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

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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



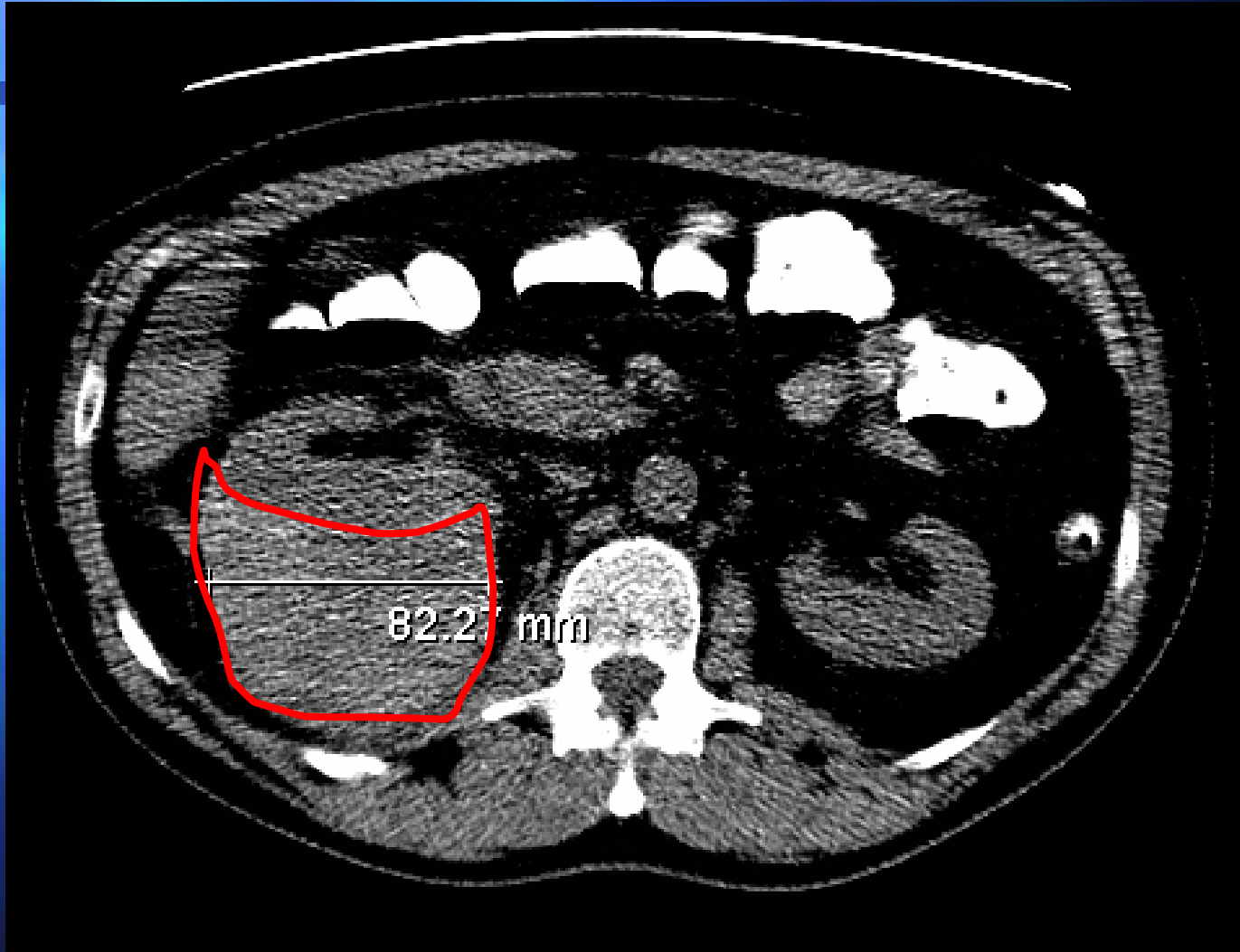
Differential Diagnosis

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

A CT Urogram was ordered...

