INTRODUCTION

Venous infarction of brain comprises only 1% of all strokes [1]. Many predisposing conditions such as dehydration, coagulopathies, pregnancy, trauma, surgical interventions, inherited collagen disorders, and autoimmune vascular diseases may result in cerebral vein thrombosis. Fortunately not all of veins lead to severe complications. However, in case of clinical manifestations developed, diagnosis must be done immediately in order to investigate and treat possible reasons. This chapter aims to present anatomical configuration of cerebral venous system regarding possible significant origin of “stroke.”

DURAL VENOUS SINUSES

The dural sinuses are large endothelial-lined trabeculated channels that collect cerebral blood from the superficial, deep, and posterior fossa and drain into the internal jugular vein at the level of the jugular bulb (Fig. 5.1) [2]. These sinuses, which lie between the superficial (periosteal) and deep (meningeal) layers of the dura mater, also excrete cerebrospinal fluid (CSF) via arachnoid granulations (i.e., Pacchionian granulations) that emerge from the subarachnoid space [3]. These arachnoid granulations (villi) are commonly found around the superior sagittal and transverse sinuses [1]. Furthermore, cavernous sinuses (CS), which are paired dural venous sinuses, contain cranial nerves, arteries, and veins.

Superior Sagittal Sinus

The superior sagittal sinus (SSS), which is the longest dural sinus, lies along the superior edge of the falx cerebri, which is attached to the crista galli at the interhemispheric space just underneath the cranial vault. The SSS originates from the anterior part of the frontal lobe at the foramen caecum and drains into the torcular herophili [4]. Contact with the SSS leads to the development of an impression on the frontal and parietal bone.

The SSS enlarges posteriorly due to tributaries from cortical veins and arachnoid granulations. Concurrently, emissary veins carry diploic blood into the SSS. Thus, the posterior portion of the SSS is more visible in the venous phase of digital subtraction angiography (DSA) and magnetic resonance venography (MRV). The radiological appearance of the SSS is curvilinear with an enlarged line in the sagittal view and a reverse triangular shape in the coronal view. A rudimentary view of the anterior one-third portion of the SSS has been well characterized [5].

Inferior Sagittal Sinus

The inferior sagittal sinus (ISS) originates from the inferior edge of the anterior one-third portion of the falx cerebri and lies within the interhemispheric spaces. This relatively small sinus collects anterior pericallosal veins [3]. The ISS has a curvilinear shape like the SSS. The ISS joins with the great cerebral vein (i.e., vein of Galen) at the level of the falcotentorial junction, which both drain into the straight sinus [5].

Straight Sinus

The straight sinus (SS) originates from the falcotentorial junction via the union of the great cerebral vein and the ISS. The SS receives veins from the falx cerebri, tentorium cerebelli, and adjacent brain parenchyma. The SS drains into the torcular herophili together with the SSS [3]. As a variation, the SS may also drain into the transverse sinus; this variation tends to occur more frequently on the left side [1].
I. ANATOMY AND PHYSIOLOGY

FIGURE 5.1  Magnetic resonance venography of brain with lateral (A), oblique (B), and anteroposterior (C) views. Superior sagittal, straight, and occipital sinuses join at the point of torcular herophili. Then they drain into transverse, sigmoid sinuses and internal jugular vein orderly. Superficial middle cerebral vein makes anastomosis to superior sagittal sinus via vein of Trolard, to transverse sinus via vein of Labbé, and to cavernous sinus via sphenoparietal sinus. Intercavernous plexus and clival plexus also make connection between two cavernous sinuses.
Transverse (Lateral) Sinuses

The transverse (lateral) sinuses (TS) originate from the torcular herophili and drain into the sigmoid sinuses. The TS are located at the posterior edge of the tentorium cerebelli. Like the SSS, the TS also absorb CSF via arachnoid granulations. The TS are mostly asymmetric; the right TS tends to be larger [3]. Radiological view of hypoplastic TS or absence of TS should differentiate from TS thrombosis.

