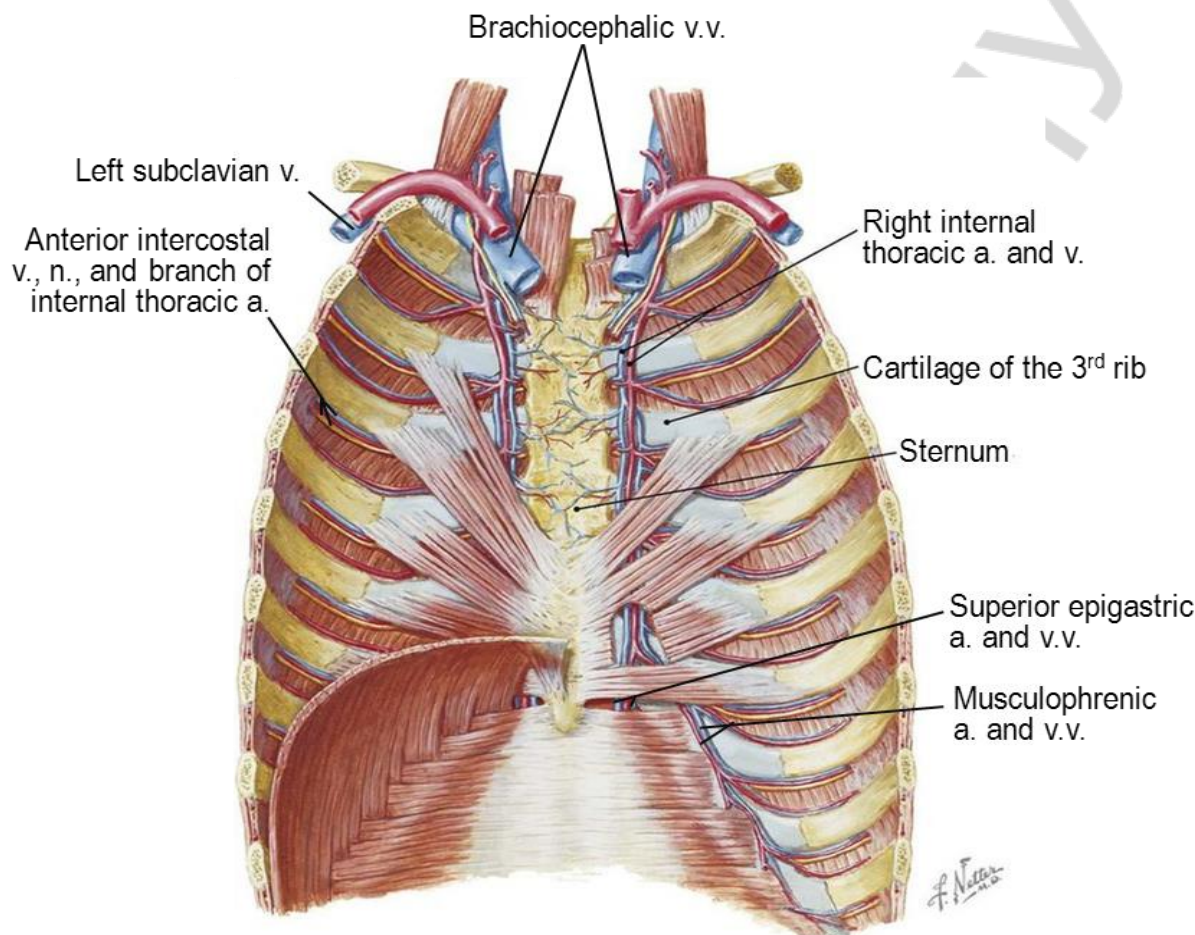


Fig. 2. Internal thoracic artery and veins (posterior view of anterior thoracic wall) [11]

AZYGOS VENOUS SYSTEM

The **azygos venous system** is composed by three veins lying in the posterior mediastinum along the vertebral column: the **azygos vein** conveying blood to the SVC; and its tributaries - the **hemiazygos vein** and the **accessory hemiazygos vein** (Fig. 3).

1. The **azygos vein** (means “unpaired vein”) arises at the aortic hiatus (T12 vertebra) from the union of the **right ascending lumbar vein** and **right subcostal vein** (Fig. 3,4).. It runs upwards along the right side of the vertebral column, right to the thoracic duct and aorta. Above the right bronchus it arches forward and joins the SVC. At this level it receives the **right superior intercostal vein** draining superior intercostal spaces (2nd to 4th).

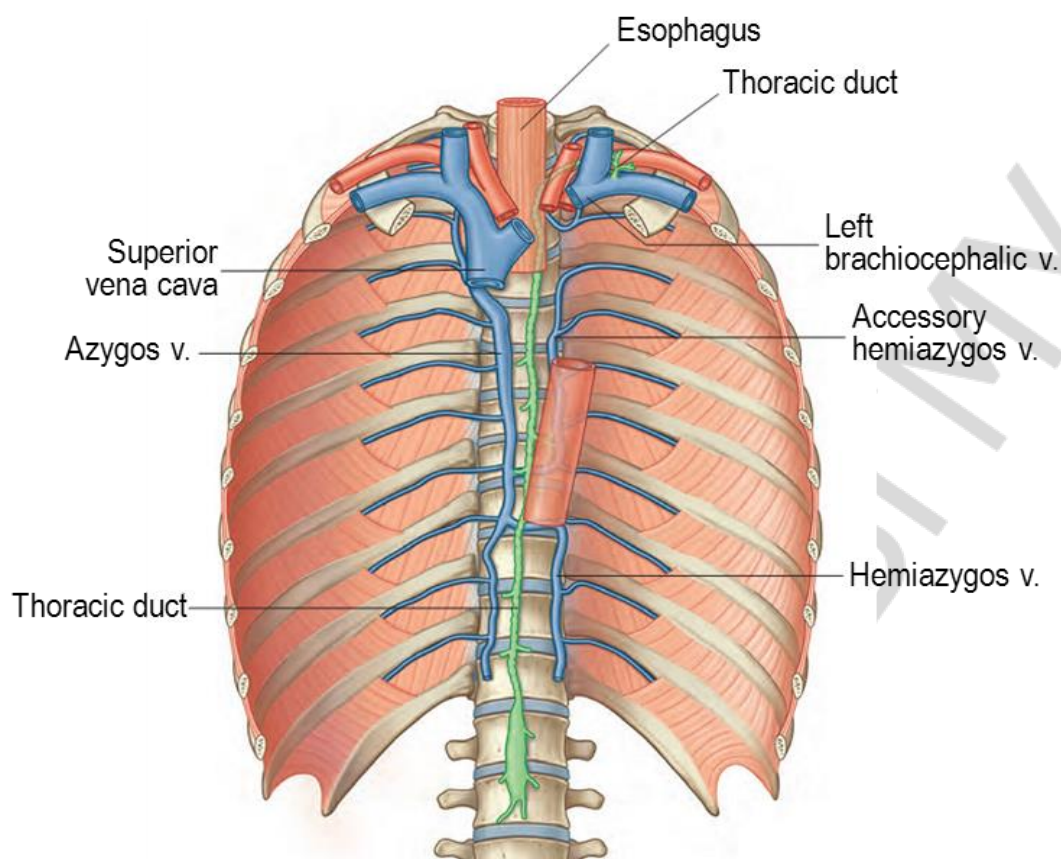


Fig. 3. Veins of azygos system [3]

2. The **hemiazygos vein** (syn. **inferior hemiazygos vein**), the larger tributary of the azygos vein, arises from the **left ascending lumbar vein** (and often from the left renal vein), passes through the left crus of the diaphragm, and ascends along the left side of the vertebral bodies behind the esophagus and aorta (Fig. 3,4). At the T8-T9 vertebrae it turns right and joins the azygos vein.

3. The **accessory hemiazygos vein** (syn. **superior hemiazygos vein**) descends on the left side of the vertebral column from the T4-T5 to T8 vertebra where it turns right and joins the azygos vein (Fig. 3,4).

The tributaries of these veins generally *correspond to the visceral and parietal branches of the thoracic aorta*:

- The **esophageal** (from the thoracic part of the esophagus), **bronchial** (small vessels carrying deoxygenated blood from the bronchial tree and lungs tissue), **pericardial**, and **mediastinal** (from the connective tissue and lymph nodes of the mediastinum) **tributaries (veins)** drain the thoracic viscera;

- The **superior phrenic veins**, **subcostal** and **posterior intercostal veins** drain the thoracic walls, back, vertebral column, spinal cord, and its meninges.

Generally, the veins of the **right side** connect to the **azygos vein**; those of the **left side** connect to the **hemiazygos** and **accessory hemiazygos veins**.

The **posterior intercostal veins**, in particular, are drained as follows (Fig. 4):

- On the **right** side — into the **azygos vein** via the **right superior intercostal vein** or directly (5th and below), except for the 1st one, the right brachiocephalic vein tributary;
- On the **left** side: the **middle** veins (5th - 8th) — into the **accessory hemiazygos vein**; the **inferior** veins (9th - 11th) — into the **hemiazygos vein** (the superior veins — into the left brachiocephalic vein).

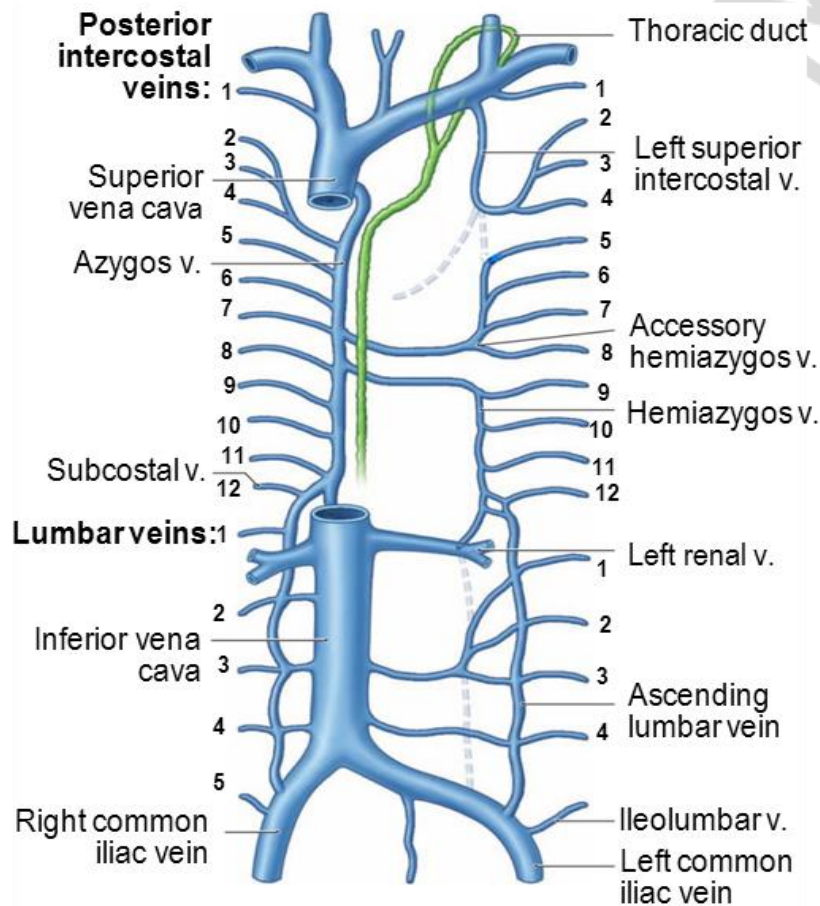


Fig. 4. Drainage of posterior intercostal and lumbar veins [1]

The veins of the azygos system anastomose with the tributaries of the internal thoracic veins; communicate with the **vertebral venous plexuses** directly and by way of the posterior intercostal veins. Via the **ascending lumbar veins** they connect to the IVC tributaries draining the lumbar region. The azygos venous system becomes a collateral route between the SVC and IVC in the event of their obstruction.

VEINS OF THE VERTEBRAL COLUMN

Veins of the vertebral column interconnect to form the internal and external venous plexuses extending from the base of the skull to the sacrum (Fig. 5). The **anterior** and **posterior external vertebral plexuses** are located on the external aspects of the vertebral column - anterior to the vertebral bodies and posterior to the vertebral arches and processes, respectively. The **anterior** and **posterior internal vertebral plexuses** lie in the anterior and posterior parts of the epidural space of the vertebral canal. They receive the **radicular veins**, which drain the **anterior** and **posterior spinal veins** passing along the spinal cord, and the **basivertebral veins** from vertebral bodies (Fig. 5B).

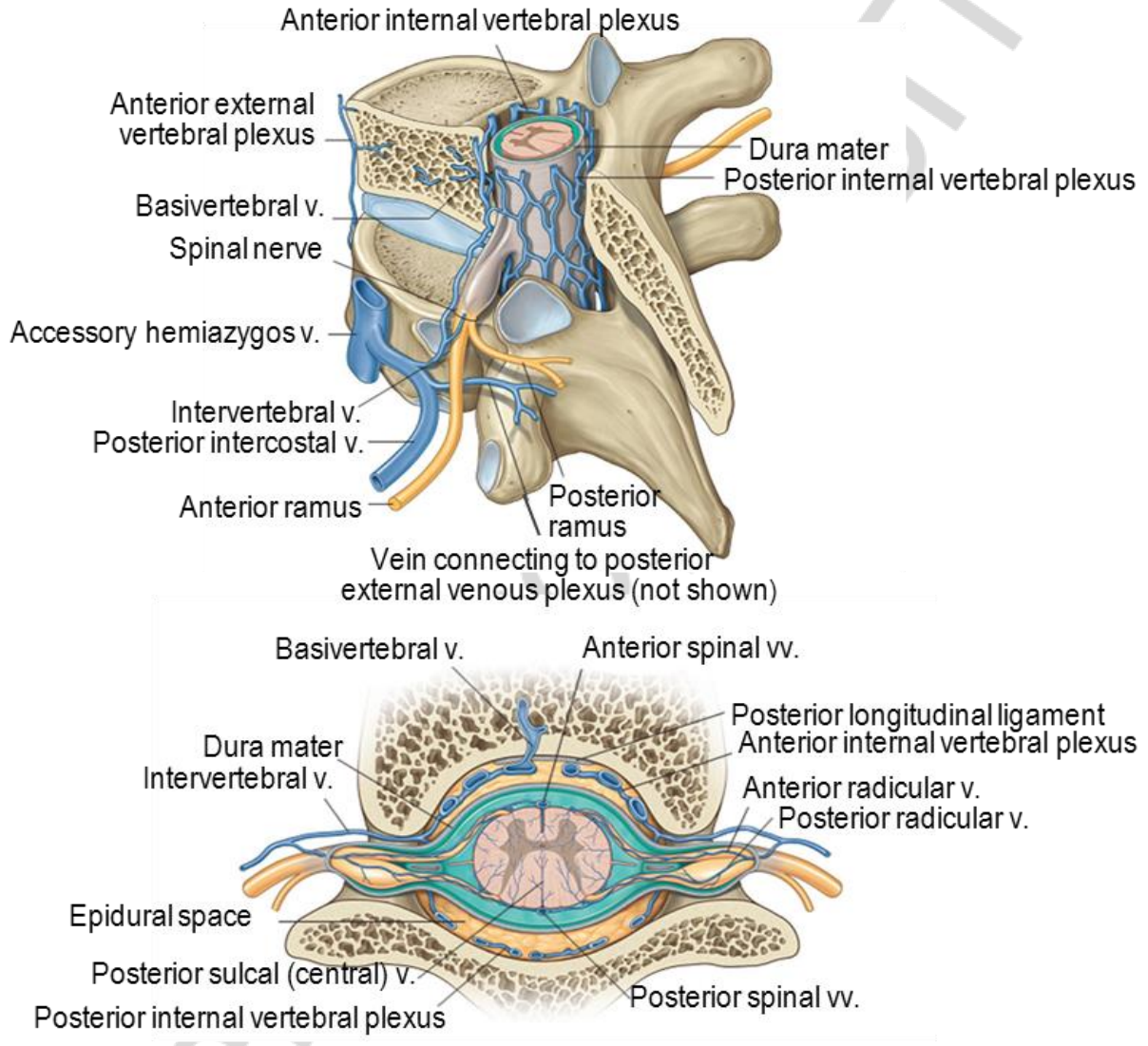


Fig. 5. External and internal vertebral plexuses (at the thoracic level) A — side view; B — transverse cross-section [3]

The internal and external vertebral plexuses are connected by the **intervertebral veins**, passing through the intervertebral foramina, and both drain into

segmental veins according to the levels of the spine: 1) the vertebral vein and deep cervical veins in the neck (Fig. 6), 2) the posterior intercostal veins and three veins of the azygos system directly in the thorax (Fig. 5A), 3) the lumbar and ascending lumbar veins in the abdomen, and 4) the sacral veins in the pelvis. Around the foramen magnum the internal vertebral plexuses continue with the **suboccipital plexus**, as well as with the *basilar venous plexus* and *dural venous sinuses* inside the skull. The veins of the vertebral plexuses have no valves and provide a connection between the SVC and IVC systems along the entire length of the spine including the intracranial veins. This can be a pathway for distribution of infectious agents or metastases of tumor cells.

