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To

The Souls of My Parents

Who taught me to pursue my dreams

and

To My Family,

My Wife And My Daughter

Their love and encouragement

make everything worthwhile

CONTENTS

List of Abbreviations

Acal	Anterior calcarine artery
AChA	Anterior Choroidal Aretry
AD	Alzheimer disease
ALV	Alveus
Amy N	Amygdaloid nuclei
CA	Cornu Ammonis
CF	Choroidal fissure
Ch	Choroid plexus
CN	Caudate nucleus
COE, COS	Collateral eminence and sulcus
CPS	Complex partial seizures
CrCi	Crural cistern
CSF	Cerebrospinal fluid
CT	Computed Tomography
DG	Dentate gyrus
EEG	Electroencephalography
FMR1	Functional Magnetic Resonance Imaging
H	Hippocampus
HF	Hippocapal fissure
ICA	Internal Carotid artery
IGF	Isthmus of gyrus tornicatus
ILG	Intralimbic gyrus
LPch	Lateral Posterior choroidal artery
MC	Middle cerebral artery
MRI	Magnetic Rresonance Imaging
MRR	Magnetic Resonance Relaxometry
MRS	Magnetic Resonance Spectroscopy
MTS	Mesial temporal sclerosis
NPH	Normal pressure hydrocephus
PC	Posterior cerebral artery
PCA	Posterior Choriodal Artery
PET	Position Emission Tomography
PH	Parahippocampal gyrus
PHFs	Perihippocampal fissures
PMC	Perimesencephalic cistern
S	Subiculum
SPECT	Single Photon Emission Computed Tomography
TFB	Transverse fissure of bichat
TH	Temporal Horn
UG	Uncinate gyrus
UR	Uncal recess
US	Uncal sulcus

Chapter I

INTRODUCTION

INTRODUCTION

Understanding the three dimensional anatomy of perihippocampal fissures (PHFs) can be of great help in reaching the correct diagnosis of diseases of the mesial temporal lobe. Disorders of the parenchyma and cerebrospinal fluid spaces are reflected by specific changes in the PHFs.[1]

With the advent of recent imaging modalities, increased attention has been paid to the hippocampus, parahippocampal gyrus, amygdala and other structures of the mesial temporal lobe and how these structures are affected by pathologic conditions such as Alzheimer disease (AD), mesial temporal sclerosis (MTS), normal pressure hydrocephalus (NPH) and various tumors.[2-8]

The fissures of the mesial temporal lobe are collectively described as the perihippocampal fissures (PHFs). The anatomic changes that the structures of the mesial temporal lobe undergo due to different disease states are reflected on the surrounding PHFs. An assessment of such changes in the PHFs can lead to correct diagnosis of pathologic conditions in this area.[9]

Gross Anatomy of the hippocampus and PHFs :

The PHFs include the transverse fissure of Bichat and its two lateral extensions : the choroidal fissure and hippocampal fissure. The *transverse fissure* is the lateral extension of the perimesencephalic cistern, which separates the thalamus superiorly from the parahippocampal gyrus inferiorly. The *superior lateral extension* of the transverse fissure is the choroidal fissure, which extends superior to the hippocampus. The *inferior lateral extension* of the transverse fissure is the hippocampal fissure, which extends between the hippocampus and parahippocamapl gyrus, thereby forming the infromedial border of the hippocampus.[9] (Fig. 1, 2)

The lateral margin of the hippocampus is formed by the temporal horn of lateral ventricle. An important anatomic point is that the temporal horn does not communicate with the transverse fissure and its extensions. The fimbria and the choroid plexus form a border between these two CSF filled structures.[9] One of the most important structures in the mesial temporal lobe that is in close relation to the PHFs is the hippocampus which is a complex structure that forms part of the medial wall of the cerebral hemisphere. Ananzi, the sixteenth-century anatomist, introduced the term hippocampus, which in latin means sea horse or monster. It could perhaps be related to the bulge it forms on the floor of the temporal horn, giving it the impression of a sea serpent.[10]

Figure 1. ***Normal anatomy.*** Coronal pathologic section through the mesial temporal lobe, including the hippocampus (*H*). Shows the PHFs the transverse fissure of Bichat (arrowhead). Hippocampal fissure (straight solid arrows), and choroidal fissure (curved arrow). The transverse fissure communicates with the perimesencephalic cistern (lower left side of image) the choroid plexus and fimbria (open arrow) form a physical barrier between the temporal horn (*TH*) and choroidal fissure. *PH*=parahippocampal gyrus.

