University of Sudan of Science and Technology
College of Graduate Studies

Assessment of Magnetic Resonance Spectroscopy in Diagnosis of Brain Lesions

تقييم التحليل الطيفي بالرنين المغنطيسي في تشخيص افات الدماغ

A thesis Submitted for Partial Fulfillments of the Requirements of M.Sc Degree in Diagnostic Radiologic Technology

Prepared by:
Tasneem Hider Mahjoob Mohamed Ahmed

Supervisor:
Dr. Ikhlas Abdelaziz Hassan

2018

الاية

قال تعالى:

وَأَن لَّيْسَ لِلْإِنسَانِ إِلَّا مَا سَعَىٰ (39) وَأَنَّ سَعْيَهُ سَوْفَ يُرَىٰ(40) ثُمَّ يُجْزَاهُ الْجَزَاءَ الْأَوْفَىٰ(41)

سورة النحل

Dedication

To my mother ,

Whose sincere prayers helped me to overcome the obstacles

To my father,

My pride, support and my guidance

To my beloved brother,

My loyal companion, my source of happiness and joy

To my sister and her beloved children

My little angles

To my friends,

My inspiration and my source of energy,

To those souls left us behind,

Leaving us holding patience and strength

To all those who support this work

Acknowledgments

Thanks to Allah almightily who enabled me to achieve this work.

I submit my heartiest gratitude to my respected teacher, ***Supervisor,Ikhlas Abdul-Aziz Hassan*** *for his sincere guidance and appreciated help for completing this project .*

I am deeply indebted to my respected teacher ***DR:Mohammed Abdelwahab Idris Salih*** *who supported me and inspired me through this work and I give my sincere thanks for his efforts and encouragements*

I also submit my gratitude to my wonderful friend ***Mudawei IzzAldin Mudawei*** *for his great efforts all the way long.*

I submit my gratitude to my teacher ***Dr.Ala mohammed Abd Elgyoum Mohamed*** *who guided me throughout the course of this research work.*

My joy knows no bound in expressing my cordial gratitude to my senior ***Gehad Hamid ,*** *his keen encouragement was a great help throughout my first steps in this way of my work .*

I humbly extend my thanks to all my colleagues in ***Almoalem Medical City*** *for their continuous support and to all the patients who helped me and wish the healing.*

Abstract

Early detection and management of intracranial lesions is required to improve the outcome of the disease, as this kind of lesions has a high morbidity rate. This study was carried out to assess magnetic resonance spectroscopy in diagnosis of brain lesions. This study was done at the ALmoalem Medical City - Khartoum, Sudan, during the period from November 2017 to March 2018. MRS Studies were performed on 1.5 Tesla Toshiba Exclelart Vantage whole body MR systems using standard imaging head coil. This was a descriptive retrospective and prospective in quantitative an observational cross-sectional study of 60 patients Male 32 (64%) and 18female (36%), their age ranged from (4-80years) The result of this study revealed that Majority of the patients were in the 5th decade (24%), Gliomas were the most common brain tumors (46%), Most common Tumor Site be involved was the left site (60%). In conclusion, diagnosis of benign and malignant brain tumors and differentiating them from other focal intra-cranial lesions based on imaging procedures alone is still a challenging problem, combination of proton MRS and conventional MRI protocol can provide additive valuable information helping in tissue characterization of intra-cranial tumors leading to improved diagnosis and thus reducing biopsies. We recommend to doing MRS routinely in patients with brain lesions to improve the accuracy of neuro diagnosis and for other benefit in patient management

مستلخص البحث

اجريت هذه الدراسه لوصف الطيف المغنطيسى فى افات الدماغ واظهار اهميته التشخيصيه فى التفريق بين الاورام الخبيثه و الحميده وغيرها من الافات ,ايضا لاظهار اهمية طيف الرنين المغنطيسى فى التفريق بين اورام وافات الدماغ الاخرى وربط النتائج. اجريت الدراسه فى مدينة المعلم الطبية الخرطوم - السودان فى الفتره من -نوفمبر 2017 حتى مارس 2018 وتم عمل فحوصات الطيف بالرنين المغنطيسى باستخدام جهاز رنين مغنطيسى 1.5 تسلا ماركة توشيبا لتصوير جسم الانسان ومزود بجهاز قياسي لتصوير الراس وقد اشتملت هذه الدراسة علي 50 مريض منهم 32 من الذكور(64%)و18 من الاناث (36%)

اظهرت نتائج هذة الدراسة ان غالبية المرضي كانو من العقد الخامس في العمر (24%) الاورام الدبقية كانت الاكثر شيوعا (46%) وكان الجانب الايسر من الدماغ هو الاكثر اصابة (60%)

خلصت الدراسة الى ان تشخيص اورام الدماغ الحميده والخبيثه وتمييزها عن افات الدماغ الاخرى على اساس اجراء فحص الرنين المغنطيسى فقط لا يكفى , فان امتزاج الطيف بالرنين المغنطيسى والبروتوكول التقليدى للرنين المغنطيسى يمكن ان يوفر معلومات اضافيه ذات قيمه تساعد فى توصيف الاورام الموجودة فى انسجة الدماغ مما يؤدى الى تحسين التشخيص وبالتالى تقليل اخذ العينات . نوصي بعمل الطيف المغنطيسي لاي مريض يعاني من افات الدماغ لتحسسين دقة التشخيص ومفيد في متابعة حالة المريض .

LIST OF CONTENTS

List OF Figures

List of Tables

List of Abbreviations

2D	2-dimensiona
3D	3-dimensional
ATP	Adenosine-triphosphate
CNS	Central nervous system
CSI	Chemical shift imaging
CNS	Central nervous system
CW	Continuous wave
CSF	Cerebrospinal fluid
Cr	Creatine
Cho	Choline
FID	Free induction decay
FT	Fourier transformation
FFT	Fast Fourier transformation
GBM	Glioblastoma multiform
Gd	Gadolinium
Gln	Glutamine
Glu	Glutamate
Glx	Composed peak of Glu and Gln
GBM	Glioblastoma multiform
H	Proton
Hz	Hertz
JCV	John Cunningham virus
Lac	Lactate
Lip	Lipid
MR	Magnetic resonance
MRI	Magnetic resonance imaging
MRS	Magnetic resonance spectroscopy
MRSI	Magnetic resonance spectroscopic imaging
MRA	Magnetic resonance arteriography
NAA	N-acetyl aspartate
NA	Sodium
NMR	Nuclear magnetic resonance
P	Phosphorus
PPM	Parts per million

PRESS	Point resolved surface coil spectroscopy
PML	Progressive multifocal leukoencephalopathy
RF	Radio frequency
SNR	Signal-to-noise-ratio
STEAM	Stimulated echo acquisition mode
SVS	Single-voxel spectroscopy
SPSS	Statistical package for social sciences
T1	Longitudinal relaxation time in units of ms
T2	Transverses relaxation time in units of ms
T2*	Effective transverse relaxation time in units of ms
TE	Echo time in unit of ms
TI	Inversion time
TR	Repetition time in unit of ms
T1	Longitudinal relaxation time in units of ms
TMS	Tetramethlsilane
WHO	World Health Organization

CHAPTER ONE

(Introduction)

Chapter one
Introduction

1.1 Introduction:

Imaging is becoming an increasingly important tool in both research and clinical care. A range of imaging technologies now provide unprecedented sensitivity to visualization of brain structure and function from the level of individual molecules to the whole brain. Many imaging methods are noninvasive and allow dynamic processes to be monitored over time. Imaging is enabling researchers to identify neural networks involved in cognitive processes; understand disease pathways; recognize and diagnose diseases early, when they are most effectively treated; and determine how therapies work In vivo magnetic resonance spectroscopy (MRS) of the human brain has developed rapidly since its first observation in the 1980s. Early studies in both humans and animals focused on the 31P nucleus which allowed the measurement of energy metabolites such as phosphocreatine and ATP, as well as inorganic phosphate and phosphoesters. With the development of improved techniques for spatial localization and water suppression, proton MRS became more prevalent in the 1990s because of its higher sensitivity and greater convenience (since it can be performed without hardware modification on most MRI machines, unlike MRS of other nuclei) While interest remains, particularly at high magnetic field strengths, in nuclei such as 31P,23Na, and 13C (particularly for isotopically labeled and/or hyper-polarized molecules), the vast majority of brain MRS studies in vivo use the proton. The remainder of this article therefore focuses on protocols for 1H-MRS (Jeffry.R.alger, 2006)

Magnetic resonance spectroscopy (MRS) detects electromagnetic signals produced by the atomic nuclei within molecules. It can be used to obtain in situ concentration measures for certain chemicals in living tissue. This presentation will introduce the physics and technology of MRS signal detection at a basic level. It will also introduce basic biochemical concepts that are useful for interpreting spectra

MR spectroscopy provides a measure of brain chemistry and has been recognized as a safe and invasive diagnostic method that coupled with MRI techniques, allows for the correlation of anatomical and physiological changes in the metabolic and biochemical processes occurring in a previously determined volume in the brain. The most common nuclei that are used are H (proton), Na (sodium), and P (phosphorus).Proton spectroscopy is easier to perform and provides much higher signal-to-noise than either sodium or phosphorus .Proton MRS can be performed within 10-15 minutes and can be added on to conventional MR imaging protocols. It can be used to serially monitor biochemical changes in tumors, stroke, epilepsy, metabolic disorders, infections, and neurodegenerative diseases. (Jeffry.R.alger, 2006)

Stander clinical MR images depend on magnetic resonance signals of hydrogen nuclei, which are present in very high concentrations in water and, to a lesser extent in lipids. Although other hydrogen-containing metabolites are present, their concentrations are too low to contribute significantly to the MR signal unless the water signal is suppressed. This can be achieved using a chemical-selective saturation radiofrequency pulse. Because protons are shielded by their valence electrons, every proton group experiences a slightly different magnetic field and therefore resonates at different frequencies, measured as the chemical shift away from a reference standard in parts per million (ppm). These differences can be demonstrated

by MR spectroscopy (MRS) as spectra whose peaks are attributable to particular metabolites. (Janet, Julay2012)

1.2 Problem of study:

MRS it's available and easy to use by technologist and has a good role in differentiate the different lesions in brain. But it's not wildly used in Sudan hospitals and diagnostic centers

1.3 Objectives:

1.3.1 General Objective:

To assessment of magnetic resonance spectroscopy in diagnosis of brain lesions

1.3.2 Specific Objectives:

1. To differential the benign lesions and malignant lesion
2. To determine the role of non invasive technique MRS in management of brain lesions
3. To correlate MRS findings and conventional MRI findings

1-4Thesis out line

The flowing research will be consisting of five chapters:

Chapter one will deal with introduction, problem of study, objectives and thesis out line

Chapter two will highlights the literature review related to the current study and the theoretical view for the study

Chapter three will show the methodology

Chapter four will show the results and discussion

Chapter five will show the conclusion, and recommendation, references and appendices

Chapter Two

Literature Review and

Previous Studies

Chapter Two

Literature Review

2.1 Anatomy

The brain is one of the most complex and magnificent organs in the human body. Our brain gives us awareness of ourselves and of our environment, processing a constant stream of sensory data. It controls our muscle movements, the secretions of our glands, and even our breathing and internal temperature. Every creative thought, feeling, and plan is developed by our brain. The brain's neurons record the memory of every event in our lives. There are different ways of dividing the brain anatomically into regions. Let's use a common method and divide the brain into three main regions based on embryonic development: the forebrain, midbrain and hindbrain.

2.1.1The forebrain (or prosencephalon): is made up of our incredible cerebrum, thalamus, hypothalamus and pineal gland among other features. Neuroanatomists call the cerebral area the telencephalon and use the term diencephalon (or interbrain) to refer to the area where our thalamus, hypothalamus and pineal gland reside.

2.1.2The midbrain (or mesencephalon): located near the very center of the brain between the interbrain and the hindbrain, is composed of a portion of the brainstem.

2.1.3The hindbrain (or rhombencephalon): consists of the remaining brainstem as well as our cerebellum and pons. Neuroanatomists have a word to describe the brainstem sub-region of our hindbrain, calling it the myelencephalon, while they use the wordmetencephalon in reference to our cerebellum and pons collectively.

Before exploring these different regions of the brain, first let's define the important types of cells and tissues that are the building blocks of them all. (Okumura A, Lee T, Ikeno M, Shimojima, 2012)

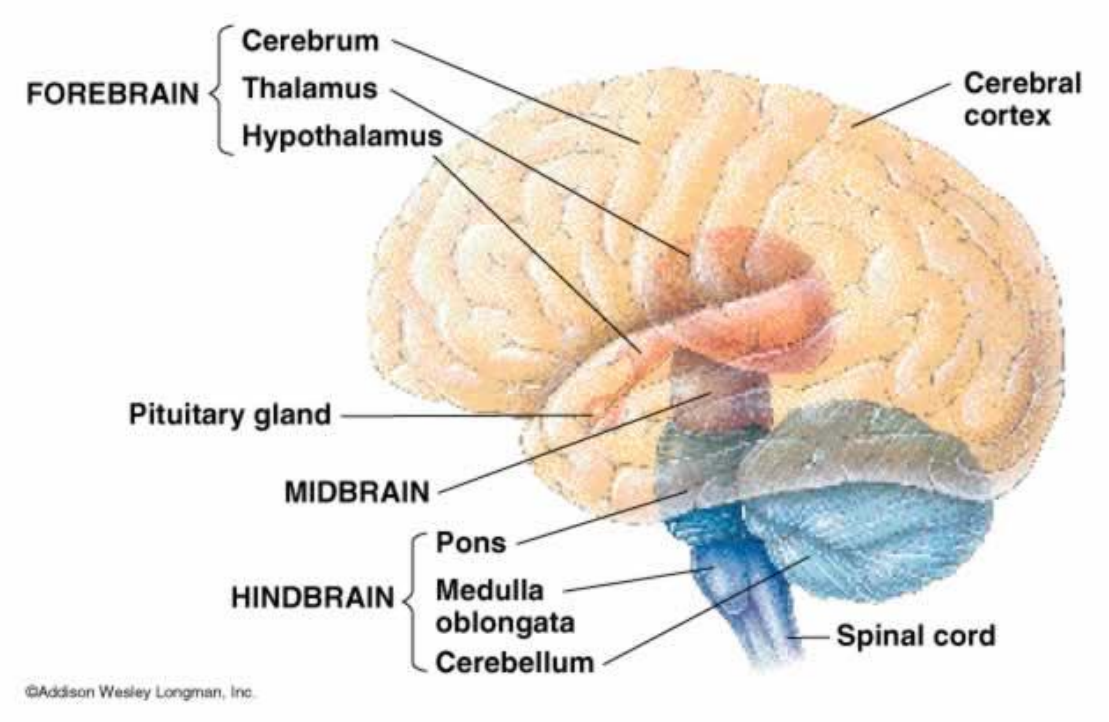


Figure (2-1): Anatomy of brain (Radiographic anatomy and physiology)

Brain cells can be broken into two groups: neurons and neuroglia. Neurons, or nerve cells, are the cells that perform all of the communication and processing within the brain. Sensory neurons entering the brain from the peripheral nervous system deliver information about the condition of the body and its surroundings. Most of the neurons in the brain's gray matter are interneurons, which are responsible for integrating and processing information delivered to the brain by sensory neurons. Interneurons send signals to motor neurons, which carry signals to muscles and glands.

Neuroglias, or glial cells, act as the helper cells of the brain; they support and protect the neurons. In the brain there are four types of glial cells: astrocytes, oligodendrocytes, microglia, and ependymal cells. Astrocytes protect neurons by filtering nutrients out of the blood and preventing chemicals and pathogens from leaving the capillaries of the brain. Oligodendrocytes wrap the axons of neurons in the brain to produce the insulation known as myelin. Myelinated axons transmit nerve signals much faster than unmyelinated

axons, so oligodendrocytes accelerate the communication speed of the brain. Microglia act much like white blood cells by attacking and destroying pathogens that invade the brain. Ependymal cells line the capillaries of the choroid plexuses and filter blood plasma to produce cerebrospinal fluid. The tissue of the brain can be broken down into two major classes: gray matter and white matter. (Okumura A, Lee T, Ikeno M, Shimojima, 2012)

2.1.4Gray matter: is made of mostly unmyelinated neurons, most of which are interneurons. The gray matter regions are the areas of nerve connections and processing.

