A New Approach in Neuroimaging:

ROLE OF 3T MRI IN MR SPECTROSCOPY & FUNCTIONAL MR

Essay

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{وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ وَسَتُرَدُّونَ إِلَى عَالِمِ الْغَيْبِ وَالشَّهَادَةِ فَيُنَبِّئُكُمْ بِمَا كُنْتُمْ تَعْمَلُونَ}

صدق الله العظيم

(سورة التوبة: ١٠٥)

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Chapter (1)

A Hint on Neuroanatomy

CEREBRAL HEMISPHERES

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.

CEREBRAL CORTEX:

The supero-lateral surface of each cerebral hemisphere has two deep sulci; these are; **The lateral sulcus**, also known as the sylvian fissure, which separates the frontal and temporal lobes and **the central sulcus** (of Rolando), which passes upwards from the lateral sulcus to the superior border of the hemisphere. This separates the frontal and parietal lobes.

The parieto-occipital sulcus on the medial surface of the hemisphere separates the parietal and occipital lobes. On the lateral surface of the hemispheres there is no complete sulcal separation of the parietal, temporal and occipital lobes. The boundary between the parietal and temporal lobes lies on a line extended back from the lateral sulcus. The boundary separating the parietal and temporal

lobes from the occipital lobe is a line between the superior border of the parieto-occipital sulcus and the preoccipital notch

**Frontal lobe*

The frontal lobe includes the entire cortex anterior to the central sulcus and superior to the lateral sulcus. It includes; **The motor cortex** or the precentral gyrus lies anterior to the central sulcus and controls voluntary movement, **Premotor cortex** lies anterior to the precentral gyrus and adjoining gyri and is associated too with the control of voluntary movement (the postero-inferior part of the premotor area on the dominant hemisphere deals with the motor aspects of speech and is called **Broca's** speech area), and the **Prefrontal area** lies anterior to the motor and premotor cortex and is involved with intellectual, emotional and autonomic activity.

**Parietal lobe*

The parietal lobe is posterior to the central sulcus, superior to the lateral sulcus and a line drawn from the latter's posterior end to the occipital lobe. Areas with known-function include the sensory cortex (known as the **Postcentral gyrus** which controls somatic sensations), and the **Parietal association cortex** (posterior to the sensory cortex and involved with recognition and integration of sensory stimuli).