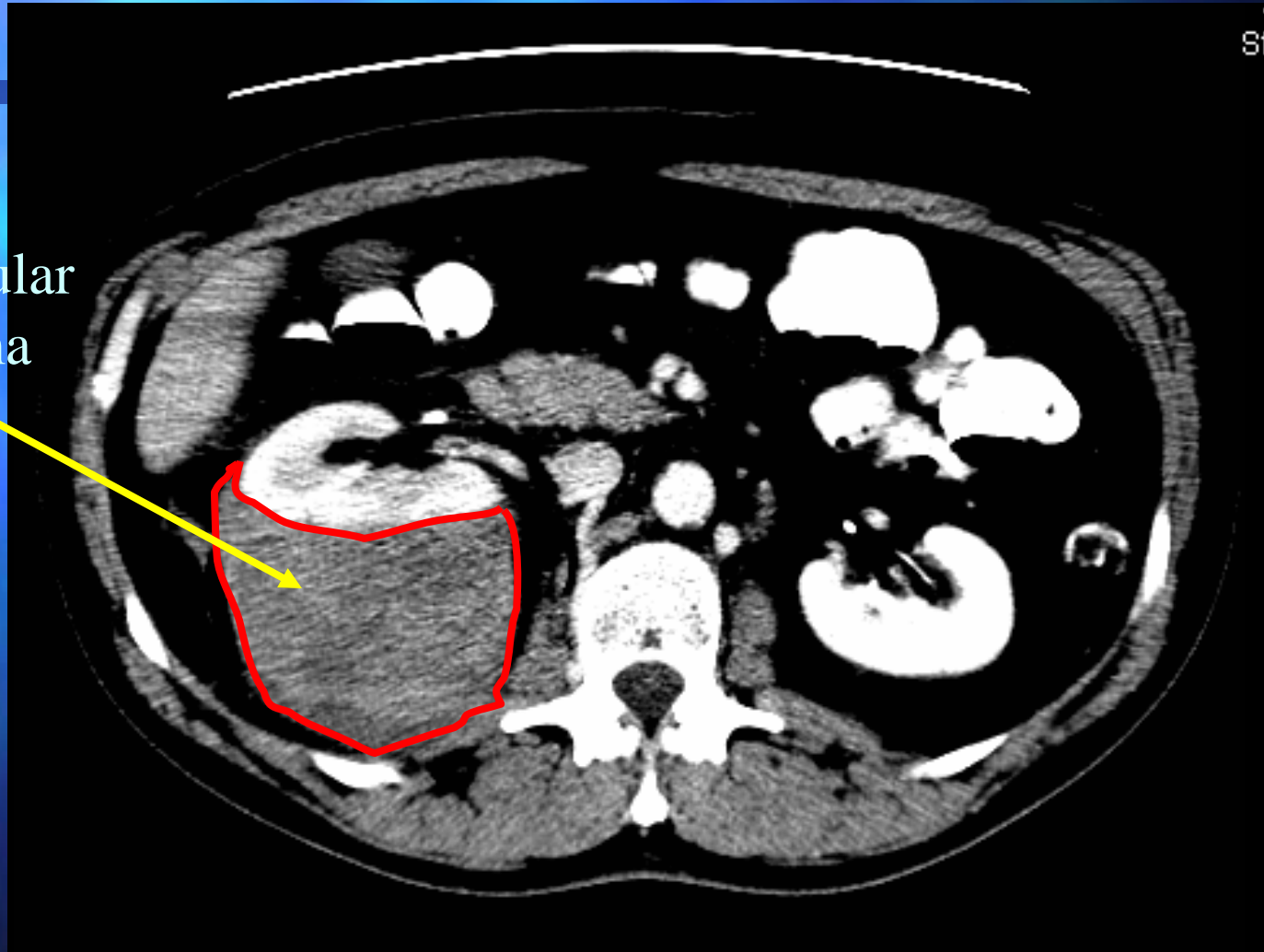


Low-dose CT Urogram w/o IV contrast





CT Urogram w/ IV contrast



Subcapsular
hematoma



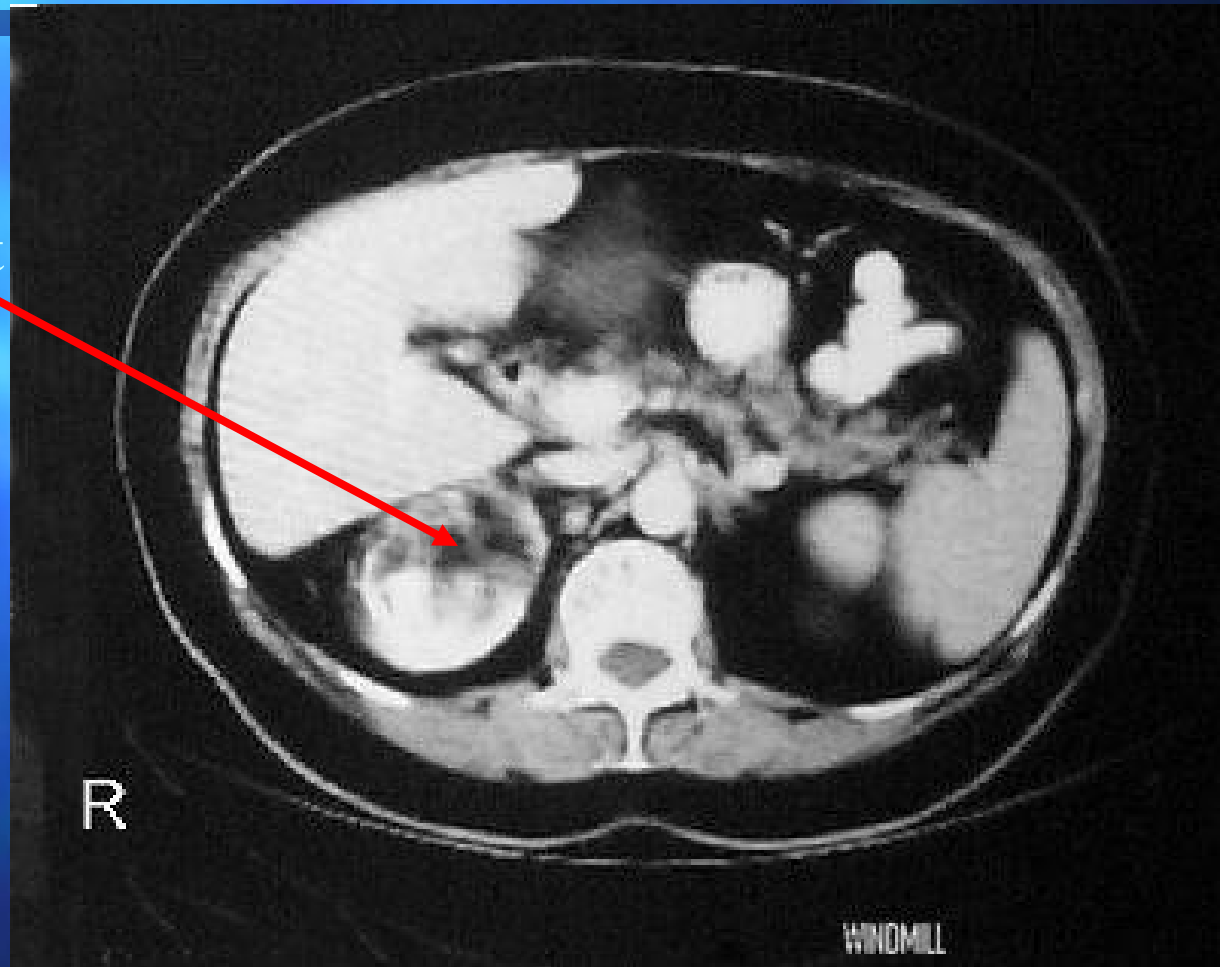
Differential Diagnosis after CT