VEINS OF THE HEAD AND NECK

Veins of the head and neck differ from the corresponding arteries in their courses, connections, and names more than in other regions of the body. The main venous vessels draining blood from the head and neck are the internal and external jugular veins (Fig. 6). The **internal jugular veins** are the major deep veins in the neck, which drain the head and anterior part of the neck. The **external jugular veins** collect blood mainly from the posterior head and, together with the **anterior jugular veins**, from the neck (skin, subcutaneous tissue, and some deeper structures). Both external and anterior jugular veins drain into the subclavian vein.

Blood from the cervical spine and surrounding muscles is mainly drained into the brachiocephalic veins (described above) via the **vertebral veins** assisted by the smaller **deep cervical veins** (Fig. 6).

INTERNAL JUGULAR VEIN

The **right** and **left internal jugular veins** are the biggest veins in the neck. Each vein begins at the jugular foramen in the posterior cranial fossa as continuation of the sigmoid sinus. In the neck it runs downwards medial to the sternocleidomastoid muscle in the carotid sheath, together with the internal and then common carotid arteries and the vagus nerve. Behind the clavicle it unites with the *subclavian vein* to form the *brachiocephalic vein*. The internal jugular vein has dilations at its upper and lower ends, the **superior** and **inferior bulbs**. At these levels valves are located.

The tributaries of the internal jugular veins can be divided into *cranial*, which drain almost all blood from the brain and skull, and *extracranial*, draining superficial and deep regions of the face, most of the scalp and viscera of the neck.

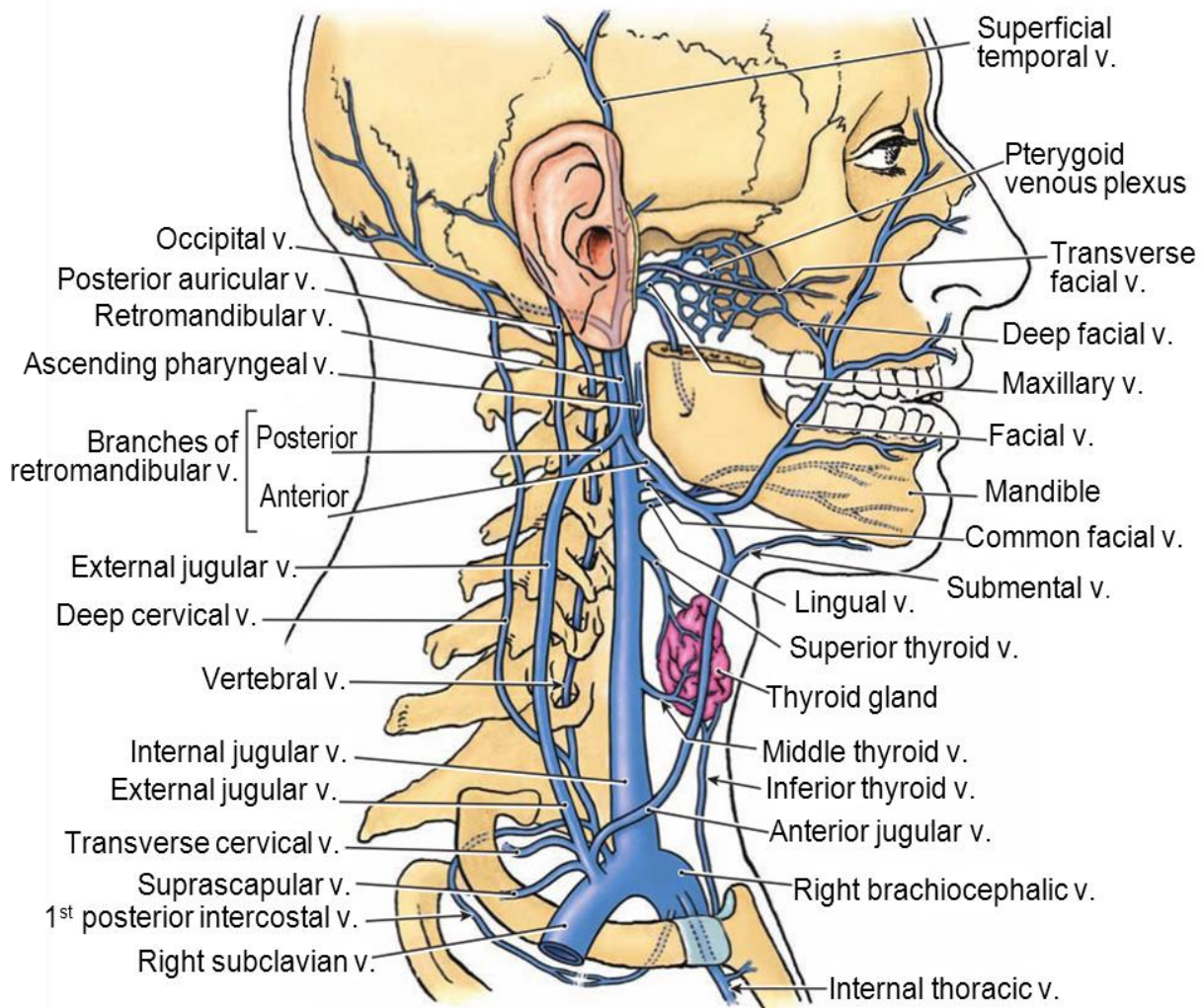


Fig. 6. Veins of the head and neck [1]

CRANIAL TRIBUTARIES OF THE INTERNAL JUGULAR VEIN

The **cranial veins** (also referred to as intracranial veins) include: veins located in the cranial cavity — *veins of brain, meningeal veins, dural venous sinuses*; veins of the cranial bones — *diploic*; veins passing through the cranial foramina out — *emissary veins; orbital veins*; and *labyrinthine veins*. Almost all blood from the cranial veins is drained into the internal jugular veins through the system of the dural venous sinuses.

Based on the location and direction of blood outflow the dural sinuses can be divided into upper and lower groups. The upper group includes sinuses located along the calvaria and their continuation in the posterior cranial fossa: the unpaired **superior and inferior sagittal sinuses, straight sinus, confluence of sinuses, occipital sinus**, and the paired **transverse and sigmoid sinuses** (Fig. 6,7). The lower group includes sinuses of the cranial base lying anterior to the foramen magnum: the **sphenoparietal, cavernous and intercavernous, superior and inferior petrosal sinuses** (Fig. 6,7).

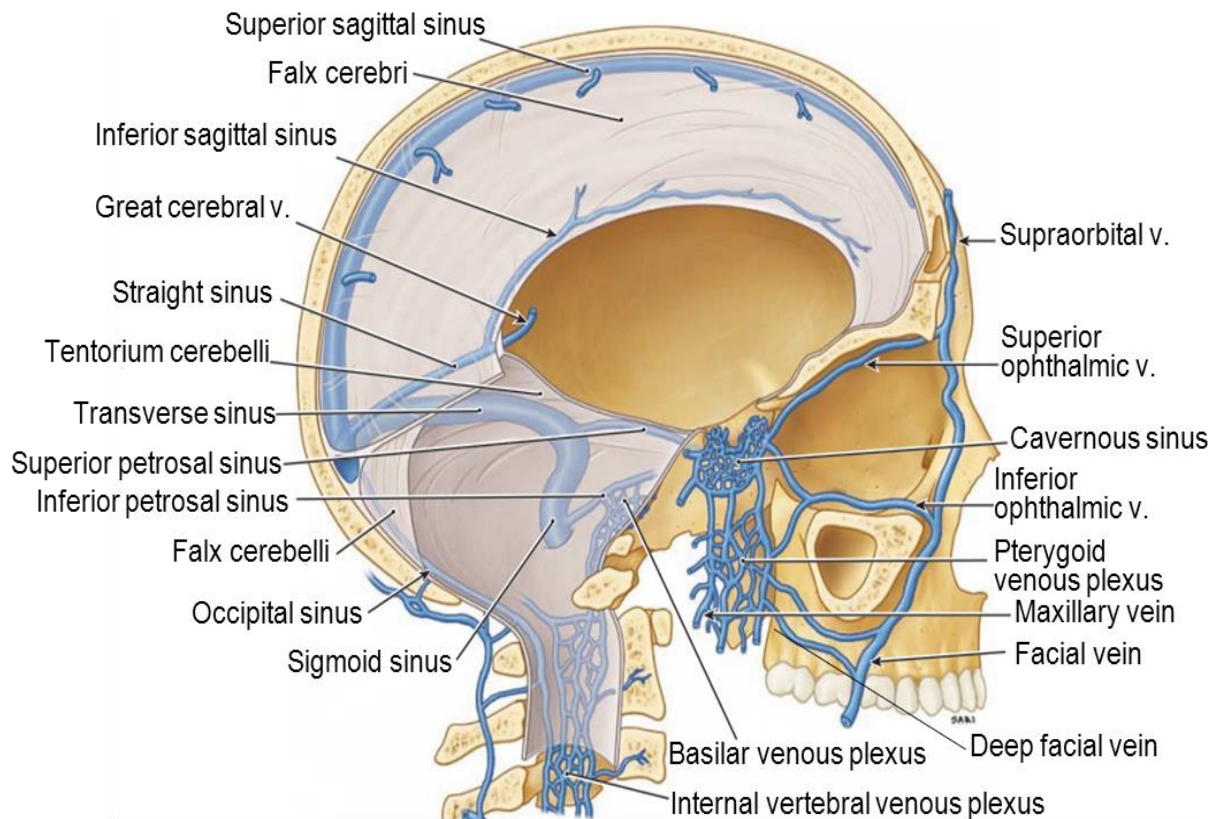


Fig. 7. Dural venous sinuses and related venous plexuses: sagittal section of the skull [7]

- The **superior sagittal sinus** lies in the midline of the calvaria along the attachment of the falx cerebri separating the cerebral hemispheres. It runs from the foramen cecum to the internal occipital protuberance, where ends at the **confluence of sinuses** (commonly it continues as the right transverse sinus). The superior sagittal sinus connects on both sides with the 2-3 extensions, the **lateral lacunae**. Arachnoid granulations protrude through the walls of the sinus and lateral lacunae to transfer the CSF to the venous system (Fig. 11).

- The smaller **inferior sagittal sinus** passes along the inferior margin of the falx cerebri and posteriorly empties into the straight sinus.

- The **straight sinus** (*Lat.* Sinus rectus) is formed by the fusion of the inferior sagittal sinus and the **great cerebral vein** draining the deep structures of the brain. The straight sinus passes through the junction of the falx cerebri and tentorium cerebelli (the dural projection separating the cerebellum from the cerebrum), and posteriorly joins with the **confluence of sinuses**.

- The **confluence of sinuses** is a dilation of sinuses at the internal occipital protuberance where several sinuses are connected. The straight and superior sagittal sinuses join here and continue with the right and left transverse sinuses and the small occipital sinus.

- The **transverse sinuses** pass on either side of the confluence of sinuses along the tentorium cerebelli attachment to the occipital bone. At the mastoid angle of the parietal bone each becomes the sigmoid sinus.

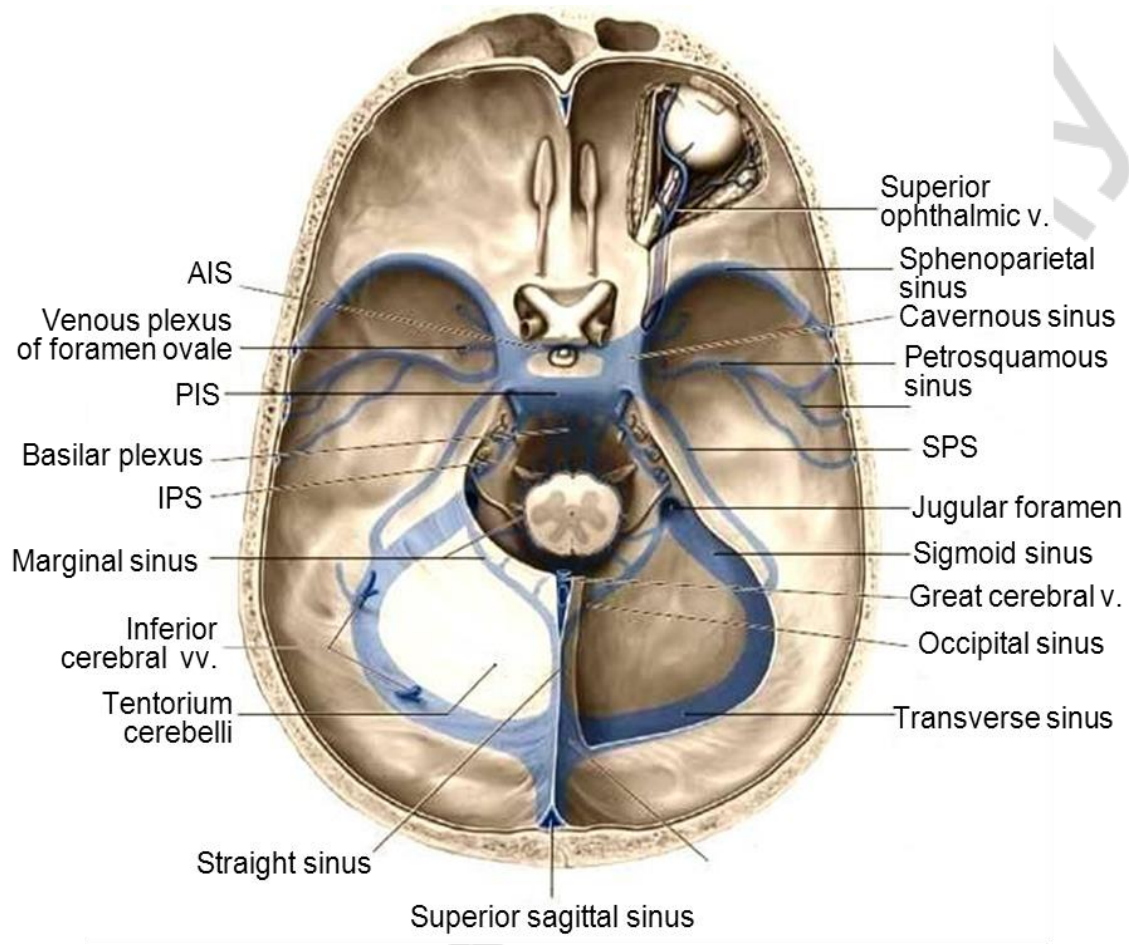


Fig. 8. Dural venous sinuses with tributaries in the cranial base (superior view of the opened cranial cavity: tentorium cerebelli is removed on the right side): AIS and PIS — anterior and posterior intercavernous sinuses; SPS and IPS — superior and inferior petrosal sinuses [6]

- The S-shaped paired **sigmoid sinus** passes inferomedially in a groove of the posterior cranial fossa formed by the parietal, temporal and occipital bones. It ends in the jugular foramen connecting with the superior bulb of the **internal jugular vein**.

