46 Contrast-Enhanced MRA: Basics; Renal, Abdomen

The contrast-enhanced MRA maximum intensity projection (MIP) image displayed in **Fig. 46.1A** demonstrates the abdominal aorta and common iliac arteries, with moderate to severe stenosis noted at the origin of the left renal artery (arrow). **Figure 46.1B** demonstrates extensive atherosclerotic disease involving the aorta, with severe stenosis at the origin of the left renal artery. Both studies were performed at 1.5 T.

The study presented in **Fig. 46.2** (reprinted with permission from U. Kramer, *Invest Radiol* 2007;42:747) illustrates the feasibility of high spatial resolution contrast-enhanced MRA at 3 T, providing a further improvement in evaluation of the renal artery and its branches. Early branching is demonstrated, involving both renal arteries, in this potential, living, related kidney donor. The voxel size was 1 mm^3, the contrast dose 0.1 mmol/kg injected at 2 mL/sec and the scan time 16 sec (with a parallel imaging factor of 3 employed). An additional advantage of this type of acquisition is the ability to reconstruct high-resolution images in any desired plane, given the high spatial resolution and isotropic voxel dimensions. Such reformatted images are similarly advantageous for the evaluation of renal artery stenosis. In this application, 3 T offers substantial advantages compared with 1.5 T, largely due to the inherent increase in SNR. Improved suppression of background tissue, due to the prolongation of T1 at 3 T, aids as well by further increasing CNR.

Contrast-enhanced MRA (CE-MRA) has become the exam of choice for evaluation of the abdominal aorta and renal arteries. The standard imaging sequence is a fast 3D

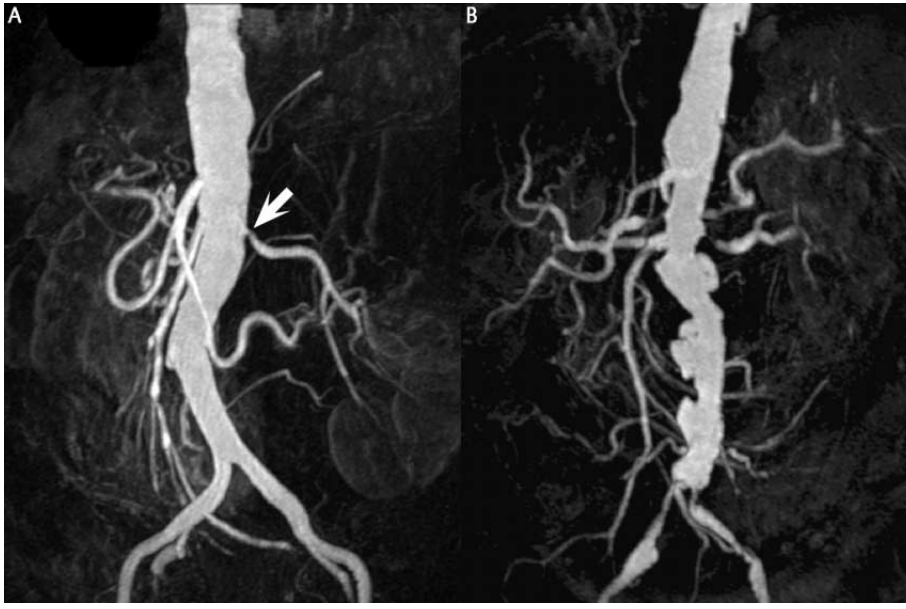

Fig. 46.1

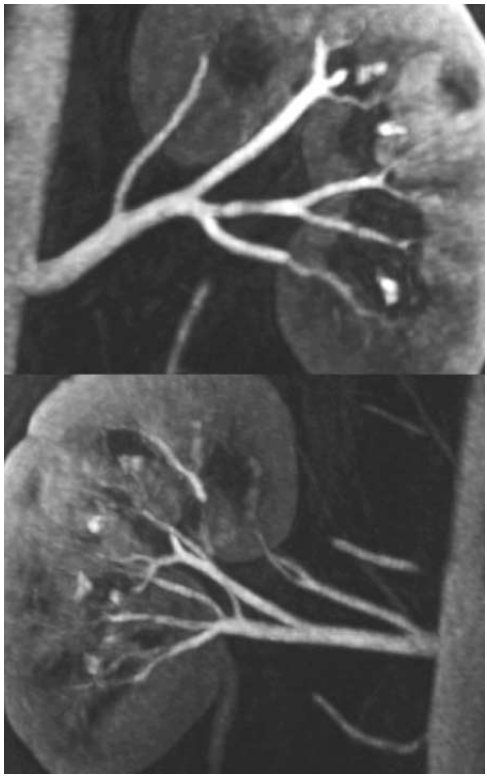

Fig. 46.2

spoiled gradient echo scan. Thin sections (on the order of 2 mm or less) are acquired in the coronal plane within a breath-hold (typically 20 sec or less), using a very short TR and TE. Acquiring a 3D volume in such a fashion results in a high degree of saturation (low MR signal) of the background tissues. Bolus injection of a gadolinium chelate leads to a substantial reduction in the T1 relaxation time of blood, producing images with very high signal intensity vascular structures, due to the gadolinium chelate "enhanced" blood within. Typically 20 to 40 mL of contrast medium is injected at a rate of 1.5 to 3 mL/sec. The bolus of contrast agent is immediately followed by a bolus of normal saline, typically 20 to 30 mL injected at the same rate. The purpose of the saline is to maintain the contrast in a tight bolus as it travels through the vascular system.

In every MR acquisition, and of particular relevance for CE-MRA, the raw data (as sampled) occupies k space, the coordinates of which are frequency and phase as opposed to x and y. High spatial frequency data, found in the periphery of k space, principally contains information regarding image detail. Low spatial frequency data, found in the center of k space, principally contains information regarding image (tissue) contrast. The position of data in k space is determined by the amplitude of the phase-encoding gradient applied prior to sampling of the echo (MR signal). Echoes acquired during the application of high-amplitude gradients principally contain information regarding spatial resolution. Echoes acquired during the application of low-amplitude gradients principally contain information regarding tissue contrast (as well as containing most of the observed signal). CE-MRA acquisitions are timed such that the acquisition of the central lines of k space coincides with the maximum concentration of contrast media (gadolinium chelate) in the area of interest.

It is therefore very important to know both the circulation time to the area of interest and the order in which the k-space data are collected. Most systems allow the operator to select the order of k-space filling. Typical terminology used refers to the filling of the central portion first as *centric* and the filling of the outer lines first as *linear*.