When is MRI Useful in Evaluating Renal Masses?

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Disclosures:

Consultant, Galil Medical Ltd, Yokneam, Israel

Book Royalties, Lippincott, Williams, & Wilkins, Philadelphia, PA
Renal Mass MRI Indications

Although CT is the initial test of choice in detecting and characterizing renal masses, MRI is valuable in selected patients.
Renal Mass MRI Indications

Patient populations...

- Iodinated CM allergy
- Renal Insufficiency (Diffusion)
- Pregnancy
- Young patients, need for serial f/u

...CT relatively contraindicated
Hyperdense, enhancing mass
Indeterminate cystic mass
Pre and post ablation
(Staging questions e.g., IVC involvement and extent)

...MRI provides added value
Renal Mass MR Protocol

- T1-w SPGR or FSE
- T2-w FRFSE or SSFSE
- Chemical Shift (In/OOP)
- T1-w SPGR, Fat suppressed, pre + post contrast material
- Subtraction images

...Enhanced Protocol
BWH Gadolinium Policy

- Obtain serum Cr / eGFR (w/in 3 wks) in pts with h/o kidney disease, DM, SLE, MM, on dialysis, or +FHx

- eGFR > 60 – any dose Gd given

- eGFR 30-60 – max 20 cc Gd

- eGFR <30, dialysis, or hepatorenal syndrome – “medical necessity”; written informed consent obtained
Renal Mass MR Protocol

- T1-w SPGR or FSE
- T2-w FRFSE or SSFSE
- Chemical Shift (In/OOP)
- GRASS
- Diffusion (DWI) B = 0, 200, 400, 800, 1000; ADC (3T)

...Unenhanced Protocol
Renal Mass MRI

- Structural analysis (Bosniak applied to MRI)
- T1 and T2
- Contrast media enhancement
- Fat cell detection (fat suppression)
- Intracytoplasmic lipid detection (chemical shift)
- Diffusion
# Cystic Renal Masses (after Bosniak)

<table>
<thead>
<tr>
<th>Cat</th>
<th>Term</th>
<th>Prob %</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Simple</td>
<td>0</td>
<td>proven</td>
</tr>
<tr>
<td>II</td>
<td>Complicated</td>
<td>@0</td>
<td>variable</td>
</tr>
<tr>
<td>IIF</td>
<td>Indeterminate</td>
<td>?</td>
<td>Israel</td>
</tr>
<tr>
<td>III</td>
<td>Indeterminate</td>
<td>50</td>
<td>Aronson</td>
</tr>
<tr>
<td>IV</td>
<td>Solid Features</td>
<td>&gt;95</td>
<td>Curry</td>
</tr>
</tbody>
</table>

References:
- Israel AJR 2003
- Aronson Urol Rad 1991
- Curry AJR 1991
- Bosniak MA Radiology 1991
- Israel and Bosniak Radiology 2005
• Of 69 cystic masses, MR identified more septa in 8 (12%) masses and thicker walls or septa in 7 (10%) compared with CT.

• In 2 (3%) masses, enhancement was different.

• MR upgraded 7 masses: II to IIF in 2, IIF to III in 3, and III to IV in 2.
Cystic Renal Masses – Bosniak applied to MRI

- MRI may show enhancement not seen at CT
- MRI may correct pseudoenhancement at CT
- MRI may miss calcifications

**MRI most helpful:**
Category IIIF and III lesions
Confirm minimal (<1 cm) cystic masses as simple...

Israel and Bosniak Radiology 2004
ROI Principles

• Same acquisition parameters pre + post
• Search enhanced images first
• Lesion ROI
• Homogeneous population of tissues
Enhancement at MRI