2.1.5White matter

: is made of mostly myelinated neurons that connect the regions of gray matter to each other and to the rest of the body. Myelinated neurons transmit nerve signals much faster than unmyelinated axons do. The white matter acts as the information highway of the brain to speed the connections between distant parts of the brain and body

2.1.3 Hindbrain (Rhombencephalon)

2.1.3.1Brainstem

connecting the brain to the spinal cord, the brainstem is the most inferior portion of our brain. Many of the most basic survival functions of the brain are controlled by the brainstem. The brainstem is made of three regions: the medulla oblongata, the pons, and the midbrain. A net-like structure of mixed gray and white matter known as the reticular formation is found in all three regions of the brainstem. The reticular formation controls muscle tone in the body and acts as the switch between consciousness and sleep in the brain. The medulla oblongata is a roughly cylindrical mass of nervous tissue that connects to the spinal cord on its inferior border and to the pons on its superior border. The medulla contains mostly white matter that carries nerve signals ascending into the brain and descending into the spinal cord. Within the medulla are several regions of gray matter that process involuntary body

functions related to homeostasis. The cardiovascular center of the medulla monitors blood pressure and oxygen levels and regulates heart rate to provide sufficient oxygen supplies to the body's tissues. The medullary rhythmicity center controls the rate of breathing to provide oxygen to the body. Vomiting, sneezing, coughing, and swallowing reflexes are coordinated in this region of the brain as well. The pons is the region of the brainstem found superior to the medulla oblongata, inferior to the midbrain, and anterior to the cerebellum. Together with the cerebellum, it forms what is called the metencephalon. About an inch long and somewhat larger and wider than the medulla, the Pons acts as the bridge for nerve signals traveling to and from the cerebellum and carries signals between the superior regions of the brain and the medulla and spinal cord. (Okumura A, Lee T, Ikeno M, Shimojima, 2012)

2.1.3.2Cerebellum:

The cerebellum is a wrinkled, hemispherical region of the brain located posterior to the brainstem and inferior to the cerebrum. The outer layer of the cerebellum, known as the cerebella cortex, is made of tightly folded gray matter that provides the processing power of the cerebellum. Deep to the cerebellar cortex is a tree-shaped layer of white matter called the arbor vitae, which means 'tree of life'? The arbor vitae connects the processing regions of cerebellar cortex to the rest of the brain and body. The cerebellum helps to control motor functions such as balance, posture, and coordination of complex muscle activities. The cerebellum receives sensory inputs from the muscles and joints of the body and uses this information to keep the body balanced and to maintain posture. The cerebellum also controls the timing and finesse of complex motor actions such as walking, writing, and speech. (Okumura A, Lee T, Ikeno M, Shimojima, 2012)

2.1.2.1 Midbrain (Mesencephalon)

The midbrain, also known as the mesencephalon, is the most superior region of the brainstem. Found between the pons and the diencephalon, the midbrain can be further subdivided into 2 main regions: the tectum and the cerebral peduncles.

The tectum is the posterior region of the midbrain, containing relays for reflexes that involve auditory and visual information. The pupillary reflex (adjustment for light intensity), accommodation reflex (focus on near or far away objects), and startle reflexes are among the many reflexes relayed through this region.

Forming the anterior region of the midbrain, the cerebral peduncles contain many nerve tracts and the substantia nigra. Nerve tracts passing through the cerebral peduncles connect regions of the cerebrum and thalamus to the spinal cord and lower regions of the brainstem. The substantia nigra is a region of dark melanin-containing neurons that is involved in the inhibition of movement. Degeneration of the substantia nigra leads to a loss of motor control known as Parkinson's disease. (Okumura A, Lee T, Ikeno M, Shimojima, 2012)

2.1.1Forbrain(Prosencephalon)

2.1.1.1Diencephalon

Superior and anterior to the midbrain is the region known as the interbrain, or diencephalon. The thalamus, hypothalamus, and pineal glands make up the major regions of the diencephalon. The thalamus consists of a pair of oval masses of gray matter inferior to the lateral ventricles and surrounding the third ventricle. Sensory neurons entering the brain from the peripheral nervous system form relays with neurons in the thalamus that continue on to the cerebral cortex. In this way the thalamus acts like the switchboard operator of the brain by routing sensory inputs to the correct regions of the cerebral cortex. The thalamus has an important role in learning by routing

sensory information into processing and memory centers of the cerebrum.The hypothalamus is a region of the brain located inferior to the thalamus and superior to the pituitary gland. The hypothalamus acts as the brain's control center for body temperature, hunger, thirst, blood pressure, heart rate, and the production of hormones. In response to changes in the condition of the body detected by sensory receptors, the hypothalamus sends signals to glands, smooth muscles, and the heart to counteract these changes. For example, in response to increases in body temperature, the hypothalamus stimulates the secretion of sweat by sweat glands in the skin. The hypothalamus also sends signals to the cerebral cortex to produce the feelings of hunger and thirst when the body is lacking food or water. These signals stimulate the conscious mind to seek out food or water to correct this situation. The hypothalamus also directly controls the pituitary gland by producing hormones. Some of these hormones, such as oxytocin and antidiuretic hormone, are produced in the hypothalamus and stored in the posterior pituitary gland. Other hormones, such as releasing and inhibiting hormones, are secreted into the blood to stimulate or inhibit hormone production in the anterior pituitary gland. The pineal gland is a small gland located posterior to the thalamus in a sub-region called the epithalamus. The pineal gland produces the hormone melatonin. Light striking the retina of the eyes sends signals to inhibit the function of the pineal gland. In the dark, the pineal gland secretes melatonin, which has a sedative effect on the brain and helps to induce sleep. This function of the pineal gland helps to explain why darkness is sleep-inducing and light tends to disturb sleep. Babies produce large amounts of melatonin, allowing them to sleep as long as 16 hours per day. The pineal gland produces less melatonin as people age, resulting in difficulty sleeping during adulthood (Okumura A, Lee T, Ikeno M, Shimojima, 2012).

2.1.1.2Cerebrum

The largest region of the human brain, our cerebrum controls higher brain functions such as language, logic, reasoning, and creativity. The cerebrum surrounds the diencephalon and is located superior to the cerebellum and brainstem. A deep furrow known as the longitudinal fissure runs midsagittally down the center of the cerebrum, dividing the cerebrum into the left and right hemispheres. Each hemisphere can be further divided into 4 lobes: frontal, parietal, temporal, and occipital. The lobes are named for the skull bones that cover them. The surface of the cerebrum is a convoluted layer of gray matter known as the cerebral cortex. Most of the processing of the cerebrum takes place within the cerebral cortex. The bulges of cortex are called gyri (singular: gyrus) while the indentations are called sulci (singular: sulcus). Deep to the cerebral cortex is a layer of cerebral white matter. White matter contains the connections between the regions of the cerebrum as well as between the cerebrum and the rest of the body. A band of white matter called the corpus callosum connects the left and right hemispheres of the cerebrum and allows the hemispheres to communicate with each other. Deep within the cerebral white matter are several regions of gray matter that make up the basal nuclei and the limbic system. The basal nuclei, including the globus pallidus, striatum, and subthalamic nucleus, work together with the substantia nigra of the midbrain to regulate and control muscle movements. Specifically, these regions help to control muscle tone, posture, and subconscious skeletal muscle. The limbic system is another group of deep gray matter regions, including the hippocampus and amygdala, which are involved in memory, survival, and emotions. The limbic system helps the body to react to emergency and highly emotional situations with fast, almost involuntary actions.With so many vital functions under the control of a single incredible organ - and so many important functions carried out in its outer layers (Okumura A, Lee T, Ikeno M, Shimojima, 2012)

2.1.6Meninges

Three layers of tissue, collectively known as the meninges, surround and protect the brain and spinal cord. The dura mater forms the leathery, outermost layer of the meninges. Dense irregular connective tissue made of tough collagen fibers gives the dura mater its strength. The dura mater forms a pocket around the brain and spinal cord to hold the cerebrospinal fluid and prevent mechanical damage to the soft nervous tissue. The name dura mater comes from the Latin for "tough mother," due to its protective nature. The arachnoid mater is found lining the inside of the dura mater. Much thinner and more delicate than the dura mater, it contains many thin fibers that connect the dura mater and pia mater. The name arachnoid mater comes from the Latin for "spider-like mother", as its fibers resemble a spider web. Beneath the arachnoid mater is a fluid-filled region known as the subarachnoid space.

As the innermost of the meningeal layers, the pia mater rests directly on the surface of the brain and spinal cord. The pia mater's many blood vessels provide nutrients and oxygen to the nervous tissue of the brain. The pia mater also helps to regulate the flow of materials from the bloodstream and cerebrospinal fluid into nervous tissue. (Okumura A, Lee T, Ikeno M, Shimojima, 2012)

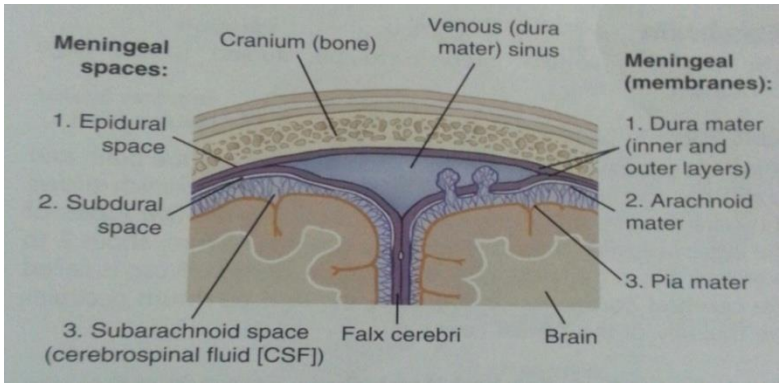


Figure (2-2): The brain (meninges) **(**Radiographic anatomy and physiology**)**

2.1.7CerebrospinalFluid:

Cerebrospinal fluid (CSF) – a clear fluid that surrounds the brain and spinal cord – provides many important functions to the central nervous system. Rather than being firmly anchored to their surrounding bones, the brain and spinal cord float within the CSF. CSF fills the subarachnoid space and exerts pressure on the outside of the brain and spinal cord. The pressure of the CSF acts as a stabilizer and shock absorber for the brain and spinal cord as they float within the hollow spaces of the skull and vertebrae. Inside of the brain, small CSF-filled cavities called ventricles expand under the pressure of CSF to lift and inflate the soft brain tissue Cerebrospinal fluid is produced in the brain by capillaries lined with ependymal cells known as choroid plexuses. Blood plasma passing through the capillaries is filtered by the ependymal cells and released into the subarachnoid space as CSF. The CSF contains glucose, oxygen, and ions, which it helps to distribute throughout the nervous tissue. CSF also transports waste products away from nervous tissues. After circulating around the brain and spinal cord, CSF enters small structures known as arachnoid villi where it is reabsorbed into the bloodstream. Arachnoid villi are finger-like extensions of the arachnoid mater that pass through the dura mater and into the superior sagittal sinus. The superior sagittal sinus is a vein that runs through the longitudinal fissure of the brain and carries blood and cerebrospinal fluid from the brain back to the heart. (Okumura A, Lee T, Ikeno M, Shimojima, 2012)

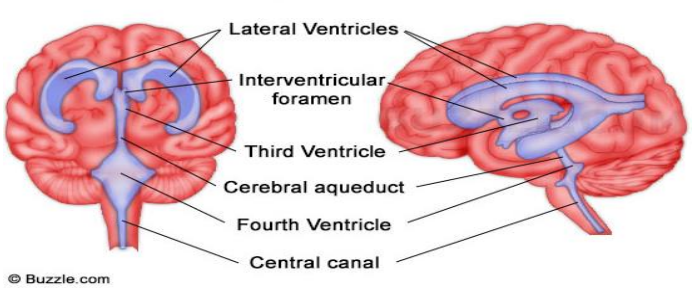


Figure (2-3): ventricles of the brain**(**(Radiographic anatomy and physiology**)**

2.1.8Functions and placements of 12 cranial nerves:

There are total 12 pairs of cranial nerves that originate from our brain and brain stem. Each of them carries different functions related to different senses of body. Apart from sensory functions there are also some that work as motor nerves or mixed nerves. Here is a brief description of 12 cranial nerves.

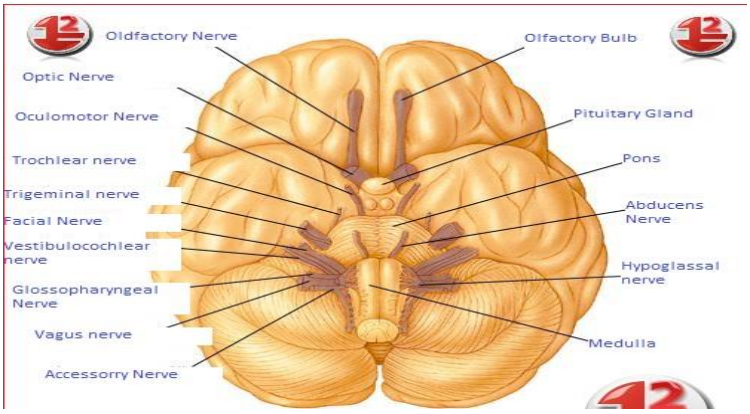


Figure (2_4): Cranial nerves(**(**Radiographic anatomy and physiology**)**

2.1.8.1 Olfactory

This is a type of sensory nerve that contributes in the sense of smell in human being. These basically provide the specific cells that are termed as olfactory epithelium. It carries the information from nasal epithelium to the olfactory center in brain.

2.1.8.2 Optic nerve

This again is a type of sensory nerve that transforms information about vision to the brain. To be specific this supplies information to the retina in the form of ganglion cells.

2.1.8.3 Oculomoter nerve

This is a form of motor nerve that supplies to different centers along midbrain. Its functions include superiorly uplifting eyelid, superiorly rotating eyeball, construction of pupil on the exposure to light and operating several eye muscles.

2.1.8.4 Trochlear

This motor nerve also supplies to the midbrain and performs the function of handling the eye muscles and turning the eye.

2.1.8.5 Trigeminal

This is a type of largest cranial nerve in all and performs many sensory functions related to nose, eyes, tongue and teeth. It basically is further divided in three branches that are ophthalmic, maxillary and mandibular nerve. This is a type of mixed nerve that performs sensory and motor functions in brain.

2.1.8.6 Abducent

This is again a type of motor nerve that supplies to the pons and perform function of turning eye laterally.

2.1.8.7 Facial

This motor nerve is responsible for different types of facial expressions. This also performs some functions of sensory nerve by supplying information about touch on face and senses of tongue in mouth. It is basically present over brain stem.

2.1.8.8 Vestibulocochlear

This motor nerve is basically functional in providing information related to balance of head and sense of sound or hearing. It carries vestibular as well as cochlear information to the brain and is placed near inner ear.

2.1.8.9 Glossopharyngeal

This is a sensory nerve which carries sensory information from pharynx (initial portion of throat) and some portion of tongue and palate. The information sent is about temperature, pressure and other related facts.

It also covers some portion of taste buds and salivary glands. The nerve also carries some motor functions such as helping in swallowing food.

2.1.8.10 Vagus

This is also a type of mixed nerve that carries both motor and sensory functions. This basically deals with the area of pharynx, larynx, esophagus, trachea, bronchi, some portion of heart and palate. It works by constricting muscles of the above areas. In sensory part, it contributes in the tasting ability of the human being.

2.1.8.11 Spinal accessory nerve

As the name intimates this motor nerve supplies information about spinal cord, trapezius and other surrounding muscles. It also provides muscle movement of the shoulders and surrounding neck.

2.1.8.12 Hypoglossal nerve

This is a typical motor nerve that deals with the muscles of tongue. These are the 12 cranial nerves that carry many important functions in body.

