Magnetic Resonance Angiography
Techniques, Indications and Practical Applications
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Those of us involved in the development of magnetic resonance angiography (MRA) in the late 1980’s could hardly envision the routine application of MRA in every MR facility everyday. In those years there was spectacular development of many new MR clinical applications. Many pioneering researchers investigated various strategies exploiting the effects of blood flow on the MR signal to optimize clinical MRA. Remarkable successes were demonstrated in rapid succession. It is very alluring to attempt to catalogue the significant contributions in the founding of clinical MRA here, but that comprehensive effort is best relegated to the careful authors of history chapters in MRA books. The following are a few milestones from the early years of MRA development.

The first research meeting devoted to Magnetic Resonance Angiography was hosted by Roberto Passariello in L’Aquila, Italy in 1989. This meeting gave rise to formation of the MR Angio Club, which then held its first meeting at Michigan State University in 1990. Those were the days when three-dimensional phase contrast MRA would take some 19 hours from the time the patient entered the magnet until images could be seen: one hour to acquire the image and 18 hours of overnight image post processing. Seeing vasculature for the first time in 3D display is when we all realized the future potential clinical utility of MRA. Computational capabilities of modern equipment have reduced the delay to a few seconds. Post processing now has taken a more central role in the communication of enormous amounts of data with less cumbersome two- or three-dimensional projections. Many variations on the MRA theme have been presented over the ensuing 15 years. For example, Dennis Parker developed the 3D multi-slab time-of-flight MRA technique which remains in routine clinical use to this day. Pulse sequence design plays a major role in the continuing advancements in the field, most notably as a consequence of more sophisticated and novel k-space filling strategies.

The work of Kent Yucel and Martin Prince at the Massachusetts General Hospital in 1992 brought gadolinium-enhanced MR angiography to clinical utility. The first-pass dynamic contrast-enhanced MRA method provides robust and reproducible imaging results that have propelled the adoption of MRA into wider clinical use. This advance reliably produced images of sufficient quality to replace invasive catheter-based x-ray contrast angiography for most diagnostic purposes. Now it is possible to acquire a high quality MR angiography study in seconds.

The advent of very high field clinical scanners operating at 3.0 Tesla is now reinvigorating earlier non-contrast methods. 3.0 T MRA benefits from two key phenomena: (1) the signal to noise of 3.0 T is twice that of the 1.5 T, offering the opportunity to either increase the spatial resolution or to shorten scan times by up to a factor of four, and, (2) the longer T1’s of tissues at 3.0 T, ~20-40% higher than 1.5T, provides better background suppression, additional inflow enhancement, and improved contrast-to-noise. Magnetization transfer would normally be considered SAR prohibitive at 3.0 T, but novel pulse sequence design has overcome this challenge. The appropriate choice of imaging parameters can minimize artifacts and exploit T1 prolongation at higher fields for better quality MRA. The availability of scanners capable of parallel imaging along with growing availability of multi-channel coils is coincident with the arrival of these very high field scanners. The future potential is bright. Early results using these combined advancements for intracranial MRA yield spatial resolution exceeding invasive DSA and provide breathtaking visualization of small arteries such as the lenticulostriate vasculature. The efficiency of the parallel imaging approach will also compliment the quality of time resolved MR techniques.
Where are we going from here? Highest on the cardiovascular unresolved diagnostic problem list is the localization and assessment of unstable plaques. Specifically designed contrast agent(s) targeted to a characteristic within the unstable plaque will comprise a Molecular MRA procedure. Clearly, the domain of MRA is embracing this pursuit. It is remarkable that, after 15 years, we are still searching for the MRA technique to completely assess atherosclerotic disease in the carotid artery. Insights into bifurcation disease drive the quest for ever higher spatial resolution and SNR to assess plaque structure and stability. In this regard, carotid MRA will require integrating the newly available technologies to achieve the necessary spatial resolution.

Fusion MRA can refer to integrated multidimensional presentations of the MRA anatomy merged with other anatomical and functional modalities. We are now beginning to see presentations of MR and CT coronary angiography fused with PET myocardial perfusion images, or short-axis MR cardiac function images, or MR perfusion reserve images. Fusing MRA images to MRI, MR CSI, PET, nuclear medicine, and CT will be a direction that this field will take.

How do we optimize the present value of this potential? The persistent need for comprehensive outcome studies for MRA endures. A persistent challenge, however, is that by the time these studies are completed, the best methods may well have changed. We, who are students of changing technologies and best practices, need to further develop methodologies to measure the merits of alternative diagnostic procedures. MRA has the probability of becoming the standard for future non-invasive technologies.

This book presents an up-to-date treatise, a much needed presentation of the current practice of clinical MRA fully exploiting the benefits of dynamic contrast-enhanced MRA. I compliment Drs. Schneider, Prince, Meaney, and Ho on producing a definitive work on a rapidly moving target. This book provides the benchmark against which future MRA developments will be measured.

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