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Initial progress on Wholebody QT applications

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Normal thought would say that wholebody ultrasound can’t be done

- Attenuation is too high
- Can’t get enough SNR
- Low frequencies don’t yield enough resolution
- It’s not practical
- We already have MRI/CT/…., so why do it?
- Nobody wants it

Wholebody Ultrasound is difficult, but possible

- What exactly are the problems?
- What are the benefits?
- How does QT solve these, or at least suggest a solution?
- Results of initial experiments in wholebody

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We need to examine some of our basic premises

- Until now, medical imaging techniques have a basis of sampling and statistics
  - Resolution and CNR limited by sampling

- Why is that? Scattering is a big part of it, computational resources another

- With inverse scattering, ultrasound tomography looks more like microscopy
  - Its more of an analog problem
  - Resolution becomes limited by diffraction

Hold that thought

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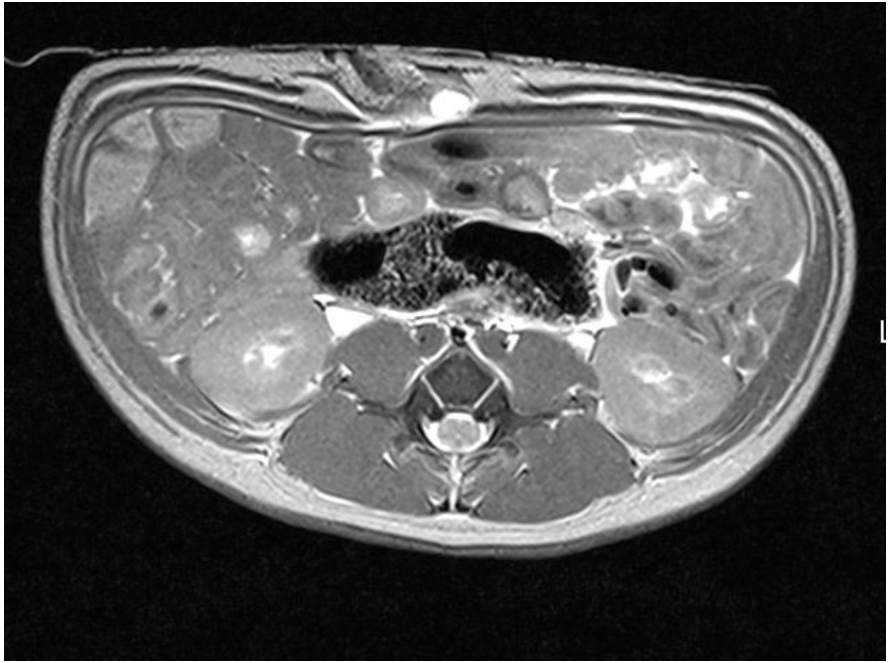
Problems with wholebody ultrasound in general

- The gold standard is MRI. This is what we should shoot for.
- Distances are long, especially for high BMI patients
- This involves more power for vanishingly small amounts of signal
- Refraction and Diffraction also steadily warp and degrade the signal

MRI (T2 Fat-suppressed sequence)