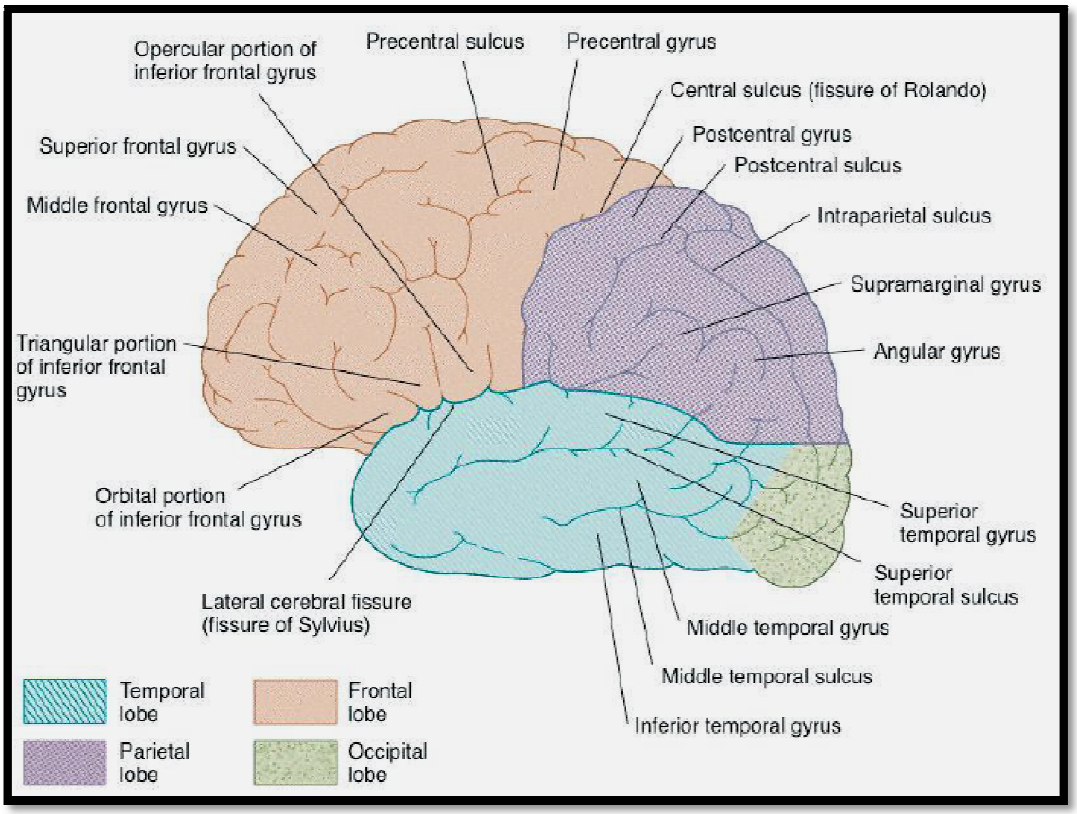

Figure (1): Lateral view of the left cerebral hemisphere, showing principal gyri and sulci

**Temporal lobe*

The temporal lobe lies inferior to the lateral sulcus and anterior to the occipital lobe. Two horizontal gyri separate the superolateral surface into superior, middle and inferior temporal gyri. Areas associated with known function include the **Auditory cortex** and the **Temporal association cortex** (situated around the auditory cortex and involved with the recognition and integration of auditory stimuli).

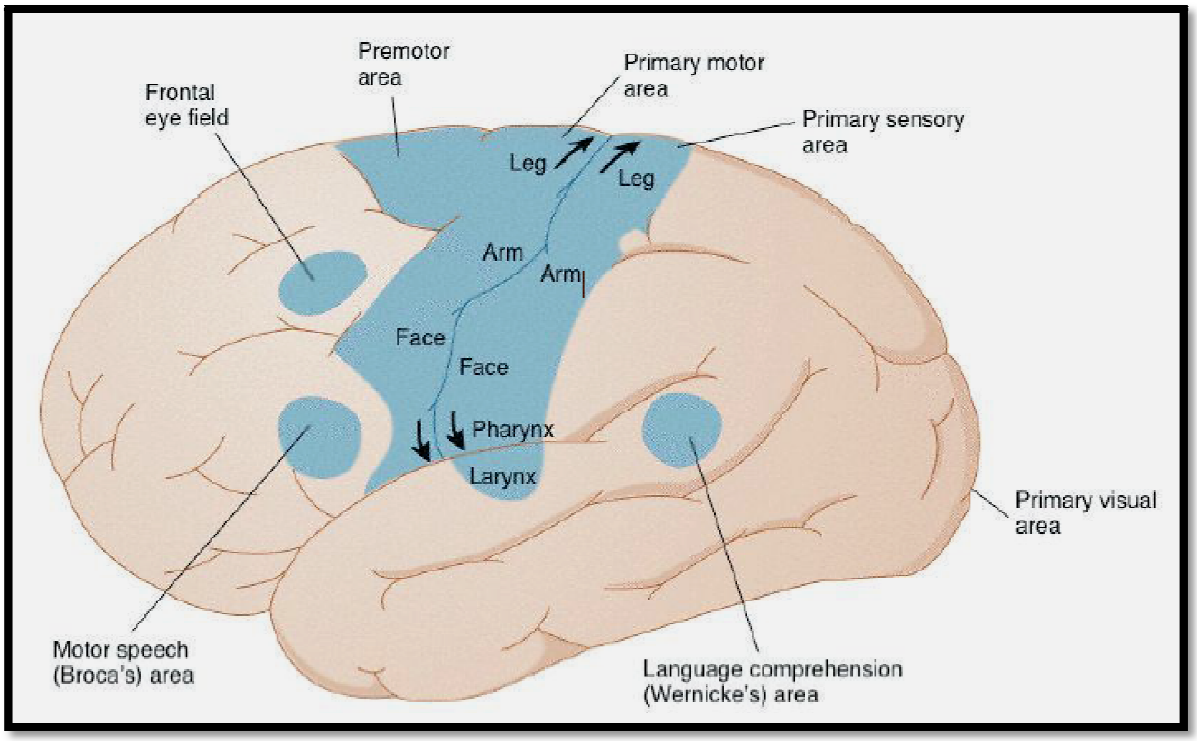

Figure (2): Lateral view of the left hemisphere showing the functions of the cortical areas

**Occipital lobe*

The occipital lobe lies posterior to the parietal and temporal lobes. There is no anatomical separation of these lobes on the superolateral surface of the hemisphere. However, on the medial surface the occipital lobe is separated from the parietal lobe by the **Parieto-occipital sulcus**. A further deep sulcus of this surface, the **Calcarine sulcus**, runs anteriorly from the occipital pole. Areas with known function include the **Visual cortex** (surrounds the calcarine sulcus and receives visual stimuli from the opposite half

field of sight) and the **Occipital association cortex** (anterior to the visual cortex and is involved with the recognition and integration of visual stimuli).