- The smallest **occipital sinus** passes along the falx cerebelli attachment to the internal occipital crest between the foramen magnum and the confluence of sinuses. Below it continues with the paired **marginal sinus** lying along the rim of the foramen magnum, thus communicating with the internal vertebral plexuses, sigmoid sinus and sinuses of the middle cranial fossa.

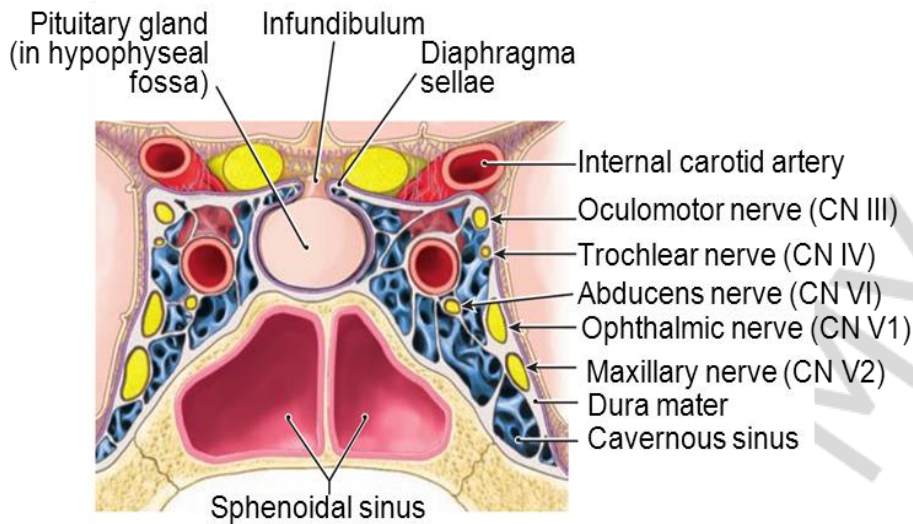


Fig. 9. Cavernous sinus in coronal section [1]

- The **cavernous sinuses** are located in the middle cranial fossa on both sides of the sella turcica. Each is presented by a venous plexus enclosed in the dural cavity (Fig. 8, 9). The internal carotid artery and the abducens nerve (VI cranial nerve) run through the cavernous sinus, and several cranial nerves (III, IV, 1st and 2nd divisions of the V) pass in its lateral wall. The right and left sinuses are connected in front and behind the pituitary stalk by the **anterior** and **posterior intercavernous sinuses**. The cavernous sinuses receive the **ophthalmic veins** from the orbit, the **sphenoparietal sinuses** passing along the lesser wings of the sphenoid bone, the **cerebral** and **hypophyseal veins**, as well as the **emissary veins** of the cranial base from the deep face (the pterygoid venous plexus). The drainage of the cavernous sinuses occurs into the petrosal sinuses and basilar venous plexus.

- The **superior** and **inferior petrosal sinuses** pass along the respective borders of the petrous parts of the temporal bones. The **superior petrosal sinuses** run along the attachment of the tentorium cerebelli to the superior borders of the petrous parts; posteriorly they join the lateral ends of the transverse sinuses. The **inferior petrosal sinuses** pass along the inferior borders of the petrous parts (in the petro-occipital fissures) and drain into the superior bulbs of the internal jugular veins. Besides small veins from the brain, the inferior petrosal sinus receives the **labyrinthine veins (internal auditory veins)** from the internal ear. The right and left inferior petrosal sinuses are connected by the **basilar venous plexus**, which descends along the clivus and communicates with the internal vertebral plexus through the foramen magnum (Fig. 7,8).

The general direction of blood flow through the dural venous sinuses is shown in the diagram (Fig. 10). The drainage from the venous sinuses occurs through the sigmoid sinus into the internal jugular vein. The other way of drain-

age, which increases in the upright position of the body, is via the basilar venous plexus into the internal vertebral plexuses. At certain conditions the minor out-flow may occur through the emissary veins (described below) to the veins of the scalp and extracranial venous plexuses of the cranial base.

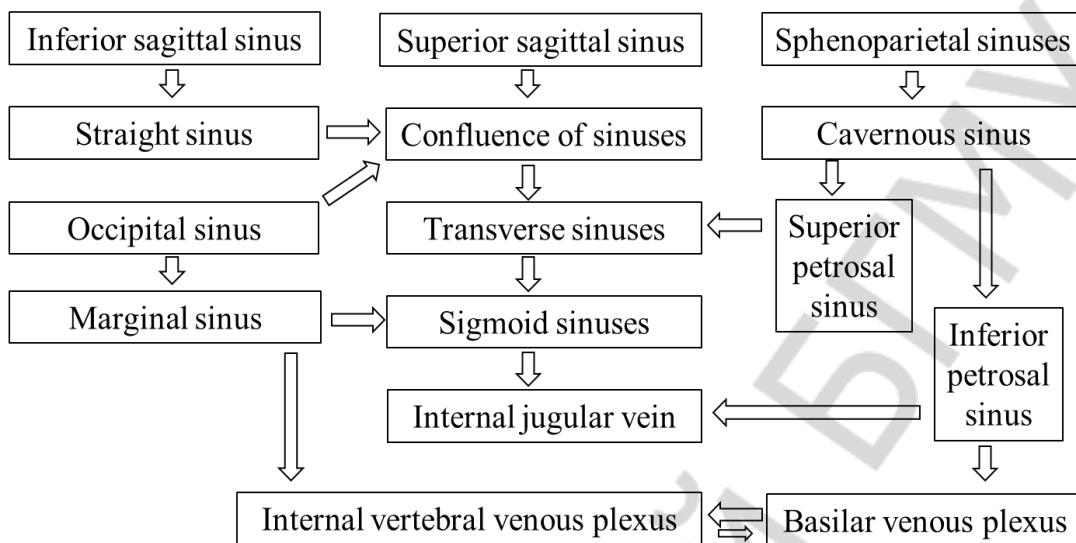


Fig. 10. Diagram illustrating the general direction of blood flow through the dural venous sinuses.

Tributaries of the dural venous sinuses

The primary tributaries that empty into the sinuses are the following (Fig. 11):

- The **emissary veins** are short veins or plexuses with no valves connecting the dural venous sinuses with the extracranial veins of the scalp or veins external to the base of the skull. The 4 of them are named **emissary veins: parietal, mastoid, condylar, and occipital emissary veins** (Fig.11). Others are veins and plexuses passing through the cranial base openings: foramen ovale, foramen lacerum, carotid canal, hypoglossal canal and some others (Fig. 8).

The emissary veins passing through the flat bones of the skull connect the sinuses with the diploic and the extracranial veins, e.g. the occipital, posterior auricular, supraorbital veins. Those in the cranial base connect the sinuses with the extracranial pterygoid, suboccipital, and vertebral venous plexuses. Particularly extensive communications exist between the cavernous sinus and the pterygoid plexus. Bidirectional blood flow through the emissary veins makes them potential routes where infections are carried into the cranial cavity from the extracranial veins. The suggested physiological role of the emissary veins is cooling the head and brain.

- The **diploic veins** (**frontal, occipital, anterior** and **posterior temporal**) are valveless endothelial lined channels in the diploe - spongy bone of the flat bones of the calvaria (Fig. 11). The diploic veins communicate with the dural venous sinuses internally and veins outside the skull.

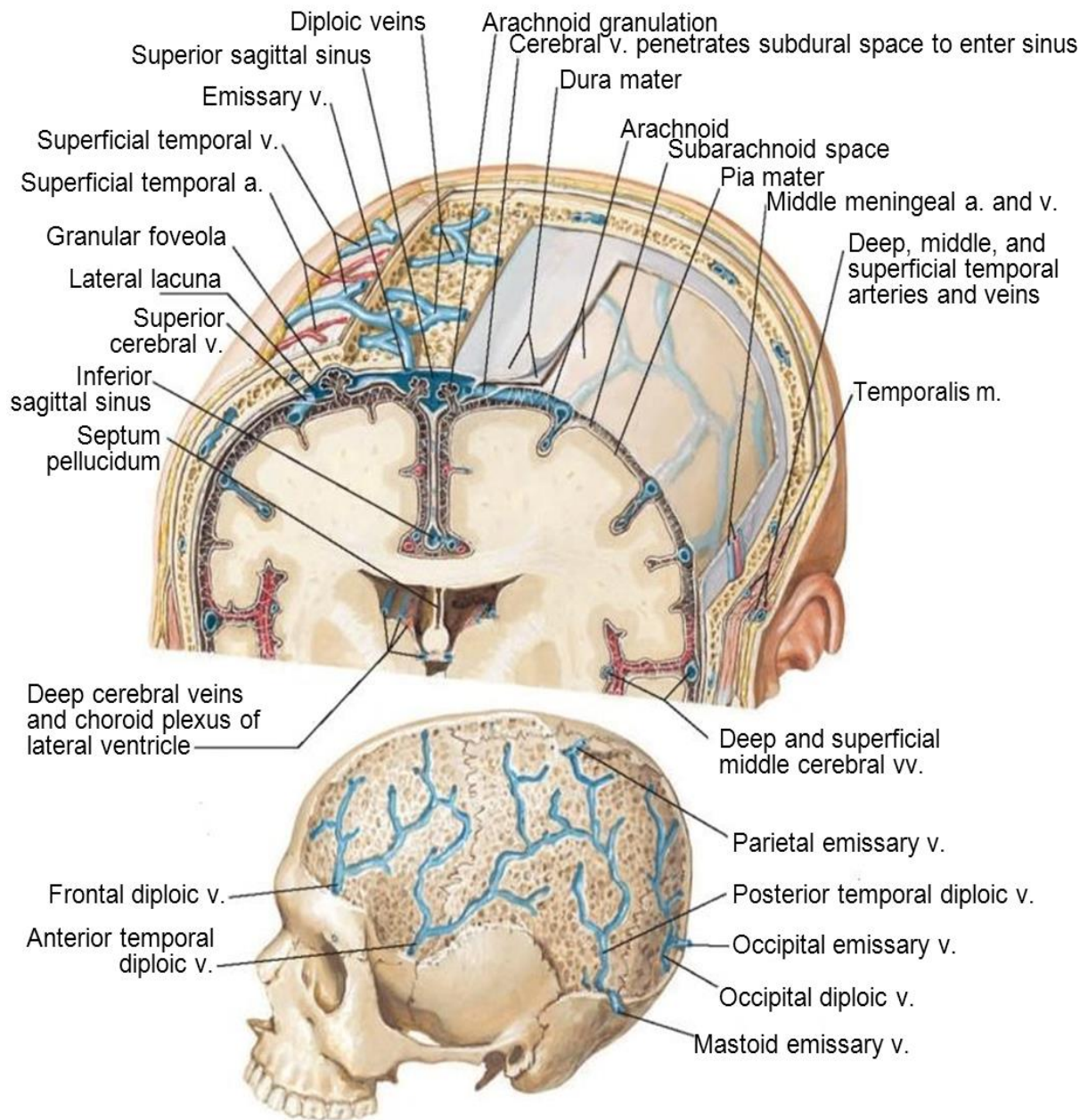


Fig. 11. Cranial tributaries of the internal jugular vein [11]

The **meningeal veins** arise between the layers of the dura mater. The larger veins accompany the meningeal arteries (Fig. 11A). They drain the dura mater and join the nearest dural sinuses. Some meningeal veins drain to the extracranial veins, e.g. the middle meningeal vein emptying into the pterygoid plexus.

- The **veins of brain** comprise the **cerebellar veins**, **veins of brainstem**, and **cerebral veins** - superficial and deep (Fig.8, 11):

- The **superficial cerebral veins** (superior, middle, and inferior) collect blood from the cerebral cortex of the respective surfaces of the hemispheres and drain into the nearest dural venous sinuses. Most of them drain into the superior sagittal sinus (from the superior surface of the brain) and to the cavernous sinus (from the inferior surfaces of the hemispheres);
- The **deep cerebral veins** drain the deeper lying areas of the cerebral cortex (orbital surface of the frontal lobe, medial surface of the temporal lobe, insula), corpus callosum, subcortical structures, choroid plexus, diencephalon, and midbrain (Fig. 7, 8, 11). The majority of deep cerebral veins drain into the largest vein of this group, the **great cerebral vein** (*syn.* vena cerebri magna, vein of Galen), which empties into the **strait sinus** (Fig. 7, 8).
- **Veins of brainstem** and **cerebellar veins** drain to the superior and inferior petrosal sinuses.

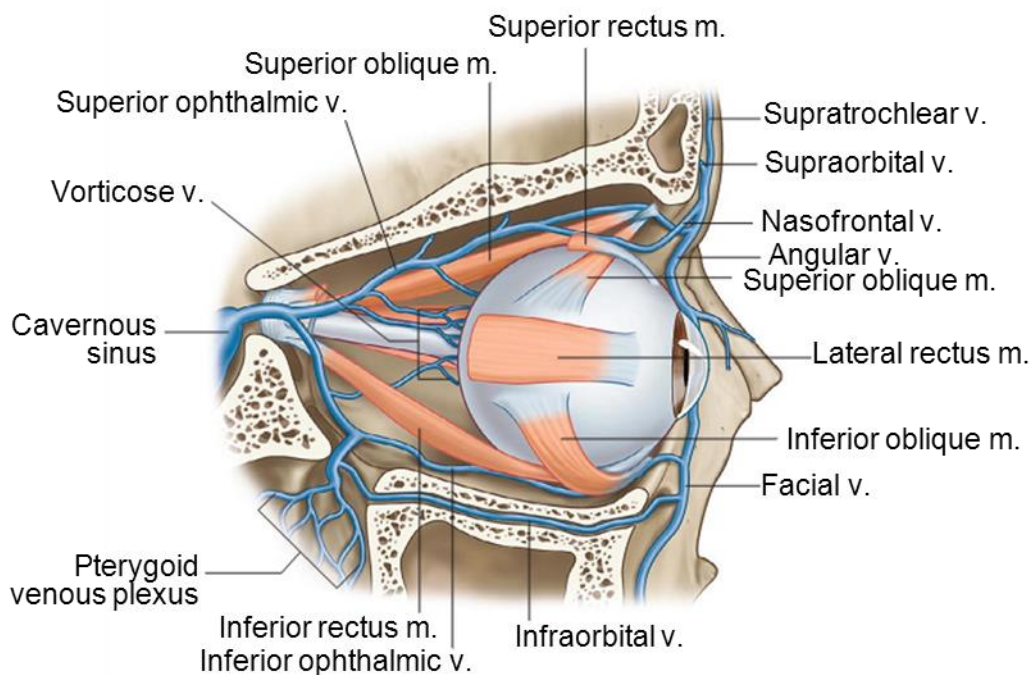


Рис. 12. Veins of the orbit and eyeball (lateral view) [3]

- The **orbital veins** are the **superior** and **inferior ophthalmic veins** and their tributaries that collect blood from the eyeball, accessory visual structures, nasal cavity, and paranasal sinuses (Fig. 7,12). The **superior ophthalmic vein** begins in the medial angle of the eye by the **nasofrontal vein**, anastomosing with the roots of the *facial vein*, and follows backward the course of the ophthalmic artery. The **inferior ophthalmic vein** begins within the orbit; via the inferior orbital fissure it communicates with the **pterygoid plexus**. The two oph-

thalmic veins connect in the depth of the orbit and via the superior orbital fissure empty to the **cavernous sinus**. Thus, via the ophthalmic veins the facial vein communicates with the intracranial dural sinuses and deep extracranial veins of the head. Tributaries of the ophthalmic veins mainly correspond to branches of the ophthalmic artery, except for special vorticose veins of the choroid, and do not include veins of the forehead. The latter drain into the facial vein.