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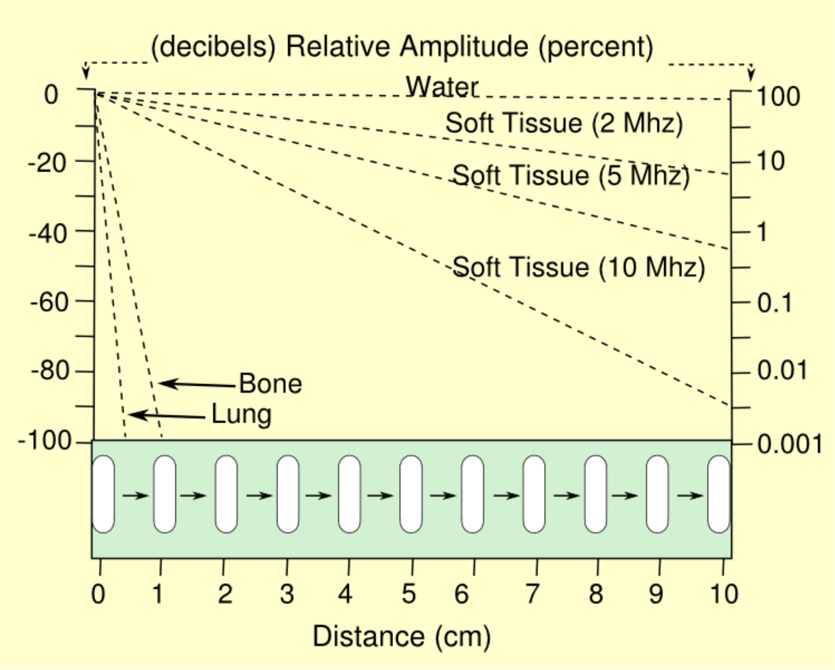
Attenuation is a large problem facing wholebody applications

- Attempts to use higher frequencies fail due to high attenuation
- SNR at any reasonable depth is not useful without additional additional methods
- There are ways to improve SNR beyond just adding power
- Clinicians tend to prefer unreasonably high frequencies because of perceived resolution at lower frequencies. (mostly due to scatter)



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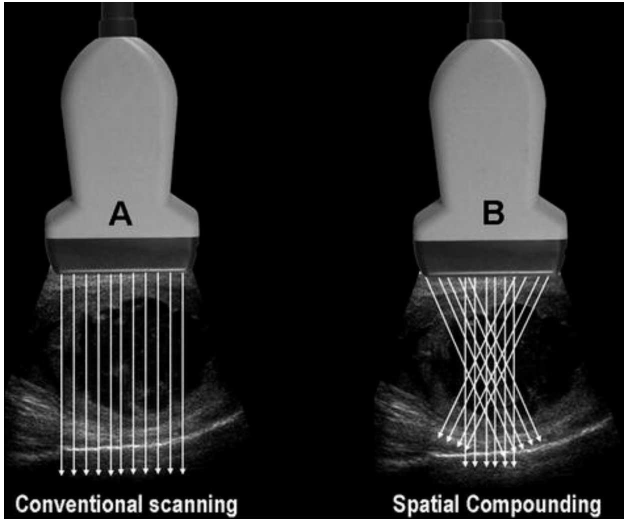
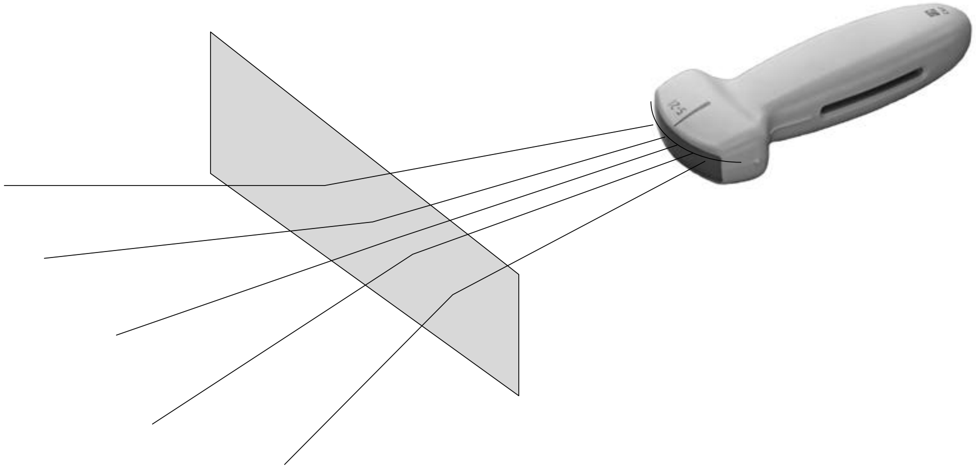
Compounding can significantly improve SNR

- Sampling a volume from multiple source locations improves the statistical quality of the measurement
- This is the equivalent in optics of using a lens with higher numerical aperture (NA)



Problems with wholebody ultrasound in general

- We think of the response from a standard ultrasound transducer as a perfectly flat fan
- In reality, it is far from flat due to refraction and diffraction effects
- This limits our ability to compound scans because nothing lines up spatially
- These problems get worse as the depth gets deeper



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To solve this problem we need to work in reverse!