(Okumura A, Lee T, Ikeno M, Shimojima, 2012)

2.1.9 Blood supply of brain

2.1.9.1 Arteries: The brain is supplied by the two internal carotid and two vertebrae arteries, the four arteries anatomists on the anterior surface of the brain and form the circle of Willis (circular arteriosus) .It divided into anterior and middle cerebral artery The circle of Willis is lies in the interpeduncular fossa at the base of the brain, it is formed by the anastomosis between the two internal carotid artery and two vertebral arteries

2.1.9.2 Veins: The veins of the brain have no vascular tissue in their thin walls, and they possess no valves they emerge from the brain and drain into cranial venous sinuses. Cerebral and cerebella veins and viena of brain stem are present, the great cerebral veins is formed by union of the two internal cerebral veins and drains into the straight sinus. (Okumura A, Lee T, Ikeno M, Shimojima, 2012)

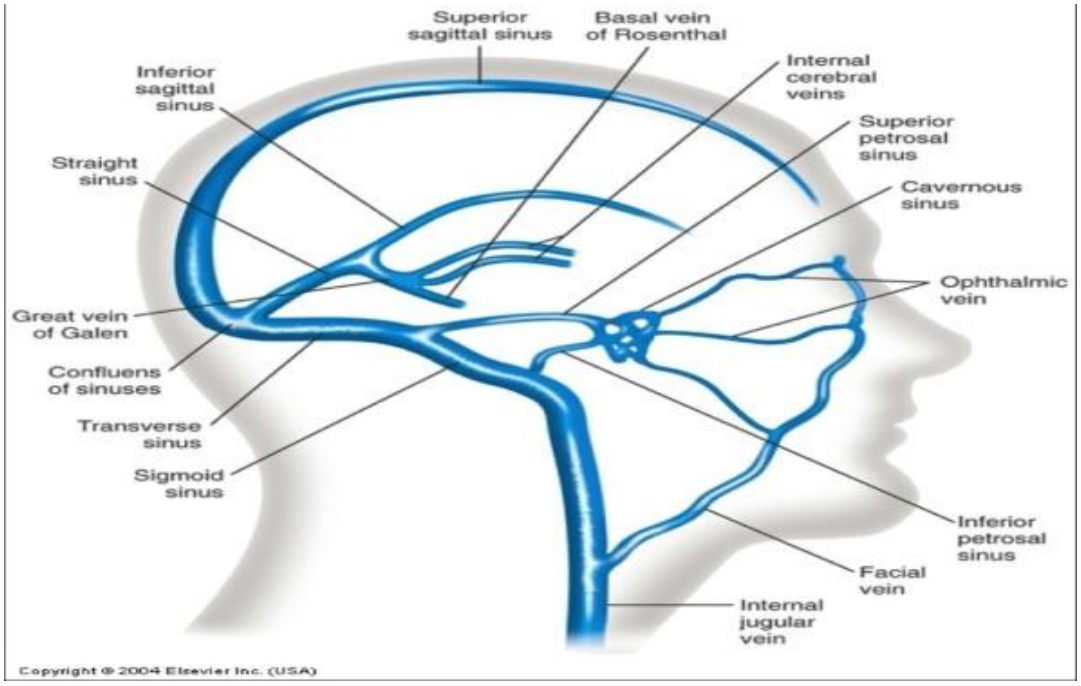


Figure (2-5): Veins circulation of the brain(**(**Radiographic anatomy and physiology**)**

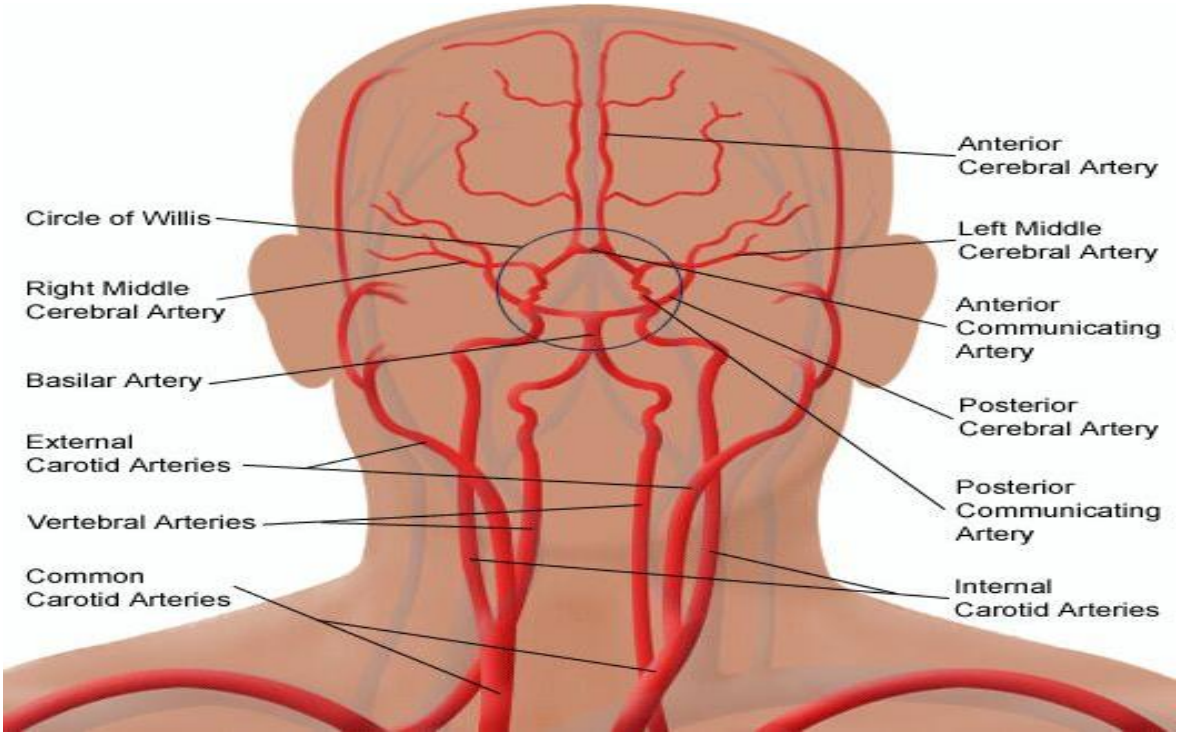


Figure (2-6): Arterial circulation of the brain(**(**Radiographic anatomy and physiology**)**

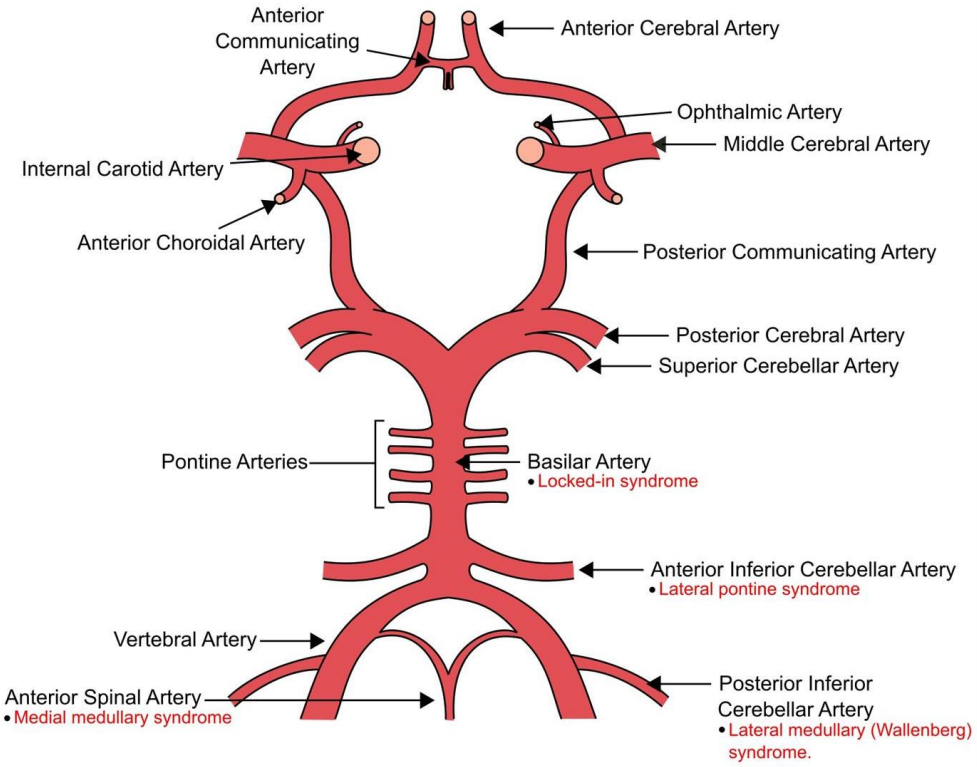


Figure (2-7): Circle of Willis ((Radiographic anatomy and physiology)

2.2 Physiologies

Regulate the heart beating. Pick the message from all parts of the body via the nerves. Mental activities involved in memory such as: sense of responsibility, intelligence, thinking. The brain play role in learning and language processing (cerebellum) It coordinates activities associated with maintenance of balance and equilibrium (cerebellum) (Beissner F, Schumann, 2013)

2-3Pathology

Pathologies of the brain is Congenital diseases (Hydrocephalus), Tumors and space occupying lesions(Mets) ,Vascular lesions (Infarction),Trauma (hemorrhagic contusion)., Infections (abscess),Degenerative & metabolic disorders (Calcification of the Basal Ganglia) and White matter diseases (Leukodystrophies). (Georgiadis P, Cavouras D, Kalatzis I, Glotsos D, 2009)

2.3.1 Hydrocephalus:

Congenital hydrocephalus is a buildup of excess cerebrospinal fluid (CSF) in the brain at birth. The extra fluid can increase pressure in the baby's brain , causing brain damage and mental and physical problems.

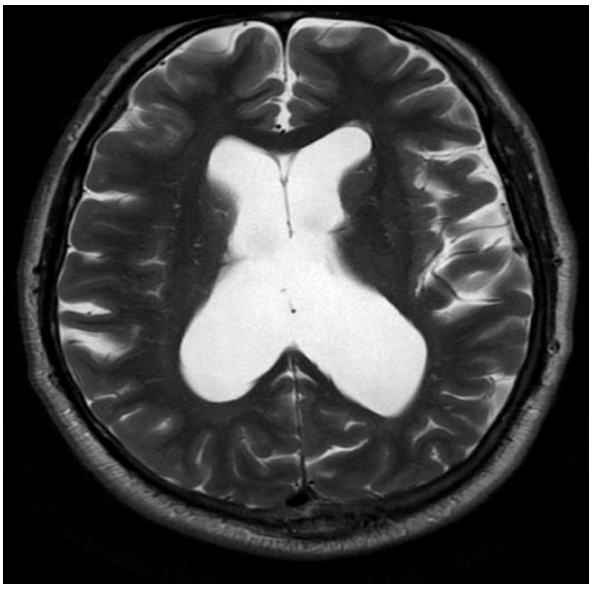
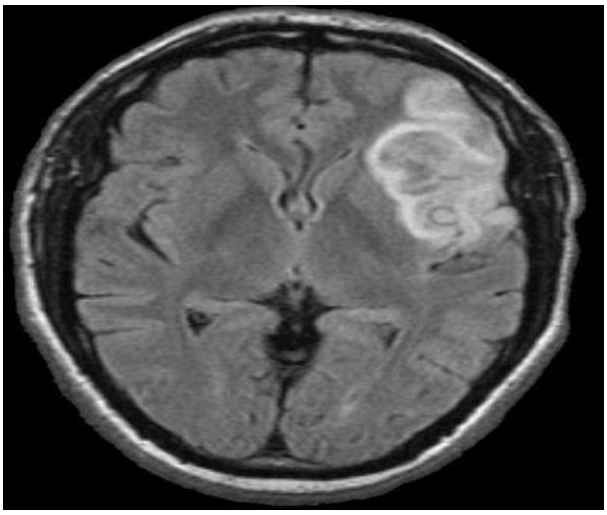


Figure (2-8): MRI brain axial T2 (Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.2 Infarction

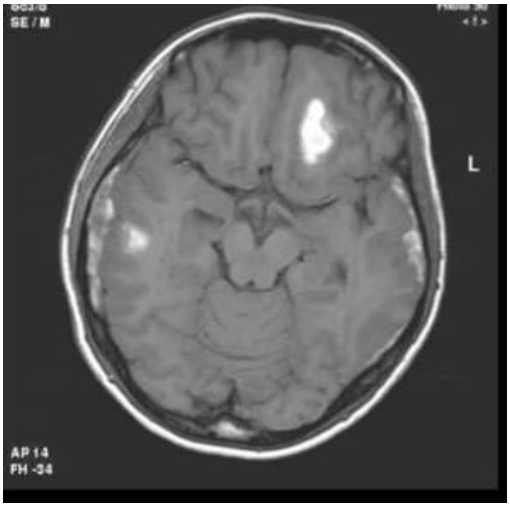
A localized area of tissue, that is dying or dead, having been deprived of its bloodsupply because of an obstruction by embolism or thrombosis.



Figuer (2-9): MRI brain axial Flair **(**(Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.3 Hemorrhagic contusion:

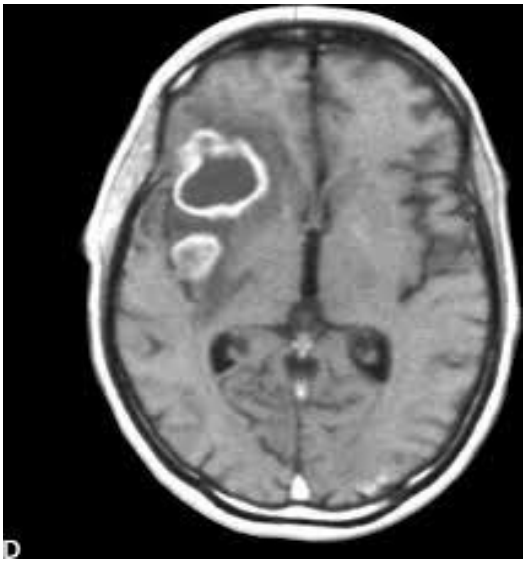
Is a type of traumatic brain injury that causes bruising the brain tissue.



Figuer (2-10): MRI brain axial T1 with contrast (Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.4 Brain abscess

A brain abscess is a collection of pus, immune cells, and other material in the brain, usually from a bacterial or fungal infection**.** (Shintaku M, Adachi Y, Arai A, Koyama J. 2007)

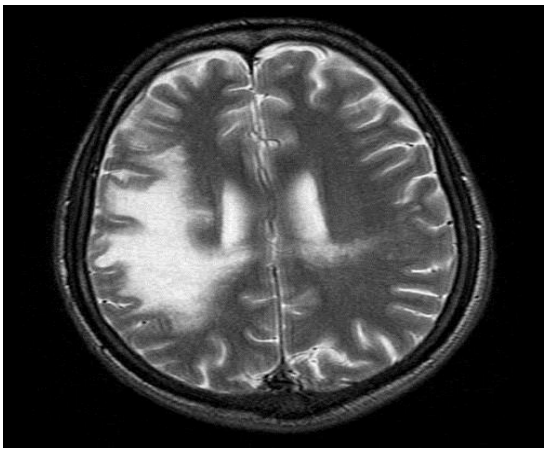


Figuer (2-11): MRI brain axial T1 with contrast

(Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.5 Progressive Multifocal Leukoencephalopathy:

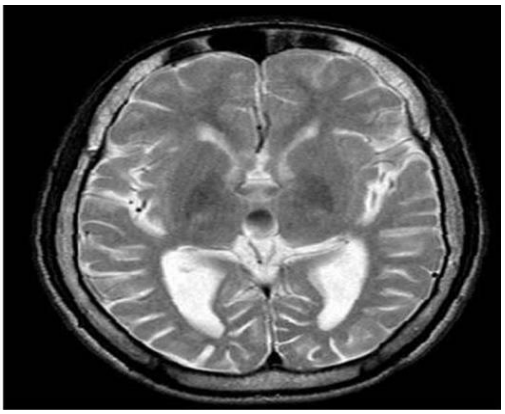
Progressive multifocal leukoencephalopathy (PML) is a rapidly progressive neuromuscular disease caused by opportunistic infection of brain cells (oligodendrocytes and astrocytes) by the JC virus (JCV).



Figuer (2-12): MRI brain axial T (Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.6 Basal Ganglia Calcification:

Abnormal calcium deposits in the part of the brain called the basal ganglia**.** It causes by Physiological**,** Hyperparathyroidism (various causes including pseudohypoparathyroidism)**,** Hyperparathyroidism**,** Familial idiopathic cerebral calcification (Fahr's syndrome)**,** Birth anoxia**,** Carbon monoxide intoxication**,** Lead poisoning**,** Tuberous sclerosis**,** Cockayne's syndrome**,** Postinfectious**,** acquired immunodeficiency syndrome (especially in children) (Shintaku M, Adachi Y, Arai A, Koyama J. 2007)



Figuer (2-13): MRI brain axial T2 (Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.7 Brain Tumors

A brain tumor is a mass of unnecessary cells growing in the brain or central spine canal. There are two basic kinds of brain tumors, primary brain tumors and metastatic brain tumors. Primary brain tumors start and tend to stay, in the brain. Metastatic brain tumors begin as cancer elsewhere in the body and spread to the brain (Shintaku M, Adachi Y, Arai A, Koyama J. 2007)

2.3.8Tumor Names

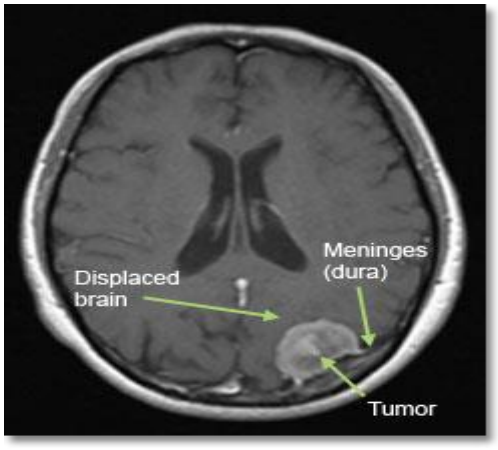
Tumors are diagnosed, and then named, based on a classification system. Most medical centers now use the World Health Organization (WHO) classification system for this purpose.

2.3.7.1 Benign brain tumors

A benign brain tumor consists of very slow growing cells, usually has distinct borders and rarely spreads. When viewed under a microscope, these cells have an almost normal appearance. Surgery alone might be an effective treatment for this type of tumor a brain tumor composed of benign cells, but located in a vital area, can be considered life-threatening – although the tumor and its cells would not be classified as malignant. (Shintaku M, Adachi Y, Arai A, Koyama J. 2007)

2.3.7.1.1 Meningioma:

A meningioma is a tumor that arises from the meninges — the membranes that surround your brain and spinal cord. Most meningiomas are noncancerous (benign), though rarely a meningioma may be cancerous (malignant). Some meningiomas are classified as atypical, meaning they're neither benign nor malignant but, rather, something in between.