- The **labyrinthine veins** drain the internal ear; they pass through the internal acoustic meatus and empty into the inferior petrosal sinus.

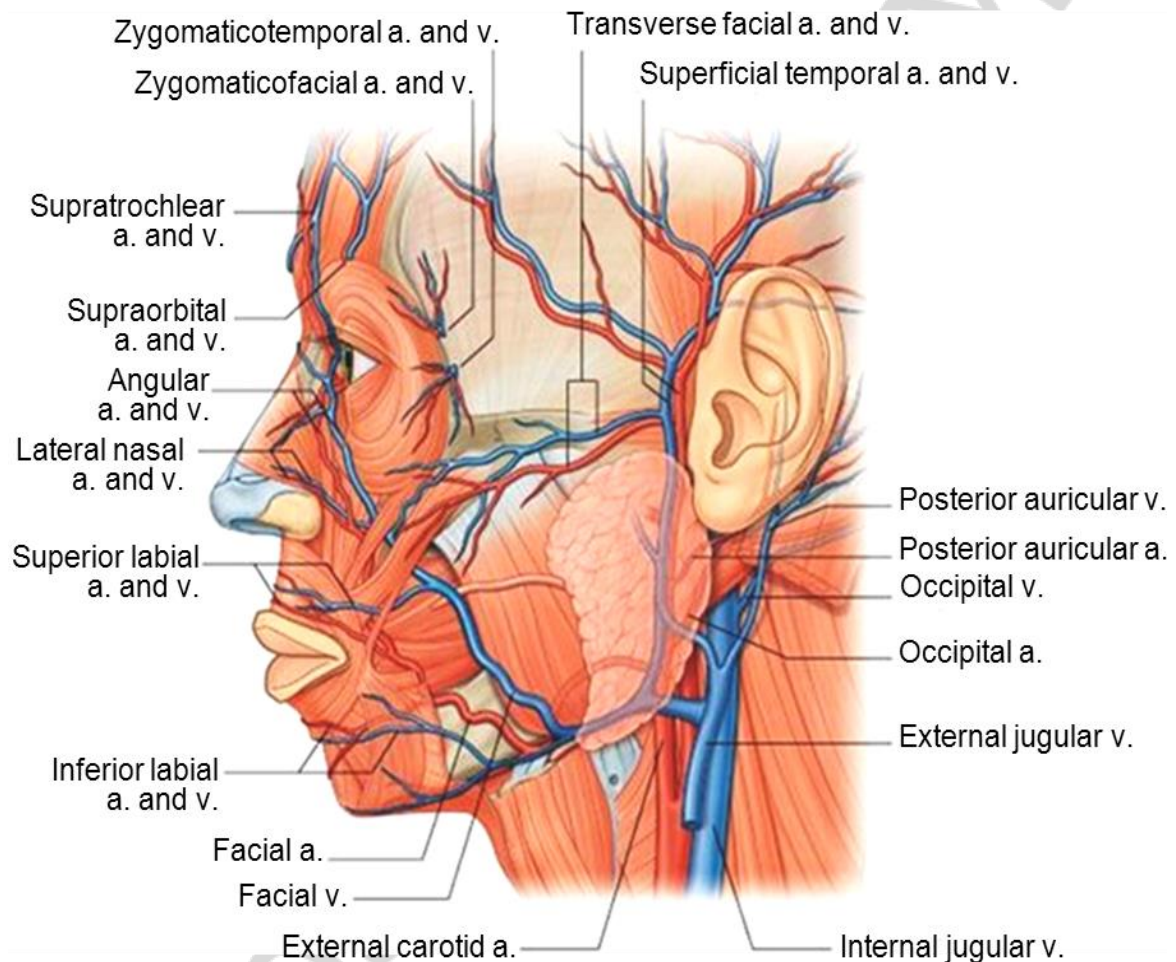


Рис. 13. Superficial veins of the face [4]

EXTRACRANIAL TRIBUTARIES OF THE INTERNAL JUGULAR VEIN

1. The common facial vein is the largest extracranial tributary of the internal jugular vein, which drains most of the scalp, anterior and lateral areas of the head and face. It is formed below the angle of mandible by the union of the **facial** and **retromandibular veins** and empties into the internal jugular vein in the neck below the hyoid bone (Fig. 6, 13, 14).

- The **facial vein** is usually referred to as superficial vein of the face. It begins from the **angular vein** formed by the fusion of the **supraorbital** and **supratrochlear veins** at the medial corner of the eye, and follows the course of the facial artery draining the corresponding areas of face (Fig. 12, 13, 14). Anterior to the masseter muscle it receives the **deep facial vein** draining the pterygoid plexus. Below the mandible it receives veins from the pharynx, palate, tongue, submandibular and thyroid glands, pierces the deep fascia and joins the **retromandibular vein**.

The facial vein communicates with the intracranial veins and deep veins of the face: with the **cavernous sinus** via the angular and superior ophthalmic veins; with the **pterygoid plexus** via the inferior ophthalmic, deep facial, and retromandibular veins.

- The **retromandibular vein** begins behind the neck of the mandible by the fusion of the **superficial temporal vein** and the **maxillary veins** (Fig. 6, 13, 14). By the **transverse facial vein** it drains the back of the face. It runs through the parotid gland, and below it forms two divisions: the anterior one connects with the facial vein; the posterior one connects with the posterior auricular vein to form the **external jugular vein**.

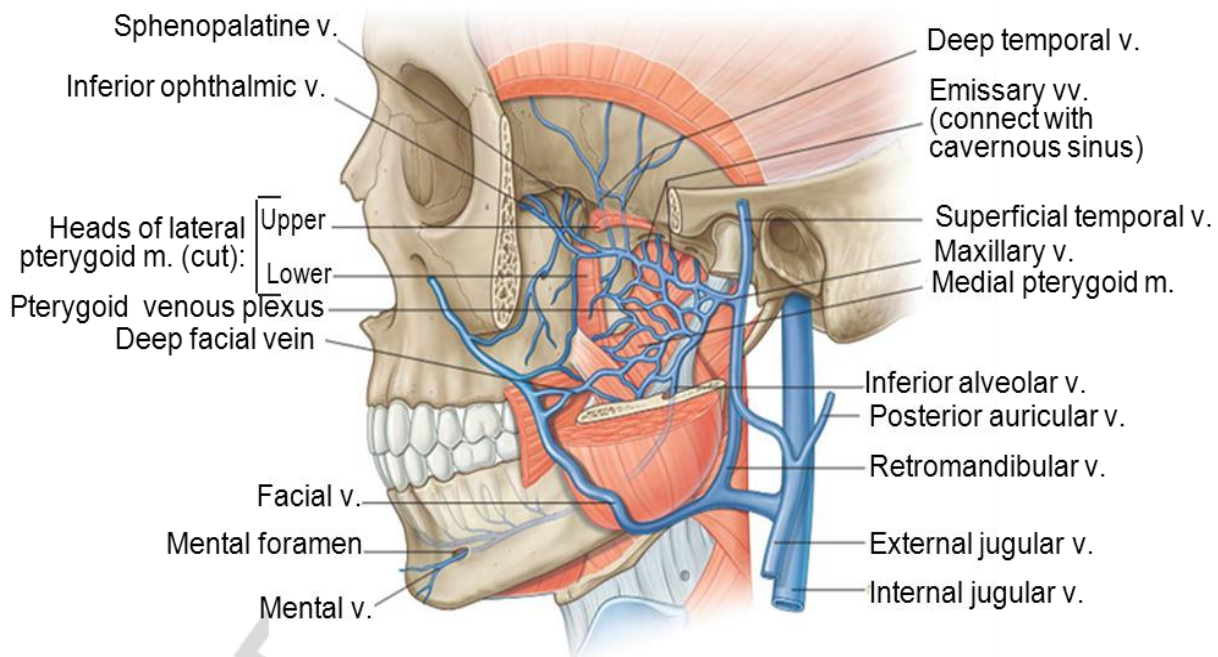


Рис. 14. Deep veins of the face: veins of the temporal and infratemporal fossae [3]

The **maxillary veins** are short vessels that run deep to the neck of mandible along the first part of the maxillary artery. The maxillary veins connect the pterygoid plexus to the retromandibular vein (Fig. 6, 7, 14). The **pterygoid plexus** surrounds the maxillary artery in the infratemporal fossa and mainly

drains the deep structures of the face supplied by the maxillary artery (parotid gland, temporomandibular joint, external and middle ear, dura mater of the middle cranial fossa, buccinator and masticatory muscles, upper and lower jaws, palate, walls of the nasal cavity).

The pterygoid plexus connects (1) with the *veins of orbit* via anastomosis with the inferior ophthalmic vein; (2) with the *cavernous sinus* via emissary veins of the cranial base; (3) with the *facial vein* via the deep facial vein and inferior ophthalmic vein.

2. The **pharyngeal veins** begin from the pharyngeal plexus on the external wall of the pharynx and open into the internal jugular vein above the greater horn of the hyoid bone (Fig. 6).

3. The **lingual vein** accompanies the lingual artery, drains the tongue and sublingual region.

4. The **superior thyroid vein** drains the upper part of the thyroid gland and the superior laryngeal vein.

5. The **middle thyroid vein** drains the lower parts of the thyroid gland and larynx, and the upper trachea. The superior, middle and inferior thyroid veins originate from the unpaired **thyroid plexus**.

6. The **sternocleidomastoid vein** drains the respective muscle.

7. The **vein of cochlear aqueduct** is the uppermost small tributary draining the internal ear. It emerges on the posterior border of the petrosal pyramid and empties into the superior bulb of the jugular vein.

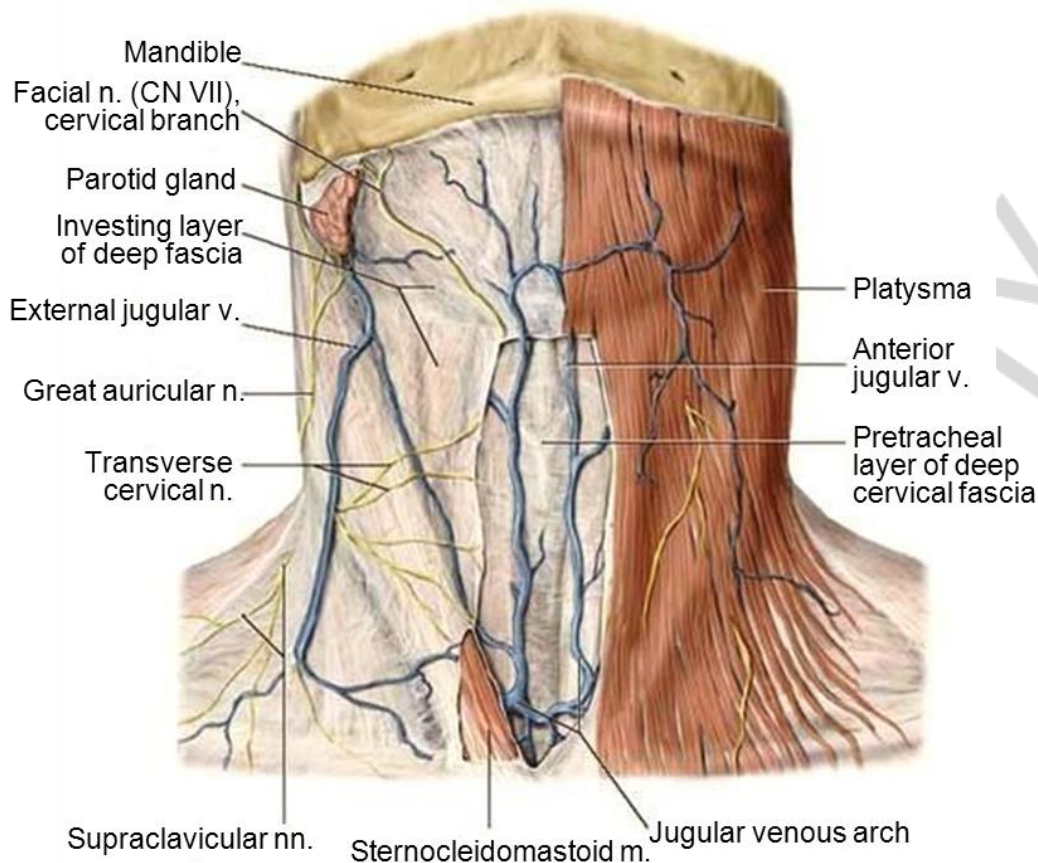


Рис. 15. Superficial veins of the neck [6]

SUPERFICIAL VEINS OF THE NECK

1. The **external jugular vein** largely drains the scalp, back of the face, including its deep region, and superficial tissues of the neck. It is formed at the level of the angle of the mandible by union of the **posterior auricular vein** (and often the **occipital vein**¹) with the posterior division of the **retromandibular vein** (Fig. 6, 13, 15). It passes downwards superficially to the sternocleidomastoid muscle (SCM) and opens into the **subclavian vein**. Its tributaries are the **anterior jugular vein (jugular venous arch)**, **suprascapular**, and **transverse cervical veins**.

2. The **anterior jugular vein** is commonly paired, originates in the subcutaneous tissue above the hyoid bone, and runs downwards between the midline and the SCM (Fig. 6, 15). It pierces the deep fascia of neck and in the suprasternal space connects with the same vein of the opposite side to form the **jugular venous arch**. The distal end of the anterior jugular vein turns laterally, posterior to the SCM, and joins the *external jugular vein* or opens directly into the *subclavian vein*.

¹ The occipital vein mainly drains into the vertebral or deep cervical vein.

The superficial and deep veins have extensive anastomoses at all levels of the neck.

SUMMARY OF VENOUS ANASTOMOSES IN THE HEAD

The three main pathways connecting the superficial and deep veins of the face are the following (Fig. 7, 12, 14):

- 1) The *nasofrontal vein* connects the *angular vein*, which is the *facial vein* tributary draining the maxillary region of the face, with the *ophthalmic veins* that, in turn, communicate with the *pterygoid plexus*;
- 2) The *deep facial vein* connects the *facial vein* (in the cheek area) and the *pterygoid plexus*;
- 3) The *retromandibular vein* draining the *pterygoid plexus* merges with the *facial vein* in the neck at the root of the common facial vein.

