LIST OF ABBREVIATION

ACA	*Anterior cerberal artery*
AICA	*Anterior inferior cerebellar artery*
BA	*Basilar artery*
CPP	*Cerebral perfusion pressure*
DCI	*Delayed cerebral ischemia*
EDV	*End-diastolic velocity*
HR	*Heart rate*
ICP	*Increased intracranial Pressure*
ICT	*Increased intracranial tension*
ICA	*Internal carotid artery*
ICHT	*Intracranial hypertension*
mBFV	*Mean blood flow velocity*
MFV	*Mean blood flow velocity*
MCA	*Middle cerebral artery*
OA	*Ophtalmic artery*
PSV	*Peak systolic velocity*
PICA	*Posterior inferior cerebellar artery*
PI	*Pulsatility index*
PMD	*Pulsed motion Doppler*
RI	*Resistance index*
SAH	*Subarachnoid hemorrhage*
S/D	*Systolic diastolic ratio*
TIBI	*Thrombolysis in brain ischemia*
TCCD	*Transcranial color-coded Duplex*
TCD	*Transcranial Doppler*
VA	*Vertebral artery*

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A-Gross anatomy

The skull vault is made up of several flat bones, joined at sutures, which can be recognized on skull radiographs. The diploic veins within the skull are large, valveless vessels with thin walls. They communicate with the meningeal veins, the dural sinuses and the scalp veins **(Ryan et al., 2011).**

The paired parietal bones form much of the side and the roof of the skull and are joined in the midline at the sagittal suture. Parietal foramina are paired foramina or areas of thin bone close to the midline in the parietal bones. They are often visible on a radiograph, may be big and may even be palpable. They may transmit emissary veins from the sagittal sinus. The frontal bone forms the front of the skull vault. It is formed by two frontal bones that unite at the metopic suture. The frontal bones join the parietal bones at the coronal suture. The junction of coronal and sagittal sutures is known as the bregma. The occipital bone forms the back of the skull vault and is joined to the parietal bones at the lambdoid suture. The lambdoid and sagittal sutures join at a point known as the lambda (figure 1) **(Ryan et al., 2011)**.

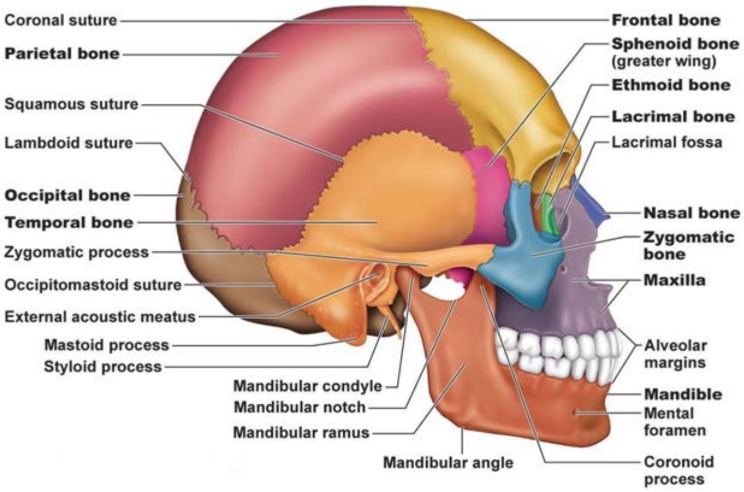

Figure1. External anatomy of the right side of the skull (Quoted from Antranik, 2013)

Surrounding and supporting the brain within the skull vault are three protective tissue layers, which also extend down the brainstem and the spinal cord. Together these layers are called the meninges (figure 2). The outermost layer of the meninges is called the dura mater because it is thick and tough. The middle layer is called the arachnoid mater because of spiderlike processes called arachnoid trabiculae that extend from it toward the third layer, the pia mater, a thin, delicate layer of cells that closely invests the surface of the brain **(Purves et al., 2001).**

