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MD Anderson Cancer Center  
Baylor College of Medicine, USA

- ISHA DIAGNOSTICS
- Malleshwaram, Bangalore
MR IMAGING OF PROSTATE
Goals

- Detection
- Localization
- Number and Volume of lesions
- Capsular penetration
- Seminal vesicle involvement
- Distant Metastasis
Imaging Modalities

- PLAIN XRAYS (till 1970)
- CONTRAST STUDIES:
- ULTRASOUND (1970-80)
- NUCLEAR MEDICINE
- ANGIOGRAPHY
- CT SCAN (1980 onwards)
- MRI (1990)
- SPECT
- PET CT
- MR TOTAL BODY DIFFUSION (MR PET !)
Not necessary to follow the order of Investigations!!!

Do the most appropriate Investigation......
Early diagnosis and Treatment

- saves money, time, energy
- gives better patient care
Which is the most Appropriate Imaging Method?!?

Know the BASIC PRINCIPLES
Nuclear Magnetic Resonance Imaging
## Imaging protocols

<table>
<thead>
<tr>
<th>SEQUENCE</th>
<th>TR</th>
<th>TE</th>
<th>ANGLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>SHORT 300-700</td>
<td>SHORT 20-40</td>
<td>NIL FAT</td>
</tr>
<tr>
<td>T2</td>
<td>LONG &gt; 2000</td>
<td>LONG &gt;100</td>
<td>NIL WATER</td>
</tr>
<tr>
<td>GRADIENT</td>
<td>SHORT</td>
<td>SHORT</td>
<td>PRESENT BLOOD Calcium</td>
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</table>
Fat Suppression
Fluid Suppression
Fluid enhancement sequence
Cor T2

MRCP
Duplex ureter upper moiety

Ca Prostate Hydroneph
Left Lower Pole Mass
Characterization Cyst: Hemorrhagic
Fat Planes
RCC: Infiltrating liver
Ca prostate with adrenal mass
MR in phase out phase study
Metastasis
Incidentaloma
IN PHASE AND OUT PHASE

chemical shift imaging

$Bo = 1.5 \, T$

$TE = n \times 4.2 \, ms$

$TE = (n - \frac{1}{2}) \times 4.2 \, ms$
<table>
<thead>
<tr>
<th>lesion</th>
<th>T1</th>
<th>T2</th>
<th>Early</th>
<th>Delayed</th>
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<tr>
<td>cyst</td>
<td>--</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hamartoma</td>
<td>--</td>
<td>++</td>
<td>Thin rim</td>
<td>rim</td>
</tr>
<tr>
<td>Hemangioma</td>
<td>--</td>
<td>++</td>
<td>nodule</td>
<td>retain</td>
</tr>
<tr>
<td>oncocytopoma</td>
<td>-=</td>
<td>++</td>
<td>++scar</td>
<td>Wash</td>
</tr>
<tr>
<td>adenoma</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>wash</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>carcinoma</td>
<td>-</td>
<td>++</td>
<td>diffuse</td>
<td>wash</td>
</tr>
<tr>
<td>Metastasis</td>
<td>-</td>
<td>++</td>
<td>ring</td>
<td>hetero</td>
</tr>
</tbody>
</table>

FAT SAT, WATER

SAT \[\text{IN} \text{OUT}\] PHASE
Prostate imaging

High Resolution T2W TSE

- CLEAR
- Resolution $0.75 \times 0.85$ mm$^2$
- Slice Thickness 3mm
MRI: BPH

Mild & Moderate
Median Lobe enlargement:

Trans urethral resection
Intra Capsular Lesion
Peripheral Ca extra capsular extension
Extension into seminal vesicle:

Axial

Coronal
Tissue characterization

- Non Intense: Calculus, Gas
- Hypo intense: Fibrous lesions
- Hyper intense: Malignant Lesions
- Super Intense: Fluid (Cysts)
Lesion Characterization

- Solid vs Cyst
- Fat vs Fluid
- Hemorrhage
- Calcification

- BENIGN vs MALIGNANT !?
Molecular Imaging

- In phase out phase
- Dynamic contrast enhancement
- Diffusion weighted (DWIBS/ MR PET)
- Spectroscopy
Dynamic contrast studies

- **Benign tumors**: slow enhancement & retain contrast
- **Malignant tumors**: early take up and washout
- **Endocrinal tumors**: rapid enhance and wash out
- **Cysts and Hematoma**: Do not enhance
Enhancement of adrenal lesions

![Graph showing enhancement over time for malignancies and adenomas.](image-url)
Benign vs Malignant
MR PET (Proton Enhanced Tomo)

DIFFUSION WEIGHTED IMAGING

BACKGROUND SUPPRESSION (DWIBS)
Hyper acute infarcts
Restricted Diffusion

- Intra-extra cellular fluid ISCHEMIA
- Cell Density TUMORS
- Infective components ABSCESS
MR PET Diffusion Body Scanning

