

BODY MRI IN PEDIATRIC ONCOLOGY

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INTRODUCTION:

Pediatric tumors are rare; and solid tumors are less common compared to leukemia/lymphoma and CNS tumors.[1] The reported incidence of pediatric cancers in India ranges from 38 to 124 per million children per year [1]. Although solid tumors constitute only about 10-12% of the total childhood cancers [1]; they have very heterogeneous biological behavior and prognosis. Ascertaining proper diagnosis and securing timely treatment remain the key to a favorable outcome in children with cancers. Appropriate choice of imaging modality, hence, remains crucial.

Magnetic Resonance Imaging (MRI) is a revolutionary imaging invention in the history of medical diagnostics. The basis of MRI lies on the theory that atomic nuclei can absorb and emit radio waves when exposed to a sufficiently strong magnetic field. Since human body has abundant water, the signals from hydrogen atom in the water can be measured, when exposed to a strong magnetic field. A cancerous tissue contains more water than a normal one. Hence the MRI signal from hydrogen protons in cancerous tissue will be different from the normal tissue. This principle forms the basis of imaging in a clinical MR scanner [2].

ADVANTAGE OF MRI OVER CT

- MRI, unlike CT has no risk of ionizing radiation. This remains a big advantage while imaging a child having multiple follow up imaging. A child is expected to have a longer

life expectancy; and hence the detrimental side effects of ionizing radiation including susceptibility to development of radiation induced cancers become more worrisome in them.

- MRI has superior soft tissue contrast resolution than CT, and is capable of tissue characterization.(Fig 1)
- Organ specific contrast agents are available with MRI. Hepatocyte specific contrast agents such as Gd-BOPTA (Multilane) are invaluable in the characterization of liver tumors.
- Special sequences like chemical shift MRI, dynamic contrast enhanced MRI, DWI, MR spectroscopy and whole body MRI impart additional edge of this imaging modality (discussed later).

SEQUENCES IN ONCOLOGY AND TISSUE CHARACTERIZATION

Although the imaging protocol varies according to the clinical indication and from patient-to patient; the basic sequences in body MRI in pediatric oncology include

- Spin echo T1W and Fast spin echo T2W images
- Gradient echo images (GRE) : balanced, T1W and T2W
- Diffusion weighted image
- Contrast enhanced images (dynamic and post-contrast), depending on the clinical indication

Table 1. Tissue characterization on MRI (Fig 2)

Other sequences	T2W	T1W	
	Hyperintense	Hypointense	Water

Very hypointense on fat suppressed sequences like STIR (short <i>tau</i> inversion recovery)	Hyperintense	Hyperintense	Fat
	Hypointense	Hypointense	Fibrous tissue (mature)
Hypointense, ‘ blooming’ on GRE	Hypointense	Hyperintense	Hemorrhage (subacute)

Chemical shift MRI (CSI)

It is a novel imaging sequence based on the fact that fat protons precess at a lower frequency than water protons. Chemical shift imaging on MRI identifies intracellular lipid because of the different resonant frequencies of fat and water protons in a given voxel. [3] In This phenomenon results in loss of signal intensity on out-of-phase imaging when compared with in-phase images in CSI. It is very useful in *differentiating adrenal adenoma from metastases*.

Multiphase contrast enhanced MRI (Fig 3)

Multiphase contrast enhanced MR images are acquired at different time intervals after intravenous injection of contrast agent. *Hepatic tumor characterization* is one of the most important use of multiphase contrast enhanced MR imaging. In hepatic tumor evaluation, imaging is typically performed at arterial (20-25 sec), portal venous (50-60 sec), and delayed phases (120 sec). *Renal tumors* (e.g. Wilm’s tumor) evaluation requires imaging in three distinct phases (cortico-medullary, nephrographic and excretory phases).

Dynamic contrast enhanced MRI (DCE-MR) involves multiple repeated imaging of the same volume of tissue within a specified time interval, thereby determining the perfusion parameters of the tissue as well as permeability. Unlike adult tumors (breast, musculoskeletal, genitourinary cancers), DCE-MR is not commonly used for pediatric abdominopelvic malignancies. Respiratory motion, and long breath hold requirement remain the main obstacles in their use in pediatric abdominopelvic tumors.