1. Using transmission ultrasound (low F), solve for attenuation and speed
   - This enables a variety of spatial corrections in reflection data
2. Correct for refraction, diffraction, and attenuation in reflection modes
   - Eliminate geometric artifacts
3. Compound over the widest angle range possible
   - This improves SNR while retaining good resolution
4. Parametrically combine reflection and transmission information
   - This creates images with the most useful components of both

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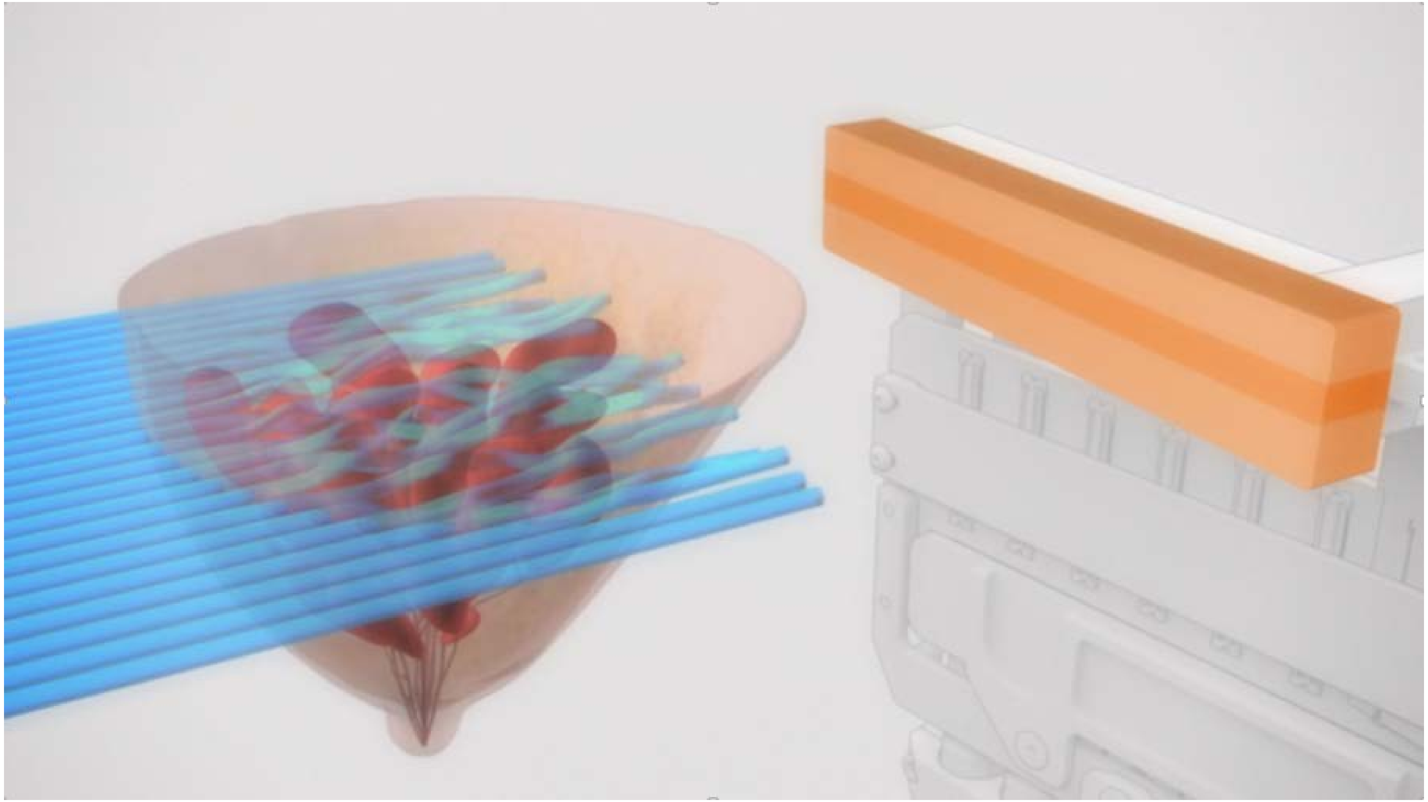
Transmission Ultrasound in 3D