The anastomoses between the dural venous sinuses and extracranial veins can be grouped as follows (Fig. 7, 14):

- 1) The **cavernous sinus** anastomoses:
 - a. By numerous *emissary veins* of the cranial base with the *pterygoid plexus* in the infratemporal fossa (in the depth of the face);
 - b. By the *ophthalmic veins* with the *angular vein* and *facial vein tributaries* at the medial corner of the eye;
- 2) The **petrosal sinuses** (and through it the cavernous sinuses) via the *basilar venous plexus* communicate with the *internal vertebral plexus*.
- 3) The **dural sinuses of calvaria and posterior cranial fossa** (superior sagittal, transverse, sigmoid, occipital) connect through the *emissary veins* with the *veins of the scalp* and the *suboccipital venous plexus*;

CLINICAL NOTE: Numerous anastomoses of the veins of head, the lack of valves in many of them, changes in the intracranial and intravenous pressure make possible the bidirectional or retrograde (opposing gravity) flow of blood, which can cause the spread of infection from the superficial veins to the deep and intracranial veins, i.e. dural venous sinuses. The connections of the cavernous sinuses are the most clinically significant due to dangerous conditions developed in case of its infection (thrombosis). The veins draining the upper lip (so called “danger triangle”), nose, periodontal tissues, walls of the nasal cavity and paranasal sinuses through the facial, superior ophthalmic veins, and the pterygoid plexus are the most common pathways for spread of infection into the cavernous sinuses.

VEINS OF THE UPPER LIMBS

The veins of the upper limb are divided into superficial and deep groups. The **superficial veins** lie above the deep fascia and drain blood from the skin and subcutaneous tissue into the large deep veins. The **deep veins** drain the deep structures, such as bones, muscles, and joints. They follow the course of the ar-

teries, having the same names, and are generally paired (venae comitantes), except for the larger proximally located veins.

The blood from the fingers (digital veins) drains into both systems of veins: 1) the **dorsal metacarpal veins** and **dorsal venous network of hand**, which gives rise to superficial veins of the forearm; and 2) to the **palmar venous arches**², which gives rise to deep veins of the forearm: the **ulnar vein** arises from the **superficial palmar venous arch**; the **radial vein** arises from the **deep palmar venous arch**, draining the **palmar metacarpal veins**. The deep and superficial veins anastomose, especially within the hand and wrist.

SUPERFICIAL VEINS OF THE UPPER LIMBS

The superficial veins of the upper limb include the following: the dorsal metacarpal veins, dorsal venous network of hand, cephalic vein, basilic vein, median antebrachial vein, and median cubital vein (Fig. 16).

The dorsal metacarpal veins lying under the skin of the dorsum of hand communicate to form the **dorsal venous network of hand** that drains into the cephalic and basilic veins.

The **cephalic vein** originates at the base of the thumb (anatomical snuff-box), winds round the radial side to the anterior aspect of the forearm and ascends along the anterolateral surface of the forearm, elbow and arm. In the arm it runs along the lateral border of the biceps brachii muscle above the lateral bicipital groove, then in the deltopectoral groove, where it pierces the deep (claviopectoral) fascia and joins the proximal end of the *axillary vein*.

The **basilic vein** begins from the ulnar aspect of the dorsal venous network of hand and ascends anteriorly along the medial side of the forearm, cubital fossa, and lower arm, pierces the deep (brachial) fascia, follows further upward and joins with the *brachial veins*.

The **median antebrachial vein** originates in the wrist region from the venous plexus of the palm and empties into the basilic or median cubital vein.

The **median cubital vein** connects the cephalic and basilic veins in the cubital fossa; it is a large branch running usually upwards and medially. The median cubital vein is commonly used for venipuncture (puncture of a vein to draw blood or inject a solution). Besides, many small veins link the cephalic and basilic veins.

² The superficial and deep palmar venous arches are paired venae comitantes accompanying the corresponding arterial arches.

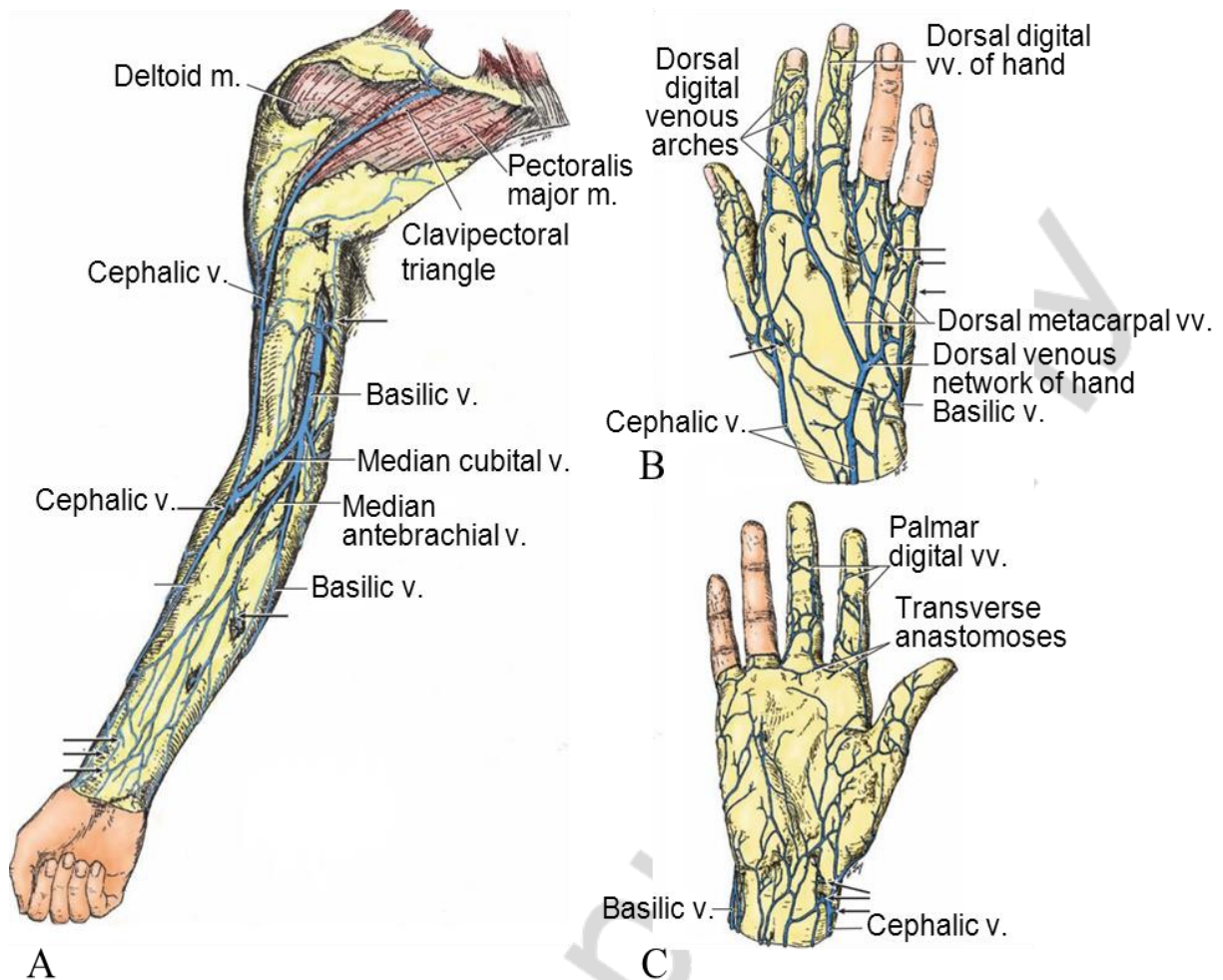


Рис. 16. Superficial veins of the upper limb:
 A and C — anterior view; B - posterior view; arrows show perforating veins [1]

DEEP VEINS OF THE UPPER LIMBS

The main deep veins of the upper limb are the *paired* deep and superficial venous palmar arches, radial vein, ulnar vein, anterior and posterior interosseous veins, brachial vein, and the *unpaired* axillary and subclavian veins. Tributaries of the deep veins are generally similar to branches of the corresponding arteries (Fig. 17).

The **deep and superficial venous palmar arches** give rise (as described above) to the deep veins of the forearm — the **radial and ulnar veins**, which join in the cubital fossa to form the **brachial vein**.

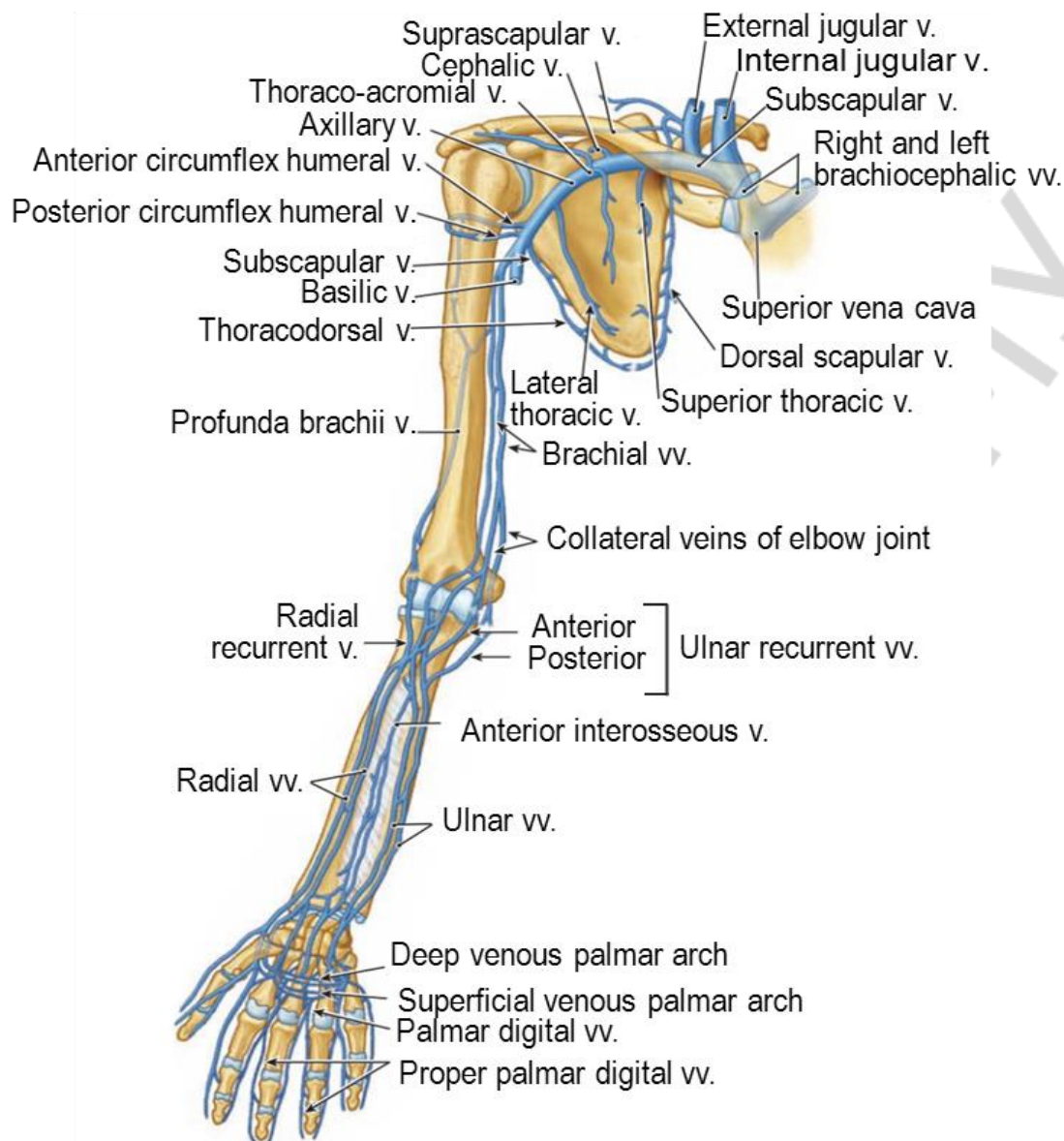


Рис. 17. Deep veins of the upper limb (anterior view) [1]

The **axillary vein** is formed at the lower border of the teres major muscle by the fusion of the two **brachial veins** and the **basilic vein** and passes in the axillary fossa medial to the axillary artery. The other tributaries are mostly the *same as branches of the axillary artery* — the **anterior and posterior circumflex humeral, subscapular, and lateral thoracic veins**. Besides, the axillary vein receives the subcutaneous veins: the **thoracoepigastric vein** from the anterolateral body wall and the **cephalic vein** from the upper limb, draining the shoulder region as well (Fig. 18).

The **subclavian vein** originates at the lateral border of the 1st rib as the continuation of the axillary vein. It runs under the clavicle in front of the anterior scalene muscle up to its medial border, where joins with the *internal jugular*

vein to form the *brachiocephalic vein*. The subclavian vein receives the **external jugular vein** from the neck, and often its tributary — the **anterior jugular vein**, the **dorsal scapular vein** and **pectoral veins** from the respective areas *supplied by the adjacent segments of the subclavian and axillary arteries*.

SYSTEM OF THE INFERIOR VENA CAVA

The **inferior vena cava (IVC)** is the largest venous vessel that drains veins collecting blood from the lower body (structures below the diaphragm): the lower back, the walls and organs of the abdominal and pelvic cavities, the lower limbs.

VEINS OF THE ABDOMEN

Two big veins, the **IVC** and **portal vein**, drain most blood from the organs and walls of the abdominal cavity. The smaller veins of the abdomen can be referred to as *visceral*, *parietal*, and *superficial* subcutaneous veins.

The *visceral veins* drain into both the IVC and the portal vein. The IVC tributaries correspond to the *paired visceral branches of the abdominal aorta* but include the hepatic veins as well. The portal vein tributaries mostly correspond to the *unpaired visceral branches of the abdominal aorta*.

The *parietal veins* of the superoposterior abdominal wall are drained into the IVC and, in part, into the SVC via the ascending lumbar veins. The major veins of the anterolateral wall carry blood into both caval systems: the **superior epigastric veins** empty into the **internal thoracic veins** (SVC system); the **inferior epigastric veins** — into the **external iliac veins** (IVC system). The epigastric veins anastomose with each other within the rectus sheath and communicate with the para-umbilical veins (portal system) around the umbilicus.

The *superficial veins* of the abdomen drain blood in three main directions (Fig. 18): 1) the **thoraco-epigastric veins** into the **axillary veins** (SVC system); 2) the **superficial epigastric** and **superficial circumflex iliac veins** into the **great saphenous** or **femoral veins** (IVC system); 3) the **para-umbilical veins** into the **portal vein** (the minor path in norm). The superficial veins have extensive connections with each other and with the deep veins. They can become enlarged during portal hypertension, when the venous flow through the liver is compromised.

