Introduction

Stroke is the third leading cause of deaths after cardiovascular diseases and cancers. It is classically characterized as a neurological deficit attributed to an acute focal injury of the central nervous system (CNS) by vascular causes ***(Easton et al., 2009).***

In USA, incidence for first-time stroke is more than 700.000 per year, of which 20% of the patients will die within the first year after the onset of the stroke. Keeping the current trends, this number is projected to rise up to 1 million per year by the year 2050. Although stroke often is considered a disease of the elderly, one third of strokes occur in persons younger than 65 years, men being at higher risk for stroke than women ***(Mena et al., 2014).***

Strokes are broadly classified as either hemorrhagic or ischemic. Of all strokes, 87 % are ischemic, 10 % are intracerebral hemorrhagic strokes (ICH), and 3 % are subarachnoid hemorrhage strokes (SAH) ***(Roger et al., 2012).***

Ischemic strokes are caused by a blockage in a blood vessel in or leading to the brain. Not all are alike; each subtype develops for different reasons, and poses particular challenges for diagnosis and treatment.

The subtypes of ischemic stroke are:

- **Embolic** (a blood clot from the heart, aorta, or other source travels toward the brain, blocking a blood vessel that supplies blood to the brain) - about 25% of ischemic strokes.
- **Large-artery atherothrombotic stroke** (atherosclerotic plaque builds up and narrows an artery in any of four strategic locations) -- about 15% of ischemic strokes.
- **Small-vessel (lacunar) stroke** (caused by obstruction of a single blood vessel that branches off the circle of arteries in the brain known as the circle of Willis) - about 25% of ischemic strokes.
- **Cryptogenic** stroke (an ischemic stroke is classified as cryptogenic if, after attempts to pinpoint the origin of a stroke, no source can be identified) - about 25% to 30% of ischemic strokes.
- **Other subtypes** of ischemic stroke (these include rarer causes such as arteritis (inflammation of small blood vessels), genetic factors affecting small vessels, or traumatic dissection (tearing) of a large artery outside the brain, usually in younger people) - about 5% of ischemic strokes ***(Rost, 2016)***.

Non contrast CT is still the mostly commonly used initial imaging modality in hyper acute stroke. It is widely available, besides being quick and easy to perform in most stroke patients. It accurately identifies Intracranial haemorrhage as well as subarachnoid haemorrhage as soon as it has occurred, but non contrast CT is relatively insensitive for the detection of acute cortical or subcortical infarctions, especially in the posterior fossa. This illustrates the need for new imaging modalities as MRI and CT brain perfusion ***(Wardlaw et al., 2003).***

CT brain perfusion tracks an IV bolus of iodinated contrast over time with sections of the brain imaged repeatedly. This allows the measurements of parameters such as cerebral blood volume, cerebral blood flow, mean transit time, time to peak enhancement .These parameters can be extrapolated to delineate areas of hypo-perfusion and irreversible infarction by creating perfusion maps. CTP has shown incremental increased sensitivity and specificity in diagnosing acute ischemic stroke compared to non contrast CT. CT perfusion is easily available and can be performed on a standard helical CT after NCCT. In acute stroke CTP provides information on the penumbra (tissue at risk) and on the infracted tissue with defined cut-offs for each criteria ***(Hopyan et al., 2010)***.

Aim of the Work

The aim of this work is to highlight the role of perfusion CT in early detection, accurate assessment of cases with ischemic cerebrovascular stroke.

