

Optimizing Liver 3D Arterial Phase Imaging with Gadoxetate Disodium

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Introduction: Arterial phase bolus timing for liver MRI is critical for diagnosing arterial-enhancing lesions, which are common in cirrhosis and other diseases. However, patient variability can make Gd bolus timing challenging. Liver imaging has improved with introduction of gadoxetate but the small FDA approved dose, 0.03mmol/kg, makes arterial phase bolus timing even more difficult. In this study, we propose optimizing arterial phase image quality by separately reconstructing select portions of a spiral 3D dataset. Here, we manually select spiral data for creating arterial and portal phases and anticipate automating reconstruction in the future.

Materials & Methods: 3D image data from 85 patients were analyzed retrospectively. Image data were acquired using a 3D spiral fat-suppressed gradient echo sequence [1] in a single breath-hold with the following parameters: TR/TE/flip = 6.1/0.6/12°, 888 sampling points per spiral leaf, 48 leaves, 256x256x36-58 acquisition matrix, 34-44cm FOV, 5mm slice thickness, readout bandwidth ±125kHz, spectrally selective fat saturation, partial slice encoding factor of 0.7 and an axial imaging plane. For a given spiral leaf, all slice encodings were acquired in segments following the spectrally selective fat saturation pulse. The angle between consecutive spiral leaves was based on the golden ratio to enable flexible view sharing. Starting at 10 seconds post a 2cc/s injection of 10cc gadoxetate disodium, an acquisition of three to four consecutive 3D volumes was performed in a single 30-40s breath-hold.

A single slice was reconstructed at ~ 4.2 frames per second using TRACER [2] to obtain aorta, portal vein and liver enhancement curves (Figure 1). From these curves subsets of the data corresponding to arterial and portal phases were identified to reconstruct pure arterial and portal venous phases. These were compared to reconstructions of the entire breath hold data collection.

Results: Figure 2 shows examples of optimized arterial and portal venous phases produced from the single 3D spiral breath hold data acquisition. In every patient, good arterial phase images were retrospectively reconstructed successfully in spite of using a fixed delay of 10 seconds between beginning gadoxetate injection and initiating spiral data acquisition. Figure 3 shows the effect of age on aorta peak width and bolus arrival time for gadoxetate revealing the challenge of achieving perfect bolus timing. Variability in bolus width and arrival time can also occur with cardiac disease, anxiety/tachycardia and aortic aneurysms.

Discussion: These data in 85 subjects demonstrate the ability to retrospectively create optimal arterial and portal venous phase 3D dynamic liver images from a small gadoxetate bolus using spiral 3D k-space mapping. The ability to analyze the vascular and organ enhancement curves at a temporal resolution of ~4 frames/s enables precise delineation of the beginning and end of arterial and portal venous phases for retrospective reconstruction of a subset of the data which has optimal bolus timing. Although the manual analysis performed here was tedious, we anticipate that automation is possible. Furthermore, data from respiratory bellows and other motion detectors could be utilized to selectively eliminate motion corrupted data from retrospective reconstructions. Time resolved movies of the evolution of contrast dynamics over the course of the breath hold are also possible. To the extent that longer bolus durations are likely to provide higher image quality, beta blockers and other mechanisms to reduce cardiac output may further improve the technique.

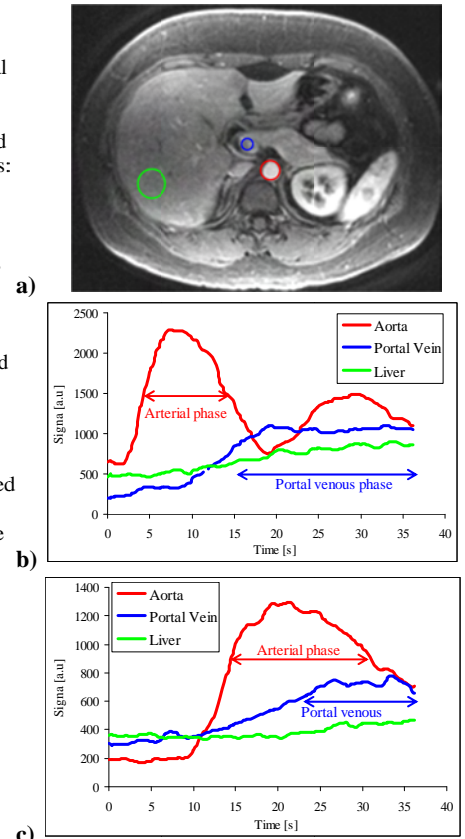


Fig 1. Region of interest map (a) showing the enhancement pattern of hepatic arterial, portal venous and liver in fast flow (b) and slow flow (c).

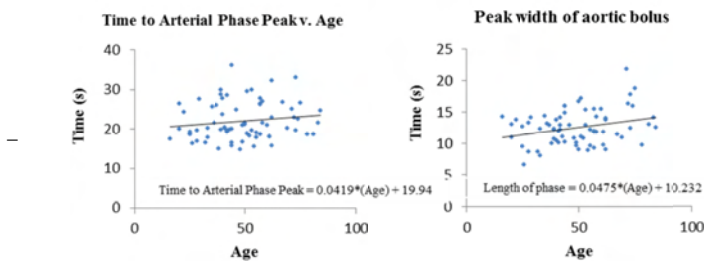


Fig 3 Scatterplot of signal characteristics as a function of age

References

- 1) Agrawal M et al RSNA2011, pSSJ06
- 2) Xu Bo et al, ISMRM 2011, p3330
- 3) Spincemaille P et al. MRA Club 2010, Seoul Korea

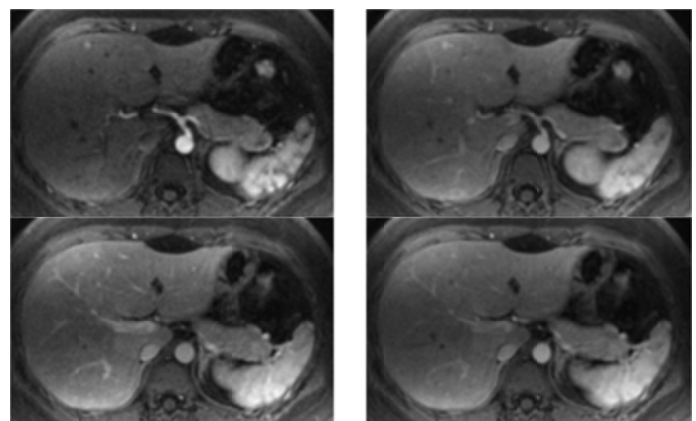


Fig 2 Narrow arterial phase (top, left) and portal venous phase (bottom, left) compared to reconstructions using all data (right column)