Magnetic Resonance Venography

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10.1 Introduction

The literature of conventional contrast angiography has traditionally focused on arteriography and in fact, many texts make scant reference to venography. Indeed, good-quality conventional venography has long been a challenging procedure for several reasons. First, unlike arteriography, where smaller distal branches are visualized from a central injection in a larger artery, the vein in question or one of its smaller tributaries needs to be directly cannulated for opacification as flow is away from the point of injection towards larger vessels; e.g., a small foot vein must be cannulated in order to study the veins of a lower limb. Second, full evaluation of all the lower limb veins for exclusion of thrombus with conventional venography can actually be quite a complex and technically demanding undertaking, requiring large volumes of contrast medium, careful biplane filming of all veins, and intermittent application of tourniquets [1]. Furthermore, the study of large central veins requires simultaneous bilateral limb injections in order to opacify these capacious low-pressure vessels, for example, bilateral arm injections to show the SVC (Fig. 10.1).

However, even with this technique of bilateral simultaneous injection the full opacification of large central veins can be problematic due to the influx of unopacified blood from other tributaries, e.g., from the jugular veins to the brachiocephalic veins, from the renal veins to the IVC, etc. Meanwhile, some veins cannot be routinely evaluated even with a meticulous technique as their tributaries are not accessible (e.g., the deep femoral vein), and diagnosis of deep venous thrombosis (DVT) in evaluable veins often has to be inferred from the non-opacification of those that would be expected to be seen, rather than from more direct visualization of thrombosis such as a contrast-outlining clot shown as a filling defect. Finally, particularly for lower limb venography, large volumes of iodinated contrast medium are required and even with modern contrast media, the development of phlebitis or deep venous thrombosis is a recognized complication of the procedure, while provocation of pulmonary thromboembolism has also been recorded.

Other non-invasive modalities have had success in venous imaging but have their shortcomings in comprehensive assessment; for example, while ultrasound techniques are widely and successfully employed in evaluation of the superficial veins of the legs and in suspected lower-limb DVT, significant limitations persist for the evaluation of deeply situated or inaccessible veins and delineation of the small deep calf veins remains challenging, particularly in the swollen leg. CT has been little used for primary diagnosis of DVT, although there are advocates of its use as an adjunct to the investigation of pulmonary embolism where a delayed scan 3 min after a CT pulmonary angiography study is used to assess the large veins of the pelvis and thighs. However, this is not widely practiced and due to contrast extraction in the limbs, venous opacification is often poor while small deep calf veins are not assessable [2]. In the thorax central venous assessment by CT is often hampered by beam hardening artifacts at the thoracic inlet, and inflow of unopacified blood may be problematic, similar to conventional venography. The techniques of magnetic resonance venography (MRV) have largely overcome many of the pitfalls of other modalities for diagnostic use [3], particularly the contrast-enhanced techniques, though their clinical uptake has until now been slow out – with specialist centres. Now with the ease of performance of MRV using blood pool contrast agents reducing timing errors etc. this is likely to change. The following discussion examines the history of body MRV with a brief description of the applicable techniques, the use of blood pool contrast agents, and how they enhance MRV.

10.2 Magnetic Resonance Venography

Magnetic Resonance Angiography (MRA) was initially developed in the 1980s with the flow sensitive MRA techniques (Time of Flight and Phase Contrast) relying on maximisation of signal difference between flowing blood in the lumen versus the vessel wall and surrounding tissues. This can be problematic for venous imaging where