Diffusion-Weighted MR Imaging for Brain Tumor Characterization

Essay

*Submitted for Partial Fulfillment of Master Degree in **Radiodiagnosis***

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قَالُوا سُبْحَانَكَ لاَ عِلْمَ لَنَا إِلاَّ مَا
عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ

صدق الله العظيم

سورة البقرة آية (٣٢)

Acknowledgement

*Thanks first and last to **Allah** as we owe him for his great care, support and guidance in every step in our life.*

*I'd like to express my respectful thanks and profound gratitude to **Prof. Dr. Yasser Abdel Azeem Abbas,** Professor of Radiodiagnosis, Faculty of Medicine, Ain Shams University, for giving me the honor and great advantage of working under his supervision. His valuable teaching and continuing education to me extend far beyond the limits of this assay.*

*My sincere thanks and utmost appreciation are humbly presented to **Dr. Enas Abdel Ghany Ibrahiem,** Lecturer of Radiodiagnosis, Faculty of Medicine, Ain Shams University for her meticulous supervision, professional experience and tremendous assistance. I really appreciate her patience and support.*

My deepest gratitude I extend to my whole family who offered me support, advice and motivation.

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List of Abbreviations

ADC................Apparent diffusion coefficient

CPA ....Cerebello-pontine angle

CSF ....Cerebro-spinal fluid

DENTs............Dysembryoplastic neuroepithelial tumors

DTI..................Diffusion tensor image

EPI ....Echo-planner image

FA ....Fractional anisotrophy

GBM ....Glioblastoma multiforme

HASTE ....Half-fourier single shot turbo spin echo

JPA..................Juvenile pilocytic astrocytoma

MD..................Mean diffusibility

PCNSL............Primary central nervous system lymphoma

PNETs.............Primitive neuro-ectodermal tumors

PXA ....Pleomorphic xanthoastrocytoma

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Introduction

Physical Aspects of Diffusion:

Introduction

MR imaging is now a well established tool for evaluation of brain tumors but conventional MR technique continue to have important limitations. These limitations include inability to reliably distinguish exact limits of tumor extension and discriminate recurrent tumor and radiation necrosis ***(Wong et al., ٢٠٠٠)***.

In the past few years, a number of advanced MR imaging techniques have been developed that provide new methods for the assessment of brain tumors. One of these techniques is diffusion MR imaging which is now recognized as an important new mean for assessing tumors and tumor therapies ***(Covarrubias et al., ٢٠٠٤)***. Diffusion techniques are being used to characterize tumors by helping distinguish tumor types, assess tumor grade, and attempt to determine tumor margins. In addition, the role of these techniques for evaluating response to tumor therapy is markedly gaining acceptance ***(Provenzale et al., ٢٠٠٦)***. This includes diffusion tensor imaging (DTI) which is a technique that has been developed more recently than isotropic (trace-weighted) DW imaging ***(Kealey et al., ٢٠٠٤).***

Diffusion-weighted (DW) imaging may allow the cellularity of tumors to be graded noninvasively; because cells constitute a relative barrier to water diffusion, compared with extracerebral space. Tumors that are more cellular would be expected to show less of an increase in ADC than tumors that are less cellular ***(Sadeghi et al., ٢٠٠٣).***

Aim of the Work

To demonstrate the value of diffusion-weighted MR imaging as an emerging techniques for imaging of brain tumors.

Gross Anatomy of the Brain

The cranial cavity is the interior of the skull that accommodates the brain and its associated structures. The cranial cavity is separated into supratentorial and infratentorial compartments by a rigid sheet of dura (the tentorium cerebelli). The supratentorial compartment is the larger of the two and is occupied by the cerebral hemispheres. The infratentorial compartment is occupied by the brainstem and the cerebellar hemispheres ***(Stark and Bradley, ١٩٩٩).***

The Cerebral Hemispheres

The cerebral hemispheres fill the cranial vault above the tentorium cerebelli. Right and left hemispheres are connected by the corpus callosum and 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 hemisphere ***(Ryan and McNicholas, ١٩٩٨).***

The cortex is thrown into a complicated series of tortuous folds, the gyri, the grooves between them are the sulci or fissures. Some of the larger sulci are used to divide the surface of the hemisphere into lobes; each cerebral hemisphere is divided into five lobes namely frontal, parietal, temporal, occipital lobes in addition to a buried area called the insula. The limbic lobe is seen on the medial surface only ***(Ghali, ١٩٩٧).***

There are three surfaces for each hemisphere, separated by three borders. The superior border separates the medial and lateral surfaces, the inferolateral border separates the inferior and lateral surface, and the inferomedial border separates the medial and inferior surfaces ***(Rao, ١٩٩٢).***

