KARNATAKA RADIOLOGY EDUCATION PROGRAM

MR SPECTROSCOPY

MAGNETIC RESONANCE SPECTROSCOPY

- It is an advanced MRI technique that allows non-invasive evaluation of tissue molecular composition.
- It is utilized to diagnose & monitor disease and also assess response to treatment.

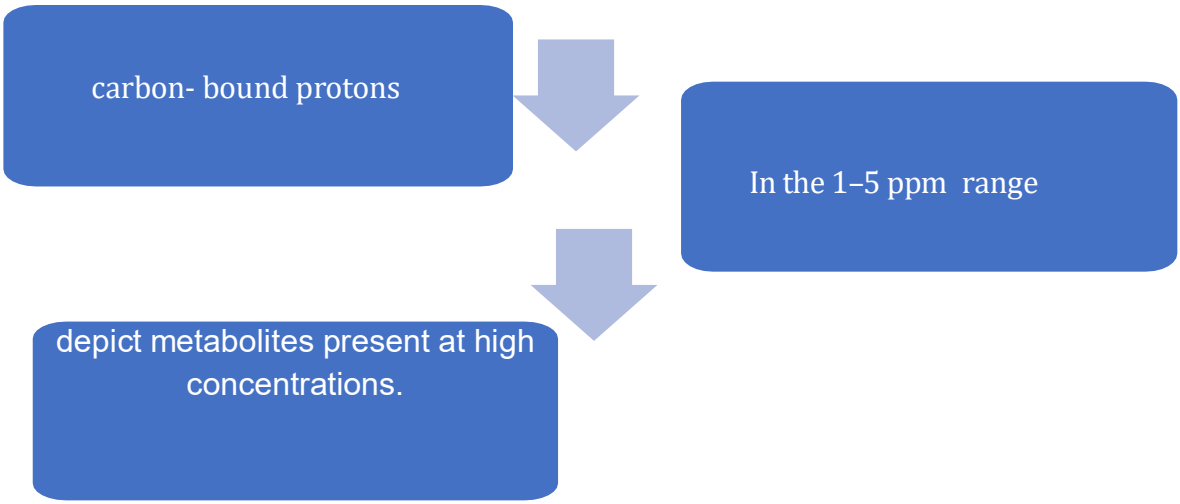
PRINCIPLE:-

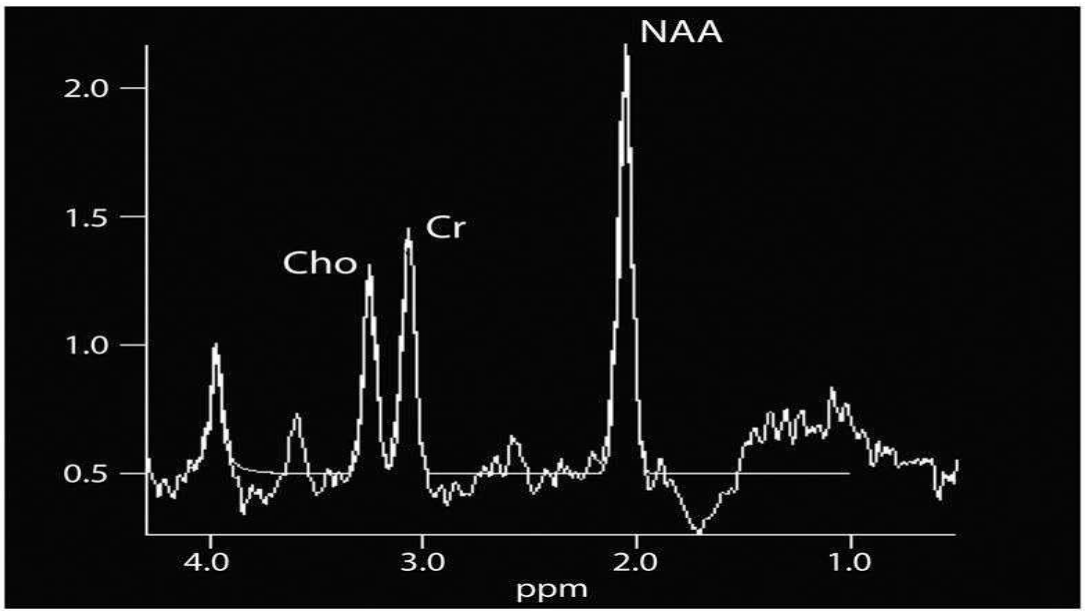
It obtains chemical information of region of interest, displayed as numerical values.