- Angiomyolipoma
- Renal Cell Carcinoma



Renal Angiomyolipoma

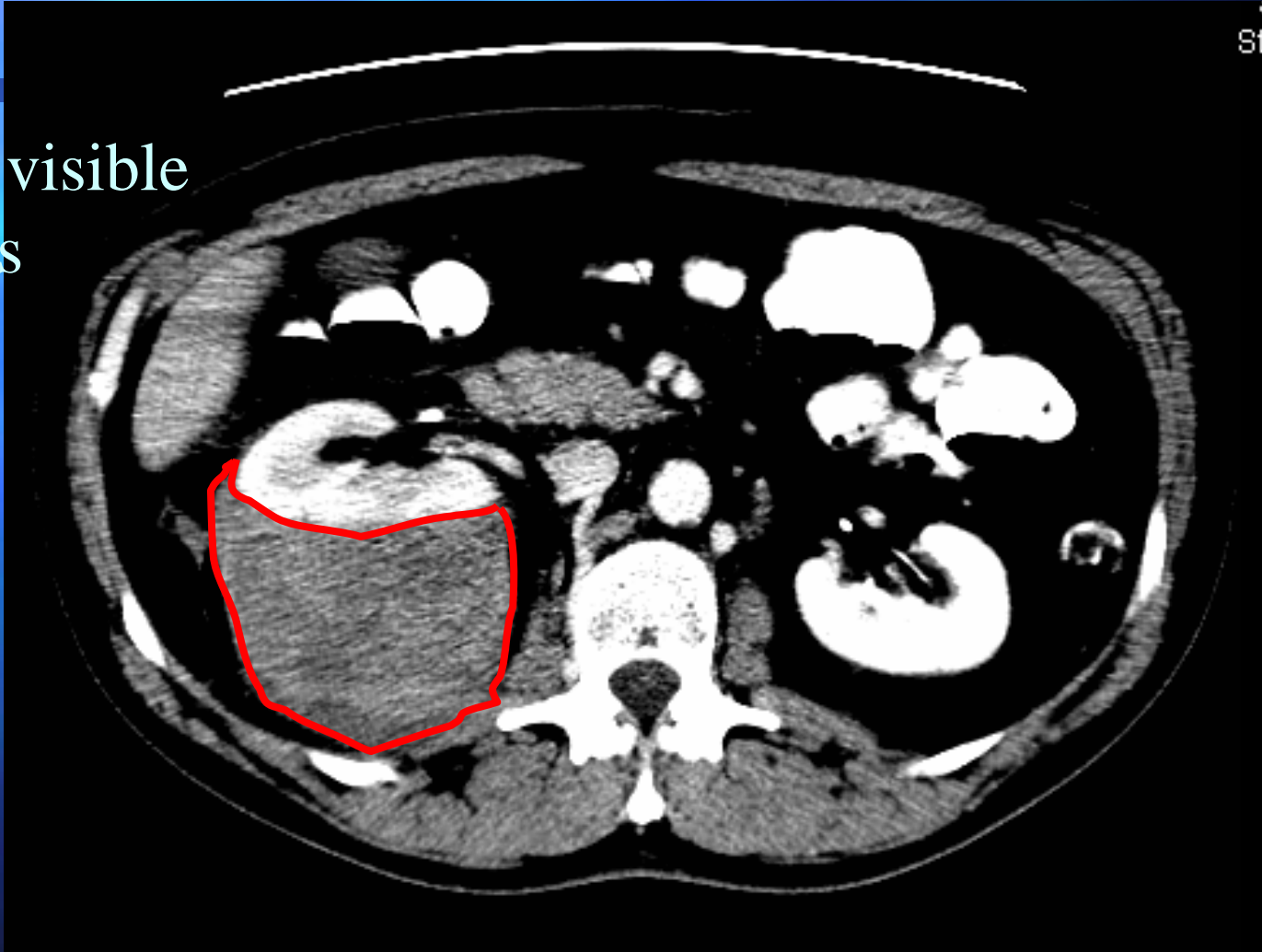
Hamartoma
muscle, vasc, fat





CT w/ IV contrast

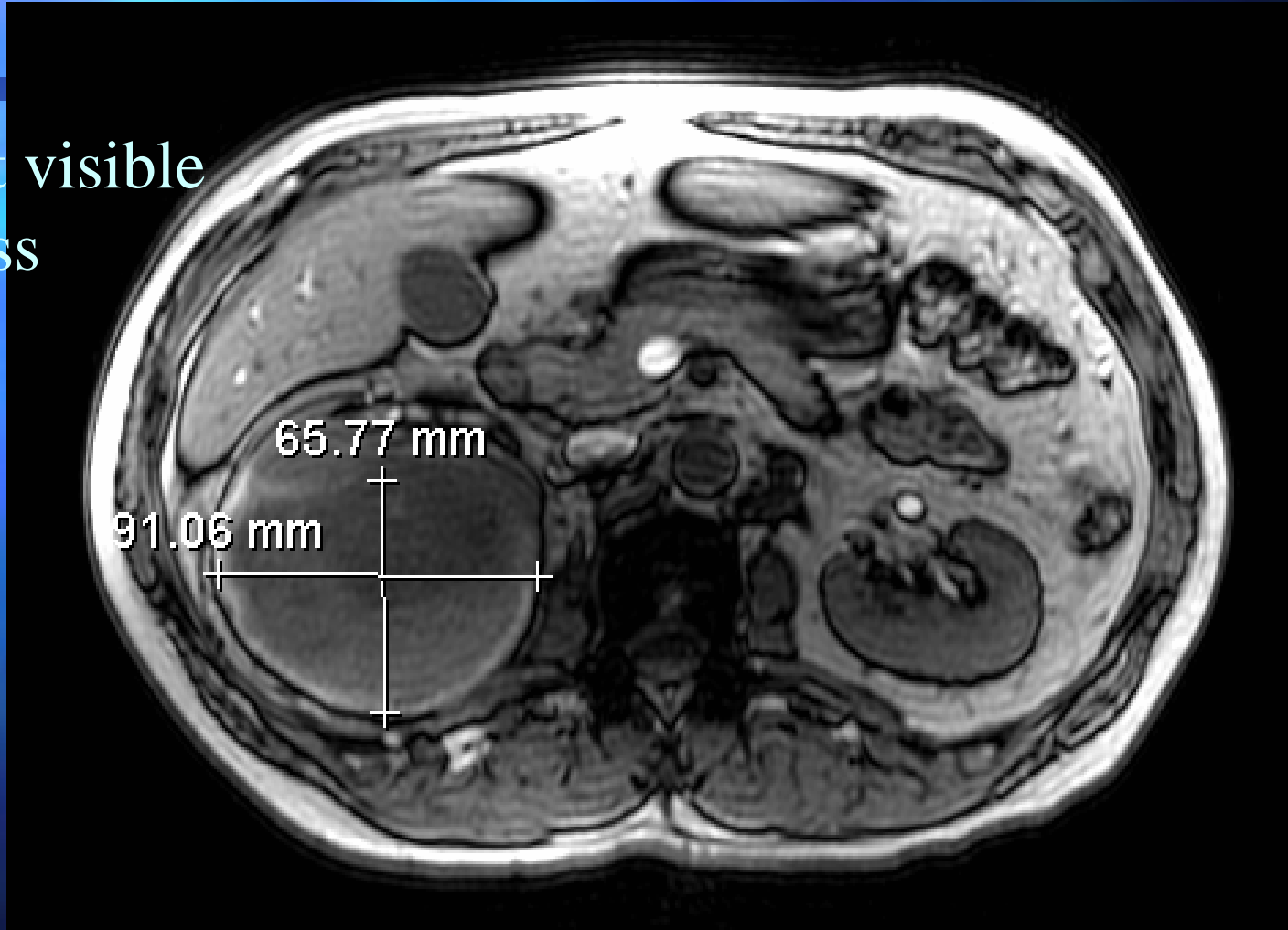