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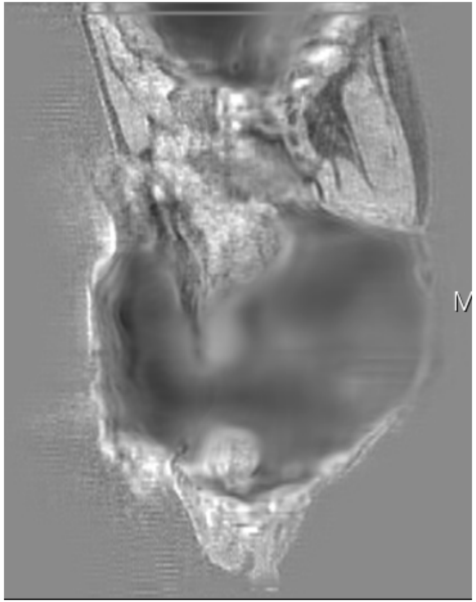
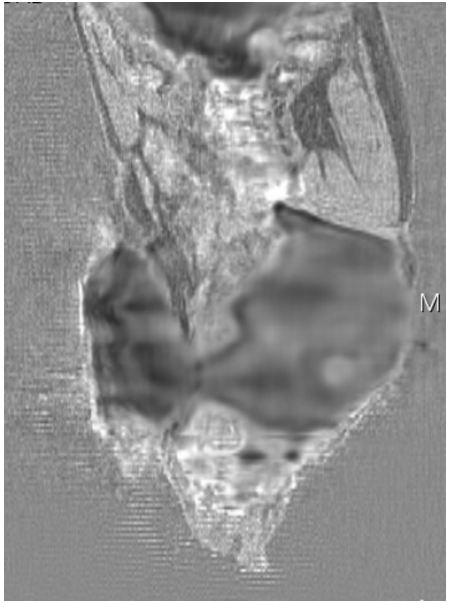
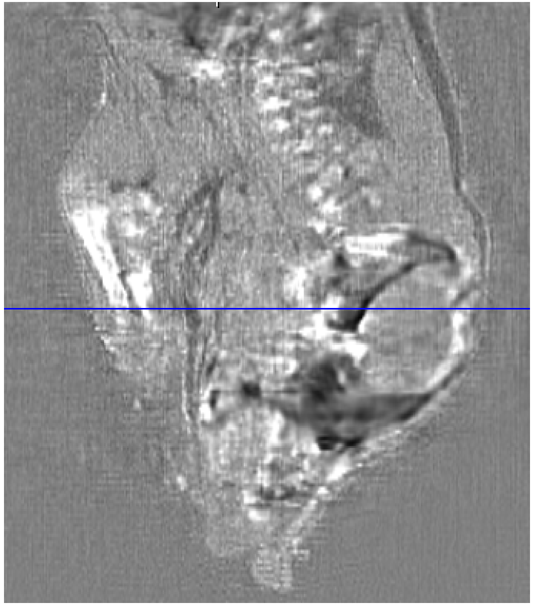
Ultra Low Frequency Transmission