- **Unequivocal** ≥ 20%
- **Equivocal** 15 – 19%
- **None** < 15%

% = SI Change / Native SI

Ho VB Radiology 2002
# Renal Cell Carcinoma

<table>
<thead>
<tr>
<th>Subtype</th>
<th>Prevalence</th>
<th>Prognosis*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear cell</td>
<td>70%</td>
<td>55-60%</td>
</tr>
<tr>
<td>Papillary</td>
<td>15-20%</td>
<td>80-90%</td>
</tr>
<tr>
<td>Chromophobe</td>
<td>6-11%</td>
<td>90%</td>
</tr>
<tr>
<td>Collecting duct</td>
<td>&lt;1%</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Unclassified</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*5-yr survival

Kim AJR 02 178:1499
## MRI Features of Renal Masses

<table>
<thead>
<tr>
<th>T1</th>
<th>T2</th>
<th>CE</th>
<th>Dx</th>
</tr>
</thead>
<tbody>
<tr>
<td>dark</td>
<td>bright</td>
<td>-</td>
<td>Simple Cyst</td>
</tr>
<tr>
<td>bright</td>
<td>bright</td>
<td>-</td>
<td>High Protein Cyst</td>
</tr>
<tr>
<td>bright</td>
<td>dark</td>
<td>-</td>
<td>Hemorrhage/Cyst</td>
</tr>
<tr>
<td>dark</td>
<td>bright</td>
<td>+</td>
<td>RCC (CC type)</td>
</tr>
<tr>
<td>dark/</td>
<td>dark</td>
<td>+</td>
<td>AML, RCC (papillary)</td>
</tr>
<tr>
<td>bright</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bright</td>
<td>bright</td>
<td>+</td>
<td>AML, RCC (CC)</td>
</tr>
</tbody>
</table>
### MRI of Papillary RCC (n=20)

<table>
<thead>
<tr>
<th>MRI Feature</th>
<th>T1 SE</th>
<th>T1 GE</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypointense</td>
<td>0</td>
<td>9 (53%)</td>
<td>14 (70%)</td>
</tr>
<tr>
<td>Isointense</td>
<td>13 (93%)</td>
<td>8 (47%)</td>
<td>0</td>
</tr>
<tr>
<td>Hyperintense</td>
<td>1 (7%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Heterogenous</td>
<td>0</td>
<td>0</td>
<td>6 (30%)</td>
</tr>
<tr>
<td>Not performed</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

83% (10/12) of small (<3cm) tumors were T2-hypointense

Oliva et al AJR 2009
AML – Keys to Diagnosis

4% AMLs contain no definite fat by imaging

Angiomyolipolipomatosis with minimal fat
AML without Fat by Imaging

• Retrospective review of 175 resected lesions suspicious for RCC by imaging.

• All 6 AMLs were uniformly hyperdense, enhanced, and were hypointense on T2.

• Of 100 RCCs reviewed: only 2% were uniformly hyperdense & enhancing.

Jinzaki et al, Radiology 1997
Angiomyolipoma

The identification of fat cells in a noncalcified renal mass, in an adult, is virtually diagnostic of a benign renal angiomyolipoma.
<table>
<thead>
<tr>
<th>Tissue</th>
<th>Fat Cells (FC)</th>
<th>Intracytoplasmic Lipid (ICL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidney</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCC</td>
<td>N *</td>
<td>Y</td>
</tr>
<tr>
<td>AML</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

* Except case reports
AML with Minimal Fat

- Biopsy can be used to diagnose AML, particularly with the aid of immunocytochemistry.

<table>
<thead>
<tr>
<th></th>
<th>AML</th>
<th>RCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>MART1</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>SMA</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>HMB-45</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>RCC</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

Granter et al. Cancer 1999
AML – Diagnostic Criteria

- CT - ROI < -10 HU
- MRI - fat suppression (not alone)
- Biopsy - fat cells; thick walled vessels; smooth muscle (SMA and HMB45)

AML w/ imageable fat cells!
AML w/o imageable fat cells!
AML with Minimal fat

- AMLs demonstrating no fat have a characteristic appearance (hyperdense and enhancing) that is not common for RCC.
- Biopsy can be used to biopsy them, and avoid unnecessary surgery.
Renal Mass Biopsy