No fat visible
in mass





T1-Weighted Axial MR

No fat visible
in mass





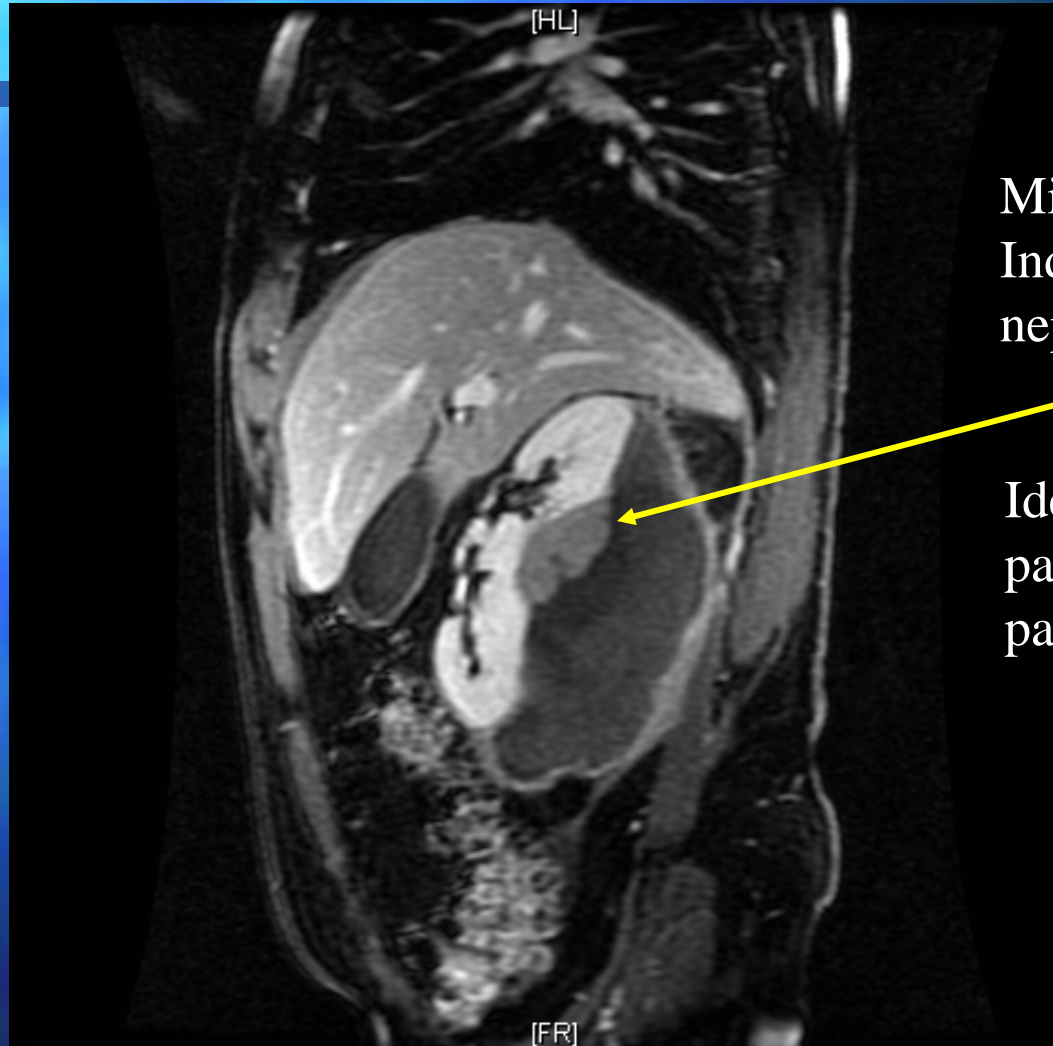
Coronal SSFSE/HASTE MR

Hematoma
beginning to
organize





Sagittal LAVA MR

