49 Dynamic MRA (TWIST/TREAT)

One of the major disadvantages of contrast-enhanced MR angiography (MRA) has been the limitation in temporal resolution. Acquisition time could be substantially reduced using conventional MRA techniques, however at the expense of a marked reduction in spatial resolution. On the other hand, acquiring MRA images with a spatial resolution close to conventional digital subtraction angiography is feasible, but acquisition time would increase and therefore temporal resolution would be impaired, a major drawback.

With the evolution in hardware (strong and fast gradients) and software in the past several years, acquisition times can now be markedly decreased for contrast-enhanced MRA. Based in part on the use of parallel imaging in combination with the improved SNR of 3 T systems, high temporal resolution MRA studies became feasible without diminishing image quality in terms of spatial resolution. For example, recent studies have demonstrated a temporal resolution for high-resolution contrast-enhanced MRA of the carotid arteries as high as 1.5 seconds per scan (3D volume acquisition).

Strategies to reduce acquisition time per 3D volume include the reduction of TR, a rectangular FOV, partial Fourier data sampling, and parallel imaging (applied both in-plane and through-plane). In this setting, the main technical advance to substantially further reduce acquisition time consisted of the application of highly accelerated, parallel imaging in combination with temporal echo sharing. These fast, time-resolved MRA techniques are now available from several vendors, with two common acronyms for this approach being TWIST (time-resolved angiography with interleaved stochastic trajectories) and TREAT (time-resolved echo-shared angiographic technique).

These imaging techniques are based on special k-space sampling. In this setting, k space is divided into two regions. Whereas the centrally located region of k space provides information regarding image contrast, the peripherally located aspect of k space contributes principally to high spatial resolution. The main factor contributing to the acceleration of the sequence acquisition in this particular imaging approach is the fact that k-space lines in the center are more frequently sampled than are the k-space lines in the periphery during the passage of the contrast medium bolus through the covered 3D volume. For that reason, the frame rate with this technique is much higher than in conventional full k-space acquisition. The acceleration depends on the factor of this undersampling of peripheral k-space lines.

Major advantages of time-resolved MRA protocols include (1) a substantial reduction in gadolinium chelate dose (currently half to a quarter of that required with conventional techniques), (2) the ability to obtain multiple phases, enabling demonstration of arterial and venous flow, directionality of flow, and visualization of delayed filling, and (3) the lack of a need for a test bolus. Given the advent of nephrogenic systemic fibrosis (NSF), with the incidence of this disease dependent not only upon the agent used but also on dose (both as given in a single setting, as well as cumulative), time-resolved MRA is likely to play a major role in MR in the future. Other advantages include decreased arterial-venous overlay, reduction in motion artifacts, and the additional diagnostic information available from the temporal assessment of contrast enhancement of the vessels and tissue perfusion.

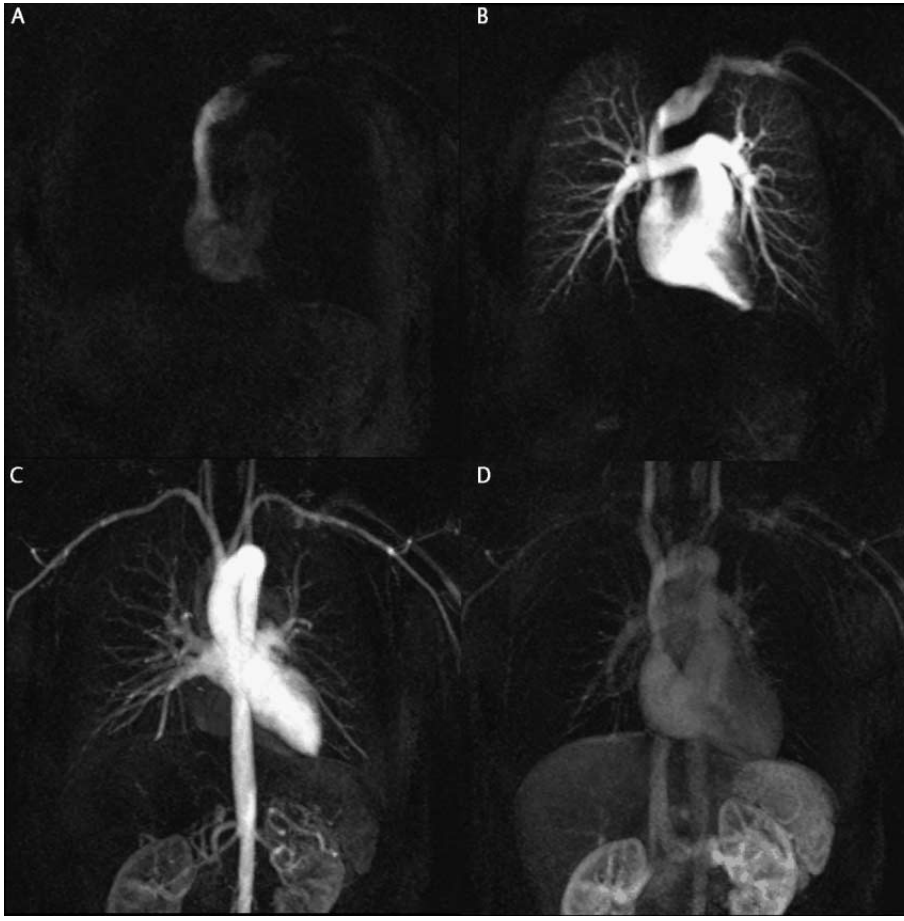

Fig. 49.1

Figure 49.1 (courtesy of Günther Schneider) demonstrates four consecutive maximum intensity projection (MIP) reconstructions of a dynamic contrast-enhanced MRA study of the thorax and upper abdomen acquired during a single breath-hold. Temporal resolution in this sequence acquisition was 2 sec per acquisition. (**A**) displays the arrival of the contrast bolus in the superior vena cava and the right atrium, and (**B**) demonstrates excellent depiction of the pulmonary arteries. The MRA data set in (**C**) was acquired during the systemic arterial phase with the contrast agent in the aorta, the supraaortic vessels, and the abdominal branches. (**D**) depicts the systemic venous phase with good delineation of the superior and inferior vena cava, the right atrium, and the abdominal veins.