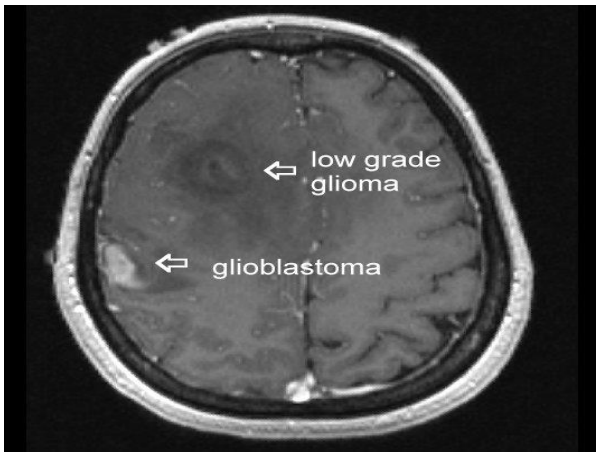


Figuer (2-14): MRI brain axial T1 with contrast

(Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.7.1.2 Glioma:

The most primary brain tumors begin in glial cells.



Figuer (2-15): MRI brain axial T1 with contrast(Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.7.1.3 Granuloma:

Amass or nodule of chronically inflamed tissue with granulation that is usually associated with an infective process.

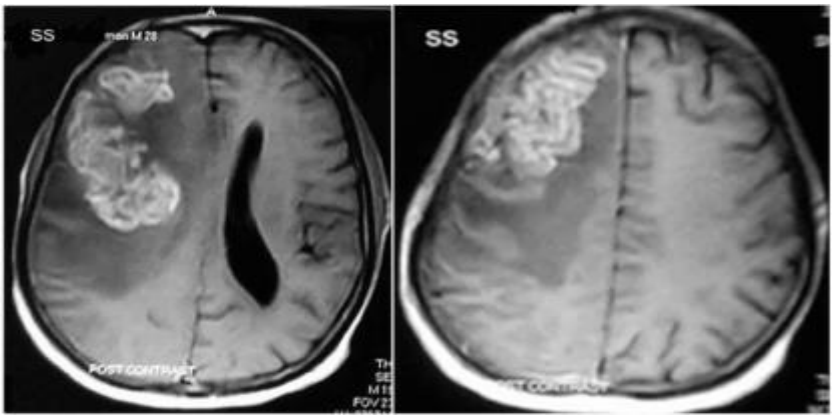
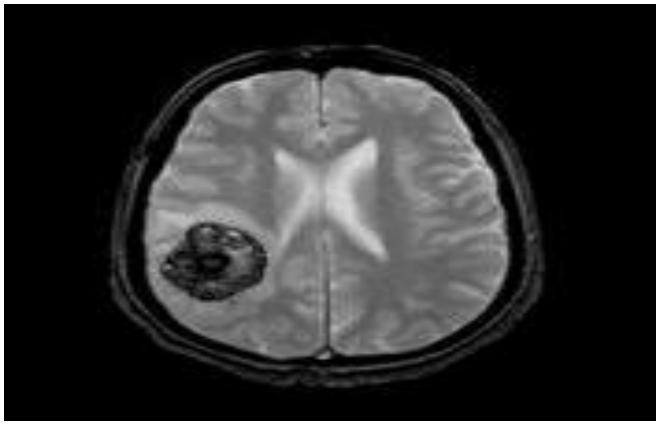


Figure (2-16): MRI brain axial section T1 waited image with contrast(Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.7.1.4 Haemangioma:

Haemangiomas are benign tumours of vascular origin usually seen in early childhood divided into infantile haemangioma and congenital haemangioma



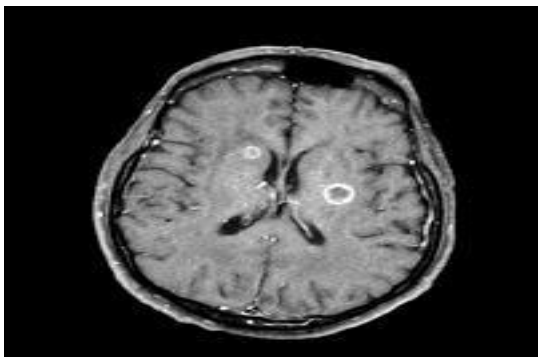
Figuer (2-17): MRI brain axial gradient echo(Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.7.2 Malignant Brain Tumors

A malignant brain tumor is usually rapid growing, invasive and life-threatening. Malignant brain tumors are sometimes called brain cancer. However, since primary brain tumors rarely spread outside the brain and spinal cord, they do not exactly fit the general definition of cancer.

2.3.7.2 .1 Metasteses:

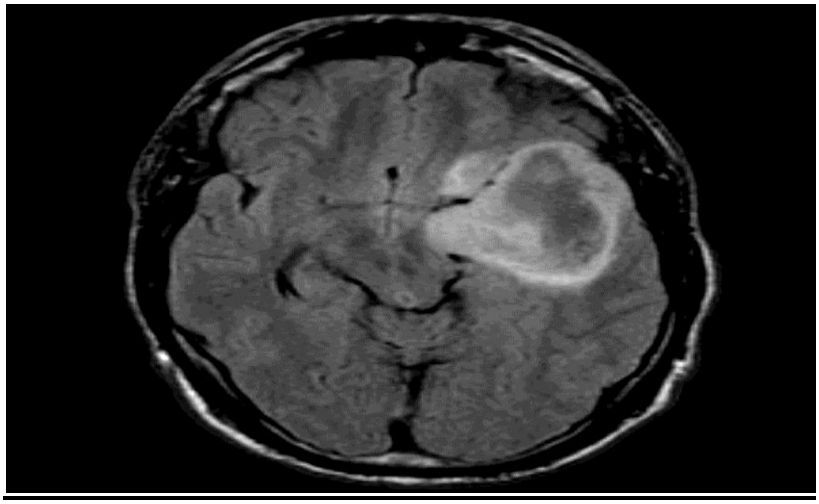
Brain Metastases is a cancer that has spread to the brain from another site in the body, commonly the lung or breast Causes: Lung cancer, Breast cancer, Genitourinary tract cancers, Osteosarcoma Melanoma, Head and neck cancer, Neuroblastoma, Gastrointestinal cancers, especially colorectal and pancreatic carcinoma and Lymphoma



Figuer (2-18): MRI brain axial T1 with contrast((Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.7.2 .2 Astrocytoma

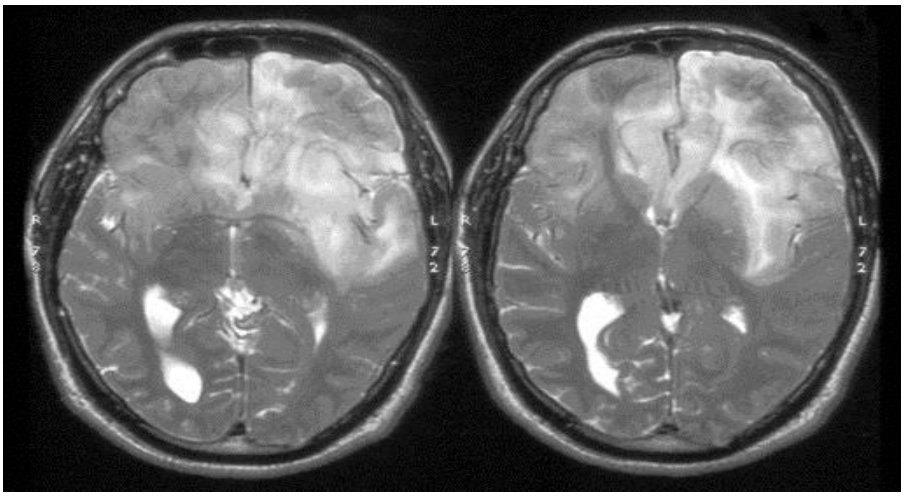
The tumor arises from star-shaped glial cells called astrocytes. It can be any grade. In adults, an astrocytoma most often arises in the cerebrum. Grade I or II astrocytoma**:** It may be called a low-grade Glioma Grade III astrocytoma**:** It's sometimes called ahigh-grade or an anaplastic astrocytoma, and Grade IV astrocytoma: It may be called a glioblastoma or malignant astrocyticglioma



Figuer (219): MRI brain axial Flair (Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.7.2 .3 Oligodendroglioma:

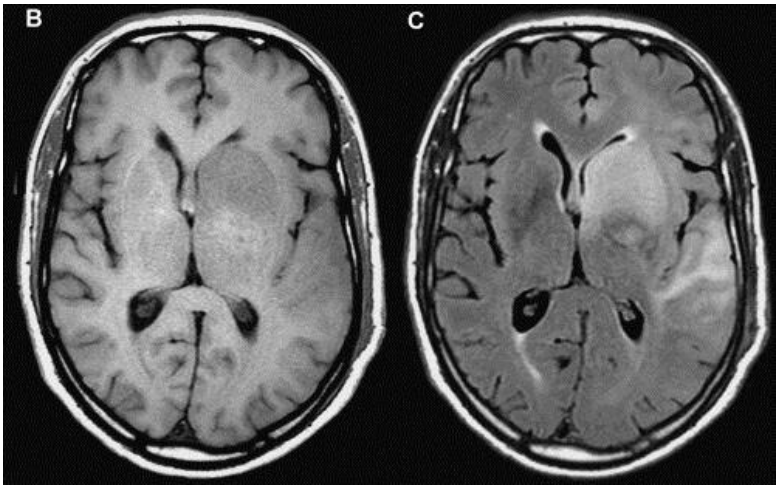
The tumor arises from cells that make the fatty substance that covers and protects nerves. It usually occurs in the cerebrum.



Figuer (2-20): MRI brain axial T2(Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.7.2.4 Glyomatosis:

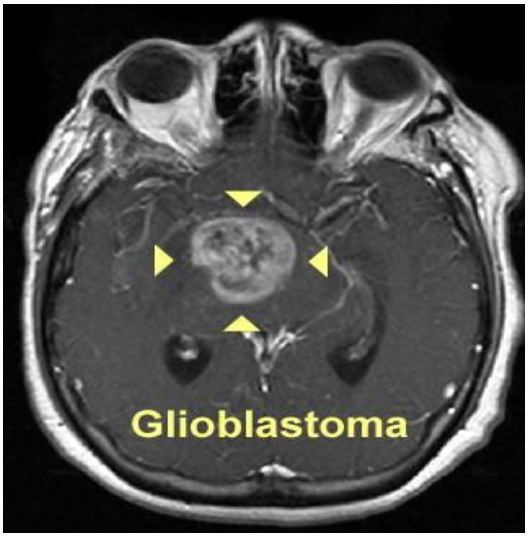
is a rare, extensively infiltrating glioma involving multiple contiguous lobes of the brain. This lethal disease affects all age groups



Figuer (2-21): MRI brain axial(B)T1(C)Flair(Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2.3.7.2 .4 Glioblastoma:

A highly malignant, rapidly growing type of brain tumor that arises from glial cells in the brain .



Figuer (2-22): MRI brain axial T1 withcontrast (Ronald L.Eisenberg Nancy M. Johnson ,Comprehensive Radiographic Pathology)

2-4Basic principles of MRS

Proton MR Spectroscopy (1HMRS) is a noninvasive imaging technique that may contribute in the preoperative diagnosis of patients with MR ring enhancing lesions. 1HMRS depends on a change in the resonance frequency

of the nuclei within the molecules, regarding their chemical bonds, which is based on the chemical shift theory. The resonance frequency difference (chemical shift) is expressed as parts per million or ppm, a value that is independent of the amplitude of the external magnetic field. The value of the chemical shift provides information about the molecular group carrying the hydrogen nuclei, and thus it provides differentiation among several metabolites. Water peak is located at 4, 7 ppm, and is much greater than the obtained signal from other hydrogen containing compounds typically identified in the brain parenchyma. Therefore, water signal needs to be suppressed for identifying any other metabolites. The reference frequency used, set at zero ppm, is that of tetra-methyl silane molecule Si-(CH3)4, which is symmetrical and has a single proton resonance. In order to perform in vivo 1HMRS, a strong magnetic field of at least 1.5T is required. It is generally accepted that, the higher the magnetic field strength, the more metabolites can be identified. Specific sequences for spectroscopic signal acquisition are either Single voxel Spectroscopy (SVS), which receives the spectrum from a single voxel only, or Chemical Shift Imaging (CSI), which measures spectra in projection, on a slice (2D CSI), or a volume (3D CSI) (Joyce SA, Yates JR, Pickard CJ, Mauri F. 2007).

3-4-1Chemical Shifts

A description of the basic principles of MRS begins at the same place as that of a description of the principles of MRI. The basic concepts of net magnetization produced by a collection of spins in a magnetic field, signal production following absorption of RF energy, and T1 and T2 relaxation are identical for MRS and MRI. However, there are two important differences between MRS and MRI. First, MRS signals are normally detected in the absence of a gradient. All molecules are detected in the presence of the same base magnetic field. The chemical shift is the only source of magnetic field variation present during signal detection. Rather

than being the source of artifactual signals as it is in MRI, the chemical shift is the means by which molecular species are identified in MRS studies. Second, unlike MRI, relaxation effects are avoided as much as possible in MRS studies. The molecules under observation are relatively small in size and have relatively long T1 and T2 values Long TR (typically ~1500 ms) is used in order to minimize T1 saturation effects. T2 dephasing effects are dominated by main field in homogeneities and are more properly described by T2*, chemical shift values are measured to a reference frequency. The traditional reference frequency used for 1H is that of tetramethylsilane (TMS) this is impractical to use in biological systems due to its toxicity and the difficulty in achieving uniform tissue distribution. In its place, an endogenous secondary reference is normally used. This is the methyl 1H signal of N-acetyl aspartate, which has a chemical shift of 2.0 ppm relative to TMS. This allows standard tables of chemical shifts to be used and for in vivo spectral displays to match with traditional displays (Figure 2-23) (Kodibagkar VD, Wang X, Mason RP. 2008;13:1371-84. Epub 2007/11/06.)

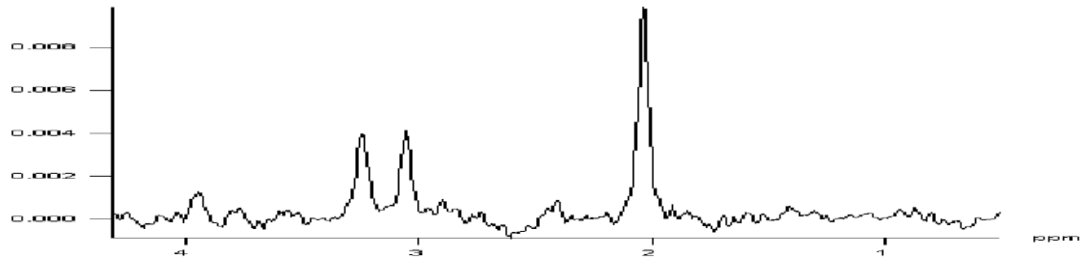


Figure (2-23): Typical 1H spectrum from normal brain. Measurement parameters: pulse sequence, PRESS; TR, 1500 ms; TE, 270 ms; NSA, 256; voxel size, 20 × 20 × 20 mm

The resonance frequency of the protons is in a first approximation a function of the main magnetic field strength. However, the electronic environments of molecules cause a small modulation of the main magnetic field. If the electrons are close to the proton, there is a shielding effect and

the proton sees a minimally smaller magnetic field (Fig.2-23) minimally smaller magnetic field. This in turn results in slightly different resonance frequencies for protons in different molecules and even for protons in the same molecule but at different positions. Since the chemical structure of molecules determines the electronic environment this shift in the frequency has been named chemical shift. For in vivo MR spectroscopy, analyzing chemical shifts has been the main method for peak assignment (Poussaint TY, Rodriguez D.. 2006;16(1):169-92, ix. Epub 2006/03/18.)

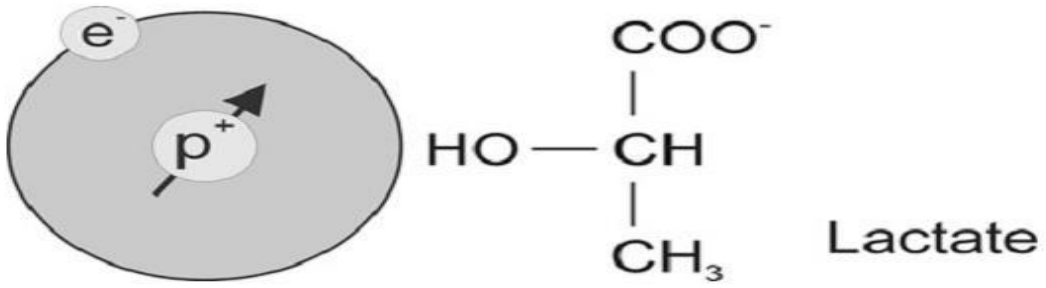


Figure (2-24): Left: Hydrogen atom with nucleus (proton) and single electron. The electron modifies the magnetic field seen by the proton. Right: All protons potentially provide an MR detectable signal.