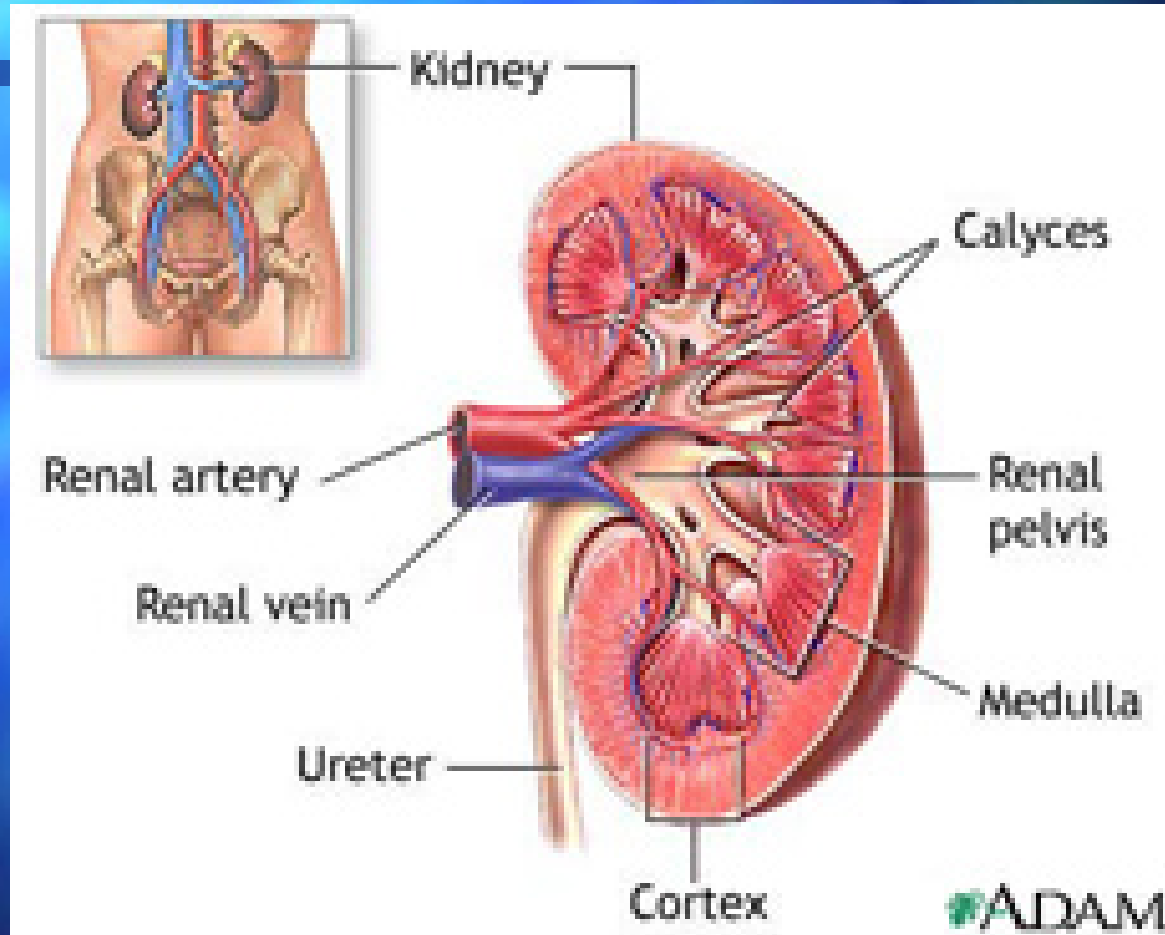


Midpolar mass -
Indication for radical
nephrectomy

Identified on
pathology as a
papillary RCC



Renal Anatomy





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

