Low-dose Contrast-Enhanced Time-Resolved Renal MRA

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Introduction:

Dynamic imaging of the kidneys using MR offers non-invasive information about the renal anatomy and function. However, despite many improvements in renal MRA, there is a need for higher temporal resolution in time-resolved MRA, while minimizing the risks associated with gadolinium based contrast agents. In this study, low-dose renal MRA was performed using the previously developed CAMERA (Contrast-enhanced Angiography with Multi-Echo and RAdial *k*-space) technique (1) to achieve higher temporal resolution without undersampling.

Methods:

In CAMERA, data is acquired in radial in-plane and Cartesian through-plane *k*-space, or "stack of stars." Multiple-echoes are used in partition direction, in an interleaved manner to cover multiple partitions during each TR, similar to segmented echo-planar imaging. With an echo train length (ETL) of 4, approximately twofold acceleration is achieved. Sliding window reconstruction was applied to further increase the frame rate(2,3). Typical imaging parameters were as follows: ETL=4, TEs=1.5, 2.5, 3.5, 4.5ms, TR=5.8ms, Flip Angle=35, FOV=260x260mm, Slice Thickness=3mm, $N_{partitions}$=32, $N_{projections}$=192, N_{RO}=192.

Healthy volunteers were recruited with IRB approval. The scan protocol includes a set of 3 consecutive scans with breath holds. For the first scan, the first pre-contrast mask, one measurement (a complete set of 3D *k*-space lines) was acquired with a breath hold, which lasts roughly 15 seconds. After a 15-second break and normal breathing, another measurement was acquired with breath hold. After another 15 second break, half-dose of contrast agent (Magnevist, Berlex, Wayne, NJ) is injected at 4ml/s, and 5 measurements are acquired, lasting about a minute, while the subject holds his breath for as long as possible.

Results:

Time-resolved renal images were successfully acquired with an apparent temporal resolution of 2 frames/sec (temporal footprint=9s). Figure 1 shows the time series of a renal MRA of a volunteer which clearly depicts the contrast passage in pulmonary vessels, aorta, renal arteries, renal parenchyma, and renal veins.

Discussion:

The CAMERA technique achieves higher SNR because shorter temporal footprint results in intrinsic signal increase when contrast signal is transient (4,5). Also, a longer TR from multi-echo imaging allows more time for re-growth of longitudinal magnetization. Additionally, the longer TR decreases the specific absorption rate (SAR), allowing the sequence to run at the optimized angle. For high field magnets (3T or higher), SAR is a limiting factor in image quality for fast sequences like spoiled gradient echo used in time-resolved MRA.

High temporal resolution and smooth contrast curve is obtained using CAMERA and sliding window reconstruction. The temporal information can be used to measure renal perfusion (6) with greater accuracy due to more accurate temporal information obtained with CAMERA.

Conclusion:

In summary, low-dose renal MRA is feasible with high temporal resolution and high SNR using the CAMERA technique.

References

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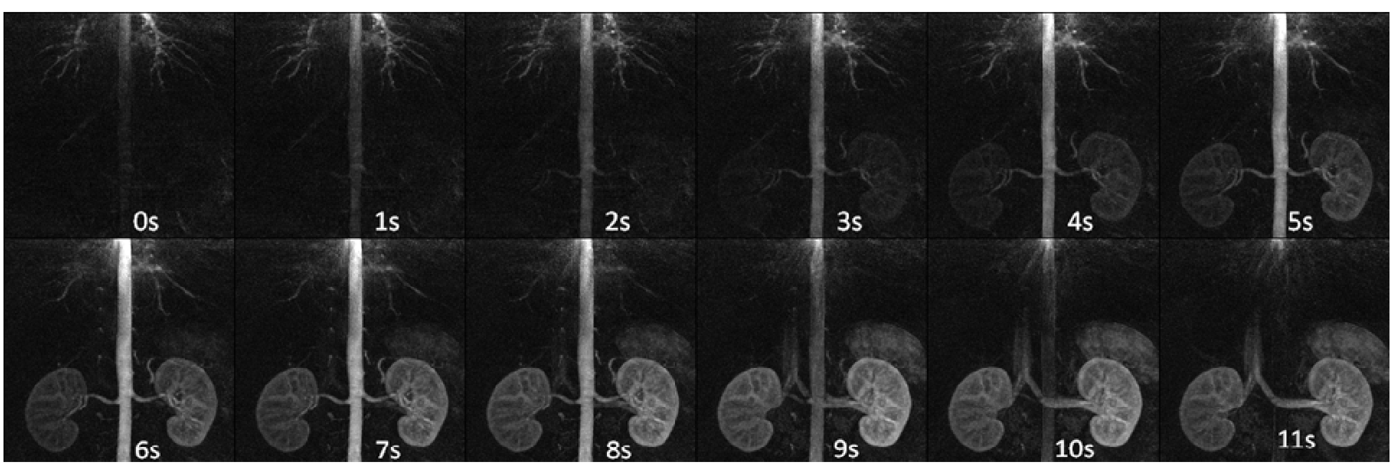

Figure 1: 4D contrast-enhanced renal MRA using CAMERA technique. Contrast passage in pulmonary vessels, aorta, renal arteries, renal parenchyma, and renal veins are clearly depicted. Frame rate=2fr/s; every other image shown.