Since the pia closely adheres to the brain as its surface curves and folds, whereas the arachnoid does not, there are places—called cisterns—where the subarachnoid space is especially large. The major arteries supplying the brain course through the subarachnoid space where they give rise to branches that penetrate the substance of the hemispheres **(Purves et al., 2001).**

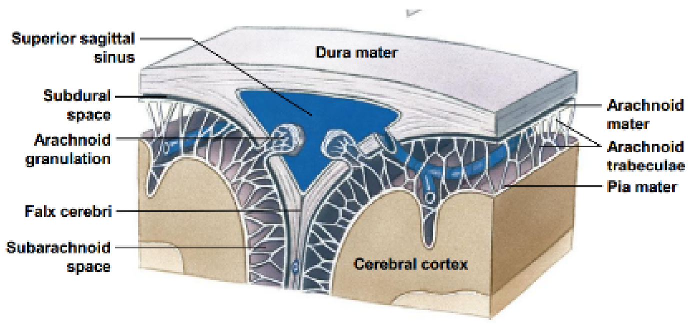

Figure 2. Cranial meninges (Quoted from Martini et al., 2011).

The cerebral hemispheres fill the cranial vault above the tentorium cerebelli. Right and left hemispheres are connected by the corpus callosum and are otherwise partly separated by the median longitudinal fissure. The hemispheres consist of cortical grey matter, white matter, basal ganglia, thalamus, hypothalamus, pituitary gland and the limbic lobe. The lateral ventricles form a cavity within each ventricle (figure 3) **(Ryan et al., 2011).**

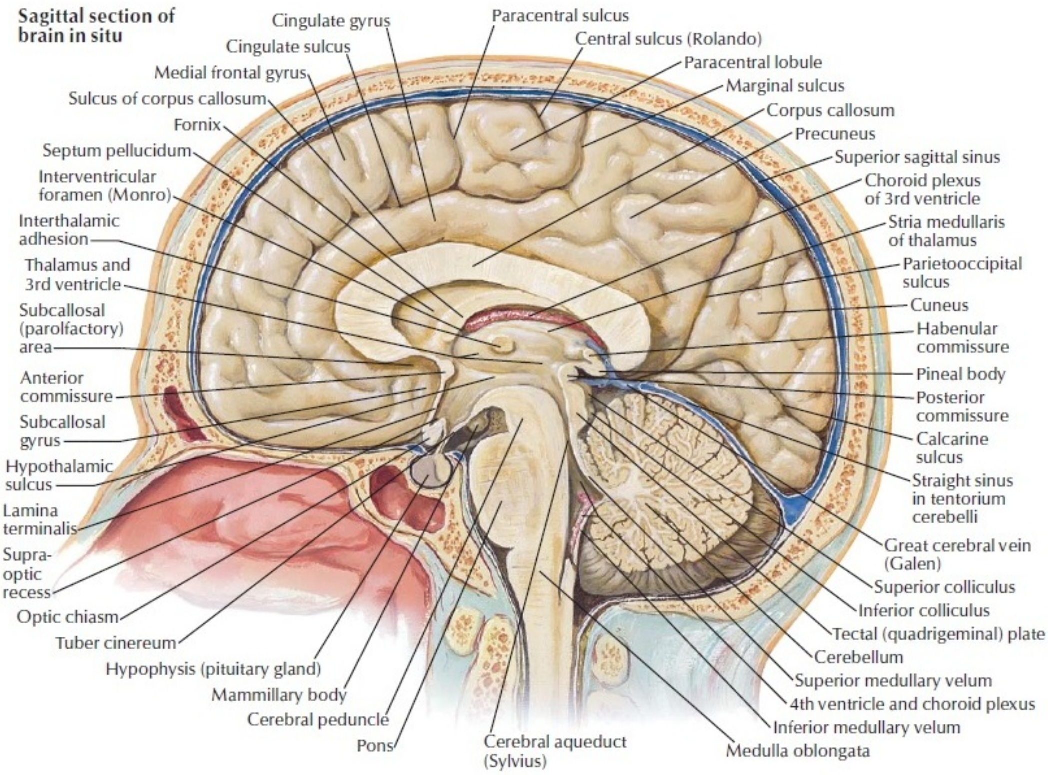

Figure3. Sagittal section of the brain (Quoted from Netter et al., 2002).