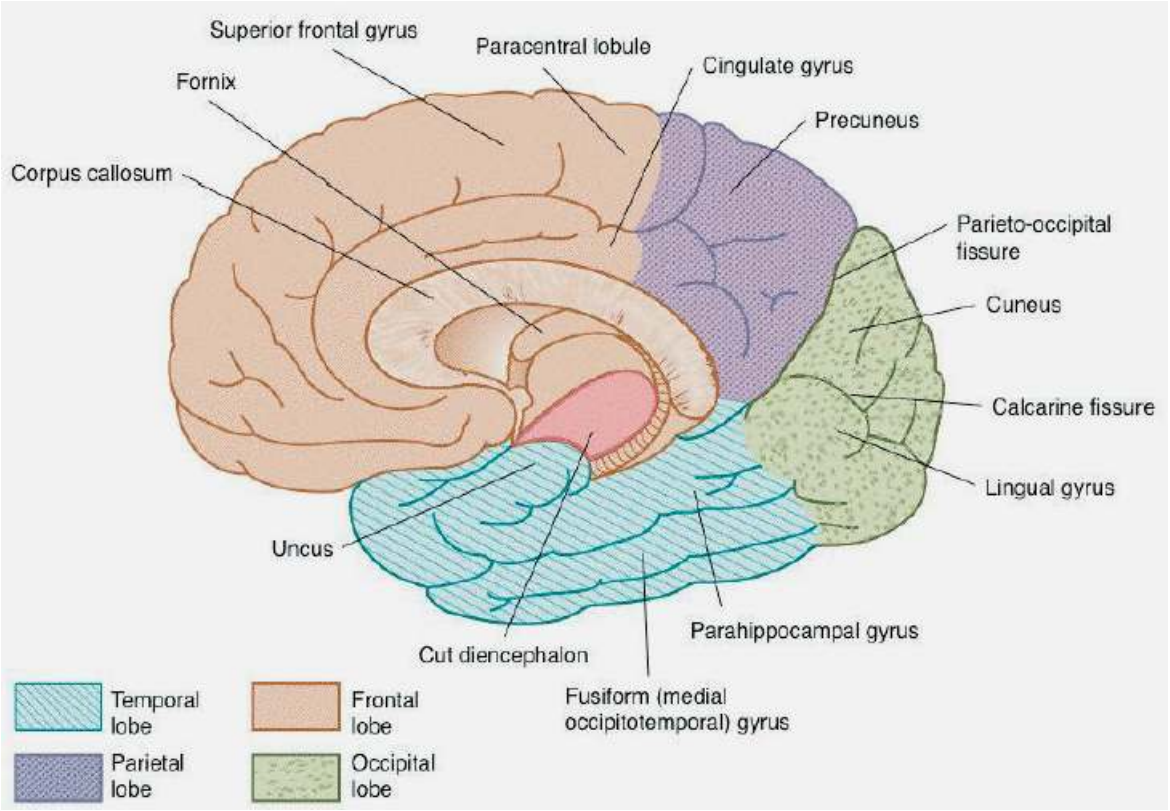

Figure (3): Medial view of the right cerebral hemisphere

**Insula (of Reil)*

This is the cortex buried in the floor of the lateral sulcus and is crossed by branches of the middle cerebral artery. Its function is unknown, although the area closest to the sensory cortex is probably related to taste. The parts of the frontal, parietal and temporal lobes that overlie the insula are called the operculum.

**Limbic Lobe:*

This is not an anatomical lobe as such but functionally related structures that surround the corpus callosum on the medial surface of the cerebral hemisphere. It includes cingulate splenial and parahippocampal gyri, the hippocampus, the dentate gyrus and the fornix. The cingulate gyrus curves around the genu and body of the corpus callosum and continues around the splenium as the splenial gyrus. This, in turn, is continuous with the dentate gyrus and the hippocampus. Also included in the limbic lobe are grey matter on the corpus callosum - called the induseum griseum – and white fibres that run along its length - the medial and lateral longitudinal striae.