Emerging Indications

• Small (≤3 cm), hyperdense, homogeneously enhancing renal masses

• Renal masses referred for percutaneous ablation

• Indeterminate cystic renal mass (Bosniak Category III)

Silverman et al Radiology 2006
Short (dark) T2 Masses

- Hemorrhagic cyst
- RCC (papillary type or clear cell RCC that bled)
- AML (fat poor, rich in smooth ms – spindle cells)
- (Leiomyoma of capsule)
Diffusion Weighted Imaging

- Random motion of water molecules (Brownian notion)
  - Free Diffusion
  - Restricted Diffusion

- Occurs in intracellular, extracellular, and intravascular spaces
Diffusion Weighted Imaging

DDx - Restricted Diffusion

- **Cancer** (increased number of cells)
- **Ischemia** (cytotoxic edema)
- **Inflammation** (increased viscosity)
ADC (Apparent Diffusion Coefficient)

**Tissues with restricted diffusion**
- Low ADC values
- Low SI on ADC map (contrasts DWI)

**Tissues with free diffusion**
- High ADC values
- High SI on ADC map (contrasts DWI)

**Pitfalls!**
- High ADC = well diff or necrotic tumor
- Low ADC = may be normal, nodes
## Diffusion Weighted Imaging

<table>
<thead>
<tr>
<th>Dx</th>
<th>T2WI*</th>
<th>DWI</th>
<th>ADC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usually Cancer</td>
<td><img src="white" alt="" /></td>
<td><img src="white" alt="" /></td>
<td><img src="black" alt="" /></td>
</tr>
<tr>
<td>T2 shine through</td>
<td><img src="white" alt="" /></td>
<td><img src="white" alt="" /></td>
<td><img src="black" alt="" /></td>
</tr>
<tr>
<td>Fibrosis</td>
<td><img src="black" alt="" /></td>
<td><img src="black" alt="" /></td>
<td><img src="black" alt="" /></td>
</tr>
</tbody>
</table>

*variable, eg, PRCC, Prostate ca – T2 hypointense*
DWI – Renal Masses

- Mean ADC of RCC (1.41) was significantly lower than benign lesions (2.23) (ADCx10^3/mm^2/sec)
- Mean ADC of oncocyotomas (1.91) was significantly higher than solid RCC (1.54).
- AML had the lowest ADC though…

Taouli et al Radiology 2009
Diagnostic Algorithm

Renal mass

<-10 H
AML

<= 20 H
Contrast CT
+ Δ 20H
Solid neoplasm

no Δ
Simple cyst

20 - 40 H
Sonography
no Δ
Sonography

>40 H
Solid neoplasm

+ Δ 20 H

< 20 H
Pre - Contrast CT

< 20 H
Contrast CT

≥20 H

20 - 40 H
Solid neoplasm

40 H

10 H
AML
Diagnostic Algorithm

- Hyperdense cyst
  - no Δ
  - + Δ 20H
    - Contrast CT
      - MRI
        - - Fat Supp
          - RCC (clear cell)
            - AML
        - + Fat Supp
          - AML
    - + OOPS
      - RCC (papillary)
        - RCC
          - Biopsy
            - RCC (papillary)
        - AML

- >40 H
  - Contrast CT
Take Home Messages

• There are specific indications for MRI of renal masses
• Apply Bosniak classification
• Use T1, T2, CE, FS, CSI, as clues
• Masses with short T2 are few
• Look for fat cells (AML)
• Don’t use OOPs alone to Dx AML
• Beware of AML with little or no fat
Take Home Messages

- MRI evaluates hyperdense masses and can be used to distinguish AML with minimal fat from clear cell RCC.
- MRI cannot be used to differentiate AML with minimal fat from papillary RCC or CCRCC that bled.
- Biopsy can be useful.
Take Home Messages

- The use of contrast-enhanced MRI in patients with eGFR <60 is evolving, as we understand the underlying causes of NSF.
- As T1, T2, FS, and CSI each contribute diagnostic information, non-contrast MRI may be useful.
- Diffusion-weighted MRI may be helpful, but needs research.