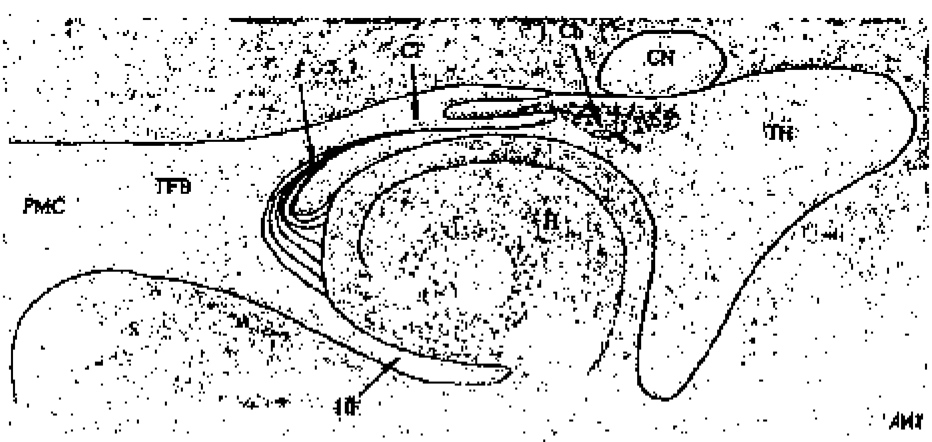

Figure 2. ***Normal anatomy.*** Coronal diagram shows the structures of the mesial temporal lobe including the PHFs.the medial aspect is on the left side of the image;the lateral aspect is on the right.The PHFs are visible but are not dilated The choroid plexus (*ch*) and fimbria (*F*)form a physical barrier between the temporal horn(*TH*) and choroidal fissure(*CF*). *CN*=caudate nucleus hippocampus. HF=hippo-campal fissure. *PMC*=Perimesencephalic cistern. S=subiculum (parahipocampal gyrus*)*. *TFB* =transverse fissure of Bichat.

The hippocampus is an important part of the limbic system, which also includes the subcallosal area, angulate gyrus, and parahippocampal gyrus. It arches across the medial fringe of the temporal lobe, sitting on the subiculum of the parahippocampal gyrus and lying just below the choroidal fissure. Understanding the anatomy of the hippocampus became more important since the discovery of the association between structure abnormality of the hippocampus and temporal lobe epilepsy.

The intricate configuration of the hippocampus arise form folding of a continuous strip of cortex at the medial aspect of the temporal lobe during ontogenesis. This layer rolls in on itself along a longitudinal groove, the hippocampal sulcus. This results in the formation of two complex, interfolded layers of primitive gray matter known as the dentate gyrus and cornu Ammonis. Its ancient phylogenicity is exemplified by the trilaminal arrangement of the cortical surface, as compared with the six layered cortex that is present in the neocritcal structures of the brain. The cornu Ammonis is continuous through the subiculum with the parahippocamapl gyrus. The hippocampal sulcus separates the dentate gyrus form the subiculum inferiorly. The later portion of this fissure is usually obliterated in utero, but a residual cavity of this fissure can be seen on magnetic resonance (MR) images in 10% of the normal population. In most normal subjects, the MR appearance of the medial hippocampal fissure is that of a slit like cerebrospinal space.[1,9,10]