The exact frequency of the signal depends on the molecular structure and the position of the proton in the molecule. For example, protons of the CH3 group of lactate resonate at 1.33 ppm whereas the CH proton resonates at 4.1 ppmt.

2.4.2 J-coupling:

In addition to chemical shifts, the spectrum is also modulated by J-coupling (or scalar coupling). J-coupling is the result of an internal indirect interaction of two spins via the intervening electron structure of the molecule. The coupling strength is measured in Hertz (Hz) and is independent of the external B0 field strength. J-coupling between the same species of spins, e.g., proton and proton is termed homo-nuclear J-coupling whereas J-coupling

between different species of spins, e.g., proton and phosphorous is referred to as heteronuclear J-coupling.

J-coupling results in a modulation of the signal intensity depending on sequence type and acquisition parameters, particularly the echo time

The most prominent example in proton spectroscopy is lactate where there is a 7 Hz strong coupling between the two MR-detectable proton groups. Other molecules with more complex J-coupling patterns are glutamate and glutamine with three J-coupled proton groups. A spectrum of N acetylaspartate (NAA) is shown in (Fig.2-24). NAA has both uncoupled and J-coupled protons.

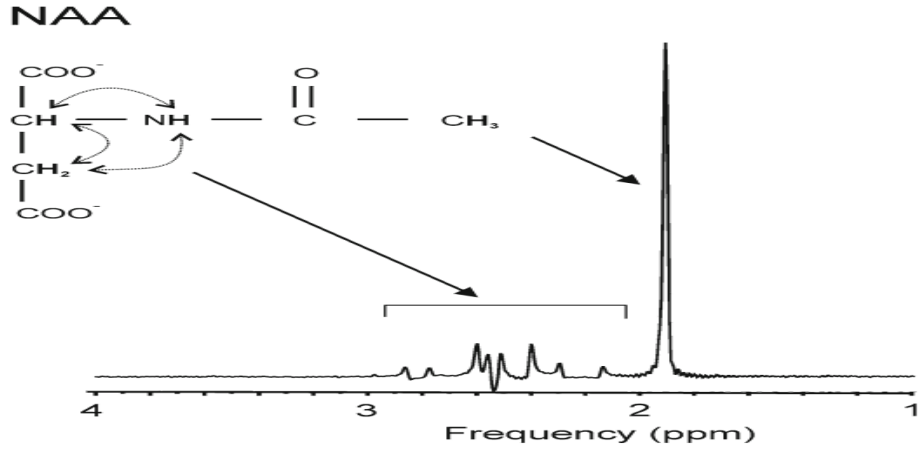


Figure (2-25): The spectrum of the N-acetyl-aspartate (NAA) molecule is shown (standard PRESS, echo time (TE) 35 ms, 1.5 Tesla).

The NAA molecule has protons at different positions. The three protons of the -CH3 group are equivalent and their individual signals add-up and give the prominent peak at 2.0 ppm. The other protons attached to carbons of NAA molecule also provide a signal. The protons of the –NH, –CH, and –CH2 are in close proximity in the molecule and do interact via J-coupling (indicated by dashed arrows in above figure). J-couplings split peaks and modulate the phase of a signal. The result is a more complex pattern of multiple peaks, which can be asymmetric or point downwards. The signal from proton next to the nitrogen atom (amide proton) resonates at approx. 8

ppm. Due to rapid exchange with protons from surrounding water molecules, the magnetization disappears quickly and the signal from this proton is very weak. (Poussaint TY, Rodriguez D.. 2006;16(1):169-92, ix. Epub 2006/03/18.)

2.4.3: Water Suppression

Clinical MRI techniques visualize the water and fat within the desired slice. The high concentration of water and fat within the tissue makes this feasible. In MRS, the metabolites under observation are as much as 10,000 times less concentrated than water, which makes their detection in the presence of tissue water difficult. In order to accomplish this, suppression of the water is necessary. The most common approach uses a frequency-selective RF pulse or pulses known as a chemical shift selective (CHESS) pulse. It is centered at the water resonant frequency to saturate the water protons. This technique is analogous to the fat saturation pulse. Water suppression factors of 100 or more are possible from a single pulse, making it an easy and effective way for reducing the signal contamination from water. (Majos C, Alonso J, Aguilera C, Serrallonga M, Perez-Martin J, Acebes JJ, et al2003;13(3):582-91. Epub 2003/02/21.)

2.4.4: Fourier transforms spectroscopy

All MRS studies are performed by collecting time domain data after application of either a 90° pulse, or an echo-type of sequence. All resonances from the different molecules are collected simultaneously in the time domain, and the time domain signal (FID) is largely uninterruptable to the human eye. In order for a spectrum to be generated, it is necessary to perform Fourier transformation (FT), which allows the viewing of the signal intensity as a function of frequency (i.e. in the frequency domain) (Fig.2.25).

Various filtering and other manipulations are often performed on the data both before and after fast Fourier transformation (FFT), which may have quite profound effects on the quality of the final spectrum. One advantage of pulsed FT is that all signals are being recorded at once so it has a sensitivity advantage over alternative acquisition methods ("continuous wave", or CW), which recorded each part of the spectrum separately. In order to accumulate sufficient SNR with the pulsed FT method, the scan can be repeated many (N) times and averaged together ("time averaging") to improve SNR. The scan time will be N*TR, it is important to choose the correct TR and the flip angle for optimum SNR. The seminal work by Ernst indicates that for optimum SNR the minimum TR should be chosen consistent with the pulse sequence being used and the desired spectral resolution (in Hz, equal to the inverse of the data readout window (acquisition time)), and then the flip angle set.

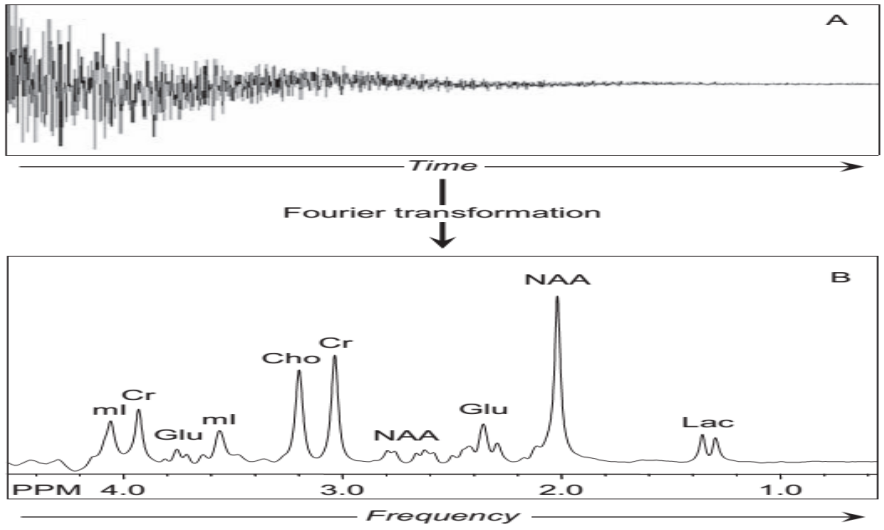


Figure (2-26): (A) An example of a free induction decay (FID, recorded as a function of time) and (B) the corresponding frequency domain spectrum obtained by Fourier transformation.

The sample is a phantom containing N-acetyl aspartate (NAA, 2.01 and 2.6 ppm), creatine (Cr, 3.02 and 3.91 ppm), choline (Cho, 3.21 ppm), myo-

inositol (mI, 3.56 and 4.05 ppm), glutamate (Glu, 2.34 and 3.74 ppm), and lactate (Lac, 1.31 ppm (doublet)), recorded at 3 T with an echo time of 30 msec. (Kang J, Liu H, Zheng YM, Qu J, Chen JP2011;354(1):261-7. Epub 2010/12/07.)

2.4.5: Localization Techniques

Current techniques used for spatial localization of the MRS signals were derived from similar techniques used in MRI. Slice selective excitation pulses in conjunction with gradient pulses are used to localize the RF energy to the desired volume of tissue. However, unlike MRI, in which the voxel size is typically 1 × 1 × 5 mm3 or less, MRS voxel sizes are usually 15 x 15 × 15 mm3 or larger. Therefore, MRS studies are limited to the examination of relatively large regions of tissue. The two general categories of localization techniques are based on the number of separate voxels from which spectra are obtained in each measurement(Kang J, Liu H, Zheng YM, Qu J, Chen JP. 2011;354(1):261-7. Epub 2010/12/07.)

2.4.5.1: Single Voxel Techniques

Single voxel techniques (also called single voxel spectroscopy or SVS) acquire spectra from a single small volume of tissue. The most common approaches excite only the desired tissue volume through the intersection of three slice-selective RF excitation pulses. Two schemes of RF pulses are used. The first approach, known as point resolved spectroscopy (PRESS), uses a 90° and two 180° RF pulses in a fashion similar to a standard multiecho sequence (Fig. 2.25). Each RF pulse is applied using a different physical gradient as the slice selection gradient. Only protons located at the intersection of all three pulses produce the spin echo at the desired TE. The other approach, known as stimulated echo acquisition method (STEAM), uses three 90° RF pulses, each with a different slice selection gradient

(Fig.2.26) the resulting stimulated echo is produced by protons located at the intersection of the pulses.

There are several differences between PRESS and STEAM. The major difference is in the nature of the echo signal. In PRESS, the entire net magnetization from the voxel is refocused to produce the echo signal, whereas in STEAM, a maximum of one-half of the entire net magnetization generates the stimulated echo. As a result, PRESS has an S/N ratio significantly larger than for STEAM for equivalent scan parameters. Another difference is that PRESS uses 180° RF pulses, whereas STEAM uses only 90° RF pulses

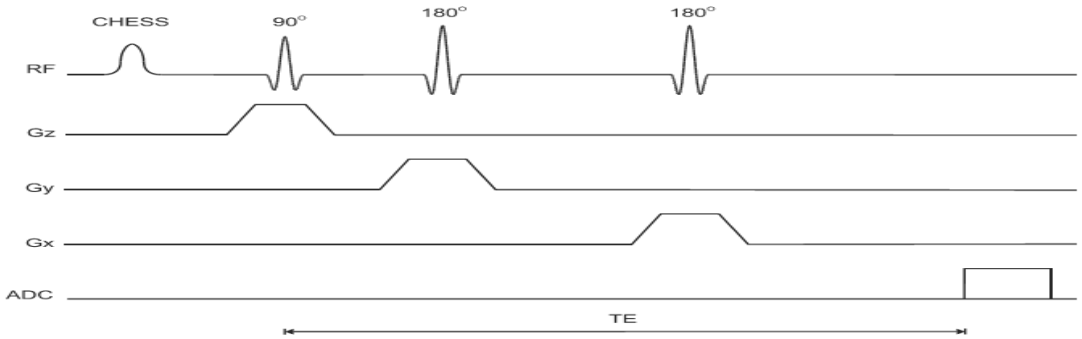


Figure (2-27): PRESS pulse sequence timing diagram. The CHESS RF pulse is used for suppression of water

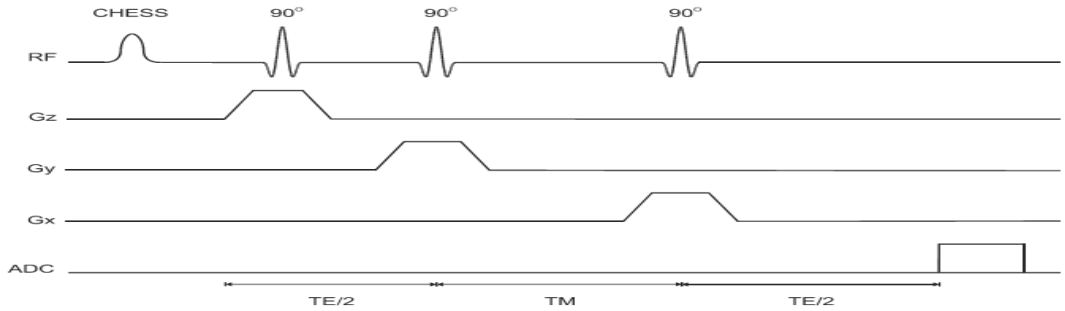


Figure (2-28): STEAM pulse sequence timing diagram. The CHESS RF pulse is used for suppression of water**.**

The voxel dimensions with PRESS may be limited by the high transmitter power for the 180° RF pulses. STEAM spectra are also unaffected by J coupling of spins, whereas PRESS spectra show a modulation of the signal from any coupled spins, such as lactate methyl protons. Finally, STEAM

allows for shorter TE values, reducing signal losses from T2 relaxation and allowing observation of metabolites with short T2*.(Kodibagkar VD, Wang X, Mason RP 2008;13:1371-84. Epub 2007/11/06.).

2.4.5.2: Multiple Voxel Techniques

Multiple voxel techniques are those from which multiple spectra are obtained during a single measurement. The most common of these methods is known as chemical shift imaging (CSI). CSI techniques are analogous to standard imaging techniques in that phase-encoding gradient tables are used for spatial localization. They are subdivided into 1D, 2D, and 3D versions, depending on the number of gradient tables used for spatial localization. The most common of these approaches is 2D-CSI, in which two gradient tables are used. Volume-selective RF excitation pulses are used, either with a PRESS or STEAM RF pulse train. The most common scheme has the three excitation pulses in mutually perpendicular directions and is termed volume-selective CSI (Fig. 2.27). This scheme enables the volume of excitation to be tailored so that areas producing contaminating signal can be avoided. For example, brain studies using volume-selective CSI can minimize the signal from the skull and subcutaneous fat. Volume-selective CSI techniques have the advantage over SVS techniques in that spectra from several volumes of tissue can be measured simultaneously, which is advantageous if the disease under observation is diffuse or covers a large area of anatomy. However, the measurement times for CSI techniques are generally relatively long, and the entire data collection must be completed in order to obtain all the localization phase-encoding steps. With SVS techniques, the measurement times are long due to multiple acquisitions necessary to produce an adequate S/N ratio, but the number of acquisitions can be adjusted depending on the voxel size. In addition, the multiple voxels must be individually post processed, making analysis of CSI data

more operators intensive. (Joyce SA, Yates JR, Pickard CJ, Mauri F2007;127(20):204107. Epub 2007/12/07).

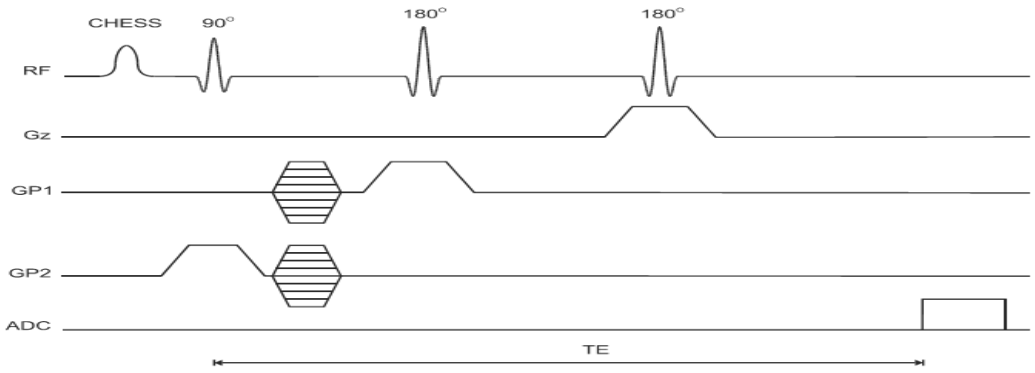


Figure (2-29): Volume selective 2D-CSI pulse sequence timing diagram, using PRESS excitation method. The CHESS RF pulse is used for suppression of water.