At given external magnetic field- chemically distinct nucleus shows different resonating frequency (CHEMICAL SHIFT) - separate peaks in MR spectrum.

^{1}H MR SPECTRUM OF THE BRAIN: METABOLITES AND THEIR BIOMARKER POTENTIAL

- Proton is abundantly present in the body and hence most suited for MRS.
- The In vivo ^{1}H MR spectroscopy focuses on





H MR spectrum acquired at 3.0 T from an area of normal brain. Choline (Cho), creatine (Cr), and N-acetyl-aspartate (NAA) are the dominant peaks, with NAA higher than both Cho and Cr.

DIAGNOSTIC USES OF METABOLITES IN MRS

1. **METABOLITE - CHOLINE**

Ppm- 3.2

ELEVATED IN- Neoplasms Inflammation Demyelination Traumatic injury

DECREASED IN- Hepatic encephalopathy Stroke

CHARACTERISTICS- Precursor of acetylcholine (component of cell membranes).Membrane synthesis.

2.METABOLITE - N- ACETYL ASPARTA TE

Ppm-2.0

ELEVATED IN- Canavan's disease

DECREASED IN- Hypoxia Neoplasm Neurodegenerative disorder Lymphoma

CHARACTERISTICS-Marker of neuronal viability & normal neuronal function.

3.METABOLITE - CREATINE

Ppm-3.0

ELEVATED IN- Hypometabolic states.

DECREASED IN- High grade gliomas Necrosis

CHARACTERISTICS- Marker of brain metabolism.

4.0 METABOLI E - LACTATE

Ppm-1.3

ELEVATED IN- Neoplasm infection. Hypoxic injury

CHARACTERISTICS- Marker of anaerobic metabolism. Indicates ischemia.

5.0 METABOLITE - LIPIDS

Ppm-1.3

ELEVATED IN- Necrotic neoplasm Abscess Lymphoma toxoplasmosis

CHARACTERISTICS- Component of cell membrane.

6.0 METABOLITE - MYO-INOSITOL

Ppm-3.5

ELEVATED IN- Low grade gliomas Renal dysfunction Diabetes mellitus

DECREASED IN- Stroke Tumor Hypoxia SIADH

CHARACTERISTICS- Marker of astrocytes. Indicates osmotic stress.