The hippocampus forms an incomplete ring of cortex around the brain stem in the medial free borders of the temporal lobe. Its crescentic form creates a bulge at the medial wall and floor of the temporal horn. The ambient cistern lies between it and brain stem and ipsilateral cerebral peduncle.[11] The hippocampus can be divided into three parts the head, the body and tail. ***The head*** is the bullous expanded segment lying posterior and inferior to the amygdala. The anterior end is grooved and arches medially slipping inferiorly and medially to the amygdala, which is separated from it by the uncal recess of the temporal horn. The margo denticulatus, the visible continuation of the dentate gyrus at the aspect of the hippocampal head, bends medially to become the band of Giacomini, which then merges with the uncus. Posterior to the band of Giacomini is a nodular eminence, the intralimibic gyrus, which is also linked by the fimbria to the hippocampal head. This structure helps to serve as a landmark separating the hippocampal head and body.

The body is oriented parasagittally with the temporal horn forming its superior and lateral relations. Its superior surface is covered by a thin layer of white matter, the alveus, whose fibers merge from a flattened band superior to the dentate gyrus known as fimbria (fringe or border line latin) at the superomedial edge. The margo denticulatus forms a series of small bumps on the medial hippocampal surface.

The tail is oriented transversely and contains several visible structures. It continues posteriorly as the indusium griseum, which curves around the corpus callosum as a thin band of gray matter known as supracollosal gyrus. The posterior extension of the fimbria at the tail ascends towards the splenium of the corpus callosum, passing below it before curving anteriorly over the thalamus forming the crus of the fornix. The two crura are closely related to the inferior surface of the corpus callosum and are connected by transverse fibers forming the commissure of the fornix. At the transition from fimbria to fornix, the fimbriodentate sulcus widens to reveal the fasciolar gyrus, which is part of cornu Ammonis (CA3) enveloped by the alveus. The posterior continuation of the dentate gyrus forms the fasciola cinerea. The gyri of Andreas Retzius or subcallosal eminence forms a bulge at the hippocampal tail and represents the continuation of CA1 portion of the cornu Ammonis.[9-14] (Fig. 3)

Internal Architecture :

The hippocampus is made up of different types of cells microscopically. The main component of the cornu Ammonis is a layer of large and small pyramidal cells with their bases facing the alveus and their apices pointing inwards toward the lateral fused portion of the hippocampal fissure. This is divided into four zones named cornu Ammonis 1 to 4 (CA1 to CA4) based on histologic differences. CA1 is that part of cornu Ammonis continuous with the subiculum. The part adjacent to the dentate gyrus is designated CA4. CA1 (Sommer sector) is most sensitive to hypoxia and is called vulnerable sector. CA2 and CA3 (spielmeyer sector) are known as resistant sectors, and CA4 (Bratz sector) is the medium vulnerability sector. The dentate gyrus contains granular cells that have distinctive axons known as mossy fibers forming contacts with the apical dendrites of the pyramidal cells of cornu Ammonis.(1,15)

The fornix is the efferent pathway of the hippocampus. These efferent fibers are mainly continuations of the axons of the pyramidal cells of cornu Ammonis. They pass through the alveus to sweep to the medial border of the ventricular surface to constitute the fimbria. The fimbria then continues posteriorly beneath the splenium of the corpus callosum to form the fornix.(15) (Fig. 4)