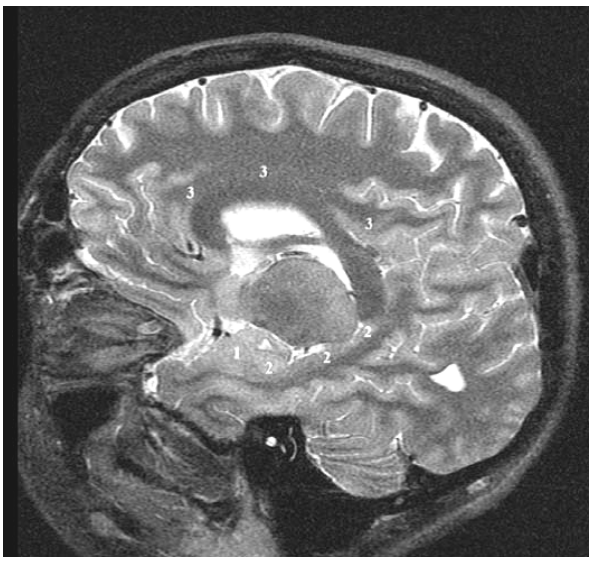

Figure (4): The limbic lobe: MR oblique cut of the brain displaying the major anatomical components composing the limbic belt. *(1)* Amygdala; (*2)*hippocampus; (*3)* cingulate gyrus

WHITE MATTER OF THE HEMISPHERES:

There are three types of fibre within the cerebral hemispheres:

1) Commissural fibres:

**The corpus callosum*:

The corpus callosum is a large midline mass of commissural fibres, each of which connects corresponding areas of both hemispheres. It is approximately 10 cm long and becomes progressively thicker towards its posterior end. Parts from anterior to posterior are: Rostrum, Genu, Trunk (body) & Splenium.

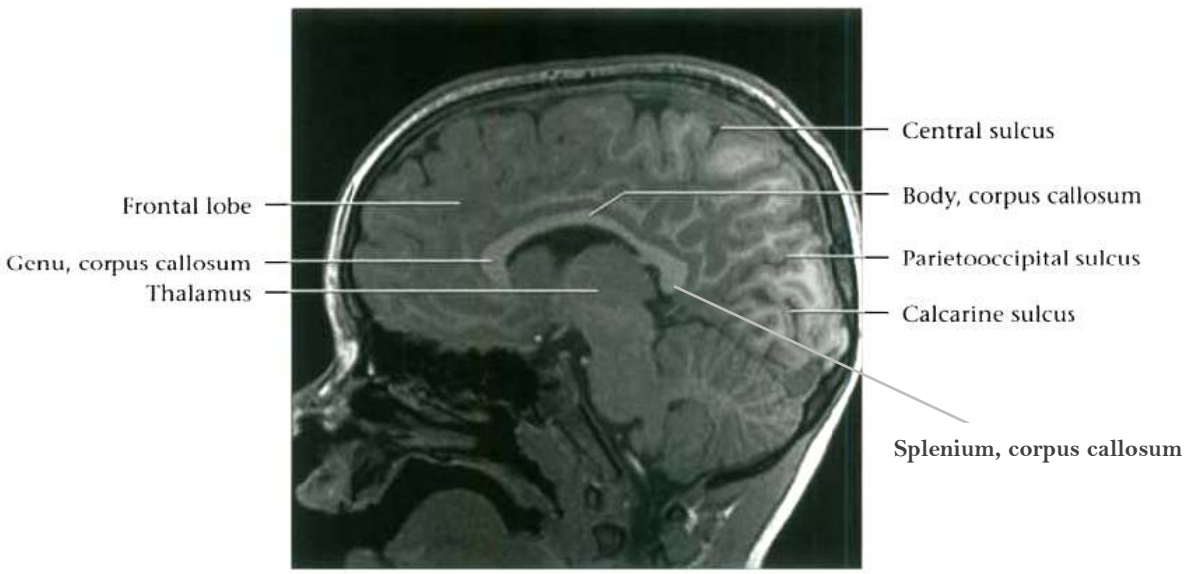

Figure (5): Sagittal T1 midline section showing different parts of corpus callosum

**Anterior commissure:*

This is a bundle of fibres in the lamina terminalis in the anterior wall of the third ventricle. The anterior commissure is part of the olfactory system.

**Habenular commissure:*

This small commissure is situated above and anterior to the pineal body. It unites the habenular striae, which are fibres from the olfactory centre.

**Posterior commissure:*

This is situated anterior and inferior to the pineal body. It connects the superior colliculi, which are concerned with light reflexes.

2) Projection fibres

These fibres join the cerebral cortex to lower centres. Some are afferent and some efferent. They are called the internal capsule, where they lie lateral to the thalamus and the corona radiata as they fan out between the internal capsule and the cerebral cortex. In cross-section, the internal capsule has an anterior limb between the caudate and lentiform nuclei and a posterior limb between the lentiform nucleus and the thalamus. Both limbs meet at a right-angle called the genu.

3) Association (arcuate) fibres:

These connect different parts of the cortex within the same hemisphere.