7.0 METABOLI E - 2- HYDROXYGLU TARATE

Ppm-2.5

ELEVATED IN- IDH-1 positive tumors

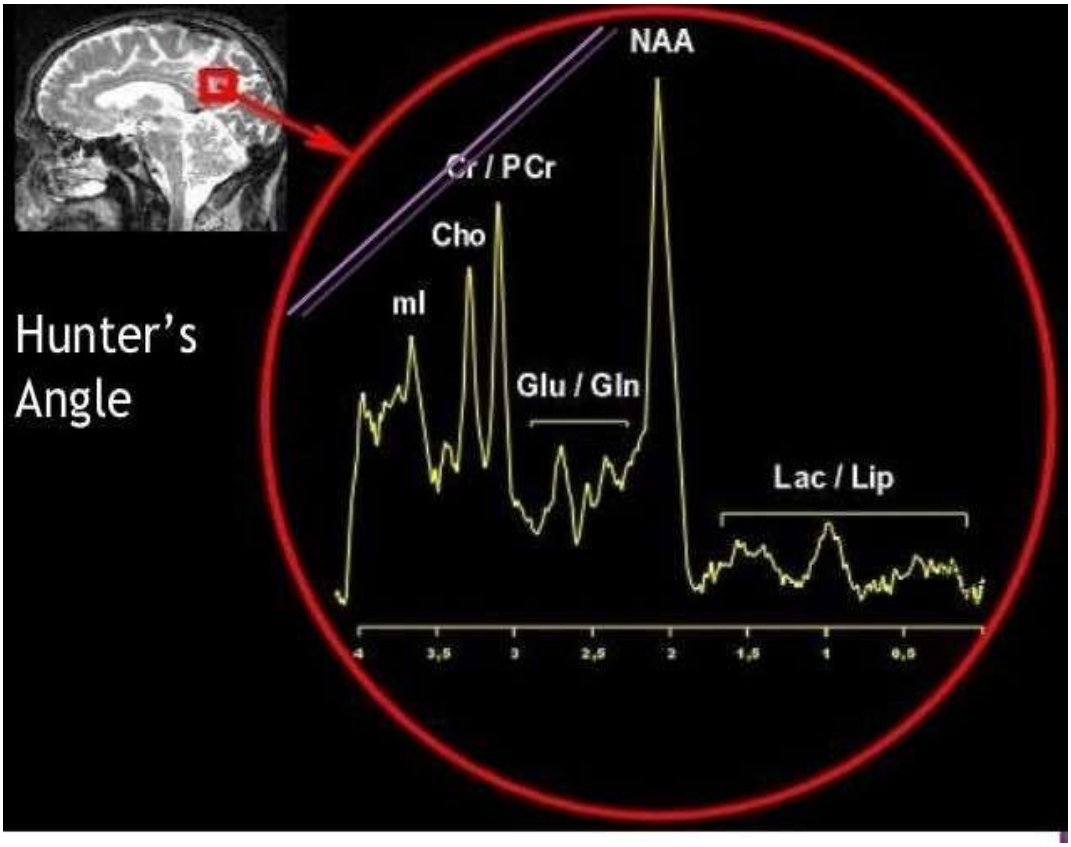
CHARACTERISTICS- Oncometabolite

HUNTER'S ANGLE

Normally, a line runs superiorly from left to right, joins tip of 3 major peaks- choline, creatine and NAA.

Forms an angle of 45 degree.

This angle is reversed in tumors due to elevated choline and reduced NAA.



ROLE OF ^{1}H MR SPECTROSCOPY INNEUROIMAGING

1. Brain tumors.
2. Distinction between radiation necrosis and recurrent tumor in postoperative patients.
3. Differentiation of intracranial ring enhancing lesions.
4. Magnetic resonance spectroscopy in demyelinating diseases.
5. Magnetic resonance spectroscopy in head trauma.

I. BRAIN TUMORS

A. GRADING OF GLIAL TUMORS

Astrocytoma reveal elevated choline, reduced Cr and NAA in comparison to the normal brain. **Lactate and lipid peaks reflect high grade tumor.**

LOW GRADE GLIOMAS

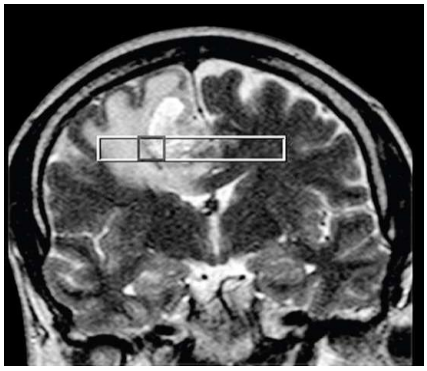
- Modest Cho elevation, NAA reduction, and Cho/Cr ratio elevation .
- MI and MI/Cr ratio can also be elevated. Typically lack Lac and Lip peaks

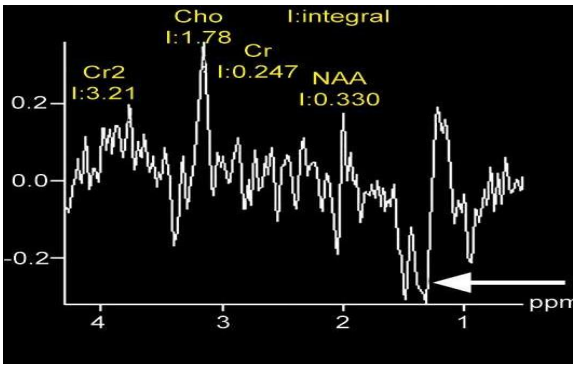
HIGH GRADE GLIOMAS

- Increased Cho and decreased Cr, NAA, and MI in grade III and IV gliomas .
- Presence of lactate and lipid peaks suggests a grade IV tumor and is not commonly seen with grade III gliomas.

