Coronary MRA at 3.0T: Promises and Challenges
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Tremendous progress has been made in coronary MRA in recent years. Clinical studies at 1.5T have shown that coronary MRA can accurately identify anomalous coronary arteries or rule out significant coronary artery stenoses in symptomatic patients, although the positive predictive value needs further improvement (1). Major causes for study failures and false positives include relatively poor SNR/CNR, artifacts caused by residual motion during long imaging times, and relatively poor spatial resolution. Imaging at 3.0T provides a potential solution to these problems. 3.0T imaging has the potential to increases SNR, which in turn allows increased spatial resolution and/or shortened imaging time. Various studies have shown SNR gains of approximately 50% at 3.0T over 1.5T with similar sequences and parameters (2,3).

Major challenges for coronary MRA at 3.0T include: higher power deposition, which may limit imaging flip angles; greater susceptibility-induced $B_0$ inhomogeneity, which may increase image artifacts, particularly for steady-state free precession (SSFP) imaging, and variable fat suppression; greater $B_1$ inhomogeneity, which may result in non-uniform T2-preparation and signal intensity heterogeneity.

$B_0$ inhomogeneity-induced artifacts typically manifest as dark “banding” or ghosting of flow in the image. Typical strategies of suppressing such artifacts include adjusting synthesizer frequency, applying localized linear or second order shimming corrections (4), and maximizing the spectral width of the pass band by minimizing TR. Because of the problems with SSFP imaging due to $B_0$ inhomogeneity, contrast-enhanced MRA with conventional gradient-echo sequence (FLASH: fast low angle shot) can be used at 3.0T because it is much less sensitive to field inhomogeneities. Slow infusion of a newly developed Gadolinium based T1-shortening contrast agent (MultiHance, Bracco Imaging) and parallel imaging allows free breathing coronary MRA to cover the entire heart within approximately 5 min at 3.0T (5).

Reduced penetration of RF pulses and increased dielectric resonance at high field lead to increased $B_1$ field inhomogeneity at 3.0T than 1.5T. Utilization of $B_1$ insensitive RF pulse (e.g., adiabatic pulse) (6) or application of buffer cushion filled with dielectric substance might alleviate some of these $B_1$ inhomogeneity effects.

In summary, 3.0T imaging of coronary arteries has gained increased interests in recent years. It has the potential to increase spatial resolution or reduce imaging time. With further development of fast imaging techniques and improved sequence design, 3.0T can potentially become a very promising platform for performing routine coronary MRA.

References