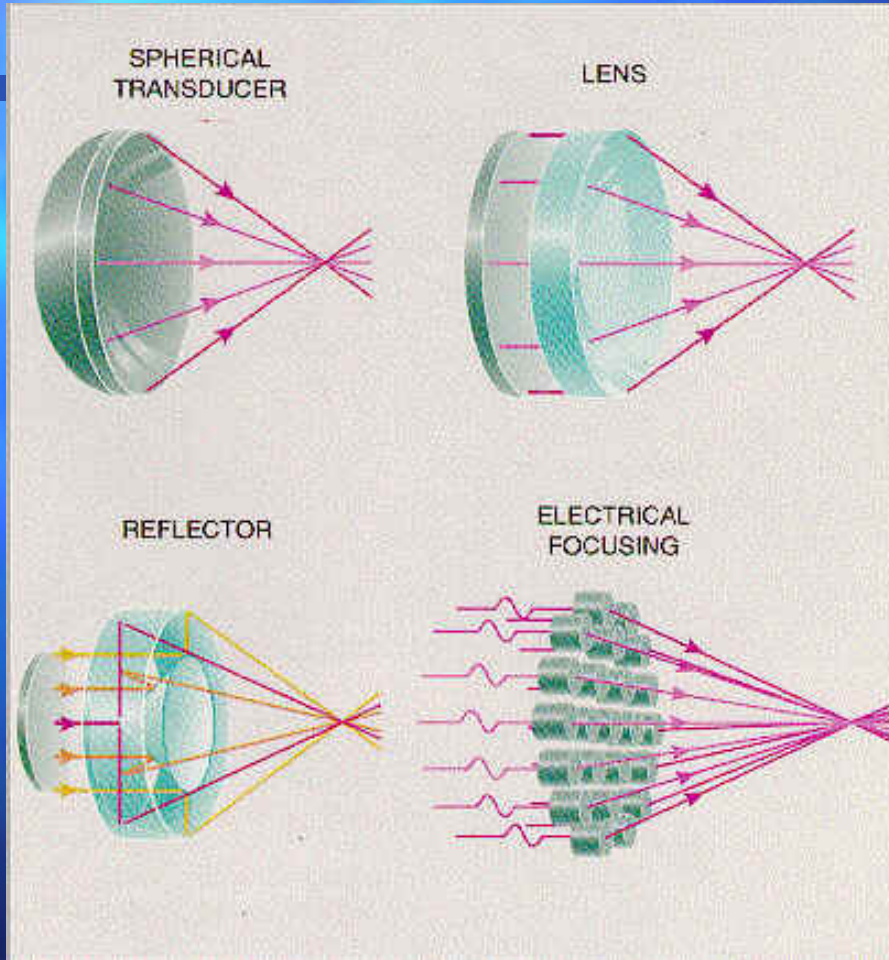


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MR-Guided Focused Ultrasound



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.