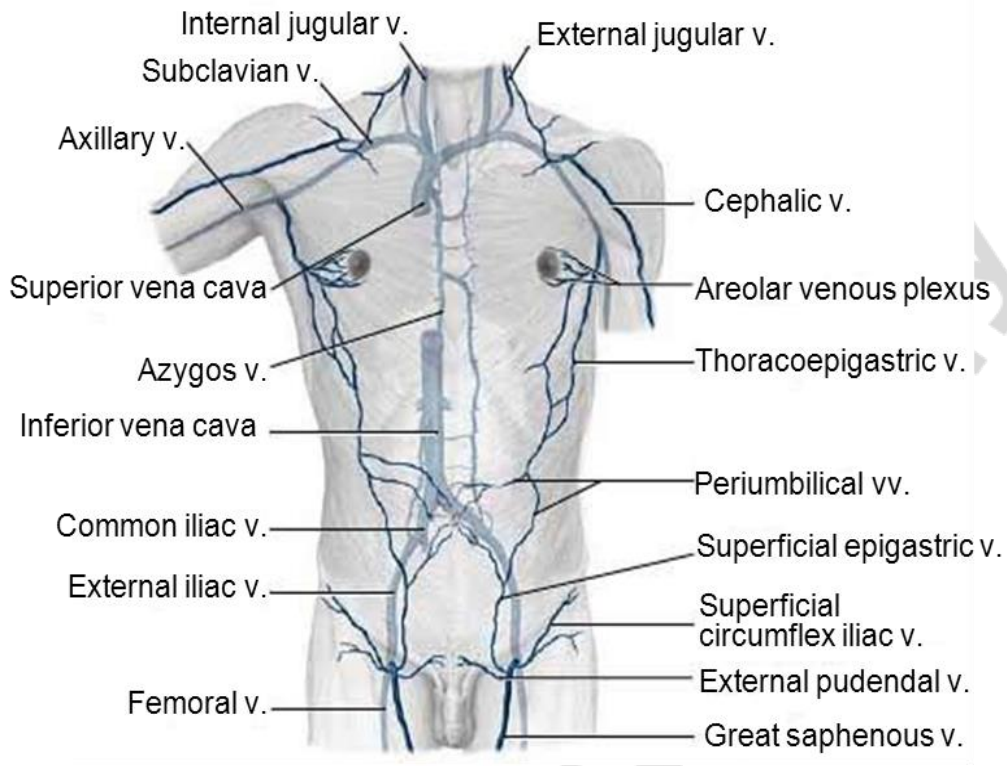


Fig. 18. Superficial veins of the anterior body wall [6]

INFERIOR VENA CAVA

The IVC is the largest vein in the body and does not have valves. It is formed by the union of the **right and left common iliac veins** at the level of the L5 vertebra right to the midline, inferior to the bifurcation of aorta and posterior to the right common iliac artery. The IVC ascends in the retroperitoneal space along the lumbar vertebrae right to the abdominal aorta. It is crossed in front by the root of the mesentery, horizontal part of the duodenum, and head of pancreas. It passes behind the liver, where receives the hepatic veins, and enters the thoracic cavity (T8 vertebral level) through the caval opening in the central tendon of the diaphragm. Almost immediately it empties into the right atrium.

The *parietal tributaries* of the IVC drain the superior and posterior abdominal walls (Fig. 19 A and B):

1) The **inferior phrenic veins** accompany the respective arteries and empty into the IVC right below the diaphragm;

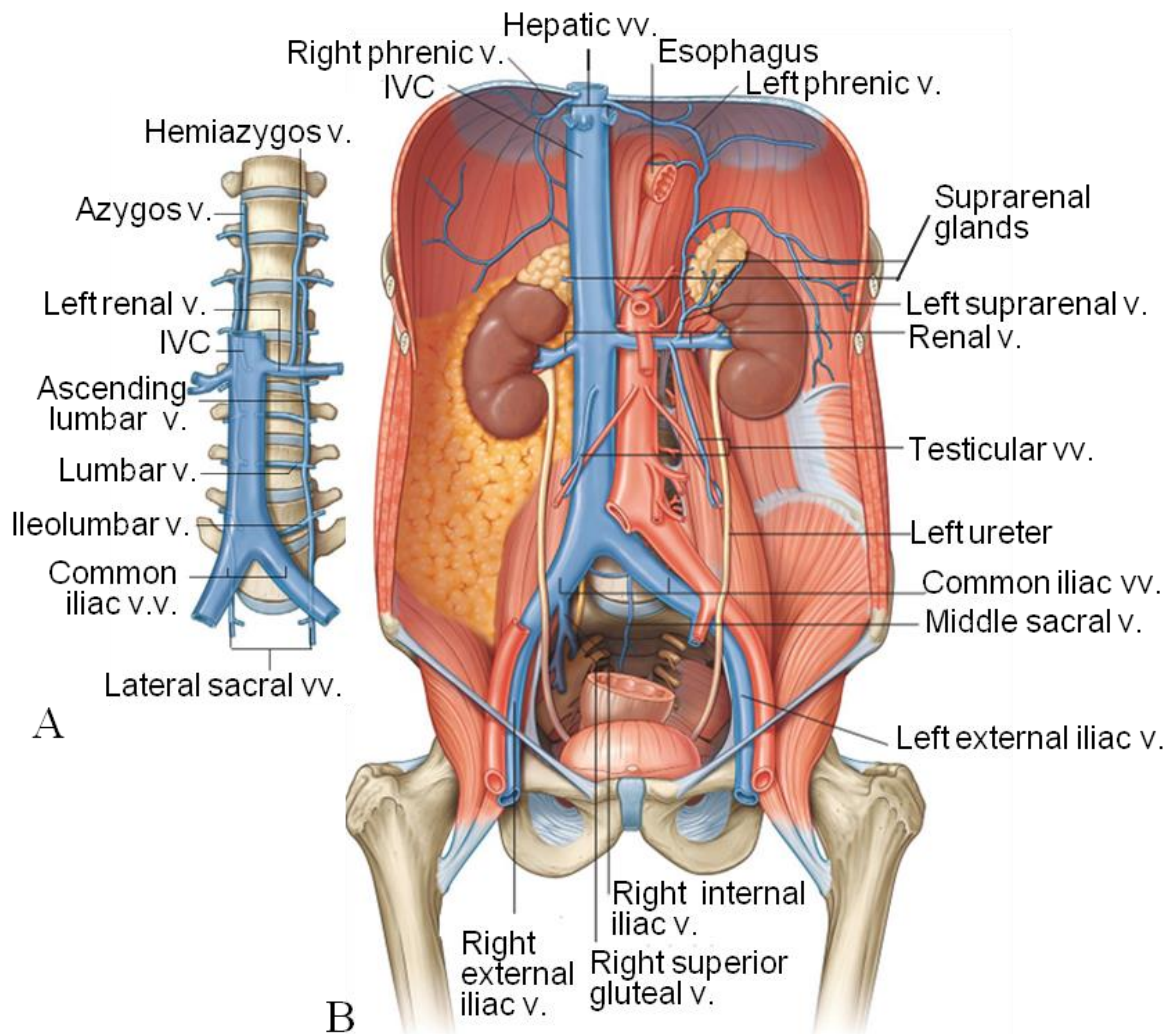


Fig. 19. Inferior vena cava (IVC) and tributaries [3]

2) The **lumbar veins** (3-4 on each side) connect with the **vertebral plexuses** and via them drain the lower back, vertebral column, and spinal cord. On the sides of the vertebrae the lumbar veins are connected by the **ascending lumbar veins**. The ascending lumbar veins, linked with the lateral sacral veins below, pass through the diaphragm and form the **azygous vein** on the right and the **hemiazygous vein** on the left.

The *visceral tributaries* of the IVC are the 1) **right and left renal veins**, 2) **right testicular/ovarian vein**, 3) **right suprarenal vein**, and 4) **hepatic veins** (Fig. 19 B).

The **renal veins** pass anterior to the renal arteries. The left renal vein is longer than the right one; it runs in front of the aorta to reach the IVC. The **left gonadal vein** and **left suprarenal vein** usually drain into the left renal vein.

The **suprarenal veins** are single vessels; each originates from the hilum on the anterior surface of the suprarenal gland. The right vein empties into the IVC, the left one — into the left renal vein.

The **testicular/ovarian veins** begin as small veins draining gonads, which anastomose around the distal ends of the testicular or ovarian arteries to form the **pampiniform plexuses** (Fig. 20, 21). The plexus in males is a part of the spermatic cord from the testis up to the superficial inguinal ring. In females it passes from the ovarian hilum through the suspensory ovarian ligament. Ascending along the artery the small veins unite and end as a single vessel. The right testicular/ovarian vein empties into the IVC, the left one — into the left renal vein.

The **hepatic veins** (usually 3) pass through the hepatic parenchyma and open into the IVC when the latter passes in the groove on the posterior surface of the liver.

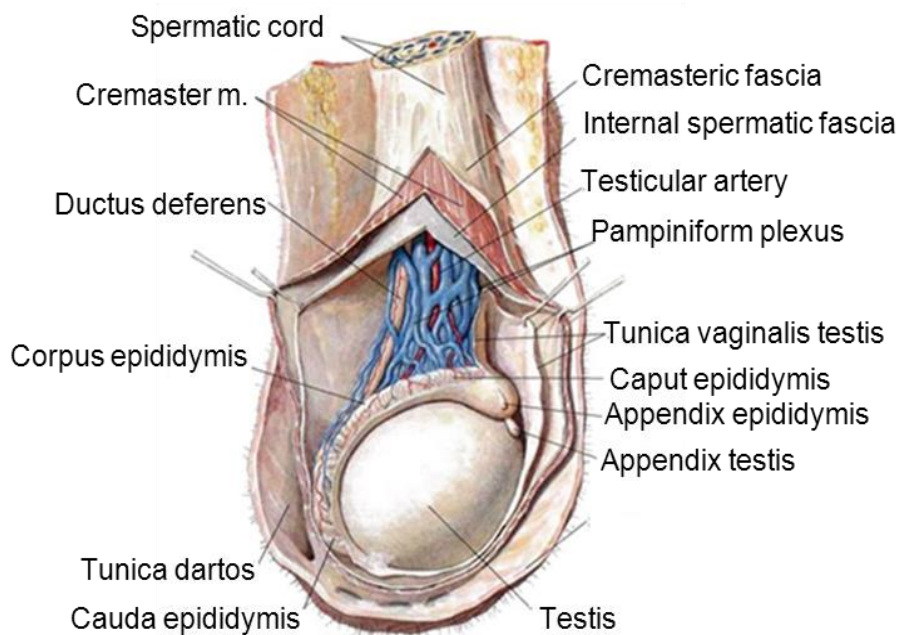


Fig. 20. Pampiniform plexus of the testicular vein

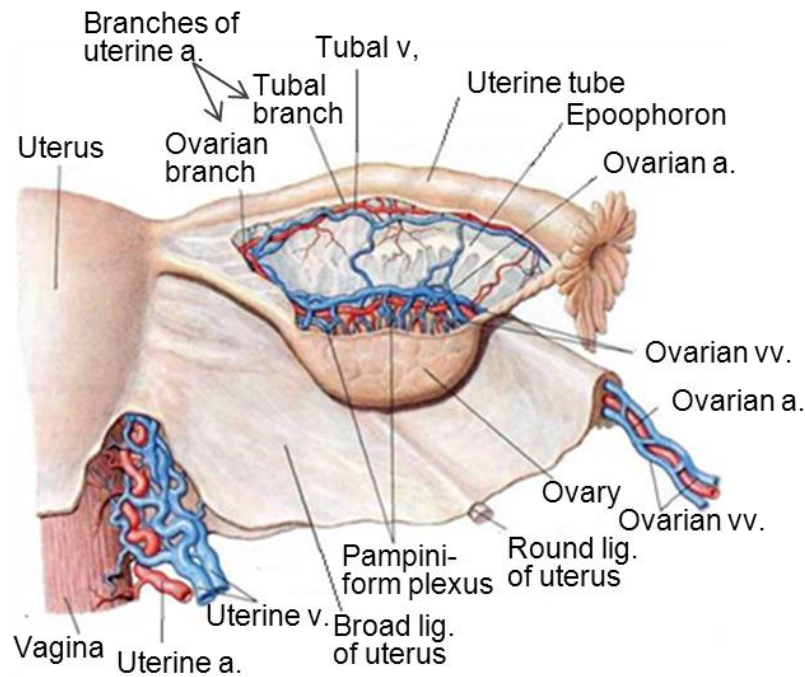


Fig. 21. Arteries and vein of the uterus, uterine tube, and ovary

PORTAL VEIN

The **portal vein** is the main vessel of the **portal venous system**. In this system blood passes through 2 systems of capillaries: the first is in the organs drained by the portal vein: the abdominal part of the alimentary tract, gallbladder, pancreas, and spleen; the second is in the liver. The vessels of the portal system do not possess valves. The portal vein carries to the liver substances absorbed from the intestine (except lipids), hormones (insulin, glucagon, somatostatin) from the pancreas, bilirubin (erythrocytes degradation product) and antibodies from the spleen. The tributaries of the portal venous system by their names and anatomical relations *mainly correspond to branches of the celiac trunk and mesenteric arteries* (Fig. 22).

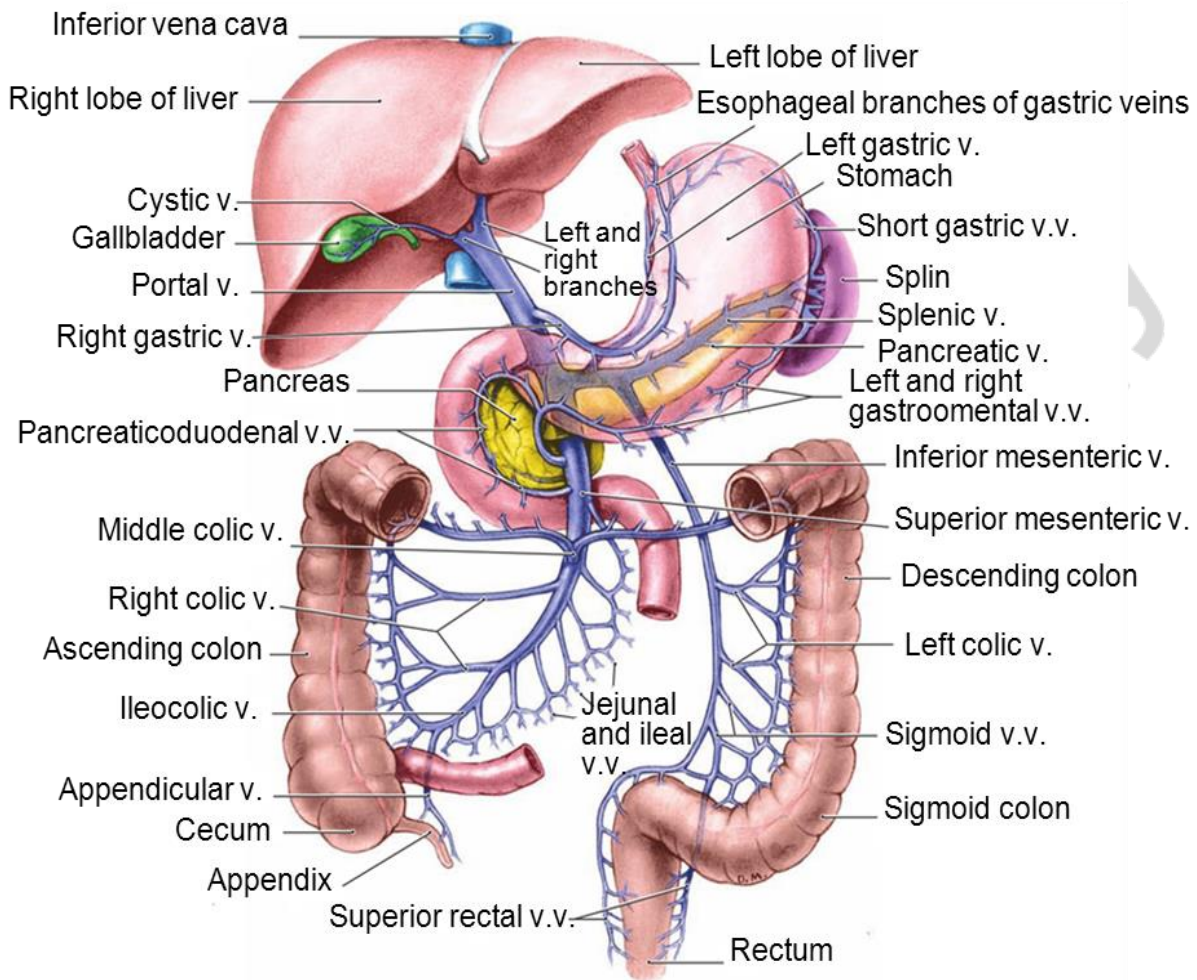


Fig. 22. Arteries and vein of the uterus, uterine tube, and ovary [1]

The portal vein is formed behind the neck of the pancreas (level of the L2 vertebra) and drains the 3 big veins — the **splenic vein**, **superior mesenteric vein (SMV)**, and **inferior mesenteric vein (IMV)**. Usually the splenic vein and SMV join to form the portal vein, whereas IMV vein empties into the splenic vein. The portal vein courses superiorly to the hepatic porta; in the hepatoduodenal ligament it lies between the bile duct (on the right) and proper hepatic artery (on the left). The portal vein receives the following *tributaries*:

- The smaller tributaries are the **right and left gastric veins**, **cystic veins** from the gallbladder, **pancreatico-duodenal veins** (superior posterior), and **para-umbilical veins**. The latter are 2-3 small veins, which pass from the anterior abdominal wall along the course of the round ligament of liver and connect with the left branch of the portal vein.
- The **splenic vein** lies inferior to the splenic artery and drains the spleen, portions of the stomach (by the **left gastro-omental vein** and **short gastric veins**), body and tail of the pancreas.