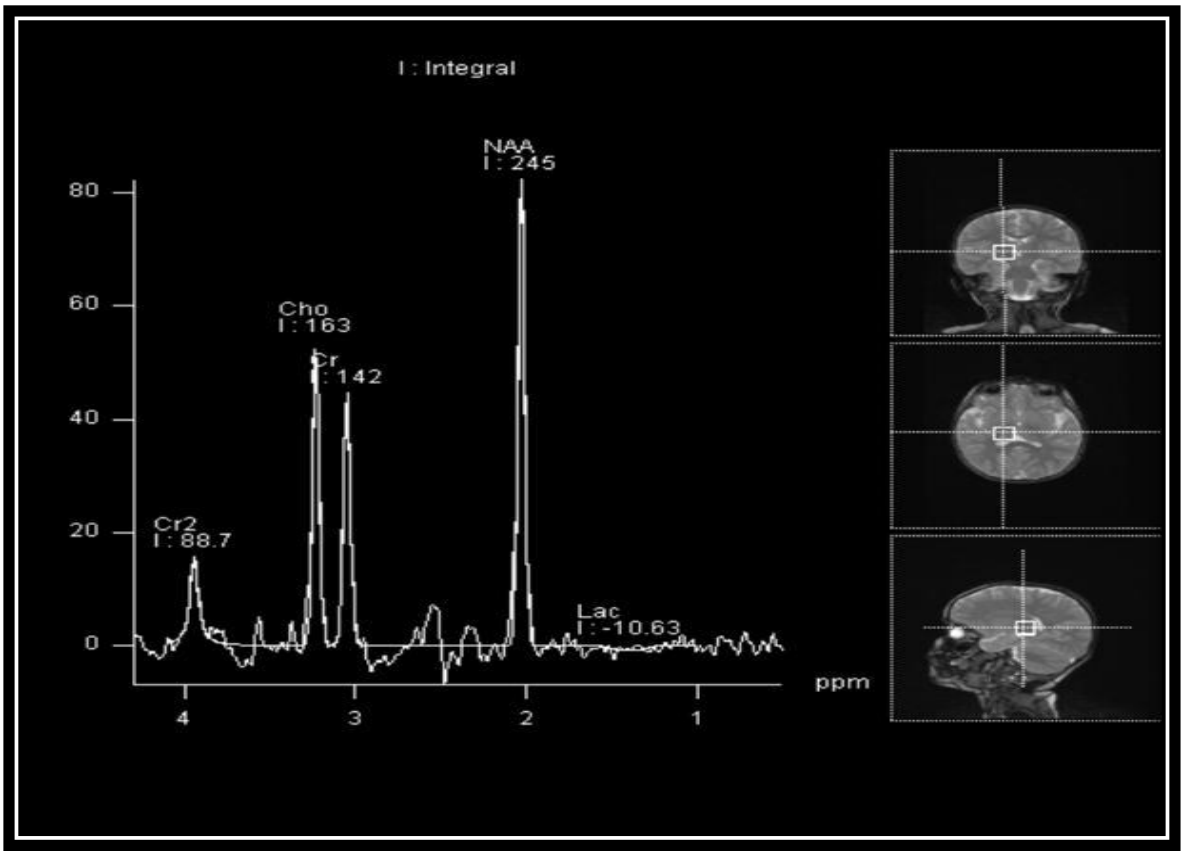


Figure (2-30): Single Voxel Techniques **(**Joyce SA, Yates JR, Pickard CJ, Mauri F. A first principles theory of nuclear magnetic resonance J-coupling in solid-state systems. The Journal of chemical physics.

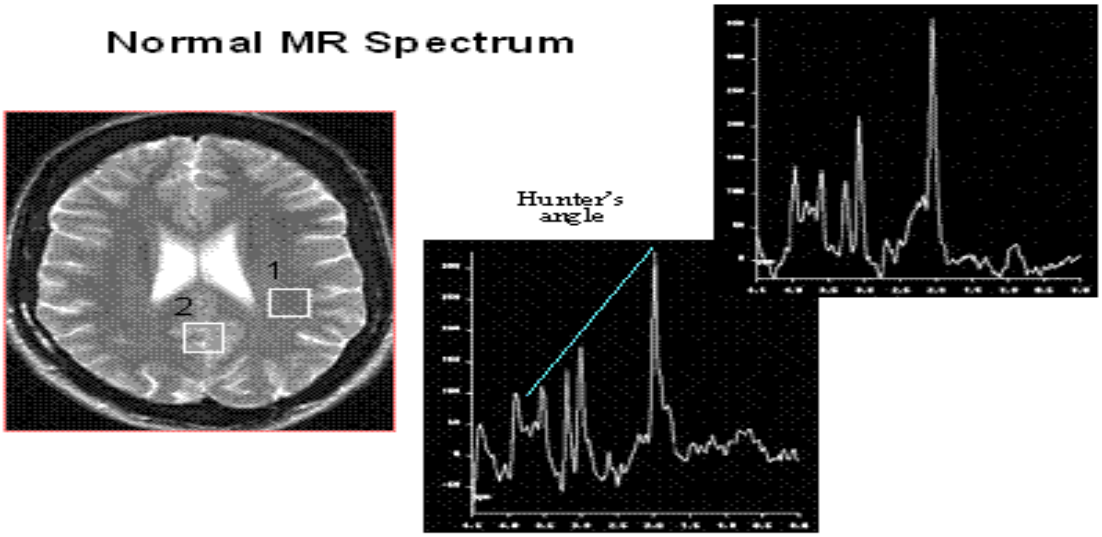


Figure (2-31): Multiple Voxel Techniques (Joyce SA, Yates JR, Pickard CJ, Mauri F. A first principles theory of nuclear magnetic resonance J-coupling in solid-state systems. The Journal of chemical physics.)

2.4.6Chemical Compounds

2.4.6.1 N-acetyleaspartate (NAA)

Marker of neuronal density and viability It is the largest peak in normal spectrum Assigned at 2.0 ppm Decrease in NAA is a non specific indicator of an insult to the neurons Not present in tumors outside the CNS (e.g. Meningioma)

2.4.6.2 Creatine (Cr)

Compounds serve as part of the energy regulating system in the brain second large peak in normal spectrum assigned at 3.03 ppm and at 3.94. The overall level of Cr remains stable in most situations good internal standard for calculation of metabolic ratios

2.4.6.3 Choline (Cho)

Third large peak assigned at 3.2 ppm. Acetylcholine is involved in memory, cognition and mood Increased choline peak reflects increase in cell membrane synthesis and increased cell numbers as in tumors

2.4.6.4 Lactate

Normally not present assigned at 1.32 ppm its presence indicates hypoxia/ischemia Also found in necrotic and cystic lesions. It has characteristic double shape that become inverted at a TE of 136 ms on PRESS sequence

2.4.6.5 Glumatate and glutamines (GLx):

Normally present. Assigned 2.1 and 2.5 ppm Glumatate involved in mitochondrial metabolism Glutamines regulate neuro-transmission

2.4.6.6 Myoinositol (MI):

Normally present Assigned at 3.56 ppm Decreased in diabetic neuropathy. Increases in Alzheimer's disease (with decreased NAA)

2.4.6.7 Lipids:

Normally not see. Assigned at 0.8, 102, 1.5, 1.6, ppm May be seen in high grade astrocytoma and Meningioma or in necrotic process

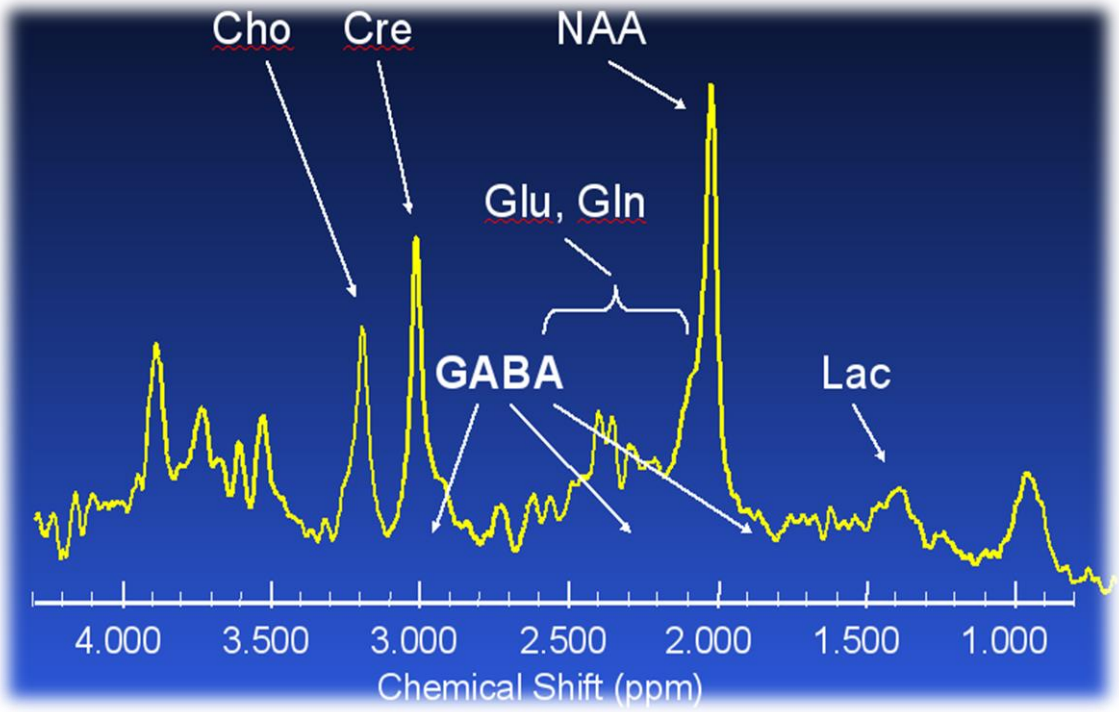


Figure (2-32): Chemical Compounds (Joyce SA, Yates JR, Pickard CJ, Mauri F. A first principles theory of nuclear magnetic resonance J-coupling in solid-state systems. The Journal of chemical physics.

2.5 Previous Studies

In reviewing of literature in locally and internationally there are some published studies regarding the brain disorders by many researchers suchas: Alexander Lin et al), created a survey on how, MRS contributes decisively to clinical decision making in a smaller but growing number. In this review, they studied how MRS provides therapeutic impact in brain tumors, metabolic disorders such as adrenoleukodystrophy and Canavan's disease, Alzheimer's disease, hypoxia, secondary to trauma or ischemia, human immunodeficiency virus dementia and lesions, as well as systemic disease such as hepatic and renal failure. Together, these eight indications for MRS apply to a majority of all cases seen. This review examined the role of MRS in enhancing routine neurological practice and treatment and concluded that:

1) There is added value from MRS where MRI is positive;

2) There is unique decision-making information in MRS when MRI is negative; and

3) MRS usefully informs decision making in neurotherapeutics. Additional efficacy studies could extend the range of this capability.

Franklyn a H et al), studied the benefits of 1H MR spectroscopy of brain tumors and masses and concluded that, its clinical application is slowly becoming a routine part of the initial diagnostic exam for brain masses, as it gives additional information to that obtained by conventional radiology.

Sergio luiz Ramen et al), studied the benefits of proton resonance spectroscopy and its clinical applications in patients with brain lesions and concluded that, it allows the detection of certain metabolites such as N-acetyl aspartate, creatinine, choline, myoinositol,amino acids and lipids among others. N-acetyl aspartate is a neuronal marker and as such, its concentration will decrease in the presence of aggression to the brain,

choline increase is the main indicator for neoplastic diseases. Myoinositol is raised in patients with Alzheimer's disease. Amino acids are encountered in brain abscesses. The presence of lipids is related to necrotic process.

Moller-Hartmen W et al), started a study to evaluate the clinical utility of 1H-MRS added to MRI for the differentiation of intracranial neoplastic and non- neoplastic mass lesions. 176 mostly histologically verified lesions were studied with a constant clinically available single volume 1H-MRS protocol following routine MRI. 12 spectra (6.8%) were not of satisfactory diagnostic quality; 164 spectroscopic data sets were therefore available for definitive evaluation. Our study shows that spectroscopy added to MRI helps in tissue characterization of intracranial mass lesions, thereby leading to an improved diagnosis of focal brain disease. Non-neoplastic lesions such as cerebral infarctions and brain abscesses are marked by decreases in choline (Cho), creatine (Cr) and N-acetyl-aspartate (NAA), while tumors generally have elevated Cho and decreased levels of Cr and NAA. Gliomas exhibit significantly increased Cho and lipid formation with higher WHO tumor grading. Metastases have elevated Cho similar to anaplastic astrocytomas, but can be differentiated from high-grade gliomas by their higher lipid levels. Extra-axial tumours, i.e. meningiomas and neurinomas, are characterized by a nearly complete absence of the neuronal marker NAA. The additive information of 1H-MRS led to a 15.4%-higher number of correct diagnoses, to 6.2% fewer incorrect and 16% fewer equivocal diagnoses than with structural MRI data alone.

Majós C et al), started a study to help in, differentiating between tumors and pseudotumoral lesions and their study aims to evaluate the potential usefulness and the added value that single-voxel proton MR spectroscopy could provide on this discrimination. A total of 84 solid brain lesions were retrospectively included in the study (68 glial tumors and 16 pseudotumoral lesions). Single-voxel spectra at TE 30 ms (short TE) and 136 ms (long TE)

were available in all cases. Differences between tumors and pseudotumors were found in myo-inositol (mIns); P < .01) at short TE, and N-acetylaspartate (NAA; P < .001), glutamine (Glx; P < .01), and choline (CHO; P < .05) at long TE. Classifiers suggested tumor when mIns/NAA ratio was more than 0.9 at short TE and also when CHO/NAA ratio was more than 1.9 at long TE. Classifier accuracy was tested in the test-set with the following results: short TE, 82% (23/28); long TE, 79% (22/28). The neuroradiologists' confidence rating of the test-cases on a 5-point scale (0-4) improved between 5% (from 2.86-3) and 27% (from 2.25-2.86) with spectroscopy (mean, 17%; P < .01).Hence, they concluded that, the proposed ratios of mIns/NAA at short TE and CHO/NAA at long TE provide valuable information to discriminate between brain tumor and pseudotumor by improving neuroradiologists' accuracy and confidence.

Darweesh A N. et al) studied Magnetic resonance spectroscopy and diffusion imaging in the evaluation of neoplastic brain lesions included thirty-six patients with histologically proven brain tumours (7 low, 13 high grade astrocytomas, 11 metastases, and 5 meningiomas) were evaluated with cMRI, MRS and DWI before surgery. They found that MR spectroscopy could differentiate benign from malignant tumours but was not useful in tumour grading. In the differentiation of malignant from benign tumours, N-acetylaspartate (NAA), Choline (Cho), Creatine, lactate/lipid, and alanin ratios were significant. Increase in lipid and alanin could distinguish metastases and meningiomas from other tumours. Increase in the lactate level correlated with the degree of malignancy. ADCs were effective for grading malignant tumours but not for distinguishing tumour types with the same grade. High grade malignant tumours had lower ADC values (0.428+0.006 · 10–3 mm2/s) than did low grade malignant (1.6+0.325 · 10–3 mm2/s), and benign (1.200+0.707 · 10–3 mm2/s) tumours. This study concluded that the combination of MRS with

cMRI and calculated ADC values added more and more information to MRimaging in the differentiation and grading of brain tumours and were more useful when done together than each alone.

Marzieh R et al), studied A Comparison of N-acetyl Aspartate Concentrations between Two Main Subtypes of Multiple Sclerosis using Magnetic Resonance Spectroscopy Imaging, using the MRSI (1.5 T) of the brain of MS patients (n = 28) was performed to determine the relative concentrations of NAA in NAWM and plaque regions and compared between two main MS subtypes of RRMS and PPMS. The images were acquisitioned with point resolved spectroscopy sequence, single voxel mode (24 mm × 24 mm × 24 mm), and repeated time (1500 ms) and echo time (35 ms). The relative concentrations of NAA in NAWM and plaque were compared between two subtypes. Results: The analysis of variance showed no significant difference in NAA of NAWM between PPMS and RRMS (P = 0.06). Similarly, there was no significant difference in NAA levels in the plaque region between PPMS and RRMS groups (P = 0.7). It should be noted that the difference in the concentrations of NAA in NAWM between RRMS and PPMS was higher than the difference between the plaque regions. Conclusion: Our findings showed that the NAA values in NAWM assessed by MRSI may be an adjunctive diagnostic index for differential diagnosis of two subtypes of MS disorder.

Bhavesh R Goyani1 et al), studied a role of magnetic resonance imaging (MRI) in intracranial space occupying lesions Their study was conducted presented with symptoms of raised ICT of sub acute onset & had lateralizing sign. A semi-structured questionnaire was prepared and demographic and clinical data like age, sex, symptoms and various morphological characters of Supratentorial SOLs were studied. A clinico-radiological correlation and confirmation of Radiological diagnosis was

done by biopsy/surgery/MRI whenever possible to minimize patient follow up.

They found that Majority of the patients were in the fourth decade (28.5%). Metastases were the most common single group of intracranial space occupying lesion (27%), Gliomas were the most common brain tumors (31.4%). Of the Gliomas, astrocytomas accounted for (81.8%). Most common hemisphere to be involved was the parietal lobe (31.4%). Intra-axial involvement (78.58 %) was most common localization in present study. Edema was the most common associated MRI finding (74.3%).

Sohail K et al), studied Magnetic Resonance Spectroscopy and its Usefulness in Brain Tumors, their Objective to evaluate the utility of magnetic resonance spectroscopy in cerebellopontine angle tumors taking biopsy as gold standard.Cross sectional comparative study done Department of Radio-Diagnosis and Imaging Lahore General Hospital Lahore, a period of six months from September 2007 to March 2008.

Using Magnetic resonance spectroscopy (MRS) is a non-invasive method, which provides insight of tumor metabolism. MRS studies were performed on 1.5 Tesla whole body MR systems using standard imaging head coil. Total 50 patients from indoor, outdoor, with suspected cerebellopontine angle (CPA) tumors based on history, clinical and pathological findings were included in this study. Patients having strong contra indication to MRI including those with cardiac pace makers, prosthetic heart valves, cochlear implants, brain aneurysm clips or coils were excluded. Patients already diagnosed, operated, or on treatment for recurrent tumors, Metastatic tumors or with jerky movements were also excluded.

