Session: ***Cardiovascular MRA With and Without Contrast***
Speaker: *Ruth P Lim, Austin Health, University of Melbourne, Melbourne, Australia*
Email: ruth.lim@austin.org.au

Highlights

- *There are many non contrast MRA techniques, which can be divided into those that obtain arterial signal from flow-related enhancement, phase of MRI signal from moving blood, or the physical MRI properties of blood*
- *Selection of appropriate non contrast MRA technique depends on the target vascular bed*
- *New developments include increased experience at ultra high field and in clinical populations*

Title of Presentation: ***Non-Contrast Enhanced MRA: Why, Where, and How?***

Target Audience

- Radiologists considering non-contrast enhanced MRA in clinical practice.
- Basic scientists interested in developing and optimizing new techniques in this field.

Outcome/Objectives

- To become familiar with non-contrast enhanced MRA techniques, with particular emphasis on recent developments
- To understand the strengths and weaknesses of these techniques, and where and how they may be most effectively applied

Outline

Techniques

Each technique will be briefly reviewed with regards to basics of how arterial signal and contrast is achieved, strengths and weaknesses, and current/ potential clinical applications, with particular focus on recently described techniques.

A. Flow-related Techniques

- Time of Flight MRA (TOF MRA):

A well-established and clinically validated technique, where the basic premise is that background tissue is suppressed, enabling contrast with arterial spins flowing into the imaging field of view. It may be applied as a 2D or 3D technique, and selective saturation pulses may also be applied to suppress undesirable inflowing (e.g. venous) spins. As TOF MRA depends on arterial inflow to visualize the arteries, it is most effective for vascular beds where there is fast or continuous inflow, and smaller volumes, since the imaging plane should be perpendicular to the main direction of vessel flow. It is therefore most effectively used in neurovascular imaging for both MRA and MRV.

- Inflow/outflow Techniques:

These are flow dependent techniques that do not require subtraction and are acquired in a fashion that differs from standard time of flight MRA. One such volumetric technique that is commercially available is inflow inversion recovery MRA, where a selective inversion prepulse is applied to suppress background tissue, and during the inversion time (TI), fresh arterial blood enters the region of interest prior to a relatively rapid readout. As the technique remains dependent on arterial inflow, it is most effective for arterial beds with relatively rapid flow, e.g. the renal arteries. It is particularly effective for vascular beds with cardiac or respiratory motion, where techniques requiring image subtraction are problematic. A recently described 2-dimensional flow-dependent technique is Quiescent Interval Single Shot MRA (QISS MRA), an ECG-gated technique that employs selective saturation pulses to suppress background tissue and inflowing venous blood, and depends on fresh arterial blood to enter each slice during a “quiescent interval” in the cardiac cycle, timed to include systole, prior to a diastolic phase readout. Due to relative speed and ease of implementation, and sensitivity to relatively slow arterial flow (superior to traditional TOF MRA), the technique can be best applied to large coverage lower extremity MRA. Another example of a flow dependent technique is velocity sensitive angiography, which selectively suppresses background or slowly moving spins with a velocity selective inversion pulse.

B. Phase Dependent Techniques

- <u>Phase contrast MRA (PC MRA):</u>

PC MRA depends on the phase of moving spins to provide vessel contrast, with stationary spins effectively experiencing no overall phase shift, resulting in excellent background suppression. It is a technique that can also be applied to relatively slowly flowing vessels and hence can be applied to MR venography as well as MRA. Due to the need for multiple flow-encoding gradients, it is traditionally a relatively slow technique, again best applied to neurovascular imaging, although scan times can be markedly reduced with the use of undersampling and non-Cartesian readouts. However, it can provide functional information in addition to morphologic information, and 4 dimensional PC imaging that includes a temporal element is an emerging technique with exciting potential clinical application to aortopathy and other vascular disease.

- <u>Subtraction Arterial Spin Labeling (ASL) Techniques:</u>

With this technique, two sets of images are acquired, with differences between magnetization of arterial spins between the two sets, such that subtraction of one set from the other leads to cancellation of background tissue. Either a balanced steady state free precession (bSSFP) or fast spin echo (FSE) readout can be employed, with choice dependent on the region of interest. Different magnetization or labeling of arterial spins can be achieved either by depending on flow-related dephasing from application of gradients, or by applying radiofrequency pulses. These techniques achieve superb background suppression, but are more susceptible to motion artifact given relatively long scan time required for 2 successive acquisitions, and hence are best applied to relatively motionless vascular beds, e.g. the peripheral arteries.

C. Flow-Independent Techniques

The intrinsic properties of blood are used to achieve bright arterial signal with these techniques, and contrast with other (background) tissue, with no reliance upon blood flow. The most commonly used of these techniques is magnetization-prepared bSSFP MRA, where chemically selective fat suppression and T2 preparation are used to minimize signal from fat or tissues with relatively short T2 relaxation times. The technique is effective even in relatively slow flow vascular beds or where there is complex multidirectional anatomy, where flow dependent techniques may be challenging. This technique has particularly been applied to coronary MRA, particularly in younger patients where ionizing-radiation associated with coronary CTA is undesirable.

References

1. Miyazaki M, Lee VS. Radiology 2008; 248: 20-43
2. Wheaton A, Miyazaki M. J Magn Reson Imaging 2012; 36: 286-304.
3. Parker DL, et al. Magn Reson Med 1991; 17: 434-51.
4. Wyttenbach R, et al. Radiology 2007; 245: 186-95.
5. Edelman RR et al. Magn Reson Med 2010; 63: 951-8.
6. Fischer A et al. Invest Radiol 2014; 49: 331-8.
7. Johst S et al. PLosOne 2014; 9: e86274.
8. Dumoulin CL et al. Magn Reson Med 1989; 9: 139-49.
9. Miyazaki M et al. JMRI 2000; 12: 776-783.
10. Storey P et al. Magn Reson Med 2010; 64: 1098-1108.
11. Fan Z et al. Magn Reson Med 2009; 62: 1523-32.
12. Shin T et al. Magn Reson Med 2013; 70: 1229-40.
13. Kato S et al. J Am Coll Cardiol 2010; 56: 983-91.
14. Lim RP et al. Invest Radiol 2013; 48: 145-51.
15. Cukur T et al. Magn Reson Med 2009; 61: 1533-9.