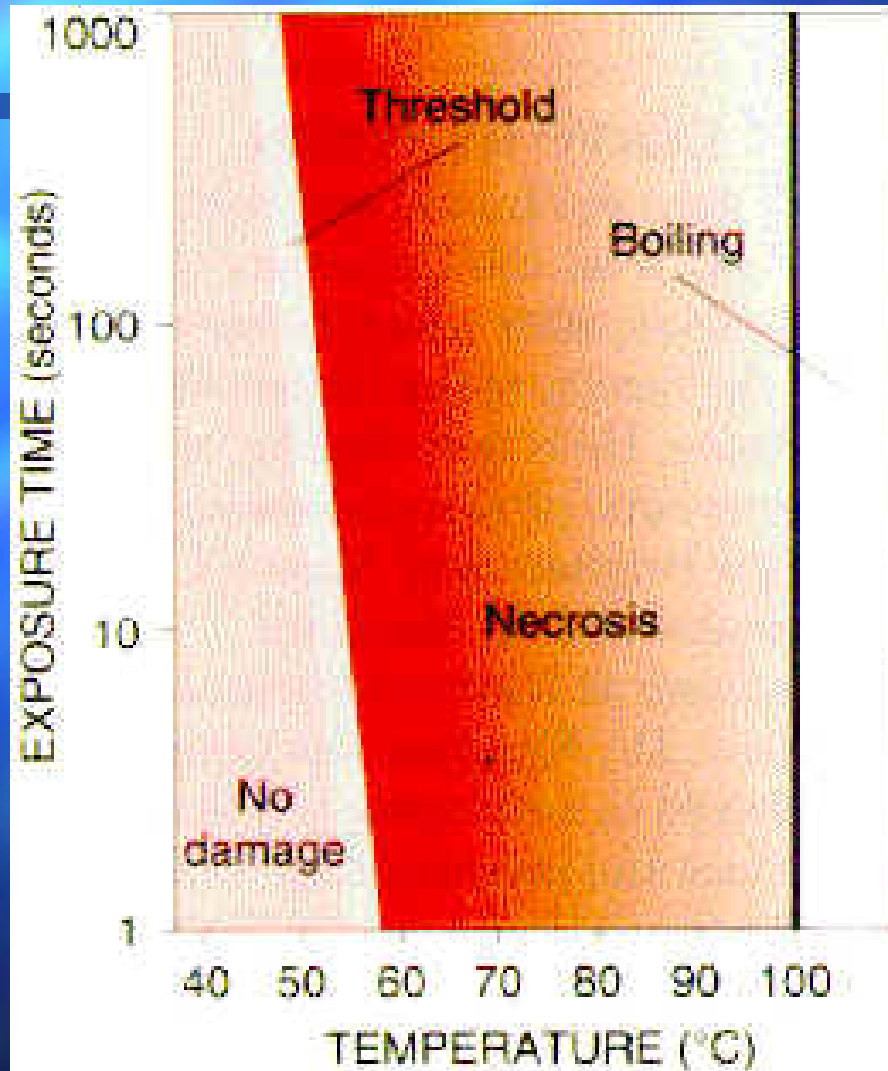


How does focused U/S destroy tissue?