They found that out of 50 patients 28 (56.0%) were male, 22 (44.0%) were females with mean age of 37.10 ± 15.07. MRS detected 43 out of 50 CPA tumors The Sensitivity, specificity rate and diagnostic accuracy of MR Spectroscopy were 95.4%, 83.3% and 94.0 % respectively. It concluded

that MR Spectroscopy is useful to arrive at a more definitive diagnosis in cerebellopontine angle tumors with similar morphological imaging patterns. Mohammed salih, 2017) Evaluation of Brain Lesions using Magnetic Resonance Spectroscopy. The result of this study revealed that Majority of the patients were in the 6th decade (75%). Malignancy were the most common lesion (46%), Gliomas were the most common brain tumors (19%).Most common lobes to be involved was the parietal lobe (18%).

Various types of brain tumors were revealed and most of malignant showed increased Cho/Cr peaks with NAA remain unchanged, the increased Cho/Cr and Cho/NAA ratio also noted with glioma.

Cases of glioma were included in the study, grading of glioma can be obtained on the basis of Cho/Cr and the presence of lipid/lactate peak; both grades of glioma showed High Cho/Cr ratio, but in high grade glioma the presence of lactate peak was noted.

There was total agreement between MRS, and histopathological results in all the cases of Meningioma included in the study. The study showed that the specific MR spectroscopic finding for Meningioma reported was the absence or very small peak of neuronal markers NAA and Cr, and markedly elevated Cho.

Chapter Three

Materials and Methods

Chapter Three

Materials and Methods

3.1 Materials

3.1.1 Equipment:

The Toshiba Excelart Vantage 1.5T MRI machine is an ultra-short, ultra-wide-bore system with adjustable lighting and ventilation features designed to ease patient anxiety without sacrificing performance. Powered by Atlas, the Toshiba Excelart Vantage 1.5T MRI system delivers high-resolution images across the entire body with faster imaging times. Each used Toshiba Excelart Vantage 1.5T MRI system features an integrated coil concept that allows for multiple examinations without repositioning the patient.

3.1.2 Study population:

Patients who presented with suspected brain lesion during the period of study inclusion criteria any gender any age patient with brain lesions and exclusion criteria any patient with contraindication to MRI

3.2 Methods:

3.2.1 Technique and protocol:

MRS studies were performed on 1.5 Tesla Toshiba whole body MR systems using standard imaging head coil. Routine brain MRI was performed in 3 orthogonal planes, including at least T1, T2, and fluid-attenuated inversion recovery (FLAIR) weighted images. T1-weighted images after intravenous gadolinium-based contrast material administration were obtained in at least 2 planes. All spectroscopy images were performed through single voxel technique. Initially, post contrast imaging was done in T1 or T2 and FLAIR without contrast to localize the lesion and then voxel was placed on volume of interest .After water suppression, appoint-resolved spectroscopy (RESS) technique was used for localization and the studies were obtained with parameters including TE and TR.

3.2.2 Data collection tools:

3.2.2.1 Data collection:

Data will be collected by validate a self-administrated through collection data sheet adopted for the study.

3.2.2.2 Data analyzing

Data will be analyzed by using the computerized program, Statistical Package for Social Sciences (SPSS)

3.4 Ethical consideration:

- Approval for this study will be obtained from Almoalem medical city
- Verbal Consent was obtained from patients and confidentiality was considered throughout the study.
- Permission from hospital authorized person was taken

Chapter four

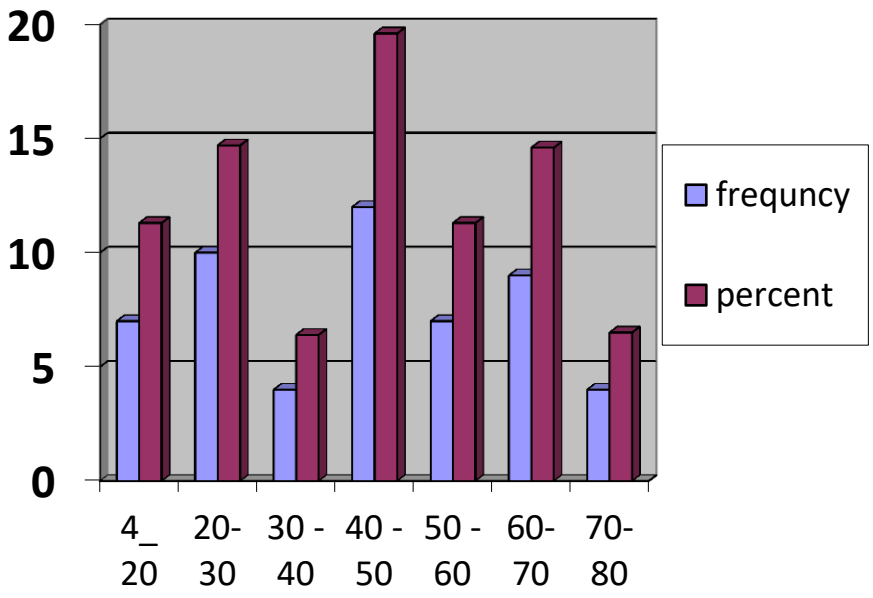
Results

Chapter four

Results

Table (4-1): Age grouping

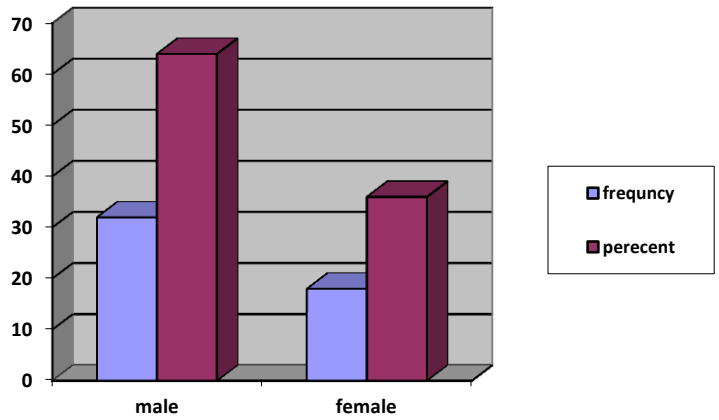
	Frequency	percent
4-19	7	14%
20-29	7	14%
30-39	6	12%
40- 49	12	24%
50- 59	4	8%
60-69	10	20%
70-79	4	8%
Total	50	100%



Figure(4-1): Age grouping Graph

Table (4-2): Gender table

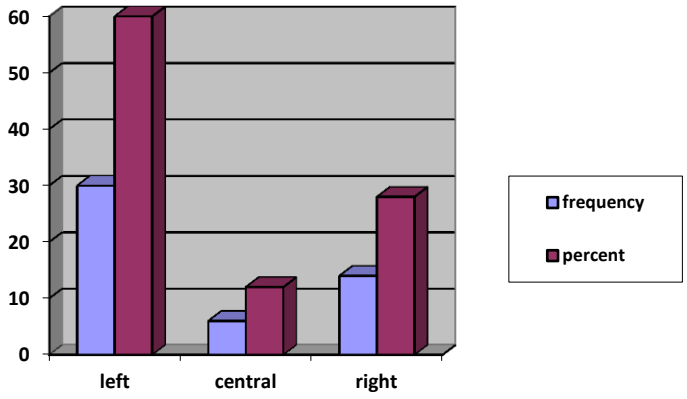
	Frequency	Percent
FEMALE	18	36%
MALE	32	64%
Total	50	100%



Figure(4-2): Gender Graph

Table (4-3): Tumor Site

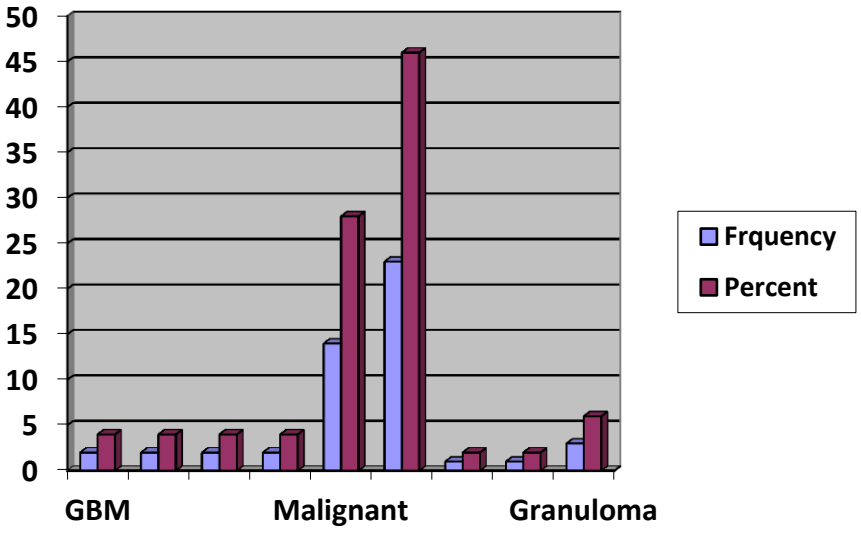
Side	Frequency	Percent
Left	30	60%
Center	6	12%
Right	14	28%
total	50	100%



Figure(4-3): Tumor Site Graph

Table (4-4): MRS finding distribution table

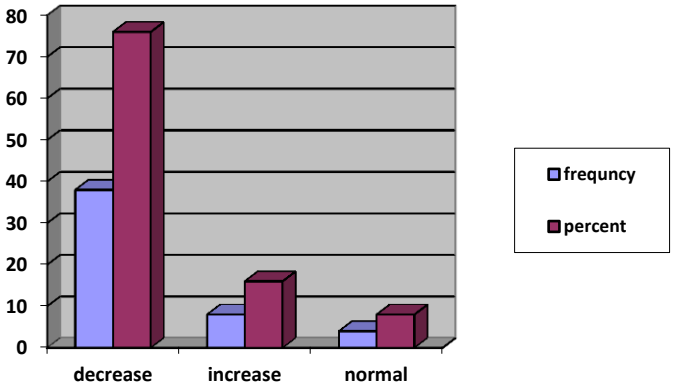
	Frequency	Percent
GBM	2	4%
Glioblastoma	2	4%
Glioma	23	46%
Glyomatosis	1	2%
Granuloma	3	6%
Haemangioma	1	2%
Malignant	14	28%
Meningioma	2	4%
Oligodendroglia	2	4%
Total	50	100%



Figure(4-4): MRS finding distribution Graph

Table (4-5): Chemical shifts

	Frequency	Percent
Increased	8	16%
Normal	4	8%
decreased	38	76%
Total	50	100%



Figure(4-5): Chemical shifts Graph

Chapter Five

Discussion, Conclusion and Recommendations

Chapter Five

Discussion, Conclusion and Recommendation

5.1 Discussion

Regarding age distribution, there were seventh groups; group one aging was between 4 to 19 years old this was 7patients (14%), the second group aging was between 20 to 29 years old this was 7patients (14%), third group aging was between 30 to 39 years old this was 6 patients (16%), fourth group aging was between 40 to 49 years old this was 12patients (24%), fifth group aging was between 50 to 59 years old this was 4patients (8%), sixth group aging was between 60 to 69 years old this was 10patients (20%) and the last group aging was between 70 to 79 years old this was 4patients (8%), the affected age lies between the age of (40 to 50) years old which is matches with (Mohammed salih, 2017) and in contrast with finding of Bhavesh R Goyani1 et al) and while in a similar study by B. Shah et al), maximum number of patient were in 1st decade (21 %) followed by 4th decade (18%). the gender distribution there in the study is wide range in male than female, number of male frequency was (32),percent (64%) and female was frequency (18), percent (36%) showed in graph(4-2). The sex ratio of the present study was found to be quite comparable with study conducted by B. Shah et al.) the present study agree with study done by Sohail K et al et al)

The different distribution of tumor in different site. The most effect side Is the left side Frequency 30(60%) when the center site the Frequency6 (12%) and Right site Frequency14 (28%).Presented in Graph (4-3).

In the present study was different lesion type the most common MRS finding the Gliomas in 46% patients followed by malignancy 28% , GBM (4%) Glioblastoma (4%) Granulomas(6%), Haemangioma(2%), Meningioma(4%), Glyomatosis(2%)and Oligodendroglioma(4%) in contrast with finding of Bhavesh R Goyani1 et al) Presented in Graph (4-4).

All mass lesions studied showed abnormal MR Spectra as compared to normal parenchyma. the chemical shift in different chemical component Nacetyleaspartate(NAA), Creatine(Cr),Choline (Cho),Lactate , Glumatate and glutamines (GLx),Myoinositol (MI),Lipids. Increase chemical component peak Frequency8 (16%) and normal chemical component peak Frequency4 (8%) and decrease chemical component peak Frequency38 (76%) Presented in Graph (4-5).

5.2 Conclusion:

- The outcomes of this study the MR spectroscopy is most sensitive diagnostic tool when add to conventional MRI examination. This study concern with MRS finding and is sensitive differentiate between benign malignant lesions.
- This study reveals that MRS is adequate tool for diagnostic brain lesion. Malignancy was the most common lesion. MRS may be an appropriate, non-invasive method for diagnosing brain tumors,
- This study showed that the presence of elevated NAA is correlated with tumor MRS findings. MR Spectroscopy can be used as a non-invasive screening test for C/P angle lesions, and a suitable alternative to biopsy.
- On the other hand MRS tool has limitation in diagnosing some brain lesion and differentiate. The technique is very sensitive to in homogeneities in the magnetic field and requires careful manual adjustment to ensure field uniformity. Artifacts can arise from braces on teeth or proximity to sinuses. If any bone is included in the Voxel, it can cause artifacts due to the lipid signal arising from bone marrow.

5.3 Recommendation

- We recommend doing MRS routinely in patients with brain lesions to improve the accuracy of neuro diagnosis and for other benefit in patient management such as: Discrimination between tumor and tumor like lesions, Differentiation between primary ,secondary neoplasm& lymphoma, Grading of cerebral gliomas, Treatment planning of gliomas, Differentiation between the recurrent / residual tumor and the radiation injury, Diagnosis of primary and secondary brain tumors and other focal intracranial lesions based on imaging procedures alone is still a challenging problem. Magnetic resonant spectroscopy may give completely different information related to brain lesions and save time risk and cost.
- We recommend to encouraging more studies to be done in MRS with a larger sample size and comparison with other imaging and histopathology findings to give us more information about the impact of the new technique MRS in our diagnosis and to help us to adhere to the discipline of evidence based medicine.

References

Abdel-Monem N. Darweesh, Manal E. Badawy, Manal Hamesa *, Noha Saber, Magnetic resonance spectroscopy and diffusion imaging in the evaluation

Alexander Lin et al ;Efficacy of proton magnetic resonance spectroscopy in neurological diagnosis and neuro -therapeutic decision making, NeuroRx, Vol 2, issue 2, 197-214

Beissner F, Schumann A, Brunn F, Eisentrager D, Bar KJ. Advances in functional magnetic resonance imaging of the human brainstem. NeuroImage. 2014;86:91-8. Epub 2013/08/13.

Bhavesh R Goyani1, Bhagwati V Ukani2, Parth Naik3, Hinal Bhagat4 Mahesh K Vadel5,Rakesh Sheth6, A Study on Role of Magnetic Resonance Imaging (MRI) In Intracranial Space Occupying Lesions, NJMR │Volume 5 │Issue 1 │Jan – March 2015

Franklyn A H et al; H MR spectroscopy of brain tumors and masses; NMR Biomed 2003;16:123-131

Janet Cochrane miller , Magnetic Resonance Spectroscopy in the Brai July2012 .volume 10,Issue7.

Jeffry R. Algers, Basic of Magnetic resonance spectroscopy for Practicing Clinician,2006 .

Joyce SA, Yates JR, Pickard CJ, Mauri F. A first principles theory of nuclear magnetic resonance J-coupling in solid-state systems. The Journal of chemical physics. 2007;127(20):204107. Epub 2007/12/07.

Kang J, Liu H, Zheng YM, Qu J, Chen JP. Application of nuclear magnetic resonance spectroscopy, Fourier transform infrared spectroscopy, UV-Visible spectroscopy and kinetic modeling for elucidation of adsorption chemistry in uptake of tetracycline by zeolite beta. Journal of colloid and interface science. 2011;354(1):261-7. Epub 2010/12/07.

Kodibagkar VD, Wang X, Mason RP. Physical principles of quantitative nuclear magnetic resonance oximetry. Frontiers in bioscience : a journal and virtual library. 2008;13:1371-84. Epub 2007/11/06.

Majós C et al; Proton MR spectroscopy improves discrimination between tumor and pseudotumoral lesion in solid brain masses. (PubMed); AJNR Am J Neuroradiol. 2009 Mar;30(3):544-51. Epub 2008 Dec 18.

Majos C, Alonso J, Aguilera C, Serrallonga M, Perez-Martin J, Acebes JJ, et al. Proton magnetic resonance spectroscopy ((1)H MRS) of human brain tumours: assessment of differences between tumour types and its applicability in brain tumour categorization. European radiology. 2003;13(3):582-91. Epub 2003/02/21.

