Time-resolved MRA from head to toe –
nice toy or helpful clinical tool?

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Time-resolved MR angiography (MRA) has been proposed as a non-invasive and non-ionizing imaging method. Compared with monophasic CTA and MRA it provides better arteriovenous differentiation and functional dynamic information that so far has been gained only with DSA.

When contrast-enhanced MRA was first introduced in 1993 acquisition time was in the range of several minutes. In addition the image acquisition had to be synchronized with the bolus arrival of the contrast agent. Several techniques have been developed since then in order to align the image acquisition with the bolus arrival including test bolus, automated bolus detection and fluoroscopic triggering. Methods with a centric k-space ordering were introduced that sample the central phase encoding views entirely during the arterial phase when triggered at the arrival of contrast material in the volume of interest. It is critical to initiate the centric k-space sampling so that the first views correspond to the peak of the arterial contrast opacification to avoid the presence of marked edge enhancement artifacts with little contrast in the center of the arteries.

Despite of all technical attempts to improve the bolus timing and to predict the optimal time delay contrast-enhanced MRA still requires expertise and trained personnel. Time-resolved MRA is a new concept that allows for fast dynamic acquisitions with acceptable spatial resolution without the need of distinctive timing methods by combining techniques to accelerate the MR acquisition. Parallel imaging (PI) has proved to allow for substantial improvement in temporal resolution as well as in spatial resolution in contrast-enhanced MRA. Although PI acceleration factors are limited at 1.5T because of signal-to-noise
limitations, this it less an issue at high field strength where PI acceleration factors of more than 8 have been successfully implemented. Furthermore, methods that undersample k-space including TRICKS (time-resolved imaging of contrast kinetics), TREAT (time-resolved echo-shared angiography technique) and 4D TRAK (time-resolved angiography with keyhole) are combined with parallel imaging in order to further enhance temporal and spatial resolution even for large field of view acquisitions. Since its clinical introduction, time-resolved MRA has been applied to virtually all anatomies from “head to toe” in the full range of clinical indications. Vascular territories with extremely short arteriovenous transit times showed the greatest benefit from time-resolved imaging as compared to static MRA including the brain, the chest, the abdomen and the foot. Nevertheless, the option to selectively visualize specific vessels and to quantify flow and pressure gradients is a clear advantage of intra-arterial methods such as DSA. One way to further improve the selectivity of non-invasive MRA and to allow for flow quantification and wall shear stress and pressure measurements might be the combination of highly accelerated MRA with non-contrast-enhanced methods such as arterial spin labelling with selective labelling pulses and phase contrast MR imaging.

In conclusion, time-resolved MRA provides high quality and dynamic visualization of the entire vessel tree and can be considered as a helpful tool to investigate vascular disease "from head to toe”.

Literature