- **Suppresses:**
  - Fat, Blood, Fluid, Body Organs, Muscles

- **Enhances:** TUMORS

Excellent Lesion/Background Contrast

Inverted window MIP

b=0  b=1000
Prostate mass
Periphal node
Cystic Renal lesions
Signal with diffusion

The SE signal with isotropic diffusion:

\[ M_T = M_T (0) e^{-\frac{TE}{T_2}} e^{-bD} \]

\[ b = \gamma^2 \delta^2 (\Delta - \delta/3) G^2 \]
The ADC value ($\times 10^{-3}$ mm$^2$/s) in the

- compared with **urine** 3.28 ± 0.20
- the normal bladder wall 2.27 ± 0.24
- prostate transition zone: 1.57 ± 0.09
- peripheral zone: 1.85 ± 0.22
- seminal vesicle 2.01 ± 0.22
- **Prostate ca** 1.18 ± 0.19

Threshold ADC value anything less than 1.5
DIFFUSION (ADC) Values

- Clear fluid
- Mitotic lesion
- Caseous fluid
- Acute Bacterial Infection
Shetty PB,


Presence of vasogenic edema (NCC) vs Infective edema (Abscess / Koch’s)
Prostate with Mets
MR- PET(DWIBS) vs. PET-CT

- No ionizing radiation, No Injections
- Fast (35 mns)
- Patient need not be motionless for 30 –45 mns like in PET.
- Less cost
- Better Accuracy !!?
MR PET vs PET CT

**PET CT Scan:**
- Shows **Metabolic Activity** (FDG Utilization)
- Brown Fat to Brain: seen as hot spots.
- All Hyper vascular lesions Post radiation scar, Fibrosis, Post operative tissues show increased FDG uptake.
MR PET (DWIBS)

- Not metabolism related
- Intra and extra cellular water diffusion
- Cell membrane properties
- Ideal micro molecular pathogenesis for cancer detection and follow up.
Malignant tissues

- Nuclear properties
- Biochem/ Membrane
- Regeneration properties Follow up
- Angeogenesis
- Metabolic Activities

Cytology
MR SPECTRO DWI
Follow up
angiography
PET CT
Tumor Response Before Frank macroscopic changes like size, shape intensity hemorrhage etc.
- Chemotherapy
- Mitotic Arrest
- DNA fragmentation: **24-48hrs**
- Cell shrinkage
- Increased Extra cellular Water
- Increased ADC
- MR PET hyper to lower
DWI in Tumor Follow UP


J. M. Provenzale, S. Mukundan, and D. P. Barboriak Diffusion-weighted and Perfusion MR Imaging for Brain Tumor Characterization and Assessment of Treatment Response Radiology, June 1, 2006; 239(3): 632 - 649.

Diffusion Weighted Whole Body Imaging (DWIBS)

- **Ideal for:**
  - Imaging tumors
  - Immediate Follow Up
  - Long term Follow up

LIVER LESION: 1 metastasis
Liver lesion 2: Benign
MR-Spectroscopy

- acquisition of spectra from small volumes (voxels) throughout the prostate gland
- detection of cellular metabolites
  - citrate in normal tissue and BPH
  - choline and creatine in tumor lesions
Prostate Spectroscopic Imaging

Voxel size: 0.64 cm³
MR-Spectroscopy
(Chol+Creat)/Citrate Ratio Images

Spectrum

Index

Chol + Creat

Citrate
MR-Spectroscopy (Chol+Creat)/Citrate Ratio Images

Ratio in Normal Prostate ↓

Ratio in Prostate Cancer ↑
Diagnostic Accuracy of Ca Prostate

- MRI + MR DIFFUSION + SPECTROSCOPY
- 90-95%
- MUCH MORE THAN ANY OTHER MODALITY
MR Prostate: Advantages

- No Radiation
- No contrast or Injections
- No Iodine side effects/ Nephro toxicity
- Imaging in Pregnancy,
- Children, Young Adults.
## Radiation (micro Gy)

<table>
<thead>
<tr>
<th></th>
<th>marrow</th>
<th>Ovaries</th>
<th>Testis</th>
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</thead>
<tbody>
<tr>
<td>KUB</td>
<td>500</td>
<td>2100</td>
<td>150</td>
</tr>
<tr>
<td>CT Abd</td>
<td>1700</td>
<td>180</td>
<td>170</td>
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</table>
COMMONLY ASKED ??

- WHY SHOULD I TAKE RADIATION RISK
- ANY ALTERNATE IMAGING MODALITIES
- WHY THE PHYSICIAN DID NOT SUGGEST IMAGING WITHOUT RADIATION RISK
MR PROSTATE
ONE STEP EVALUATION

DIAGNOSIS: BENIGN vs malignant

DYN Contrast Enhancement MR
MR DIFFUSION Spectroscopy
STAGING

- INTRA OR EXTRA CAPSULAR
- DIFFUSION STUDY OF WHOLE BODY TO DETECT METASTASIS IN
  - LYMPH NODES
  - BONES
  - LIVER

FOLLOW UP
Thank You

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