- The **SMV** lies to the right of the corresponding artery and drains portions of the stomach via the **right gastro-omental vein** and the same areas (the mid-gut derivatives) that are supplied by the superior mesenteric artery: the head of pancreas, lower duodenum, jejunum and ileum, cecum with the appendix, ascending colon, and 2/3 of the transverse colon, via the **pancreatico-duodenal, ilioocolic, right and middle colic veins**.
- The **IMV** originates in front of the left common iliac vessels. It ascends retroperitoneally left to the duodeno-jejunal flexure, and unites with the splenic vein behind the pancreas. It drains the hindgut derivatives: descending and sigmoid colon, and the upper portion of the rectum, via the **left colic, sigmoid, and superior anorectal (rectal) veins**.

Just before entering the hepatic porta the **portal vein** divides into the **right and left branches**, supplying the functional lobes (parts) of the liver. Within the liver ramifications of the portal vein follow the structural pattern of the organ, as segmental, intrasegmental, interlobular veins, and end by the capillaries, **venous sinusoids**, in the hepatic lobule. The venous sinusoids empty into the **central vein**, which carries venous blood outside the hepatic lobule. Eventually blood leaving the liver is collected into the **hepatic veins** (usually 3) and drains into the IVC. This way the blood is returned from the **portal system** into the **systemic circulation**.

CLINICAL NOTE: If blood cannot traverse the hepatic sinusoids (e.g., cirrhosis of liver), it backs up into the portal system and causes portal hypertension. The large amount of venous blood, which cannot be returned to the heart directly - through the liver, hepatic veins and IVC, finds its way to the heart through veins (deep and superficial) connecting the portal system with the systems of the superior or/and inferior vena cava.

VEINS OF THE PELVIS

The veins of the pelvis and perineum course with the respective arteries and generally have the same names and topography. The exception is the fetal **umbilical vein**, which, unlike the umbilical artery, passes through the abdomen from the umbilicus to the porta hepatis to join the portal vein; in adults it becomes the *round ligament of liver*. The iliolumbar vein usually joins the common iliac vein, as the respective artery is a branch of the internal iliac artery.

COMMON ILIAC VEIN

The common iliac vein is formed anterior to the sacro-iliac joint by the fusion of the external and internal iliac veins (**Fig. 19, 23**). The short **right common iliac vein** ascends medial and then posterior to the right common iliac artery. The **left common iliac vein** is longer; passing medial to the respective artery it crosses the L5 vertebra, receives the **median sacral veins**, and unites with the right common iliac vein to form the **IVC**. The **iliolumbar vein** is a tributary

of the common iliac vein of each side. The common iliac vein, as well as the inferior vena cava does not have valves.

EXTERNAL ILIAC VEIN

The **external iliac vein** is the continuation of the femoral vein after it passes from the thigh under the inguinal ligament. The external iliac vein ascends along the pelvic brim medial to the external iliac artery. At the sacro-iliac joint it unites with the **internal iliac vein** to form the common iliac vein. Right above the inguinal ligament it receives the main tributaries: the **inferior epigastric vein, deep circumflex iliac vein, and pubic vein.**

INTERNAL ILIAC VEIN

The **internal iliac vein** is the main vein that drains the pelvis: it collects blood from the walls and organs of the pelvis, gluteal region, perineum, and external genital organs (Fig. 23).

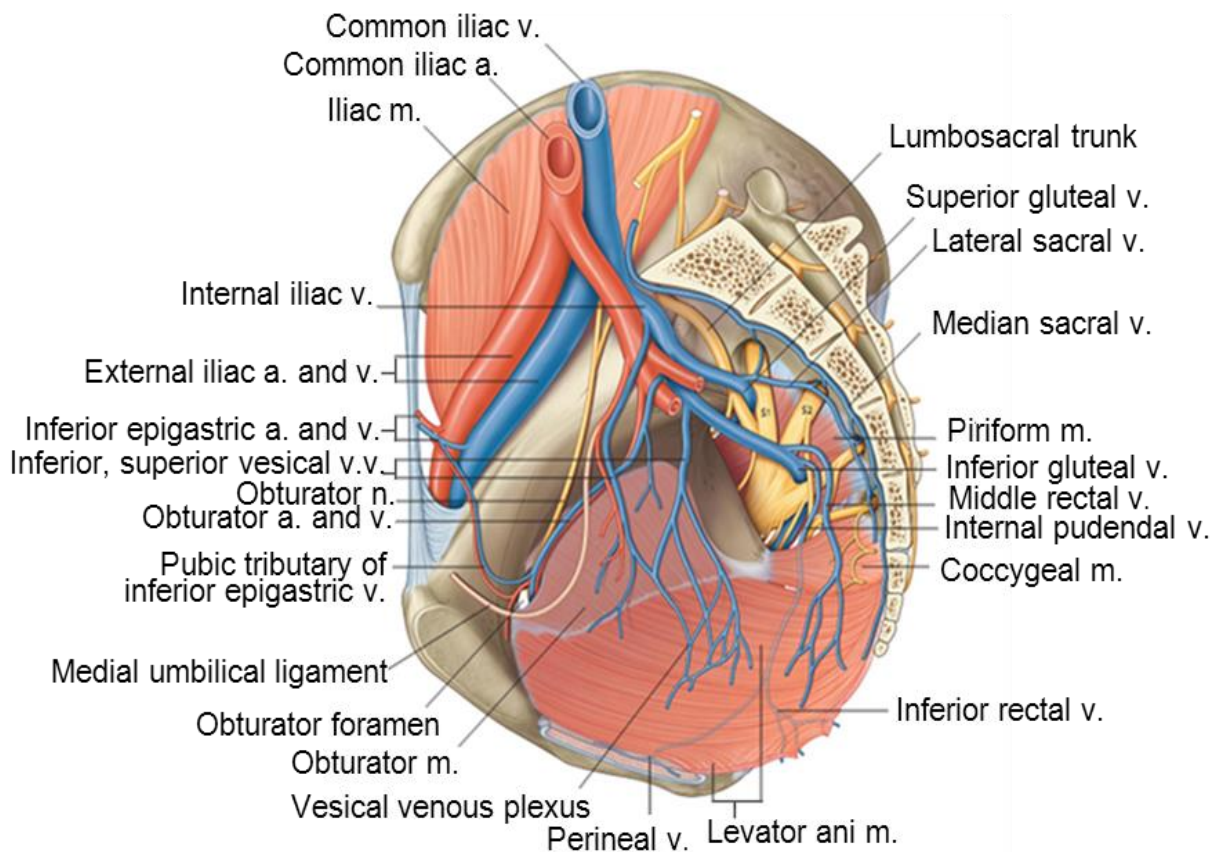


Fig. 23. Vein of the pelvis [3]

The internal iliac vein is formed at the upper margin of the greater sciatic foramen by the fusion of its *parietal tributaries*: the **superior and inferior glu-**

teal veins, internal pudendal vein, obturator vein (all the listed veins are paired outside the pelvis where they have their origins), and the **lateral sacral veins**. The **median sacral vein** joins the left common iliac vein. The **sacral veins** drain the **sacral venous plexus** on the anterior surface of the sacrum and through it communicate with the *internal vertebral plexus*.

The *visceral tributaries* of the internal iliac vein are the **middle anorectal (rectal), vesical, veins of prostate** (in male), **uterine and vaginal** (in female) **veins**. They drain the venous plexuses surrounding the expandable pelvic organs: **anorectal (rectal) and vesical plexuses**, in men — **prostatic plexus**, in women - **uterine and vaginal plexuses**. The gonads are drained mainly by the gonadal veins — **testicular or ovarian veins**, into the *inferior vena cava*.

The **anorectal (rectal) venous plexus** is drained into the internal iliac veins by two pairs of veins - **middle anorectal (rectal) veins** directly and **inferior anorectal** (syn. **rectal**) **veins** via the internal pudendal veins. Besides, it is drained into the portal system by the unpaired **superior rectal vein** (Fig. 24).

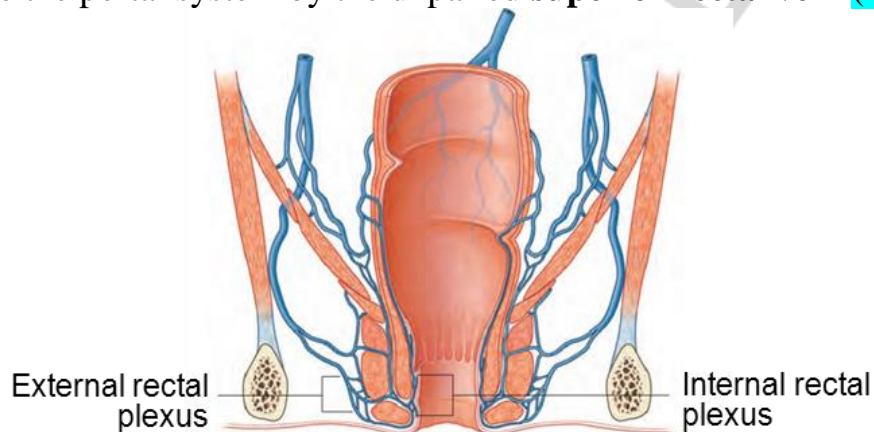


Fig. 24. Anorectal venous plexus [3]

ADVANCED: The inferior part of the anorectal plexus around the anal canal is divided into the internal and external **anorectal (rectal, or haemorrhoidal) plexuses**. The **internal plexus** lies in the submucosa of the upper part of the anal canal (above the pectinate line); it connects with the veins of the anal columns — roots of the superior rectal vein. The **external plexus** lies in the submucosa at the junction between the anal canal and skin around the external anal sphincter. The enlargement of veins of the anorectal plexus results in hemorrhoids — internal or external, respectively.

The erectile tissue of the penis or clitoris drains via the single **deep dorsal vein of penis/ clitoris** into the prostatic venous plexus (in men) and vesical venous plexus (in women). This vein passes between the two dorsal arteries of penis/clitoris and under the pubic symphysis enters the pelvic cavity to join the corresponding plexus. The subcutaneous **superficial dorsal vein of penis/ clitoris** is a tributary of the right or left **external pudendal vein**.

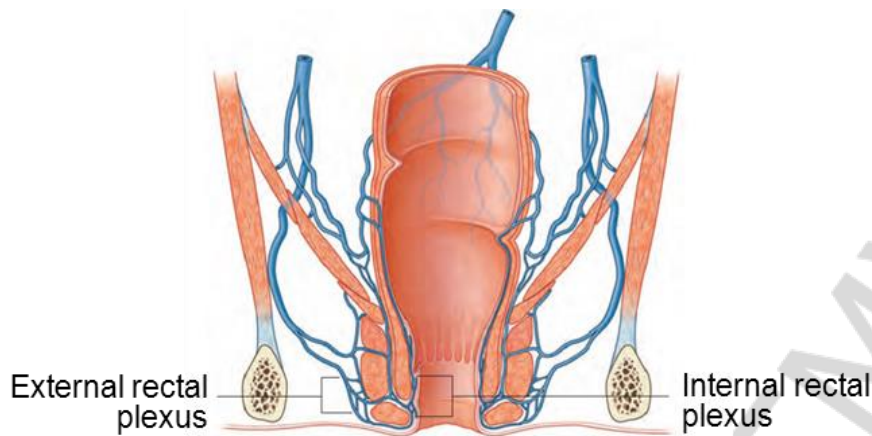


Fig. 24. Rectal venous plexus [3]

VEINS OF THE LOWER LIMB

Similar to the veins of the upper limb both *deep* and *superficial* veins are found in the lower limb. The deep, commonly paired, veins accompany the arteries, have the same names, and carry blood to the unpaired popliteal and femoral veins and then to the external iliac vein (Fig. 25). The superficial veins of the lower limb have extensive interconnections (perforating veins) with the deep veins but largely drain into the great and small saphenous veins.

The **femoral vein** is the main vessel draining the lower limb. Some blood from the upper thigh is drained via obturator and gluteal veins to the internal iliac vein.

DEEP VEINS OF THE LOWER LIMB

The *deep veins* of the leg arise from the plantar veins and deep dorsal veins of the foot. The **lateral plantar veins** (arising from the plantar venous arch), the **medial plantar veins**, and the **plantar venous network** drain the sole into the **posterior tibial vein**, which further receives tributaries from the posterior leg and the **fibular vein**. The **dorsalis pedis veins** accompanying the *dorsalis pedis artery* carry blood to the **anterior tibial vein**.

The **popliteal vein** is formed by fusion of the anterior and posterior tibial veins, and collects blood from the **genicular veins** around the knee joint. In the popliteal fossa the popliteal vein lies superficial to the popliteal artery. Entering the adductor canal it becomes the **femoral vein**. In the upper part of the femoral triangle the femoral vein receives the subcutaneous **great saphenous vein** and the major tributary, the **deep femoral vein (profunda femoris vein)**, which drains the deep thigh structures — muscles, femur and hip joint.

In the upper thigh the femoral vein lies medial to the femoral artery. It passes under the inguinal ligament through the vascular space and enters the abdominal cavity as the **external iliac vein**.

SUPERFICIAL VEINS OF THE LOWER LIMB

The veins on the dorsum of the foot (dorsal digital veins draining into dorsal metatarsal veins, dorsal venous arch and network of foot) drain largely into the superficial veins but also into the deep veins of the leg. The main *superficial veins* of the lower limb are the great and small saphenous veins (Fig. 26).