DIFFERENTIATION BETWEEN IDH MUTANT AND WILD TYPE

ASTROCYTOMAS- IDH-mutant astrocytoma shows a **2- hydroxyglutarate (2-HG) peak** not seen in wild type





Coronal T2-w image (A) shows a heterogeneous tumor in right fronto-parietal region. Elevated choline/creatine ratio and elevated choline peak in the spectrum (B). A bifid inverted lactate peak (arrow) is also seen in the spectrum. All these findings are suggestive of a high grade tumor.

B. MENINGIOMA

Meningioma show low NAA as well as a alanine peak

C. LYMPHOMA

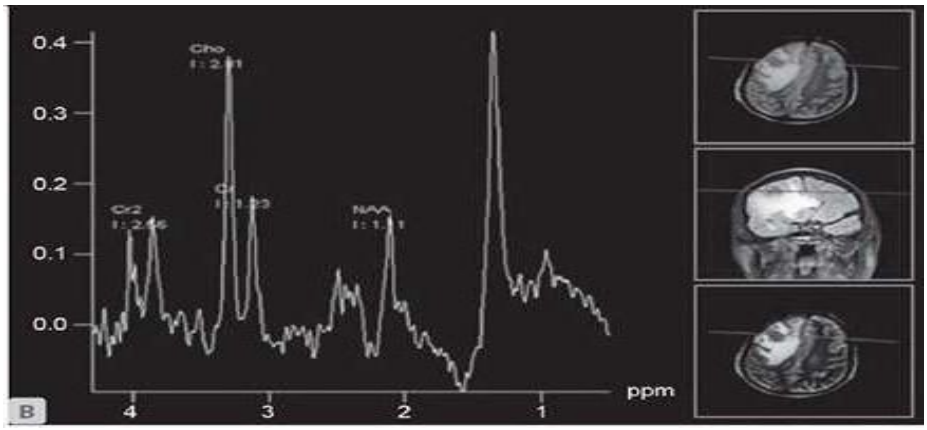
Reduced NAA and high choline with infiltration of adjacent brain.

MRS findings be indistinguishable from gliomas

D. METASTASES

Reduced NAA and Cr with high choline, +/- lipid/lactate peak.

-CSI 1H-MRS of the lesion shows marked increase in the Choline/NAA ratios with significant lipid lactate peaks suggestive of metastasis.



II.DISTINCTION BETWEEN RADIATION NECROSIS AND RECURRENT TUMOR IN POSTOPERATIVE PATIENTS

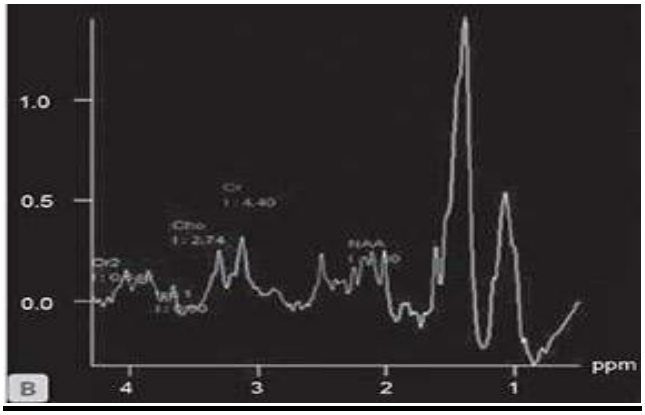
- It is the most common scenario for which MRS is utilized.
- Both of these pathologies are seen as heterogeneous mass lesions with enhancement and edema.
- Recurrent tumor, has relatively increased choline, as opposed to radiation necrosis, which shows low levels.

RECRRENT BRAIN TUMORS VS RADIATION NECROSIS

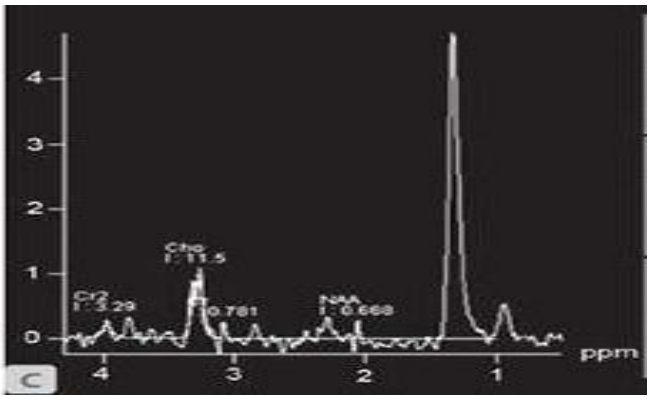
High ratios of choline/creatine (Cho/Cr) and choline/*N*acetylaspartate (Cho/NAA	Increased lactate and lipid peaks

III. DIFFERENTIATION OF INTRACRANIAL RING ENHANCING LESIONS

PYOGENIC BRAIN ABSCESSES-Lipid/lactate and amino acid peaks with other metabolites such as succinate and acetate.