Surface Features:

Supero-lateral surface: (Fig.١)

This surface presents ٢ main deep fissures namely the lateral sulcus and the central sulcus. The lateral sulcus (fissure of Sylvius) begins on the inferior surface of the hemisphere and extends to the superolateral surface passing backwards over the temporal lobe. It ends by dividing into three rami namely anterior ascending and posterior rami. The posterior ramus is the longest and conducts the middle cerebral vessels ***(Ghali, ١٩٩٧).***

The central sulcus is a prominent sulcus that starts in or near the superomedial border a little behind the mid-point between the frontal and occipital poles. It runs sinuously downwards and forwards for about ٨-١٠ cm to end a little above the posterior ramus of the lateral sulcus. This separates the frontal and parietal lobes ***(Standring et al., ١٩٩٥).***

The frontal lobe includes all the cortex anterior to the central sulcus and superior to the lateral sulcus. Three sulci over the lateral surface of the frontal lobe divide it into superior, middle and inferior frontal gyri. Two small sulci (namely the anterior and ascending rami of the lateral sulcus) divide the inferior frontal gyrus into orbital, opercular and triangular gyri. On the dominant hemisphere these areas of the cortex bounding the short sulci on the inferior frontal gyrus represent motor speech area of Broca ***(Standring et al.,* ١٩٩٥*).***

The parietal lobe includes all the cortex from the central sulcus to a line from the parieto-occipital boundary to the posterior end of the lateral sulcus. There is no clear lateral demarcation between the parietal and occipital lobes. The lateral aspect of the parietal lobe is subdivided into three areas by the postcentral and transverse (intra-parietal) sulci. The postcentral sulcus separates the postcentral gyrus from the remainder of the parietal lobe. The transverse sulcus divides the parietal lobe into superior and inferior parietal gyri ***(Standring et al.,* ١٩٩٥*).*** Areas with known function include the sensory cortex and parietal association cortex.

The temporal lobe lies inferior to the lateral sulcus and is separated from the occipital lobe by an arbitrary line drawn from the preoccipital notch to the parieto-occipital sulcus. 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 ***(Ryan and McNicholas,* ١٩٩٨*).***

The occipital lobe is behind the arbitrary line joining the preoccipital incisure to the parieto-occipital sulcus. The lateral surface of the occipital lobe is composed of a number of irregular lateral occipital gyri which are separated into groups by a more constant lateral occipital sulcus. Areas with known function include the visual cortex and visual association cortex ***(Ryan and McNicholas, ١٩٩٨).***

The insula is the cortex buried in the floor of the lateral sulcus and is crossed by the branches of the middle cerebral artery. The parts of the frontal, parietal, and temporal lobes that overly the insula are called the operculum ***(Ryan and McNicholas, ١٩٩٨).***

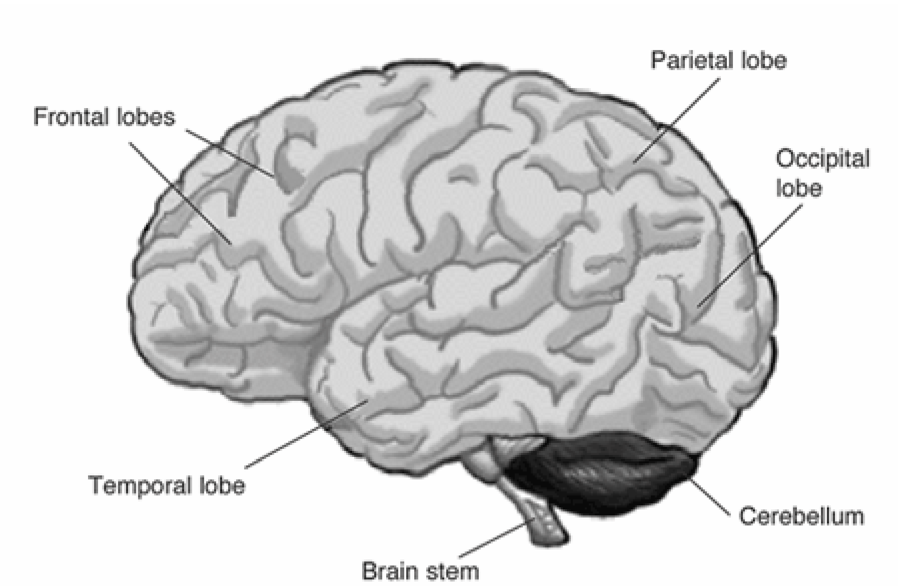

Fig. (١): Principal lobes of the cerebrum view laterally ***(Quoted from Standring et al., ١٩٩٥).***