- 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

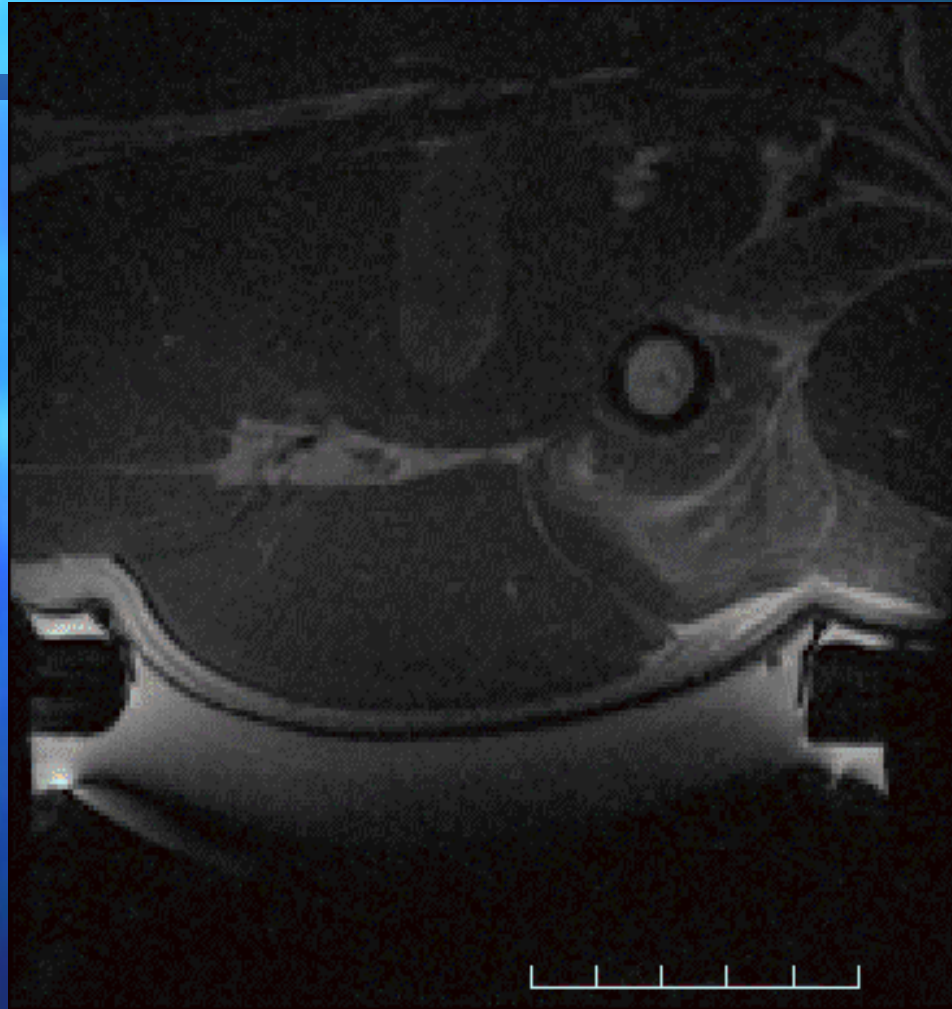


A temperature-sensitive magnetic resonance image along the transducer axis shows focal temperature elevation (*arrow*) induced by an ultrasound pulse in rabbit thigh muscle *in vivo*. The scale is in centimeters.



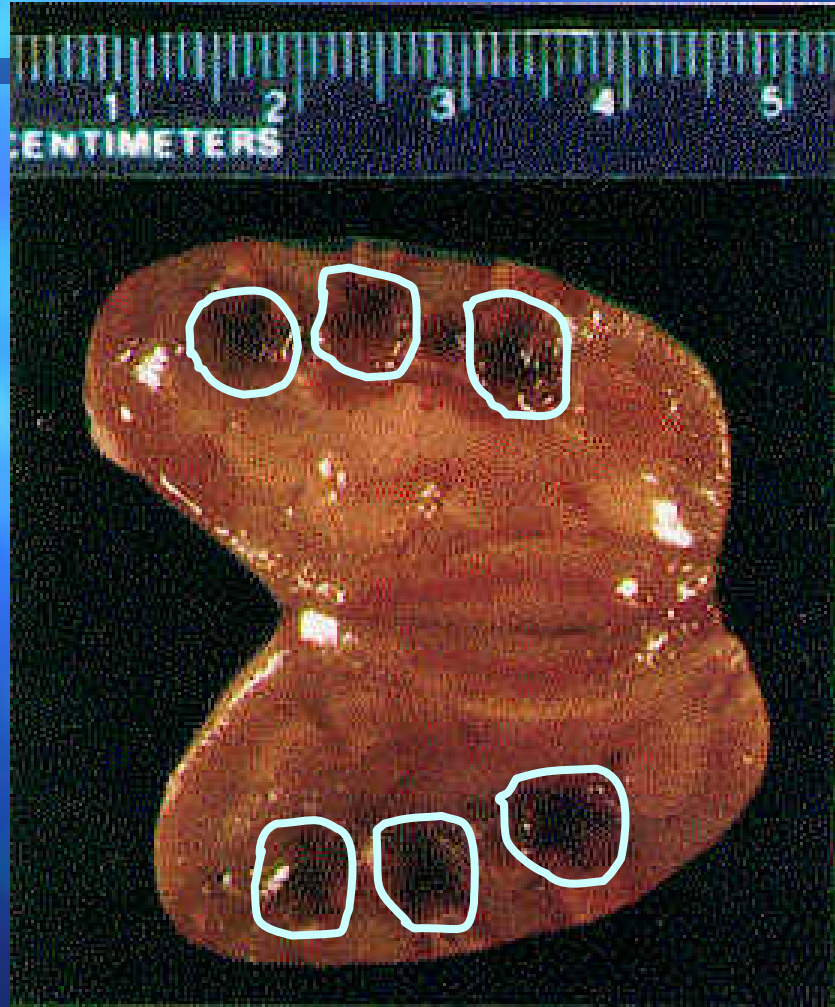
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MR Detection of Thermal Changes in Tissue





Post-Mortem Rabbit Kidney After FUS





The Future of MRGFUS

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



References

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