THE BASAL GANGLIA:

This subcortical grey matter includes:

• **The Corpus striatum**: It includes, the **Caudate nucleus**; highly curved and lies within the concavity of the lateral ventricle having a head, body and tail. Its long, thin tail ends in the amygdaloid nucleus, and **Lentiform nuclei**; This is shaped like a biconcave lens. It is made up of a larger lateral putamen and a smaller medial globus pallidus.

• **The amygdaloid body**

• **The claustrum**: This thin sheet of grey matter lies between the putamen and the insula. It is separated medially from the putamen by the external capsule and bounded laterally by a thin sheet of white matter (the extreme capsule) just deep to the insula. The claustrum is cortical in origin but its function is unknown.

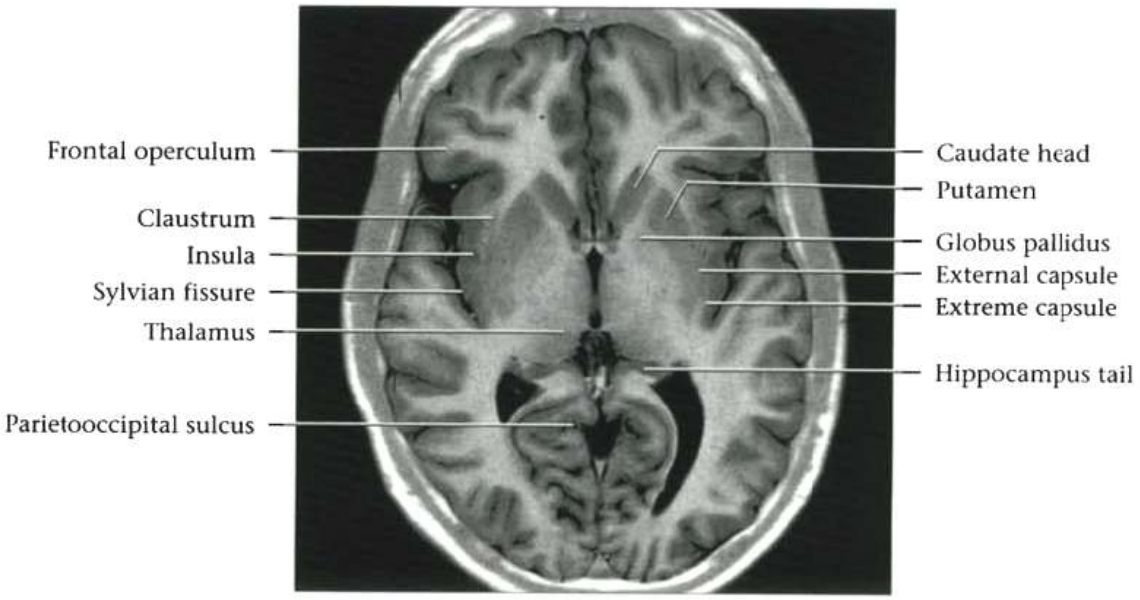

Figure (6): Axial T1 MRI showing deep gray matter anatomy.

THE BRAINSTEM:

The brainstem connects the cerebral hemispheres with the spinal cord and extends from just above the tentorial hiatus to just below the foramen magnum. It is bounded anteriorly by the clivus-basisphenoid above and the basiocciput below. The brainstem has three parts: from superior to inferior:

The Midbrain: It has anteriorly two cerebral peduncles seen separated by the inter-peduncular fossa and its posterior surface presents four rounded prominences (corpora quadrigemini or the superior and inferior colliculi).

The Pons: The bulbous anterior part of the pons consists mainly of cerebellopontine fibres continuous on each side with the middle cerebellar peduncle with a shallow groove is seen in the midline in which the basilar artery may lie, but more often lies lateral to it. The posterior surface of the pons forms the upper part of the floor of the fourth ventricle.

The Medulla: The upper part of the medulla is open as the floor of the fourth ventricle, whereas its lower part is closed around the central canal.

CEREBELLUM:

The cerebellum lies in the posterior fossa. It is separated from the occipital lobe by the tentorium and from the pons and midbrain by the fourth ventricle. It is connected to the brainstem by three pairs of cerebellar peduncles:

• Superior cerebellar peduncles (brachium conjunctivum) to the midbrain.

• Middle cerebellar peduncles (brachium pontis) to the pons.

• Inferior cerebellar peduncles (restiform body) to the medulla.

There are two hemispheres with the midline vermis between. On each side below the middle cerebellar peduncle is the flocculus. This is a small ventral portion of the hemisphere that is almost