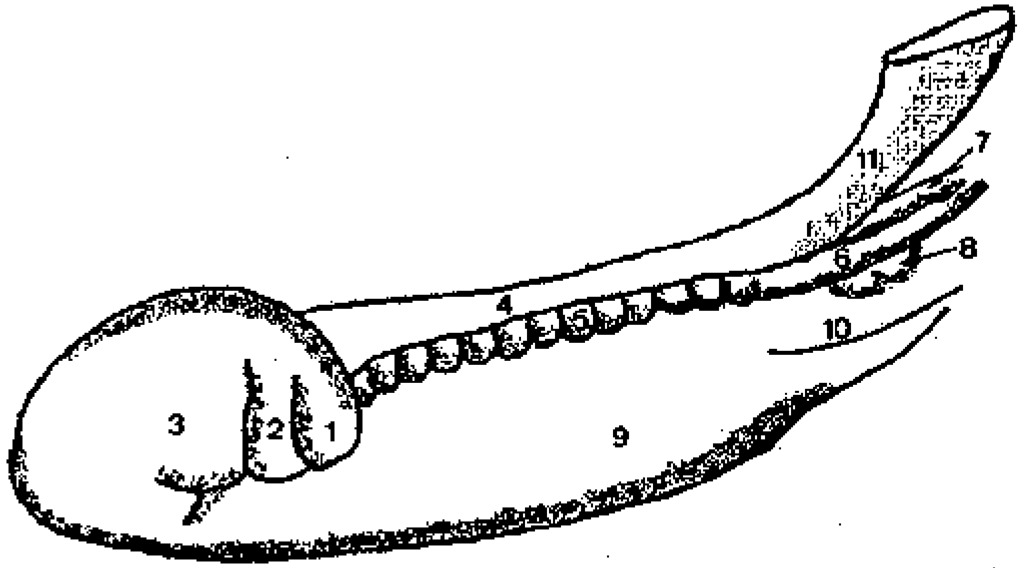

Figure 3. ***Structure of hippocampus.*** 1, intralimbic gyrus; 2,band of Giacomini; 3, uncus; 4, fimbria; 5, margo denticulatus; 6, fasciola cinerea; 7, fasciolar gyrus; 8, gyri of Andreas Retzius; 9, para hippocampal gyrus; 10 isthmus; 11, fornix. Medial view of the hippocampus showing the head, body and tail sitting on parahippocampal gyrus.

Figure 4. ***Coronal section of hippocampus.*** 1, CA1; 2,CA2; 3, CA3; 4, CA4; 5,dentate gyrus; 6, alveus; 7, choroid plexus; 8, subiculum; 9, fimbria; 10, hippocampal sulcus. Coronal sections of the hippocampal body showing the interlocking relationship between the cornu ammonis and the dentate gyrus.

Cross sectional radiographic anatomy[11-19] :

Computed tomography (CT) has limited utility in imaging of the mesial temporal lobe and especially to our concern the PHFs and the hippocampus where the beam hardening effect degrades resolution of the engulfed temporal lobes by the surrounding thick skull bones. In coronal CT sections, it is difficult to differentiate the hippocampi from adjacent structures. Axial CT slices of the brain can be tilted 20 degrees negative to the cantho-meatal line to display the hippocampus and temporal horn in longitudinal sections.

Advances in MR imaging techniques have made it the imaging modality of choice in assessment of the hippocampus. The multiplanar capability of MR imaging coupled with the exquisite differentiation of gray and white matter using different pulse sequences has contributed much to the understanding of normal and abnormal hippocampal anatomy.

The hippocampus is optimally studied in the coronal plane, where both hippocampi can be assessed simultaneously and comparative evaluation can be made. Minimizing head rotation avoids erroneous comparison of hippocampal structures imaged at different sections. Axial and sagittal images can help in providing further information on hippocampal anatomy and its normal relations.

T2 weighted images are useful in detecting signal abnormalities in the hippocampus. Images with exquisite anatomic resolution can be obtained with three dimensional gradient echo images in thin (3 mm or less) sections. Inversion recovery sequences can provide better T1 weighted contrast than conventional spin echo techniques. This contrast enhances gray/white matter differentiation, enabling better analysis of the internal architecture of the hippocampus. Fast gradient techniques have the advantages of both thin slice acquisition and adequate white/gray matter differentiation.

In coronal sections, the primitive cortex has resulted in the dentate gyrus and the cornu Ammonis appearing as two interlocking U's of gray matter with the cornu Ammonis forming the more lateral upside down U. This relationship is best seen in the hippocampal body and continues onto the head.

Superiorly the alveus forms a layer of subependymal white matter carrying axons exiting from the hippocampus and merges medially with the fimbria. The hippocampal sulcus, a narrow strip of cerebrospinal fluid space in normal subjects that has been noted to be enlarged in Alzheimer disease, separates the dentate gyrus from infirmly situated subiculum.