Torcular Herophili (Confluens Sinuum)

The torcular herophili, which are also known as the confluence of sinuses (confluens sinuum), represents the crossroads of the SSS, ISS, TS, and the occipital sinus, when present [3]. Anatomical localization of the torcular herophili is varied. The torcular herophili appear as an asymmetric pouch in the radiological view [5].

Sigmoid Sinuses

Sigmoid sinuses are so named due to their S-shaped curves extending from the lateral edge of the tentorium cerebelli to the jugular bulb. Asymmetry can be seen in accordance with asymmetry in TS [3].

Cavernous Sinuses

These complex large sinuses are about 2 cm long and 1 cm wide including trabeculations and contain important vessels and cranial nerves. Anatomically placed laterally to the sella turcica both CS are connected by intercavernous venous plexus at anterior and posterior edge of sella turcica and also by clival venous plexus [6].

The main tributaries of the CS are the superior and inferior ophthalmic veins and the sphenoparietal sinuses. Thus, the CS collect blood from not only the inferior parts of the frontal and parietal lobe but also the orbital cavity [4]. Sphenoparietal sinuses are anastomotic vein, which are placed on lesser sphenoid wing and make connection between CS and superficial middle cerebral vein (Sylvian vein) and also receive veins of temporal pole. The CS also receive tributaries from the skull base via the superior and inferior petrosal sinuses [3].

Cavernous segment of internal carotid artery enters in CS and runs posteriorly to superior (posterior ascending segment), then turns anteriorly in middle part of CS (horizontal segment) and before exit from CS runs to superior (anterior ascending segment) [6].

Oculomotor nerve (CNIII), trochlear nerve (CNIV), and ophthalmic divisions of trigeminal nerve (CNVI) attach to lateral wall of CS and leave intracranial space via superior orbital fissure. Maxillary divisions of trigeminal nerve (CNV2) also attach to the lateral wall of CS, however, exit extracranial space via foramen rotundum. Abduccens nerve (CNVI) is in middle part of CS, which is placed laterally to the ICA [6].

Superior and Inferior Petrosal Sinuses

The superior petrosal sinuses (SPS) are located between the petrous part of the temporal bone and anterolateral edge of the tentorium cerebelli. The SPS connect the CS to sigmoid sinuses and less frequently to TS. The inferior petrosal sinuses (IPS) lie on the petro-occipital fissure and drain the CS into the jugular bulb via the clival venous plexus [3].

Occipital Sinus

The occipital sinus, which is the smallest dural venous sinus, runs along the inner surface of the occipital bone. The occipital sinus is attached to the posterior margin of the falx cerebelli and receives tributaries from the margins of the foramen magnum. It may anastomosis with the sigmoid sinuses and posterior internal vertebral plexus that drain into the torcular herophili. The occipital sinus is an important vascular structure during posterior fossa surgery. Variations in the occipital sinus, such as double or oblique occipital sinuses or the absence of the occipital sinus, are observed in rare cases [7].

CEREBRAL VEINS

Cerebral veins accompany arteries in the subarachnoid space. Unlike veins in other parts of the body, cerebral veins do not have valves. Thus, bidirectional flow is possible in cerebral veins. The walls of cerebral veins are thin and vulnerable as they do not contain muscle tissue. Cerebral veins are subdivided into three groups according to their anatomical location [2]:
1. superficial venous system (external);
2. deep venous system (internal);
3. veins of the brain stem and posterior fossa.

Superficial Supratentorial Cortical Veins (External)

Superficial supratentorial cortical veins are located on the surface of the brain and categorized into three main groups according to their drainage [3].

• Superior Cortical Veins: These veins are also known as the superior sagittal group because they drain into the SSS [1]. The most prominent vein of this group is the superior anastomotic vein, which is
known as the vein of Trolard. This anastomotic vein connects the superficial middle cerebral vein (SMCV) to the SSS. In addition, there are 8–12 unnamed smaller veins in the upper part of the hemispheric convexity [2].