Chapter (1)
Anatomy

CT Anatomy of the Brain

Axial section at the level of foramen magnum

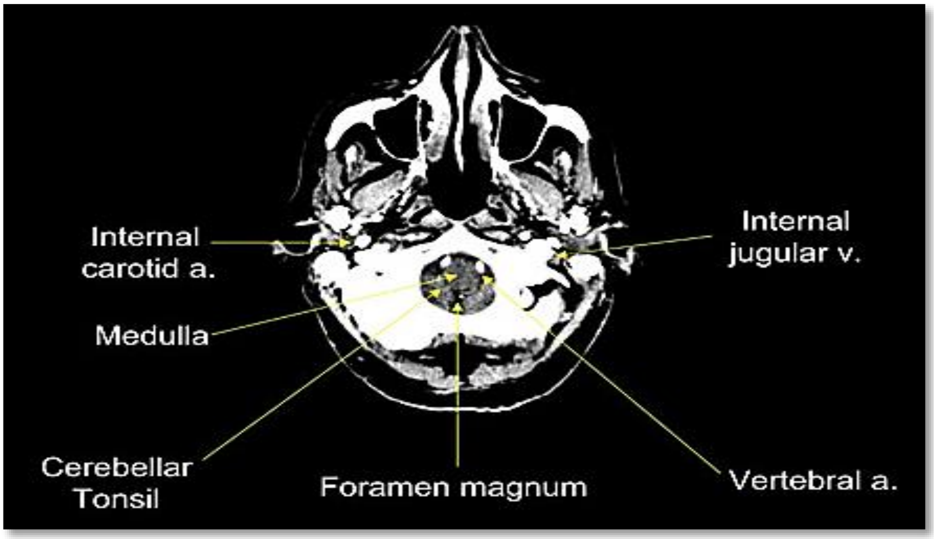


Figure (1): Axial section at the level of foramen magnum ***(Nolte &John, 2002).***

At this level, the closed medulla is seen passing through the foramen magnum with the 4th parts of both vertebral arteries seen related to its anterolateral surface. The lower ends of both cerebellar tonsils are also seen at this level posterior to the medulla oblongata (fig.1) ***(Ryan, 1994).***

Axial section at the level of open medulla

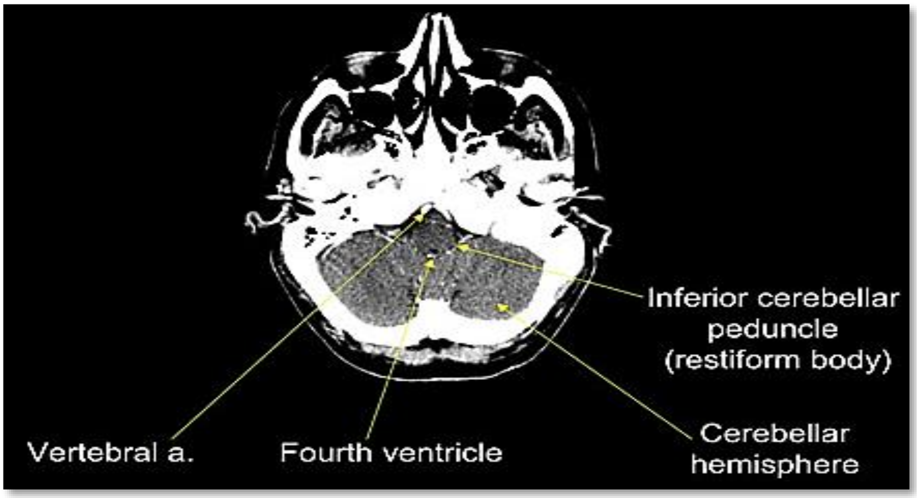


Figure (2): Axial sections at the level of Open Medulla ***(Nolte &John, 2002).***

At this level only the posterior cranial fossa is shown at this level. The open medulla is seen anteriorly with the 4th ventricle, which appears small in size comparative to the higher level, lying behind between it and cerebellar vermis. The inferior cerebellar peduncles are seen bilaterally at the posterolateral aspects of the medulla at this level. The vertebral arteries lie anterior to the medulla. Both cerebellar hemispheres are seen filling the posterolateral aspects of the posterior cranial fossa(fig.2) (***(Ryan, 1994).***