The Ventricular System

The cerebral ventricles are a series of interconnected, fluid-filled spaces that lie in the core of the forebrain and brainstem (figure 4). The largest of these spaces are the lateral ventricles (one within each of the cerebral hemispheres). Their ventral surface is usually defined by the basal ganglia, their dorsal surface by the corpus callosum, and their medial surface by the septum pellucidum, a membranous tissue sheet that forms part of the midline sagittal surface of the cerebral hemispheres **(Purves et al., 2001).**

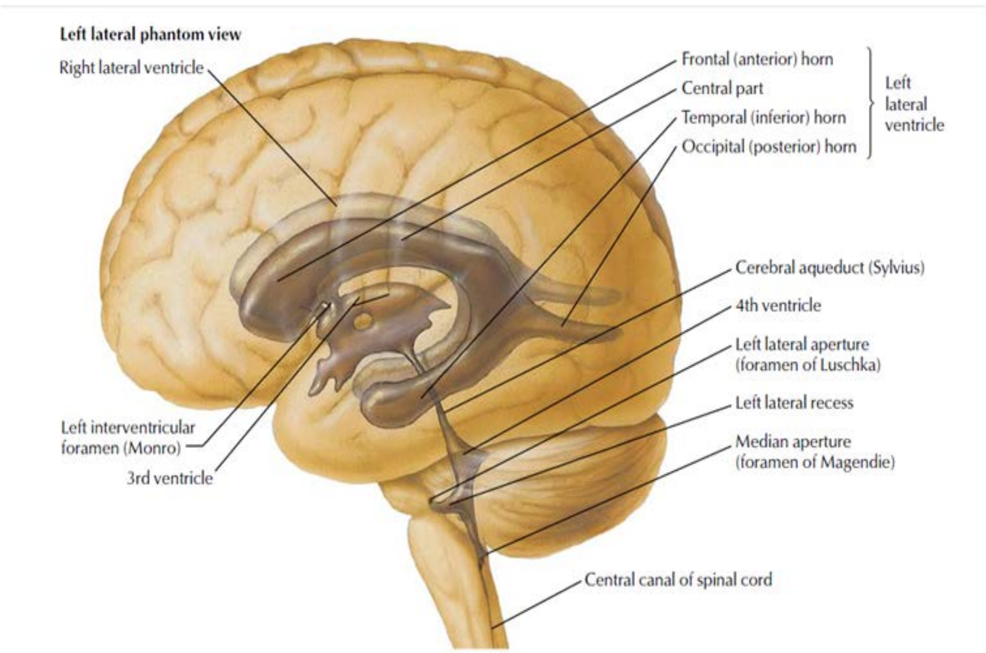

Figure 4.The ventricular system of human brain (Quoted from Netter et al., 2002).

The third ventricle forms a narrow midline space between the right and left thalamus, and communicates with the lateral ventricles through a small opening at the anterior end of the third ventricle (called the interventricular foramen). The third ventricle is continuous caudally with the cerebral aqueduct, which runs through the midbrain. At its caudal end, the aqueduct opens into the fourth ventricle, a larger space in the dorsal pons and medulla. The fourth ventricle narrows caudally to form the central canal of the spinal cord. The ventricles are filled with cerebrospinal fluid, and the lateral, third, and fourth ventricles are the site of the choroid plexus, which produces this fluid. The cerebrospinal fluid percolates through the ventricular system and flows into the subarachnoid space through perforations in the thin covering of the fourth ventricle; it is eventually absorbed by specialized structures called arachnoid villi and returned to the venous circulation **(Purves et al., 2001).**