- **Middle Cortical Veins:** These veins are also known as the sphenoidal group because they drain into the CS via the sphenoparietal sinuses. The dominant vein in this group is the SMCV, which is also known as the Sylvian vein due to its location in the Sylvian fissure (i.e., the lateral cerebral fissure). Middle cortical veins receive tributaries from the inferior part of the frontal lobe, superior temporal gyrus, and parietal opercula. The vein of Labbé (Fig. 5.2), which is another anastomotic vein of the SMCV, receives tributaries from the posterior and inferior temporal lobe and adjacent parietal lobe and drains primarily into the TS and rarely into the sigmoid sinuses [2].

- **Inferior Cortical Veins:** The major vein of this group is the deep middle cerebral vein (DMCV), which receives tributaries from the inferior frontal lobes and temporal lobes such as the insula, basal ganglia, and parahippocampal gyrus. The basal vein of Rosenthal (BVR), which is considered part of the deep venous system, is an anastomotic vein of the DMCV [2,3].

### Deep Supratentorial Cortical Veins (Internal)

Deep structures of the cerebral hemispheres, including the basal ganglia, corpus callosum, thalamus, and posterior part of the limbic system, are drained by the deep venous system, which has two major components: internal cerebral vein (ICV) and BVR [1].

Numerous smaller medullary veins emerge from the subcortical area, directly cross the white matter, and drain into the subependymal veins. Septal veins and thalamostriate veins are the most prominent vascular structures of subependymal veins. Septal veins are localized to the frontal horn and course posteriorly toward the septum pellucidum. Thalamostriate veins are anatomically located medially to the caudate nucleus and thalamus [3]. These two veins meet near the foramen of Monro which is composed of ICVs; this point of intersection is called the “venous angle.” The ICVs then course between the roof of the third ventricle and the fornices. Choroid veins, which lie along the floor of the lateral ventricle, also drain into ICVs (Fig. 5.3) [4].

The BVR originates from the intersection of the anterior cerebral vein, DMCV, and striate vein [2,4]. The great cerebral vein (i.e., the vein of Galen, VofG) originates from the intersection of two ICVs and the BVR. VofG is a 2-cm long, U-shaped midline vein that courses under the splenium of the corpus callosum in the quadrigeminal cistern [4]. The VofG and ISS intersect to form straight sinuses [3].

### Brain Stem and Posterior Fossa Veins

The brain stem and posterior fossa veins are categorized into three subgroups according to their drainage system [2,3]:

- **Superior (Galenic) Group:** This group includes precentral cerebellar (PCV), superior vermian (SVV), and anterior pontomesencephalic veins (APMV). The PCV courses between the lingual and central lobule.

![FIGURE 5.2] Cerebral veins of deep circulation and posterior fossa are shown in lateral view MR venography. Dominant structure of this system is great cerebral vein (of Galen), which is formed by joining of two internal cerebral veins, and basal cerebral vein of Rosenthal. Then it drains into straight sinus together with inferior sagittal sinus.
of vermis. The superior vermian vein originates from the top of the vermis, courses through the culmen, and drains into the PCV. The APMV includes many smaller veins that cover the cerebral peduncles and anterior surface of the pons. All veins in this group drain into the VofG.

- **Anterior (Petrosal) Group:** The petrosal vein (PV) is the dominant vascular structure of this group, which is important during cerebellopontine angle cistern surgery. Tributaries from the brain stem and cerebellum are observed as a “petrosal star” on DSA or computed tomography venography (CTV). The PV forms an anastomosis with the lateral mesencephalic vein and SPS [2].

- **Posterior (Tentorial) Group:** The inferior vermian veins lie under the vermis and receive tributaries from the inferior part of the cerebellum.

**References**