Marzieh Reshadatian, Ali Yadollahpour, Shapour Dahaz, Mohamad Javad Tahmasebi Birgani, Nastaran Majdinasab, Morteza Tahmasebi, A Comparison of N-acetyl Aspartate Concentrations between Two Main Subtypes of Multiple Sclerosis using Magnetic Resonance Spectroscopy Imaging, Asian Journal of Pharmaceutics .Oct-Dec 2016（Suppl) • 10 (4) | S796

Mohammed salih, 2017) Evaluation of Brain Lesions using Magnetic Resonance Spectroscopy in National Ribat University

Moller-Hartmen W et al; Clinical application of proton magnetic resonance in diagnosis of intracranial mass lesions; Neuroradiology 2002;44:371-378

of neoplastic brain lesions, The Egyptian Journal of Radiology and Nuclear Medicine (2014) 45, 485–493

Okumura A, Lee T, Ikeno M, Shimojima K, Kajino K, Inoue Y, et al. A severe form of epidermal nevus syndrome associated with brainstem and cerebellar malformations and neonatal medulloblastoma. Brain & development. 2012;34(10):881-5. Epub 2012/04/10.

Poretti A, Boltshauser E, Huisman TA. Cerebellar and Brainstem Malformations. Neuroimaging clinics of North America. 2016;26(3):341-57. Epub 2016/07/18.

Poussaint TY, Rodriguez D. Advanced neuroimaging of pediatric brain tumors: MR diffusion, MR perfusion, and MR spectroscopy. Neuroimaging clinics of North America. 2006;16(1):169-92, ix. Epub 2006/03/18.

Sergio L R et al, Proton magnetic resonance spectroscopy: clinical applications in patients with brain lesions; Sao Paulo Med 2003;121(6) 254-259

Shintaku M, Adachi Y, Arai A, Koyama J. Anaplastic and meningothelial meningiomas in a single tumor: A "dedifferentiated meningioma"? Neuropathology : official journal of the Japanese Society of Neuropathology. 2016. Epub 2016/07/05.

Sohail Kamran,khadija Fatima,Ayesha Haider, Magnetic Resonance Spectroscopy and its Usefulness in Brain Tumors, Ann. Pak. Inst. Med. Sci. 2013; 9(4):180-183.

Toni R, Spaletta G, Casa CD, Ravera S, Sandri G. Computation and brain processes, with special reference to neuroendocrine systems. Acta bio-medica : Atenei Parmensis. 2007;78 Suppl 1:67-83. Epub 2007/05/01.

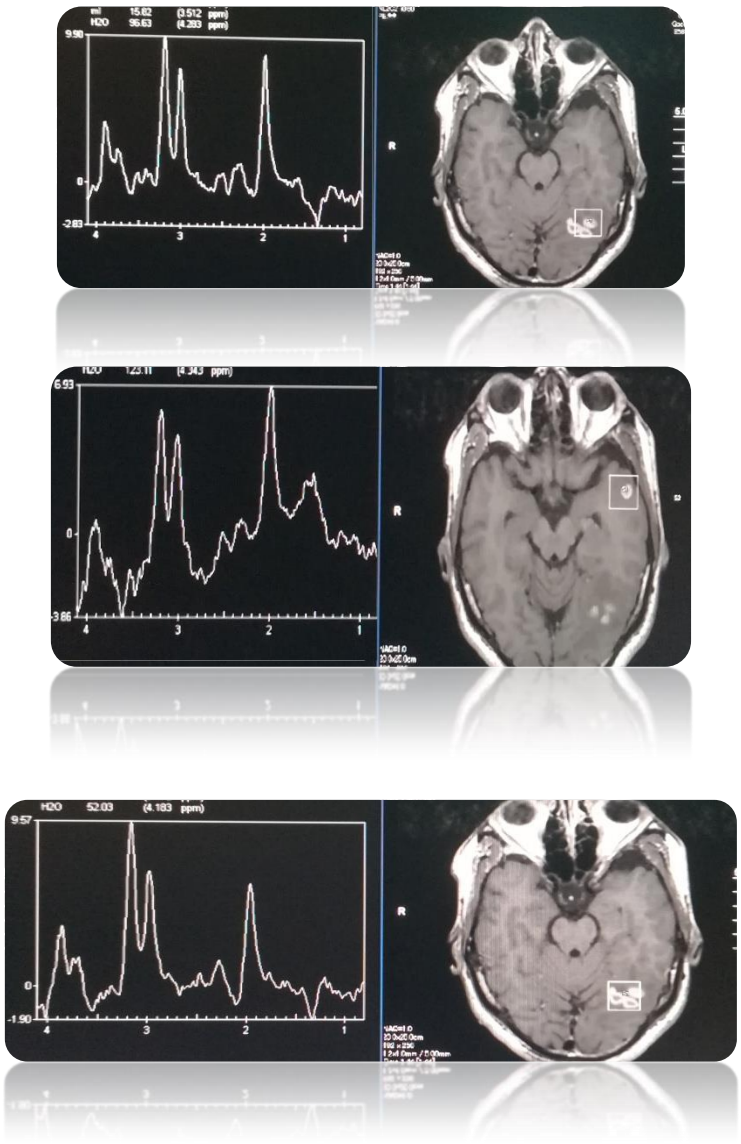
Appendices

Appendix (A)

Data collecting form

No	Age	Gender	Tumor side	MRI finding	MRS finding	Chemical shifting			
						NAA	Lactate	Cho	Cr

Appendix (B)



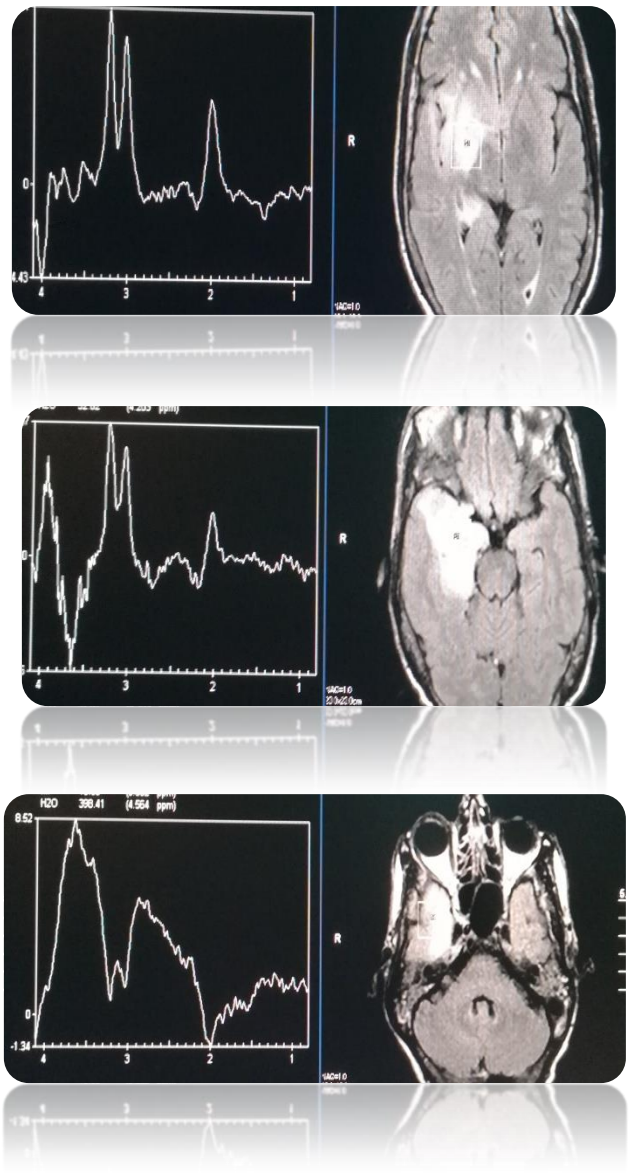
Case (1):30years old/male

MRS Findings:

- Increased choline peck.
- Increased choline/Cr ratio
- Decrease NAA peck

Impression:

Overall picture are of infavraing metastasis rather than primary brain tumor



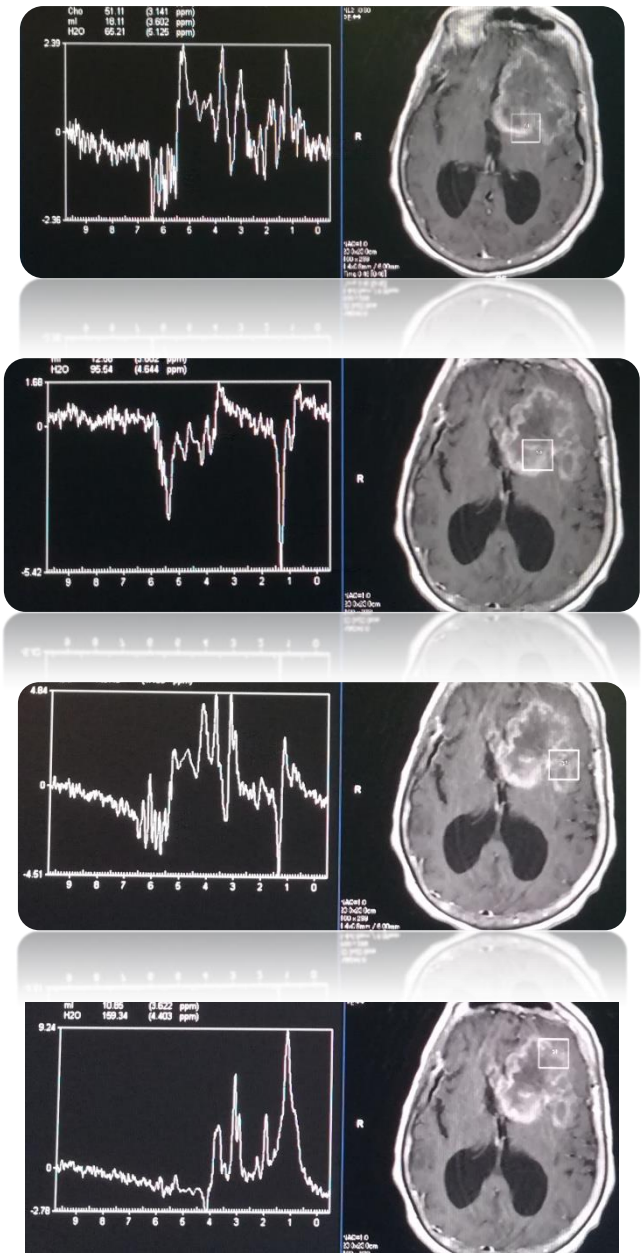
Case (2):53years old/male

MRS Findings:

- Increasedcreatine peck.
- Increased choline/Cr ratio
- Decrease NAA peck
- A new peak is seen resonating at 3.6mostly myo-inositol

Impression:

Features are representing neoplastic process mostly low grade Glioma.



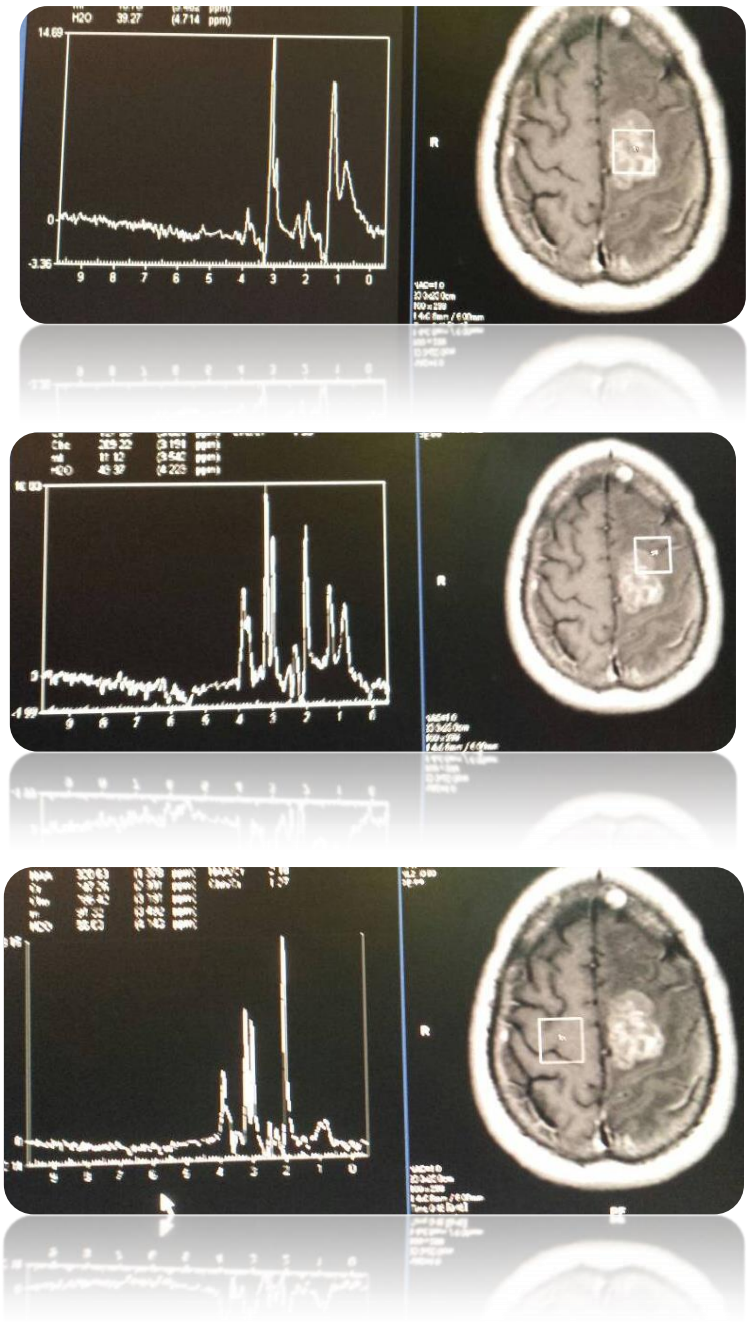
Case (3):73years old/female

MRS Findings:

- Decreased Creatine peck.
- Choline/Cr ratio of 3.78 at its maximum
- Decrease NAA peck
- Elevated choline peak

Impression:

Features are representing neoplastic process, mostly glioblastoma multiforme.



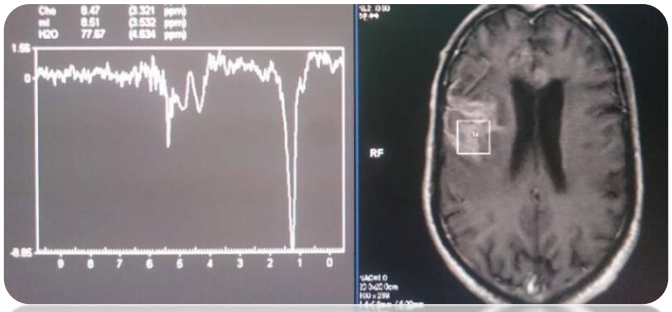
Case (4):56years old/male

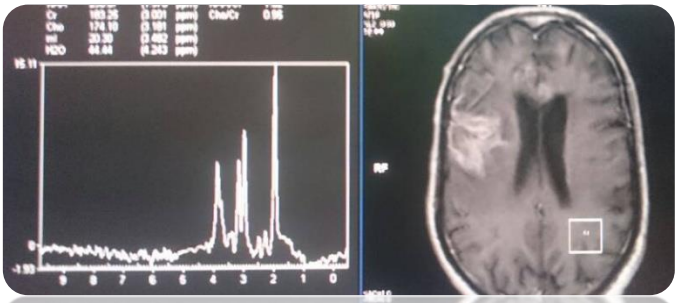
MRS Findings:

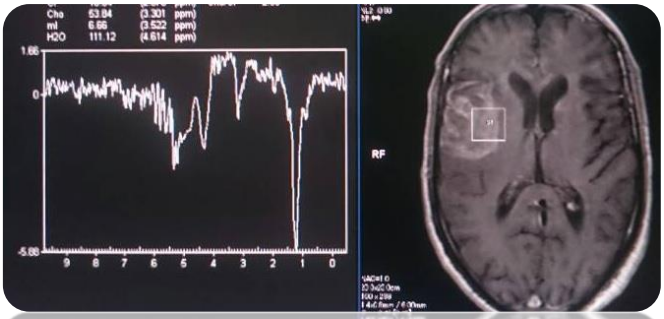
- Increased choline peck.
- Increased choline/Cr ratio
- Decrease NAA peck
- Increased lactate

Impression:

Overall picture are suggestive of neoplastic rather than inflammatory process GBM on top of DD.







Case (5):62years old/male

MRS Findings:

- Predominant elevation of lipid/lactate peak =tissue necrosis
- Significantly reduced –absent ANN and creatine = no normal neuronal tissue
- Significantly reduced –absent choline peak = no cellular proliferation or turn over.

Impression:

Overall features are favoring inflammatory / infection process with abscess formation , rather than neoplastic or ischemic .