Axial sections through the posterior fossa, pons and temporal lobes

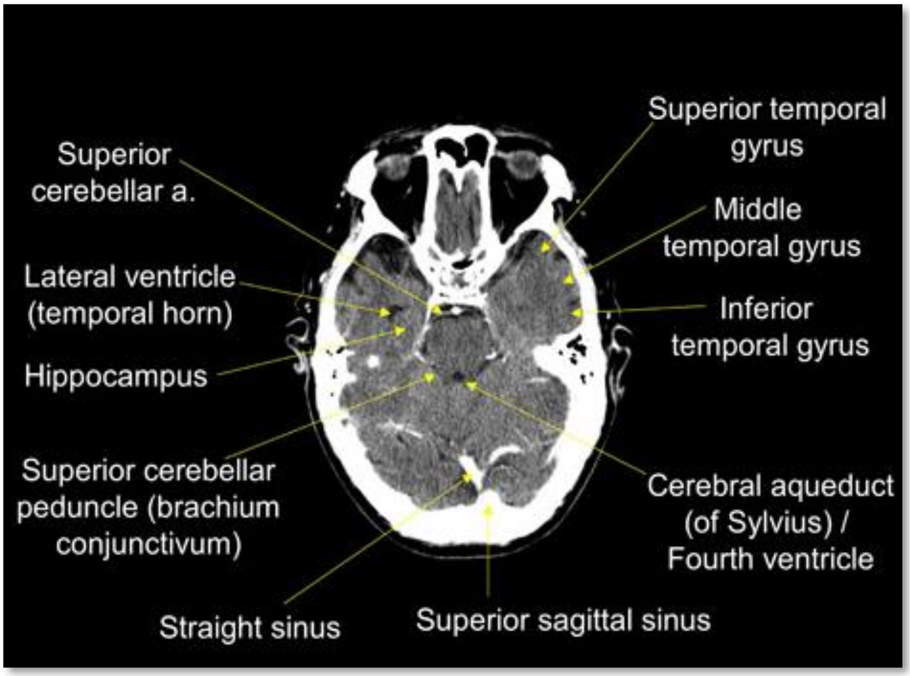


Figure (3): Axial section through the posterior fossa, pons and temporal lobes ***(Nolte &John, 2002).***

At this level, the middle part of the middle cranial fossa is seen containing the lower parts of both gyri recti .At this level middle cranial fossa is separated from the anterior fossa by greater wing of the sphenoid bone on each side and is bounded laterally by the squamous part of the temporal bone. The occipital bone surrounds the posterior cranial fossa. The internal occipital protuberance and the site of confluence of the venous sinuses are seen in the midline posteriorly. The transverse sinus is usually visible in part near this. The clivus forms the bony anterior boundary of the posterior cranial fossa in midline. In the middle cranial fossa, the temporal lobes are seen and the temporal horns of the lateral ventricles may be distinguished within them. In the posterior fossa the pons lies anteriorly in the midline. The prepontine cistern containing the basilar artery separates the pons from the clivus. The cerebellum occupies the remainder of the posterior fossa with the vermis in the midline and the hemispheres laterally. The pons is separated from the cerebellum in the midline by the fourth ventricle(fig.3) ***(Ryan, 1994)*.**

Axial section at the level of midbrain

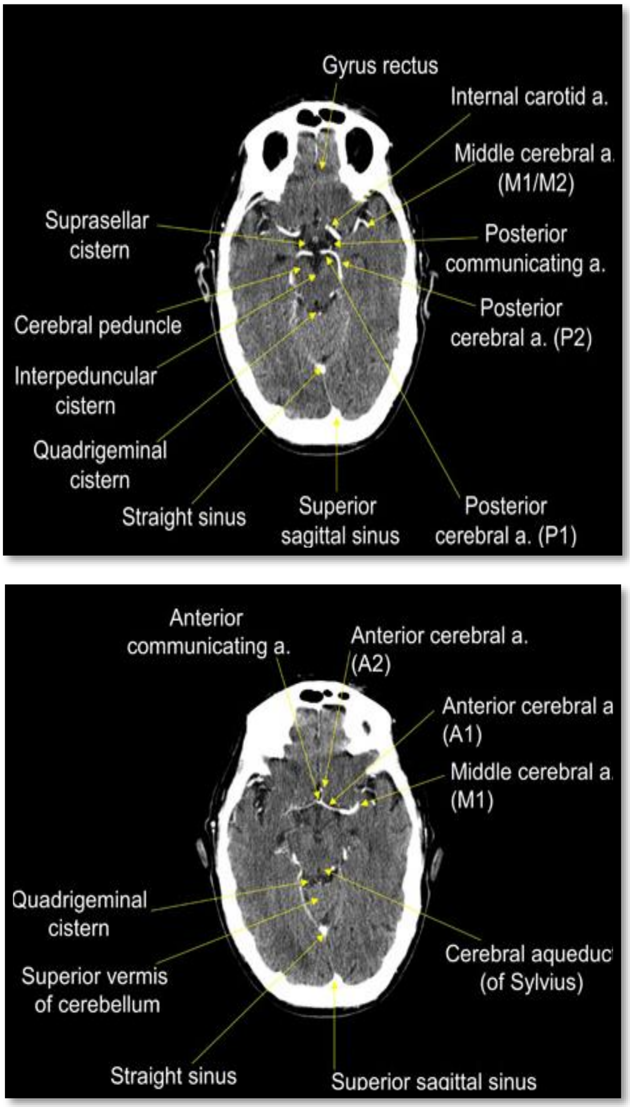
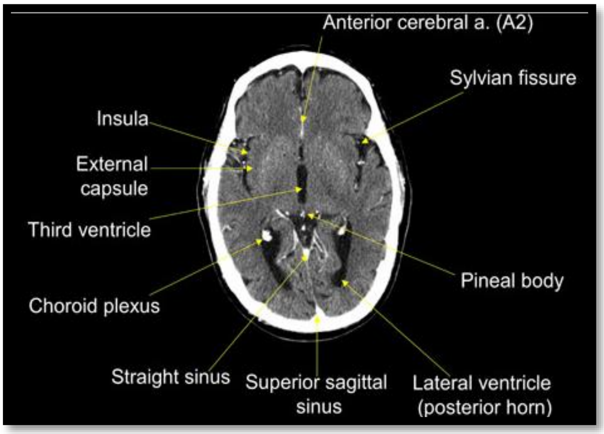