Standard Protocols



Increased Iterations at HF



Increased Iterations at LF

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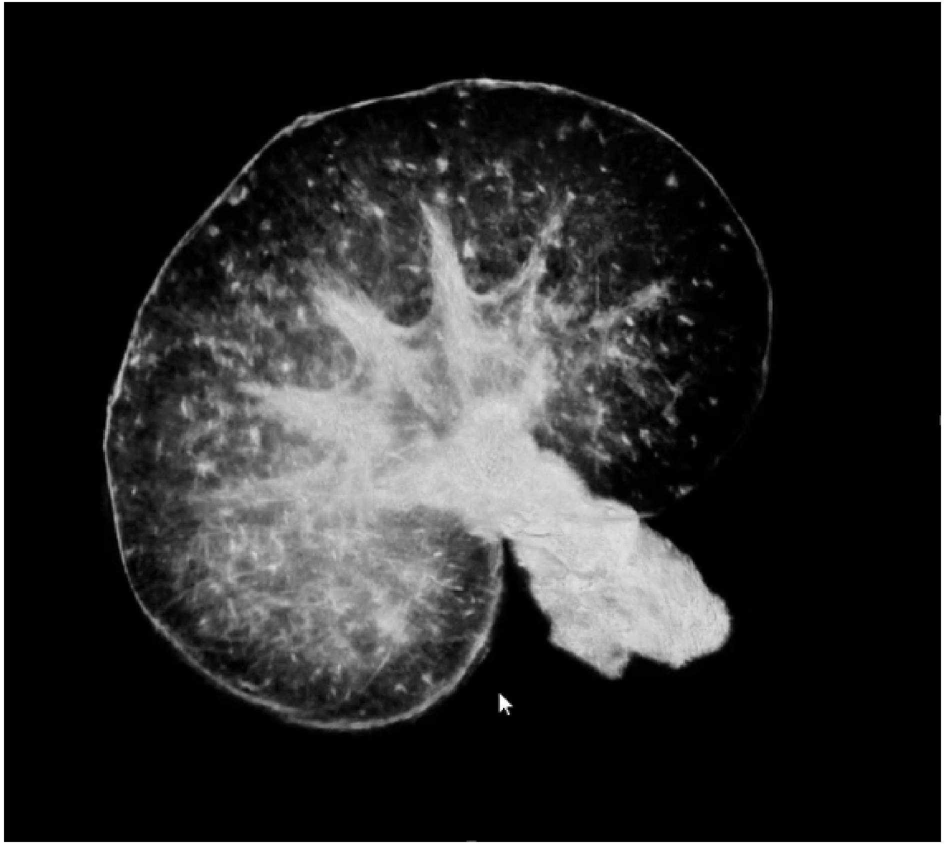
Wide angle compounded Kidney Imaging



Transmission imaging (Kidney)

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Combining Reflection and Transmission information

- Previous work in automated tissue segmentation and identification yielded excellent results (Malik et. al., 2016)
- Combining these methods parametrically can yield further improvement in the final SNR of the image volume

Parametrc Wholebody piglet cross section QT vs MRI (3T)