Diffusion weighted imaging (DWI) (Fig 4)

DWI is based on the principle of Brownian motion of water molecules. The motion of water molecules (and hence the water protons) in a free extracellular medium is random (Brownian motion); whereas in a tissue, this random motion is restricted by the cell membranes. As the malignant tissues are more cellular and densely packed than a normal tissue, the normal random motion of water is even more restricted in them.[4] This presents as restricted diffusion (hyper intense signal on DWI and hypo intensity on apparent diffusion coefficient (ADC) map). Typically images are obtained at multiple b-values (0 to 800/ 1000m/s²).

DWI is being evaluated as an *imaging biomarker for differentiating malignant tumor from benign*; and *assessing response to treatment*. It has been seen that tumors responding to treatment usually tend to show less diffusion restriction. [4, 5]

MR spectroscopy

Although widely used in CNS tumors, MR spectroscopy is not much widely used in body MRI in pediatric oncology. Physiological motions like respiratory and cardiac motions make it difficult to obtain a good spectrum from a focal abdominal/ thoracic mass. This is even more difficult in children with poor breath hold capacity.[6]

Whole body MRI (Fig 5)

Whole body MRI (WB-MRI) involves imaging of the entire body (from vertex to feet). This has been made possible by the advances in MR hardware's and sequences. In newer generation MR scanners enabled with total imaging matrix (TIM) and moving tabletop, imaging of the entire body is possible without patient repositioning. Moreover, faster imaging using parallel imaging technique (PAT) has made the imaging of the entire body possible within a reasonable time frame. Over the last decade, there has been much enthusiasm in evaluation of WB-MRI in pediatric oncology. Although there is no standardized protocol for such examination, but commonly used sequences include T1W spin echo and STIR sequences.

WB-DWI is another new imaging modality which combines the advantages of WB-MRI and DWI. Important roles of WB-MRI are listed in table 2.[7,8]

Table 2. Indications of WB-MRI in pediatric oncology

Staging of lymphoma
Staging of Langerhan's cell histiocytosis
Staging (local as well as metastasis detection) in solid tumors (ex- neuroblastoma, Ewing's sarcoma)
Screening of children with cancer predisposing conditions (ex: p53 mutations)
Screening of children with retinoblastoma for skeletal metastases or secondary malignancy
Follow up in lymphoma/ solid tumors

CHALLENGES

One of the major disadvantage of the use of MRI in pediatric oncology is the requirement of

anesthesia/ sedation for a long duration. Imaging of lung lesions remains another challenge; due to the respiratory motion and susceptibility artifact in the pulmonary parenchyma.

Imaging of treated tumors is a diagnostic challenge where active tumor/ fibrotic tissue cannot always be differentiated with certainty. Also, small mass with calcification (as in neuroblastoma) remains a diagnostic challenge with MRI.

CONCLUSION

Since the use of first clinical MRI in the 1970s, MR imaging has come a long way, only to arm the medical practitioner with multiple new techniques of fast and accurate body imaging. While the use of body MRI in children is limited by multiple challenges; newer generation scanners with faster sequences hold a promise to overcome them. The biggest advantage of avoidance of ionizing radiation can not be overemphasized. With the upcoming advances like PET-MRI and MR guided biopsy; MRI can certainly be described as the ‘one stop shop’ for pediatric oncology.

References:

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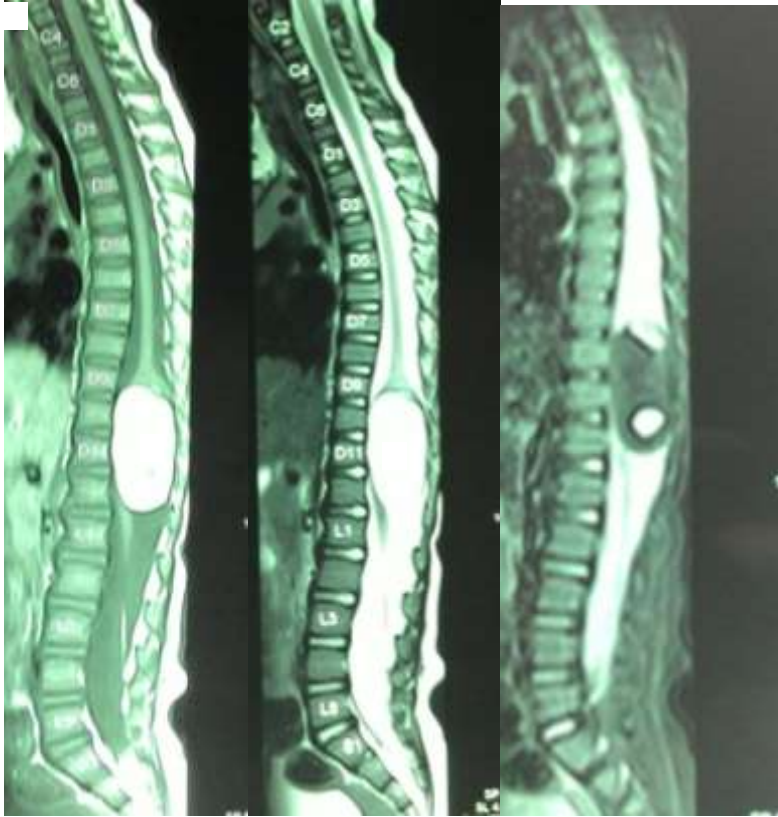
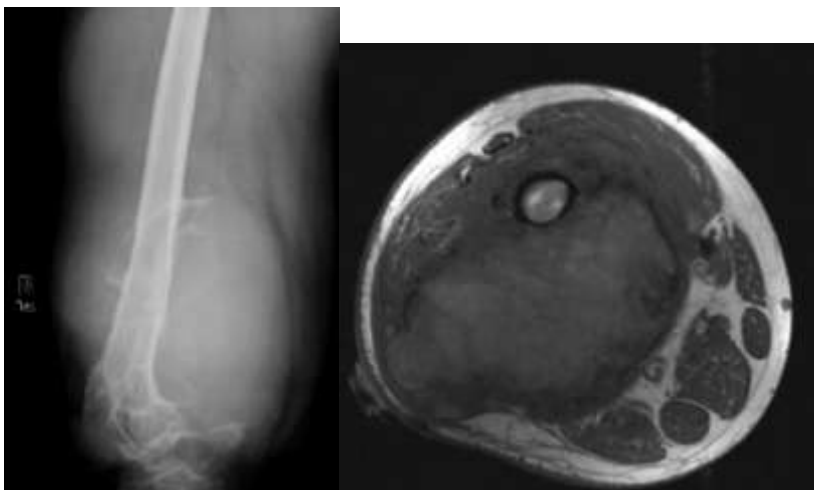


Fig 1 (a-c). Tissue characterization using MRI. Spinal dermoid in a 12 year old child. Sagittal T1W (a) and T2W (b) images show the mass (*) to be hyperintense. Signal suppression on a fat suppressed image (c) confirms the lesion to ne containing fat.



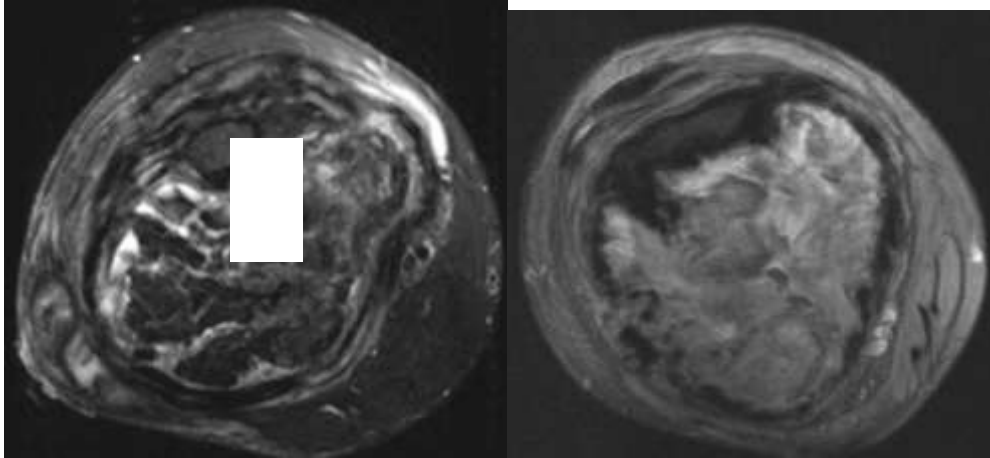
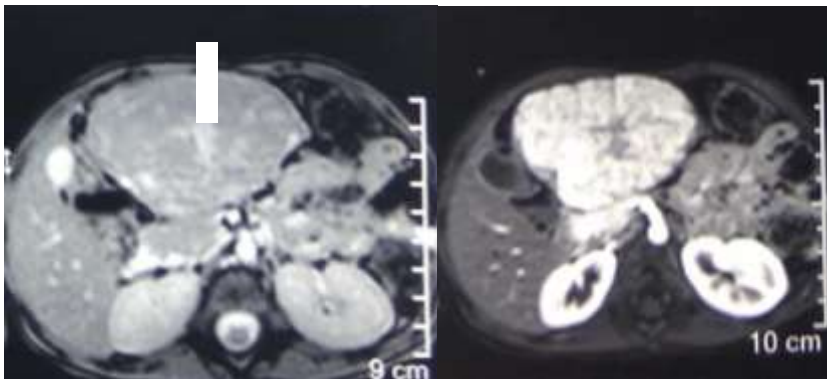


