19 Pelvic and Peripheral Veins

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CONTENTS

19.1 Introduction ........................................ 321
19.2 Technical Considerations ........................... 321
19.3 Applications of MRA ............................... 322
19.3.1 Venous Anatomy ................................. 322
19.3.2 Venous Anomalies ............................... 323
19.4 Conclusion ......................................... 335
References ............................................... 335

19.1 Introduction

Venous thrombosis in the lower extremity and pelvic veins is a serious complication that may occur especially following surgical interventions and traumatic events, as well as during pregnancy or after delivery. Pelvic and lower extremity veins are believed to be the origin of 85%-95% of pulmonary emboli. Other conditions like inborn or acquired anomalies or external compression by space-occupying lesions may also compromise blood flow in these vessels.

The traditional diagnostic workup for venous pathologies in the lower extremities and pelvis consists mainly of invasive venography with contrast material (FERRIS 1990; NAIDICH et al. 1988; REDMAN 1988). However, although rarely, complications such as systemic reactions to contrast material, tissue necrosis secondary to extravasation of contrast material, postvenographic thrombosis, and pulmonary embolism may be associated with venography. Noninvasive methods like real-time ultrasonography (US), Doppler or duplex US, impedance plethysmography, and radionuclide studies have yielded varying results: impedance plethysmography and radionuclide studies have not been sufficiently accurate to warrant the abandonment of venography (CRONAN 1991; HAYT and BINKERT 1990); ultrasound methods are accurate but user dependent and do not allow for easy examination of the calf and pelvis (CRONAN 1991; YUCEL et al. 1991). Additionally, most of these methods do not provide information on the internal iliac veins and their branches or on the ovarian veins. Moreover, complete diagnosis of venous dysplasia often requires additional direct puncture for visualization of the dysplastic vessels and their drainage.

19.2 Technical Considerations

Inflow magnetic resonance angiography (MRA) is the best method for demonstrating the lower extremity and pelvic veins. A spoiled gradient-echo sequence helps to minimize magnetization in the transverse plane of stationary tissues. The 2D technique is preferable in order to avoid saturation effects due to low flow velocities. For 2D time of flight (TOF) venography, flow compensation is routinely applied along the slice-select and readout directions. Higher order flow effects are less important than for MR arteriography since collaterals develop rapidly and abnormal vessels with normal flow patterns are more common than visible venous obstruction. Presaturation pulses above the examination plane (40–80mm thick) are crucial in order to suppress arterial blood flow signal. Slice thickness should not exceed 3–4mm in the lower extremity and 1.5–2mm for assessment of the pelvic veins since otherwise, due to their oblique direction, edge artifacts may be disturbing. The best results can be achieved using the shortest possible TR and TE in combination with a relatively large flip angle (around 60°). An imaging matrix of 128 × 256 pixels in addition to a single data acquisition is sufficient for adequate visualization. Further increase in spatial resolution or in the number of excitations (NEX) leads to a substantial increase in the examination time without a significant improvement in image quality. In contrast to MRA of the upper abdomen, MRA of the lower extremities and pelvic veins does not require breath-holding (ANGLADE et al. 1989; GEHL et al. 1990a; SPRITZER et al. 1988, 1990; TOTTERMANN et al. 1990).
The phase-contrast (PC) technique has been applied to great advantage in imaging of upper abdominal veins like the portal venous system or renal veins. Superior stationary tissue signal suppression and less sensitivity to in-plane flow saturation make 3D PC MRA highly desirable, though at the cost of long acquisition times. With 2D PC MRA, signal-to-noise ratios may be limited (Tavares et al. 1989).

The obtained axial or coronal slices can be reconstructed in multiple projections using the maximum-intensity projection (MIP) algorithm. An overlapping of the acquired slices by 0.5–1 mm helps to improve the quality of the reconstructed MIP images. Such postprocessing techniques are particularly useful for demonstration purposes and for a better overview of the whole examined region. However, accurate diagnosis always requires evaluation of all the individual slices in order to rule out partial thrombosis and to avoid misinterpretations due to overlying vessels (Gehl et al. 1990b; Richter et al. 1993).

Administration of contrast material may improve the results of MRA, particularly in vessels with very slow flow, since the shortening of T1 relaxation achieved by the available paramagnetic gadolinium (Gd) chelates decreases the signal loss due to saturation effects. Flow-related dephasing artifacts are not, however, eliminated in contrast-enhanced TOF or PC MRA (Marchal et al. 1990). Therefore in imaging of vascular malformations a 3D fat-saturated gradient-echo sequence (SPGR or spoiled FLASH) after intravenous administration of 0.1 mmol/kg Gd-DOTA or Gd-DTPA allows excellent delineation of the venous structures (Krestin et al. 1992).

19.3 Applications of MRA

19.3.1 Venous Anatomy

The veins of the lower extremities may be classified into three categories: deep veins including the main trunks and muscle veins, superficial veins, and perforating veins. The deep veins are enclosed by the deep fascia. In the calf, three main pairs of deep veins accompany the respective arteries (anterior tibial, posterior tibial, and peroneal veins). These three trunks merge in the upper third of the calf to form the popliteal vein, which is commonly single but may be paired in up to 20% of subjects. Multiple muscle veins (soleus, gastrocnemius) empty into the posterior tibial, peroneal, or popliteal veins. The main deep veins of the thigh, the superficial femoral vein and the profunda femoris vein, drain into the common femoral vein at the level of the groin. In the pelvis the internal iliac veins receive the venous drainage of the gluteal (superior and inferior), the internal pudendal, and the obturator veins and merge with the external iliac veins to form the common iliac veins. Testicular and ovarian veins drain at a higher level: on the right side directly into the inferior vena cava and on the left into the left renal vein. During pregnancy and in the postpartum period, ovarian veins are markedly enlarged (the diameter on the right may reach up to 2.5 cm). Variations in venous topography are common. Particularly duplication of deep venous trunks has to be considered in order to accurately assess thrombotic occlusion of only one branch.

The superficial veins consist mainly of the greater and lesser saphenous veins and multiple other smaller tributaries. The lesser (short) saphenous vein drains into the popliteal vein and the greater (long) saphenous vein empties into the femoral vein at the level of the groin. Above this level superficial veins play a clinical role only as collaterals following obstruction of the deep trunks.

The perforating veins of the lower extremity penetrate through the deep fascial planes and connect the deep veins with the superficial veins. They extend from the foot to the groin.

The deep veins of the lower extremity can be characterized as capacity vessels. They contain varying volumes of blood with only minimal changes in pressure. Venous blood return at rest depends on small local pressure gradients, on dynamic pressure transmitted from the arterial side, and on changes in intrathoracic pressure. Only with muscle contraction are dynamics of venous flow different because the veins of the calf are markedly compressed by the contracting muscles and refill with blood during muscle relaxation. This is the reason why accurate detection of the venous structures of the calf is not always possible by means of inflow MRA. Compression during the examination or administration of a contrast agent may improve the results. In contrast, the deep veins above the knee are well depicted. This applies to the superficial femoral and the deep femoral veins as well as the greater saphenous vein (Fig. 19.1).

In the pelvis the common iliac, the external iliac, and the internal iliac veins are adequately visualized in all patients (Gehl et al. 1990b; Richter et al. 1993;