Figure (4): Axial sections at the level of mid brain ***(Nolte &John, 2002).***

At this level, the brain is surrounded by the frontal bone anteriorly, the squamous temporal bones and the occipital bone laterally and the occipital bone posteriorly. The frontal lobes, separated by the interhemispheric fissure and the falx cerebri, occupy the anterior third of this cross section. The temporal lobes lie in the middle third of the section and appear separated from the frontal lobes by the stem of sylvian fissure. The middle cerebral artery and its branches can be seen with the sylvian fissure. Posteriorly, lie the superior most aspect of the cerebellum. The borders of the tentorium may be visible in contrast enhanced scans, allowing distinction of the temporal and occipital lobes laterally from the cerebellum medially. The midbrain is visible in the midline and the cerebral peduncles, separated by the interpeduncular cistern, can be seen on its anterior border. The ambient cistern surrounds the lateral aspect of the mid brain. The colliculi can be seen on the posterior aspect of the mid brain with the cerebral aqueduct seen anterior to them. The quadrigeminal plate cistern lies posterior to the colliculi. The great cerebral vein may be visible within this cistern but is usually better seen on higher scan. Anterior to the mid brain lies the hexagonally shaped suprasellar cistern. This contains the internal carotid artery and its branches, which shares in the circle of Willis (fig.4)***(Ryan, 1994)***

Axial sections through the cerebral ventricle, thalamus and the internal capsule



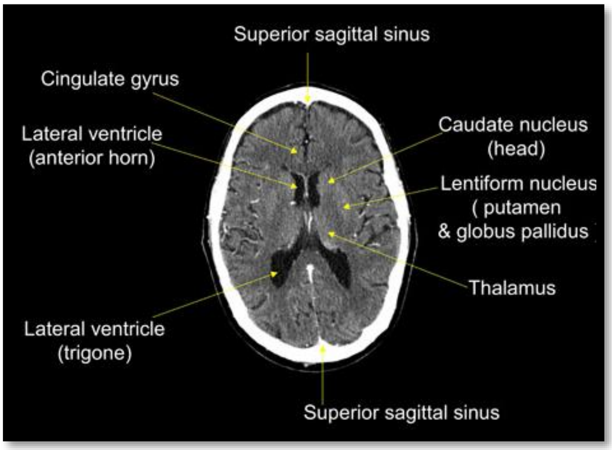
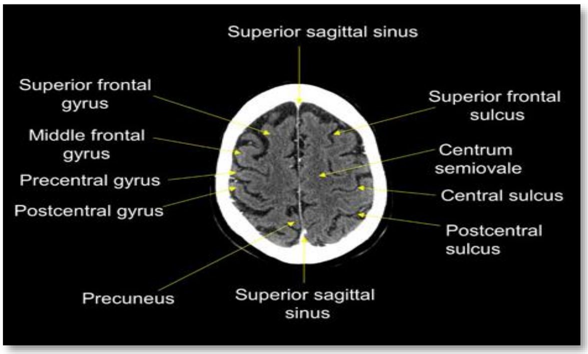