Fig 2 (a-d). Tissue characterization using MRI. Lower thigh mass in an adolescent boy. Radiograph (a) reveals a dense soft tissue lesion (arrow) with periosteal elevation. Axial images reveals the lesion to be hyperintense on T1W image (b), hypointense on T2W (c) and shows areas of 'blooming' on GRE (d). all the features suggest the presence of hemorrhage within the lesion. It was proven to be a hemophilic pseudotumor.



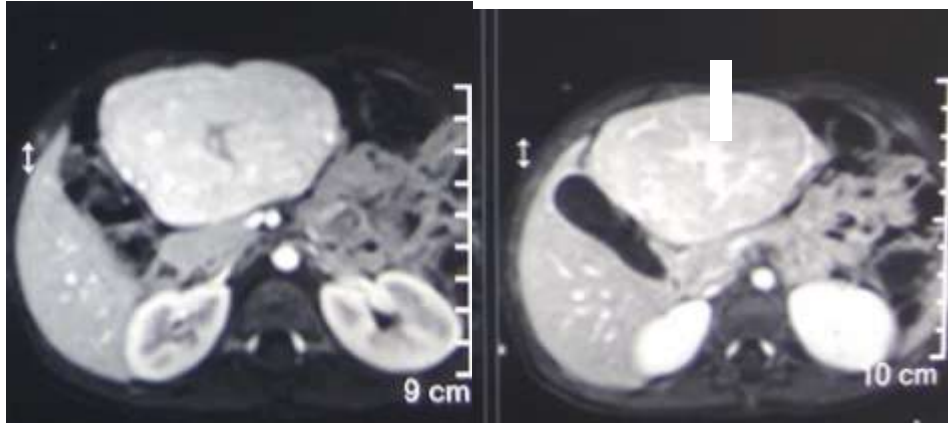


Fig 3 (a-d). Liver tumor characterization by multiphase CE-MRI. Focal nodular hyperplasia in a three year child. Axial T2W image (a) shows an isointense mass lesion arising from the left lobe of liver; having a hyperintense central scar. After gadolinium administration, the lesion shows avid enhancement on arterial phase (b), becoming isointense to liver on portal venous phase(c) and showing delayed enhancement of the central scar (d).

