Flow Contrast without Using Exogenous Agent

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Both contrast-enhanced (CE-MRA) and nonenhanced MRA have been successfully applied to every vascular territory in the body. Due to the recent association of gadolinium contrast agents and Nephrogenic Systemic Fibrosis (NSF) disease, there has been increased interest in using non-contrast MRA techniques as an alternative. Two main non-contrast enhanced applications, selective spin labeling in abdominal MRA and peripheral run-off MRA, have recently gained tremendous technical advancements and have become viable clinical alternates (1-4). Here, we present two main applications in peripheral MRA and selective flow imaging using spin labeling techniques (flow-in, flow-out, and alternate tag-on and –off acquisitions).

In peripheral run-off MRA, ECG-gated 3D partial Fourier FSE (5) (fresh blood imaging (FBI), Native SPACE, TRANCE, Delta Flow) allows separation of arteries from veins by acquiring systolic and diastolic phases. Using the correct systolic and diastolic trigger delay times, both systolic and diastolic 3D partial Fourier FSE images are acquired in a simultaneous manner and then subtracted to provide arterial images. Predetermined RO spoiler gradient pulses are applied according to flow speed in the three-station regions: iliac, thigh, and calf (6). Recently, another peripheral MRA technique, quiescent interval single-shot (QISS), has been reported (7). The QISS technique relies on a presaturation RF pulse to saturate the signal in the imaging slice. Following the presaturation, during a ‘‘quiescent interval’’ (QI) fresh inflowing blood enters the saturated slice using a maximum inflow effect during systole with a single-shot 2D bSSFP read-out.

In other areas, selective flow can be visualized using three types of techniques: flow-in, flow-out, and alternate tag-on/off (2-4, 8). The flow-in technique applies a spatially (or slab) selective inversion recovery (IR) (tagging) pulse to saturate a region of interest. Untagged spins flow into the tagged region during the inversion recovery time (TI). The flow-out technique applies both a nonselective IR pulse and a spatially selective IR pulse. Unlike the flow-in technique, double inversions using non-selective and selective pulses restore the tagged spins back to the +Mz axis which then flow out from the region, while untagged spins follow the inversion recovery process and go through the null point from –Mz to +Mz. The alternate

tag-on/off technique consists of a series of interleaved tag-on and tag-off acquisitions. The tag-on and –off data sets are reconstructed separately and subtracted. This allows depiction of only signals of the tagged region by the cancellation of the background signal.

In abdomen, the non-contrast renal artery 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 the flow-in technique with 3D bSSFP (9) (time-spatial labeling inversion pulse; Time-SLIP, syngo NATIVE trueFISP, or Flow-prep FIESTA) is applied to gain the inflow effect using an axial or coronal orientation. The flow-in technique can also be applied to depict the portal vein using 3D bSSFP and half-Fourier FSE (2).

In the flow-out technique, there is a limited supply of flow signal: only those in the spins in the tagged region can be visualized. In the flow-in technique, there is an effectively unlimited supply of inflowing blood. The 2D flow-out technique can be applied in cerebrospinal fluids (CSF) to observe bulk CSF movement (10). The alternate tag-on/off technique depicts only the tagged or marked flow with cancellation of background signal; therefore, it is suitable to study functionality of flow, but with a cost of double scan time.

References:

1) Miyazaki M and Lee VS. Radiology 248:20-43, 2008.
2) Miyazaki M and Isoda H. European Journal of Radiology 80:9-23, 2011.
3) Miyazaki M and Akahane M. JMRI 35:1-19, 2012.
4) Wheaton AJ and Miyazaki M. JMRI 36:286–304 (2012).
5) Miyazaki M, Sugiura S, Tateishi F, Wada H, Kassai Y, and Abe H. JMRI 12:776-783, 2000.
6) Miyazaki M, Takai H, Sugiura S, et al., Radiology 227:890-896, 2003.
7) Edelman RR, Sheehan JJ, Dunkle E, et al., MRM 63:951–958, 2010.
8) Kanazawa H and Miyazaki M. ISMRM 11th Annual Meeting, Hawaii, p140, 2002.
9) Parienty I, Rostoker G, Jouniaux F, et al., Radiology 259:592-601, 2011.
10) Yamada S, Miyazaki M, Kanazawa H, et al., Radiology 249:644-652, 2008.