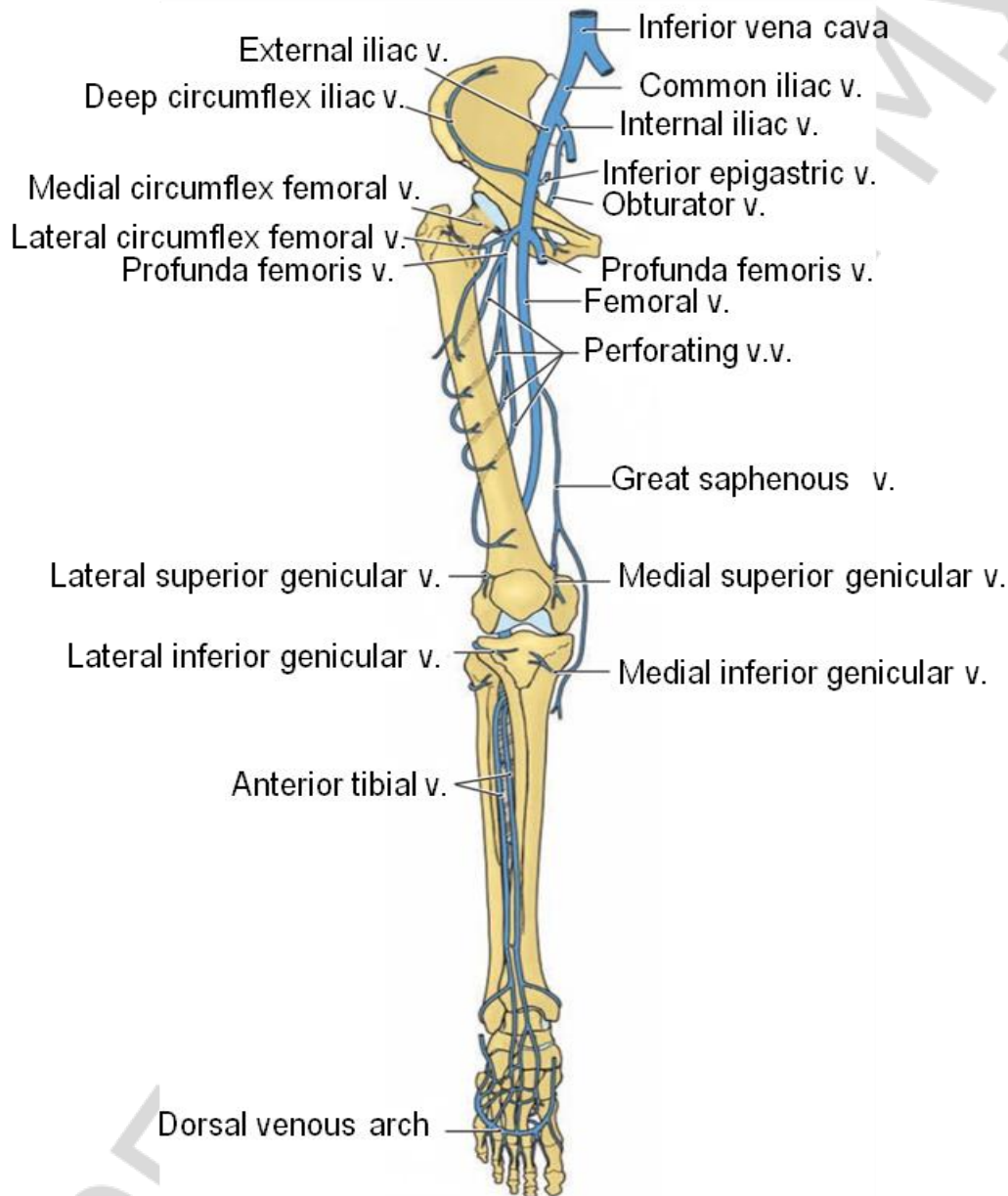


Fig. 25. Deep veins of the lower limb: anterior view [1]

The **small (short) saphenous vein** arises from the **dorsal venous arch** behind the lateral malleolus, ascends along the posterolateral aspect of the leg and piercing the deep fascia terminates in the **popliteal vein**.

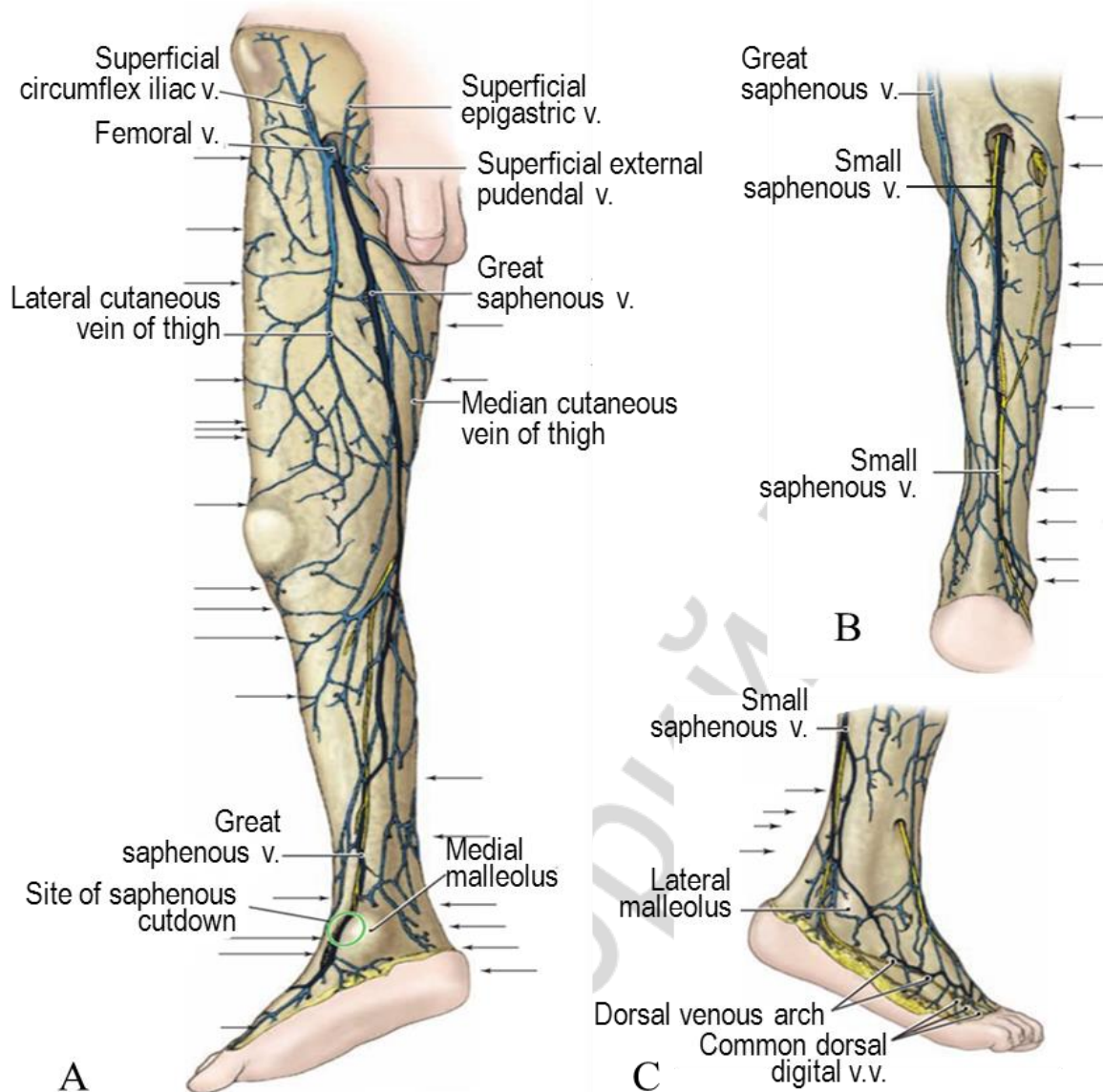


Fig. 26. Superficial veins of the lower limb: A - anteromedial view; B - posterior view; C — lateral view. Arrows indicate sites where perforating veins penetrate deep fascia [1]

The **great saphenous vein**, the longest vein in the body, arises on the medial side of the dorsum of the foot and courses in front of the medial malleolus upward along the medial aspect of the leg and anteromedial aspect of the thigh. It drains into the **femoral vein** piercing the cribriform fascia in the *saphenous hiatus* (fossa ovalis femoris). On its way the great saphenous vein receives tributaries from the skin and subcutaneous tissue of the leg and thigh. The tributaries of its proximal end, the **external pudendal**, **superficial circumflex iliac**, and **superficial epigastric veins**, drain superficial structures of the perineal area, external genitalia, and lower anterior abdominal wall adjacent to the inguinal region.

PORTOCAVAL AND CAVO-CAVAL ANASTOMOSES

Anastomoses (connections) between tributaries of the portal vein and tributaries of the SVC or/and IVC, or between only caval tributaries, serve as alternative routes of venous blood to the heart in case of impairment of regular blood flow.

The important **portocaval (porto-systemic) anastomoses** are as follows:

1. The esophageal anastomosis in the upper part of the abdominal cavity: the **esophageal veins** of the lower esophagus drain 1) into the **portal vein** via the left gastric vein and 2) into the **SVC** via the azygos system. *(These veins can dilate and form esophageal varices. Rupture of the varices causes dangerous bleeding.)*

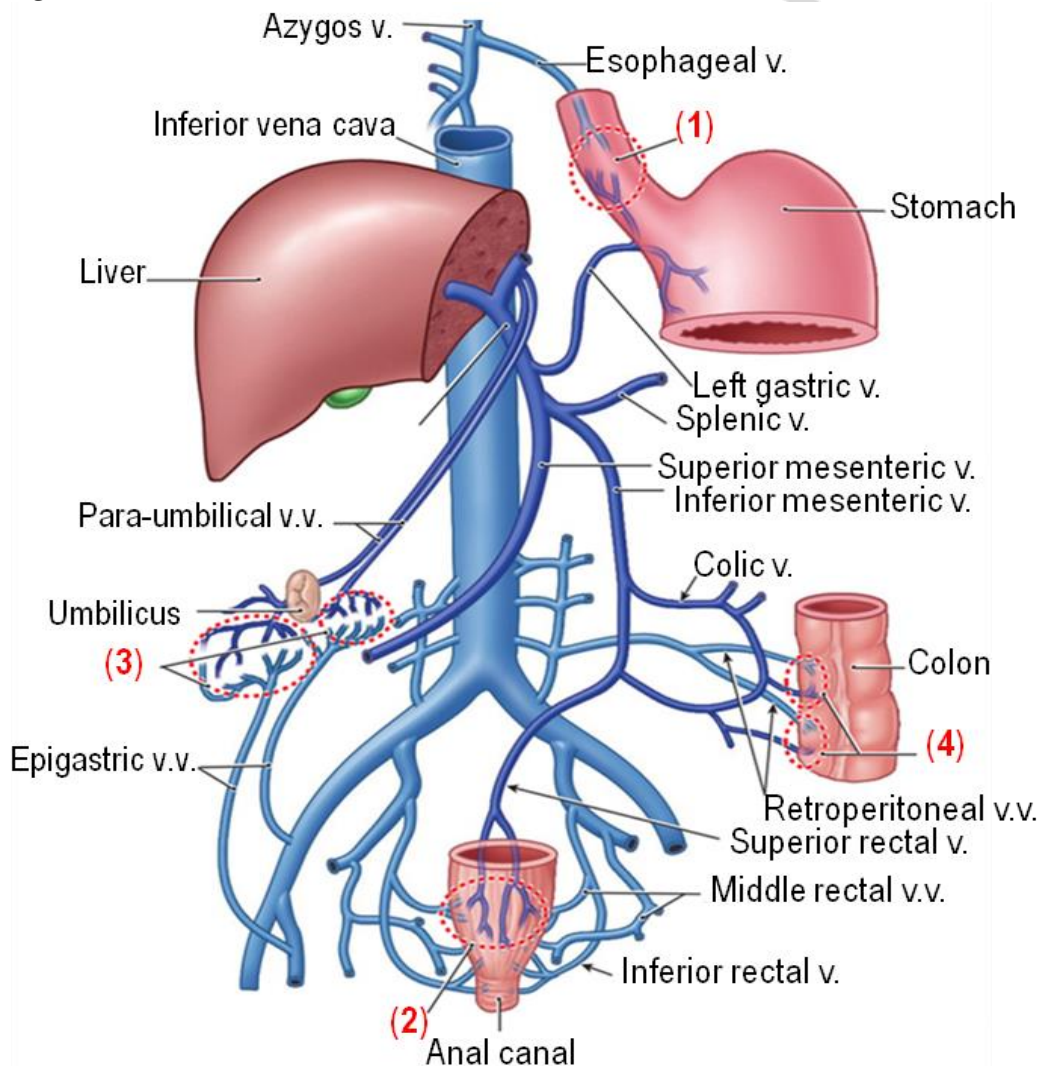


Fig. 27. Scheme of the portocaval anastomoses: 1 - esophageal anastomosis; 2 — rectal anastomosis; 3 - paraumbilical anastomosis, 4 - retroperitoneal anastomosis [1]

2. The rectal anastomosis in the lower part of the abdominal cavity: the **rectal venous plexus** is drained 1) into the **portal vein** via the superior rectal

vein and then the inferior mesenteric vein, and 2) into the **IVC** via the middle and inferior rectal veins (the latter are the tributaries of the internal pudendal veins), then the internal and common iliac veins. (*Dilated veins around the rectum and anal canal are hemorrhoids.*) **esophageal anastomosis**

3. The paraumbilical anastomosis in the anterior abdominal wall: the interconnecting **superficial** and **deep veins** can drain into the SVC, the IVC, and the portal system:

- 1) to the **SVC**: via the superior epigastric veins, then the internal thoracic and brachiocephalic veins; via the thoraco-epigastric veins, then the axillary, subclavian and brachiocephalic veins;
- 2) to the **IVC**: via the inferior epigastric veins, then the external and common iliac veins; via the superficial epigastric veins, then the femoral/great saphenous veins, and further external and common iliac veins;
- 3) to the **portal vein**: via the para-umbilical veins.

(*Being dilated due the portal hypertension the superficial veins radiating from the umbilicus form “caput medusae”.*)

4. The retroperitoneal anastomosis in the posterior abdominal wall: venous vessels of the retroperitoneal walls of the ascending and descending colon can drain 1) into the **portal system** via the right and left colic and then the superior and inferior mesenteric veins and 2) into the **IVC** via the lumbar veins.

Cavo-caval anastomoses are connections between the tributaries of the IVC and SVC. They become important in returning blood to the heart in case of obstruction of one of these veins (e.g. congenital or by a tumor). The main sites of anastomoses between the caval systems are

- *the paraumbilical region* — between the inferior and superior epigastric veins; between the superficial epigastric and thoraco-epigastric veins (described above in portocaval anastomoses);
- *the posterior wall of the body*:
 - the **ascending lumbar veins** can drain 1) into the **IVC** via the lumbar veins and 2) into the **SVC** via the azygos and hemiazygos veins;
 - the **vertebral venous plexuses** drain 1) into the **SVC**: via the deep veins of the neck (vertebral and deep cervical veins), then the brachiocephalic veins; via the posterior intercostal veins, then the azygos system; and 2) into the **IVC**: via the lumbar veins; via the sacral and then iliac veins.

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