A 52-Year-Old with Flank Pain / MR-Guided Focused Ultrasound Ablation

Jai Eswara, Harvard Medical School, Year III
Gillian Lieberman, MD
Agenda

- Patient Presentation
- Differential Diagnosis
- Anatomy
- Discussion
- MR-Guided Focused Ultrasound Ablative Therapy
Patient Presentation

- J.F. is a 52-year-old man with acute onset of right flank pain after moving heavy furniture
  - No CVAT
  - Rectal exam benign
  - Normal urinalysis
  - Guaiac negative
Differential Diagnosis

- Renal/vascular
  - Abscess/pyelonephritis
  - Infarction
  - Thrombosis
  - Nephrolithiasis
  - Tumor
- Aorta
  - AAA
- Radicular/musculoskeletal

A CT Urogram was ordered...
Low-dose CT Urogram w/o IV contrast
CT Urogram w/ IV contrast

Subcapsular hematoma
Differential Diagnosis after CT

- Angiomyolipoma
- Renal Cell Carcinoma
Renal Angiomyolipoma

Hamartoma
muscle, vasc, fat

http://www.e-radiography.net/radpath/h/haematuria.htm
CT w/ IV contrast

No fat visible in mass
T1-Weighted Axial MR

No fat visible in mass
Hematoma beginning to organize
Midpolar mass - Indication for radical nephrectomy

Identified on pathology as a papillary RCC
Types of Renal Cell Carcinoma

- Clear cell (80%)
- Papillary (15%)
- Chromophobic (5%)
Staging Renal Cell Carcinoma

- TNM classification
- T1 - mass < 7cm
- T2 - mass > 7cm
- T3 - mass extends into major veins, fat, or adrenal gland
- T4 - mass extends beyond Gerota’s fascia
Spontaneous Rupture of Papillary RCC

- Extensive necrosis in tumor leads to rupture
  - Necrosis can appear cystic on CT or U/S
- pRCC’s are FRAGILE!
- Approximately 10% may rupture

MR-Guided Focused Ultrasound
Focusing Ultrasound Waves

Ultrasound beams may be focused by curving the piezoelectric plate or by interposing a lens or reflector between a flat plate and the target. A phased array of transducers is focused electronically.

How does focused U/S destroy tissue?

- As waves interact with tissue, they transfer energy
- U/S causes gas bubbles to form within tissue
  - Collapse of the gas bubbles transfers heat to nearby tissue (“cavitation”)

Thermal Ablation of Tissue

Protein coagulation and consequent tissue damage result from a combination of temperature elevation and exposure duration. The graph shows the relationship between these factors.

MRI Planning/Monitoring of Thermal Ablation

MRI Monitoring of the Thermal Ablation of a Tumor Implanted in Rabbit Thigh with Focused Ultrasound

Advantages of MRGFUS

- Noninvasive
- No ionizing radiation
- Fast energy delivery
- MR is temperature-sensitive: T1, diffusion coefficient, proton resonant frequency
- Thermal quantification
- Target can be as small as 2 mm in diameter

Disadvantages of MRGFUS

- U/S is blocked by ____ & ____
Disadvantages of MRGFUS

- U/S is blocked by air & bone
- slow
MR Detection of Thermal Changes

A temperature-sensitive magnetic resonance image along the transducer axis shows focal temperature elevation (arrow) induced by an ultrasound pulse in rabbit thigh muscle in vivo. The scale is in centimeters.

MR Detection of Thermal Changes in Tissue

Post-Mortem Rabbit Kidney After FUS

The Future of MRGFUS

- Improvement in speed
- Optimizing MRI parameters
- Developing MRI-compatible devices
References

Acknowledgements

• Jason Handwerker, MD
• Gillian Lieberman, MD
• Larry Barbaras
• Pamela Lepkowski