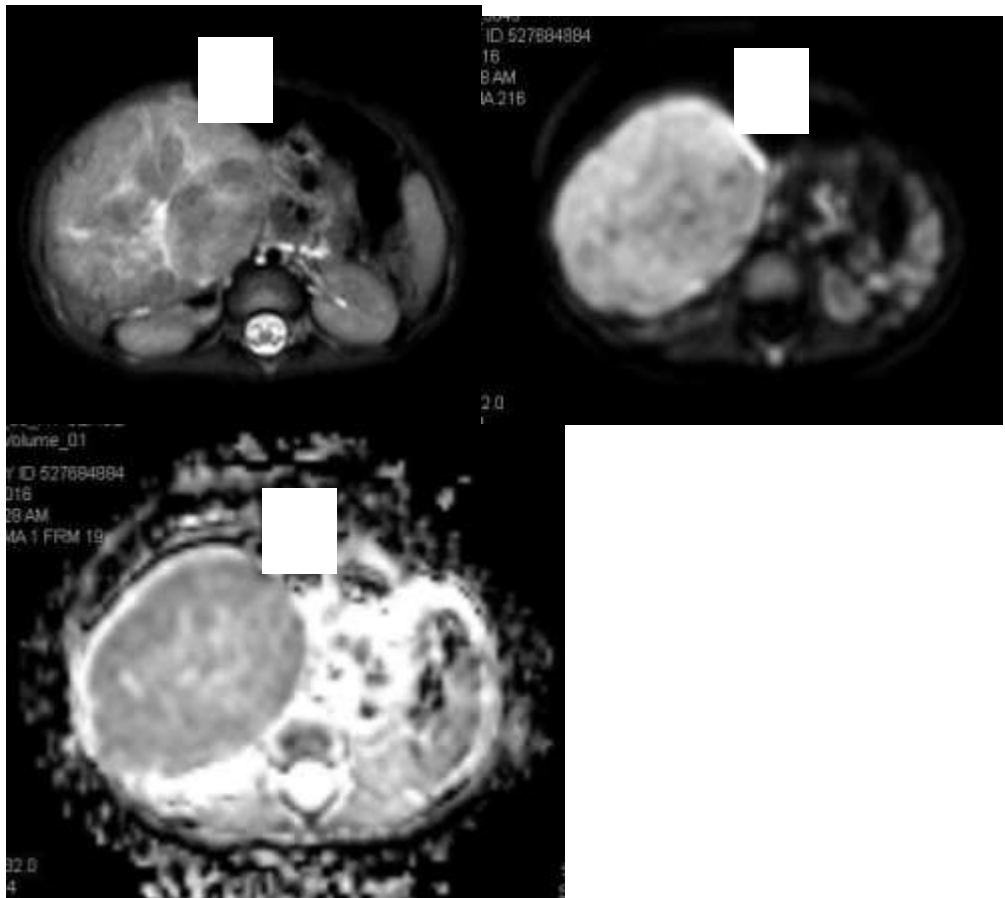


Fig 4 (a-c). Diffusion weighted MRI in hepatoblastoma in an infant. Axial T2W image (a) reveals a heterogeneous hyperintense mass arising from segment V of liver. DWI (b) at b value of 800m/s² reveals the mass to be hyperintense and hypointense of ADC map (c); suggesting diffusion restriction in a malignant mass.

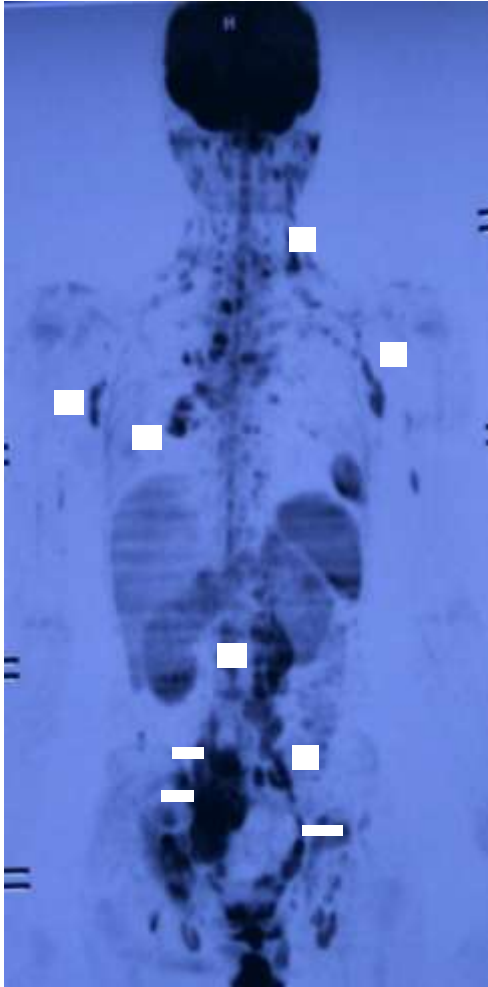


Fig 5. Whole body DWI using DWIBS technique (Diffusion weighted imaging with background body signal suppression) in staging of lymphoma. The involved nodes are left cervical, mediastinal, bilateral axillary, retroperitoneal, iliac and inguinal.