The Arterial supply of the brain

The brain receives blood from two sources: the internal carotid arteries and the vertebral arteries. The internal carotid arteries branch to form two major cerebral arteries, the anterior and middle cerebral arteries. The right and left vertebral arteries come together at the level of the pons on the ventral surface of the brainstem to form the midline basilar artery. The basilar artery joins the blood supply from the internal carotids in an arterial ring at the base of the brain called the circle of Willis. The posterior cerebral arteries arise at this confluence, as do two small bridging arteries, the anterior and posterior communicating arteries. Conjoining the two major sources of cerebral vascular supply via the circle of Willis presumably improves the chances of any region of the brain continuing to receive blood if one of the major arteries becomes occluded (**Purves et al., 2001)**.

The major branches that arise from the internal carotid artery—the anterior and middle cerebral arteries—form **the anterior circulation** that supplies the forebrain. Each gives rise to branches that supply the cortex and branches that penetrate the basal surface of the brain, supplying deep structures such as the basal ganglia, thalamus, and internal capsule. Particularly prominent are the lenticulostriate arteries that branch from the middle cerebral artery. These arteries supply the basal ganglia and thalamus. **The posterior circulation** of the brain supplies the posterior cortex, the midbrain, and the brainstem; it comprises arterial branches arising from the posterior cerebral, basilar, and vertebral arteries (figure 5) (**Purves et al., 2001**).

The pattern of arterial distribution is similar for all the subdivisions of the brainstem: Midline arteries supply medial structures, lateral arteries supply the lateral brainstem, and dorsal-lateral arteries supply dorsal-lateral brainstem structures and the cerebellum. Among the most important dorsal-lateral arteries are the posterior inferior cerebellar artery (PICA) and the anterior inferior cerebellar artery (AICA), which supply distinct regions of the medulla and pons. These arteries, as well as branches of the basilar artery that penetrate the brainstem from its ventral and lateral surfaces (called paramedian and short circumferential arteries), are especially common sites of occlusion and result in specific functional deficits of cranial nerve, somatic sensory, and motor function (**Purves et al., 2001**).

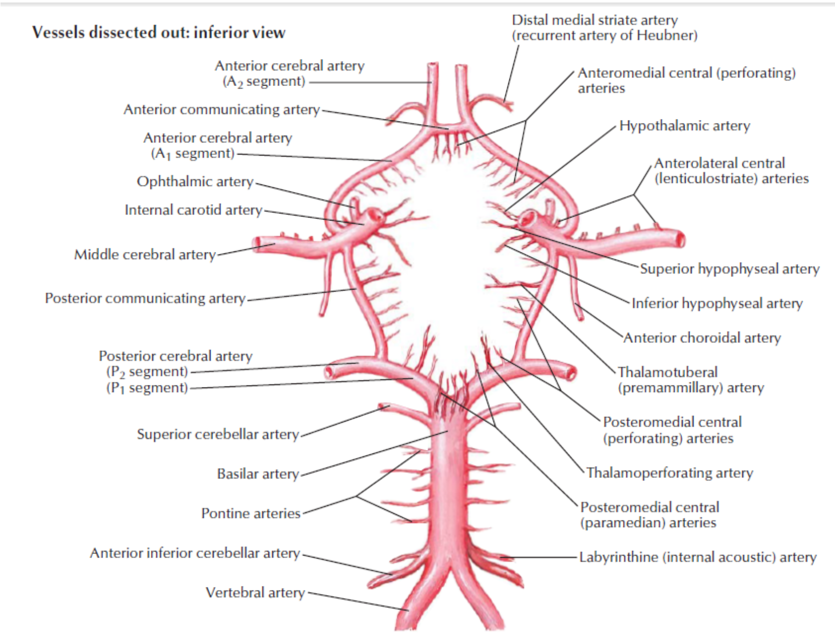

Figure 5. Inferior view of the circle of Willis (Quoted from Netter et al., 2002).