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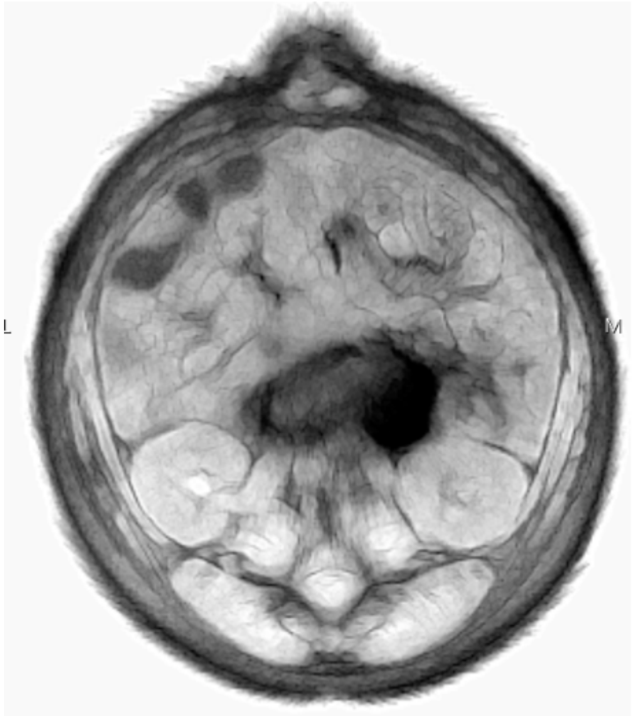
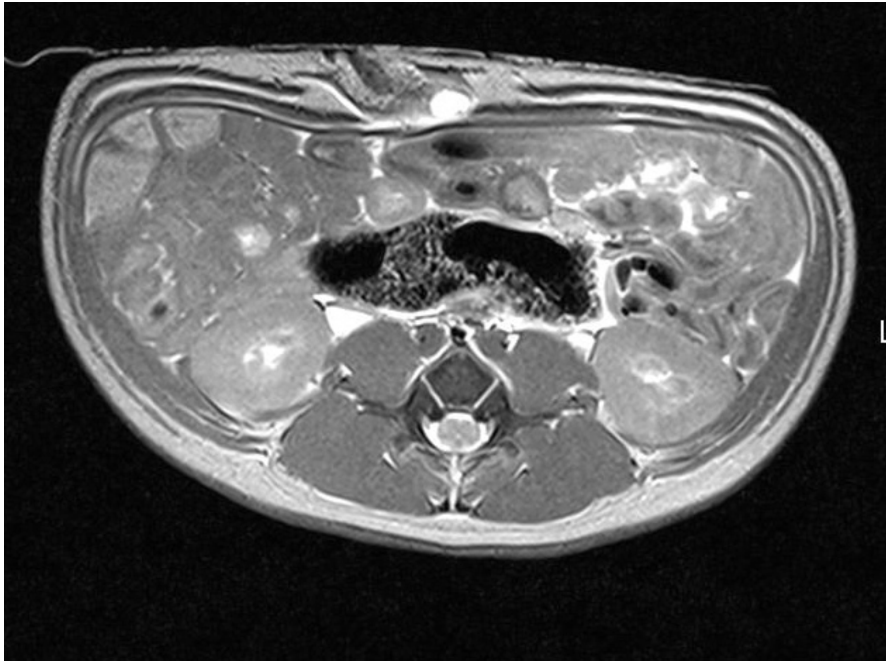


MRI (T2 Fat-suppressed sequence)



