Non-Contrast MRA: Established Techniques

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Recently, two main non-contrast MRA applications, peripheral run-off MRA and body MRA have gained tremendous technical advancements and have become a viable clinical option as an alternative to contrast-enhanced MRA. In this presentation, two techniques, ECG-gated partial Fourier fast spin echo (FSE) and balanced steady-state free precession (bSSFP) imaging, both with and without arterial spin labeling will be discussed in detail.

In peripheral run-off MRA, ECG-gated 3D partial Fourier FSE allows separation of arteries from veins by applying flow spoiler gradient pulses in the read-out (RO) direction. To find suitable ECG delay times for systole and diastole, an ECG-prep scan, single-slice multiple phases, is applied to acquire single shot images with different ECG delay times. After finding the suitable systolic and diastolic triggering delay times, both systolic and diastolic 3D partial Fourier FSE images are acquired in a simultaneous manner and then subtracted to provide arterial images. The appropriate RO spoiler gradient pulses are used in the three-station regions, the iliac, thigh, and calf.

Renal artery examinations using non-contrast MRA techniques are in high demand for patients with renal insufficiency and vascular disease. In order to depict the multiple directional vasculatures of the renal arteries, a navigator technique or respiratory-gated technique is applied using 3D bSSFP with arterial spin labeling (time-spatial labeling inversion pulse; time-SLIP, syngo NATIVE trueFISP, or Flow-prep FIESTA) is applied to gain an inflow effect using an axial or coronal orientation. The time-SLIP pulse (free hand) saturates the background signals. Aortic blood travels into the acquisition plane, and after waiting an appropriate travel time, bright blood of renal arteries and branches is visualized with a 3D bSSFP readout.

There are two types of acquisition techniques suitable to combine with time-SLIP: partial-Fourier FSE and bSSFP. The spin echo based partial-Fourier FSE sequence works well in the pulmonary vessels to reduce the susceptibility effect from the lungs. The bSSFP works well in the renal arteries with complex vessel

orientations from aorta to renal vessels. There are basically three types of applications in time-SLIP; flow-in, flow-out, and tag-on/off alternate subtraction techniques. The above-mentioned renal non-contrast time-SLIP utilizes the flow-in technique. The flow-out technique utilizes both a non-selective pulse and a selective tag pulse. The first non-selective pulse inverts all magnetization to –Mz and the second selective tag pulse brings only the tagged area magnetization back to +Mz so that marked or tagged blood that flows out from the tagged area can be depicted. The tag-on/off alternate acquisition subtraction technique allows selection of any inversion time and depiction of only the vessels of interest by cancelling the background signals. However, it takes twice the scan time compared to the flow-in or flow-out techniques. Applications of the flow-in, flow-out, and tag on/off alternate subtraction techniques will be discussed in detail.

References:

1) Miyazaki M and Lee VS. Non-Contrast-Enhanced Magnetic Resonance Angiography: state-of-the-art. ***Radiology*** 248:20-43, 2008.
2) Miyazaki M, Takai H, Sugiura S, Wada H, Kuwahara R, and Urata J. Peripheral MR angiography: Separation of arteries from veins with flow-spoiled gradient pulses in Electrocardiography-triggered three-dimensional half-Fourier fast spin-echo imaging. ***Radiology*** 227:890-896, 2003.
3) Miyazaki M, Sugiura S, Tateishi F, Wada H, Kassai Y, and Abe H. Non-contrast-enhanced MR angiography using 3D ECG-synchronized half-Fourier fast spin echo. ***JMRI*** 12:776-783, 2000.
4) Urata J, Miyazaki M, Wada, H, Nakaura T, Yamashita Y, Takahashi M, Clinical Evaluation of the Aortic Diseases using Nonenhanced MRA with ECG-triggered 3D half-Fourier FSE. ***JMRI***, 14:113-120, 2001.
5) Kanazawa H and Miyazaki M. Time-spatial labeling inversion tag (t-SLIT) using a selective IR-tag on/off pulse in 2D and 3D half-Fourier FSE as arterial spin labeling. Presented at the ISMRM 11th Annual Meeting, Hawaii, p140, 2002.
6) Spuentrup E, Manning WJ, Bornert P, Kissinger KV, Botnar RM, Stuber M. Renal arteries: navigator-gated balanced fast field-echo projection MR angiography with aortic spin labeling—initial experience. ***Radiology*** 225:589–596, 2002.
7) Katoh M, Buecker A, Stuber M, Gunther RW, Spuentrup E. Free-breathing renal MR angiography with steady-state free-precession (SSFP) and slab-selective spin inversion: initial results. ***Kidney Int.*** 66:1272–1278, 2004.
8) Utsunomiya D, Miyazaki M, Nomitsu Y, Okigawa T, Urata J, and Yamashita Y. Clinical role of non-contrast MR angiography for evaluation of renal artery stenosis. ***Circulation Journal***, 72: 1627-1630, 2008.
9) Shonai T, Takahashi T, Ikeguchi H, Miyazaki M, Amano K, Yui M. Improved arterial visibility using STIR fat suppression in non-contrast-enhanced Time-Spatial Labeling Pulse (Time-SLIP) renal MR angiography. ***JMRI*** 29:1471–1477 (2009).