Commonest variants of the circle of Willis:

The circle of Willis is subject to many variations. Although it is complete in 90% of subjects, variation of at least one vessel, enough to affect its role as a collateral route, is found in 60% of people **(Ryan et al., 2011)**.

1- Hypoplastic posterior communicating artery (22%).
2- Large posterior communicating artery associated with a reduction in size of the proximal part of the ipsilateral posterior cerebral artery so that the posterior cerebral artery effectively receives its supply from the middle cerebral artery (reports of incidence vary from 6% to 40%). Such an artery is called a 'fetal' posterior communicating artery.
3- Hypoplastic proximal segment of the anterior cerebral artery (the pre-communicating horizontal A1 segment) on one side, with both anterior cerebral vessels supplied from that of the other side (30%).
4- Hypoplastic anterior communicating artery (3%).
5- Anterior cerebral artery may be fused as a single trunk, an azygous anterior cerebral artery **(Ryanet al., 2011)**.

The commonest variations are seen in (figure 6) as follows:

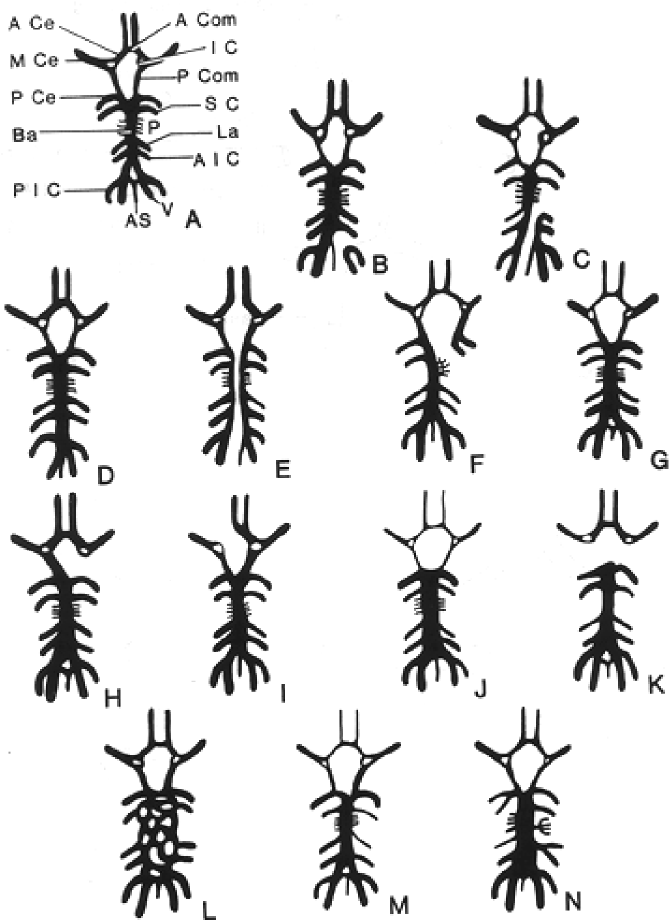

Figure 6. Variations of Circle of Willis and Related Vessels (Quoted from Bergman et al., 1995).

A: Normal cerebral arterial circle and associated vessels. **A Com**, anterior communicating; **A Ce**, anterior cerebral; **M Ce**, Middle cerebral; **P Ce**, posterior cerebral; **IC**, internal carotid stump; **P Com**, posterior communicating; **SC**, superior cerebeilar; **Ba,** basilar; **La**, labyrinthine; **AIC**, anterior inferior cerebellar; **PIC**, posterior inferior cerebellar; **V**, vertebral; **AS**, anterior spinal; **P**, pontine.