Figure (5): Axial CT sections through the cerebral ventricle, thalamus and the internal capsule **(Nolte &John, 2002).**

At these levels, the brain is surrounded by the frontal bone anteriorly, the temporal and parietal bones laterally and occipital bones posteriorly, the ventricles and CSF cisterns are the most prominent features in this section. In the anterior part of the scan the frontal horns of the lateral ventricle are seen close to the midline, separated by the thin septum pellucidum, the two walls of which may separated forming the cavum septum pellucidum. The lateral wall of the frontal horn in concave where it is indented by the head of the caudate nucleus. The trigones of the body of the lateral ventricles are seen posteriorly. The choroid plexuses are prominent within this part of the ventricle and may be calcified. The third ventricle is a narrow slit-like space in the midline starting anteriorly just behind the frontal horns of the lateral ventricles. The interventricular foramina of monro may be visible at this point.In the upper part of the quadrigeminal cistern, the posterior ends of the internal cerebral veins can be seen uniting together to form the great cerebral vein. The pineal gland lies within this cistern and the habenular commissure, if calcified can be sometimes seen anterior to the pineal gland. The anterior part of this section is occupied mostly by the frontal lobes, which are separated by the interhemispheric fissure and the falx cerebri. The middle third contains the basal ganglia, the thalamus and the internal capsule. The head of the caudate nuclei lie between the frontal horn of the lateral ventricle and the anterior limb of the internal capsule(fig.5)***(Ryan, 1994)***.

The thalami lie on each side of the third ventricle and medial to the posterior limb of the internal capsule .The lentiform nucleus lies lateral to the internal capsule with the globus pallidus situated medially and the putamen laterally. A thin sheet of grey matter, the claustrum, can seen lateral to the putamen, separated from it by the external capsule. The insula lies in the floor of the sylvian fissure, and the part of the frontal, parietal and temporal lobes overlying this are called the opercula. The posterior part of the temporal lobes and the occipital lobes occupy the posterior third of this cross section(fig.5) ***(Ryan, 1994)***.

Axial sections above the level of lateral ventricles



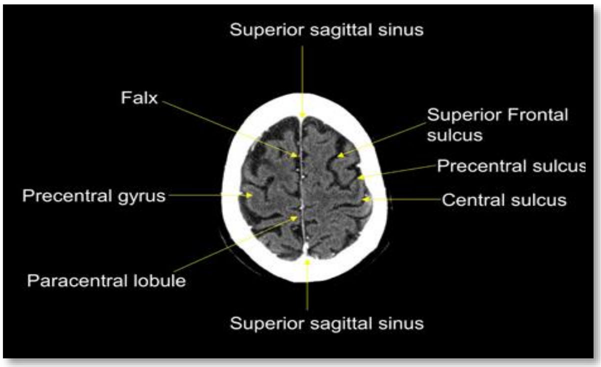


Figure (6): axial CT sections above the level of lateral ventricles ***(Nolte &John, 2002).***

At this level, the brain is surrounded by the frontal bone anteriorly, the parietal bones on either sides. The falx cerebri is seen separating both cerebral hemispheres with the superior sagittal sinus visualized along its ends in the postcontrast studies. The frontal lobes occupy the anterior half of this cross section while the parietal lobes lie in the posterior half of the section. The upper aspect of the sulci and gyri along the medial and supero-lateral surfaces of these lobes are demonstrated at these sections(fig.6) ***(Ryan, 1994).***

Anatomy of Intracranial Vessels Arterial System

Internal carotid artery

Course

The internal carotid artery enters the base of the skull through the carotid canal, where it begins a series of 90 degree turns which lead it to eventually terminate as the middle and anterior cerebral arteries.

It first turns 90 degrees anteromedially within the carotid canal to run through the petrous temporal bone. It then proceeds to exit the carotid canal and turn 90 degrees superiorly within the carotid sinus and finally another 90 degree turn anteriorly to travel along the roof of the cavernous sinus, where it grooves the body of the sphenoid. Here the abducent nerve is intimately related to the ICA on its lateral side. At the anterior end of the cavernous sinus, the ICA makes another 90 degree turn superiorly and then posteriorly to pass medial to the anterior clinoid process. At this point it divides into the middle and anterior cerebral branches and gives off other smaller branches, such as the anterior choroidal artery and the posterior communicating artery.