TUBERCULOUS ABSCESSES-Lipid and lactate levels .

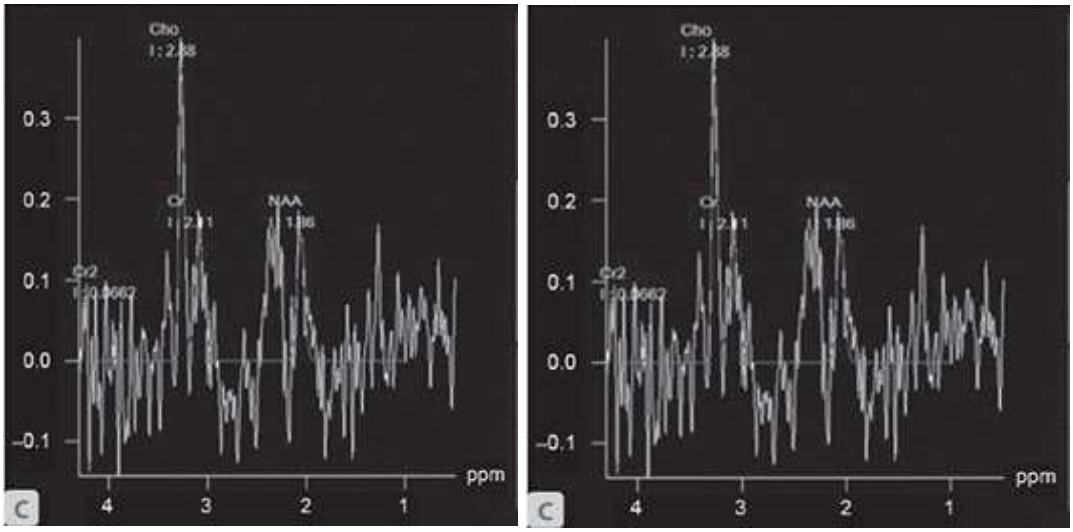


NEUROCYSTICERCOSIS-Elevated lactate, alanine, succinate and choline levels. Reduced level of NAA and creatine.

TUBERCULOMA-Prominent lipids, increased choline. Reduced level of NAA and creatine.

IV. MAGNETIC RESONANCE SPECTROSCOPY IN DEMYELINATING DISEASES

A. MULTIPLE SCLEROSIS



(C) CSI 1H-MRS (TE = 135 ms) from the left periventricular lesion shows increased choline and decreased NAA suggestive of acute lesion; (D) CSI 1H-MRS (TE = 135 ms) from the lesion in right periventricular location shows normalized choline and NAA levels suggestive of chronic lesion.

B. TUMEFACTIVE DEMYELINATION-Characterized by reduced NAA, raised choline, lipid/ lactate peaks and glutamate/glutamine peaks.

V. MAGNETIC RESONANCE SPECTROSCOPY IN HEAD TRAUMA

MRS provide insight as to how patients should be treated and whether treatment is effective.

Injured region had highly increased lactate signal and decreased NAA, Cr and Cho.

LIMITATIONS

- The lack of definitive imaging findings has been the primary reason MRS is not used more frequently
- Artifacts and noise that limits interpretation.
- Susceptibility from adjacent bone or air limit signal from portions of the brain near skull base and calvarium.
- Surgical clips disrupt local field homogeneity and affect the quality of the data.
- Imaging can also be time-consuming and require technologist or radiologist intervention.

Compiled by: Dr Akash Yadav

Under guidance of Dr Pravin G U principal professor.radiodiagnosis

REFERENCES-MRI MADE EASY, OSBORN'S BRAIN AND MR SPECTROSCOPY OF BRAIN TUMORS-MENG LAW.