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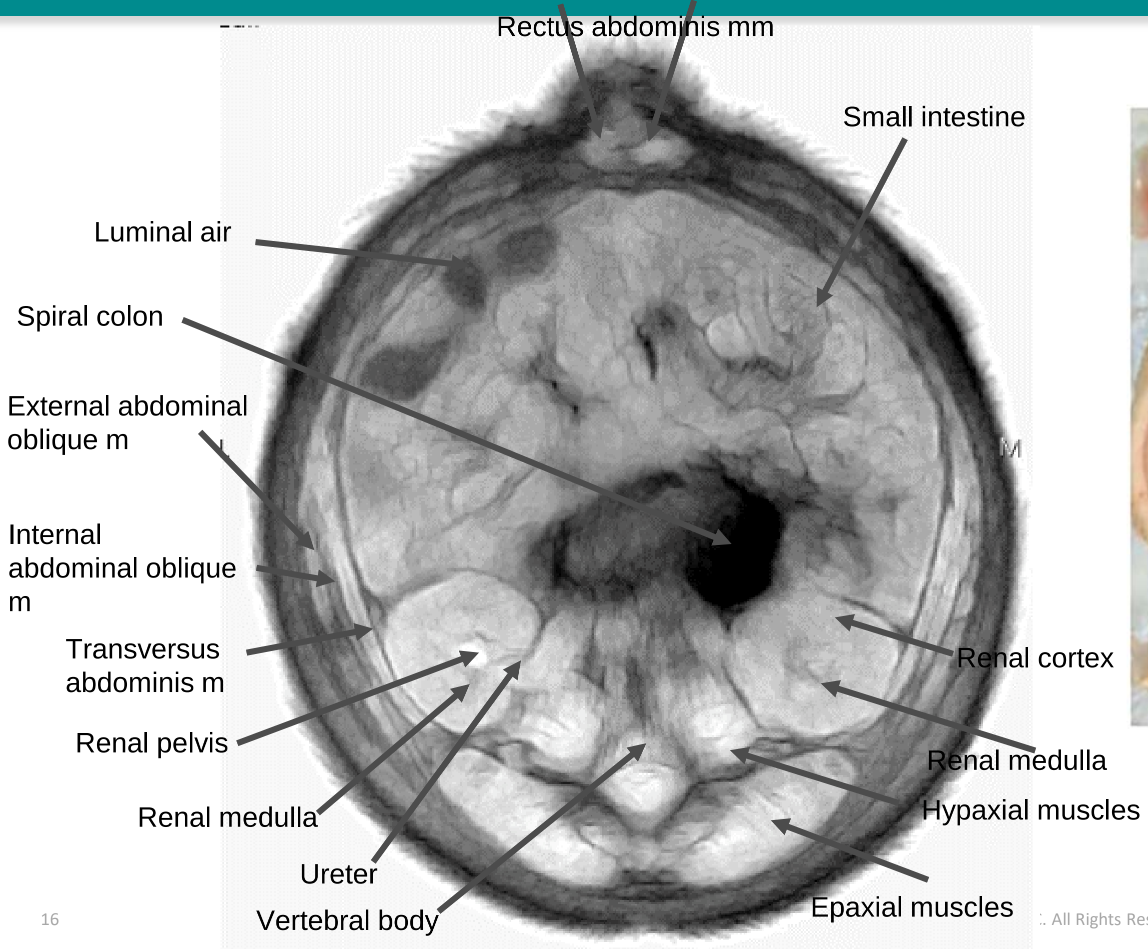
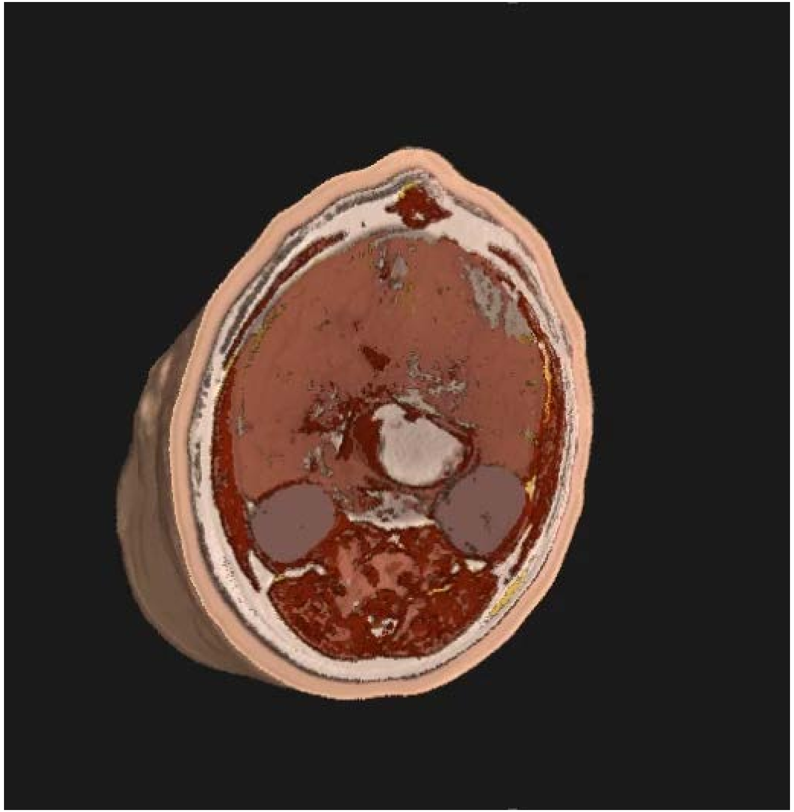
ANATOMY CORRELATION OF QT



Piglet Abdomen

Anatomical correlation courtesy of
Dr. Catherine Ruoff, DVM, Texas A&M University

Wholebody Ultrasound works



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Questions?