

Advanced venous imaging and image-guided venous interventions

Venous disease, particularly venous thromboembolism, is associated with significant mortality and morbidity. Over 200,000 first lifetime cases of venous thromboembolism occur every year in the United States. If the disease remains undetected, long-term morbidity can be significant. Up to 40% of patients with symptomatic deep vein thrombosis (DVT) develop post-thrombotic syndrome within 2 years, with markedly increased risk for those who suffer from recurrent episodes of DVT. Furthermore, approximately 5% of patients with pulmonary embolism (PE) secondary to venous thrombotic disease develop chronic pulmonary hypertension with decreased cardiopulmonary capacity.

Ultrasound is the first line modality for the detection of DVT. CT and MR venography may play a complimentary role to ultrasound, especially for iliofemoral or subclavian DVT. CT venography can also serve as guide for catheter based interventions, such as catheter-directed thrombolysis. Contrast enhanced MR venography enables characterization of the thrombus with regard to acuity, which may help individual patient management. Dilation, wall thickening and surrounding edema as inflammatory responses are seen in acute to subacute DVT; whereas signal heterogeneity within the thrombus and post thrombotic residual material is visualized in more chronic cases of DVT.

A variety of minimally invasive image-guided interventions can be performed for treatment of venous thromboembolism. Catheter-directed thrombolysis with or without mechanical thrombectomy in acute DVT can clear thrombus from the veins, thereby preserving the venous valves and decreasing the risk of post thrombotic syndrome.

Chronic lower extremity venous insufficiency can reveal a spectrum of manifestations from spider or varicose veins to lipodermatosclerosis and venous ulcers in more severe cases. Treatment options include endovascular radiofrequency or laser ablation techniques as well as sclerotherapy based approaches. Endovascular techniques have proven equality to surgical technique with regard to treatment efficacy but with the major advantages of faster recovery times and decreased pain levels.

In massive and submassive acute PE, mechanical clot maceration and ultrasound-assisted catheter directed thrombolysis may improve outcome and is associated with low rates of major bleeding events, including intracranial hemorrhage.

These different aspects of venous imaging and venous interventions are discussed in a variety of high quality papers in this focused issue. The paper from Grewal and colleagues is dealing with complications associated with inferior vena cava filters including procedure related and post procedure complications (1). The article from Hulsberg and colleagues describes minimal invasive treatment options for the major venous compression syndromes, namely Paget-Schroetter syndrome, nutcracker syndrome and May-Thurner syndrome (2). The manuscript from Kuyumcu and Walker elaborates on a variety of inferior vena cava filter retrieval techniques (3). Golowa *et al.* are discussing the clinical presentation of inferior vena cava thrombosis and endovascular management options (4). Behraves and colleagues are focusing in their paper on the clinical and imaging aspects of venous malformations including treatment strategies (5). Catheter directed interventions for acute DVT treatment are gaining increasing popularity due to a reduction in the number of post thrombotic syndromes as discussed by Kohi *et al.* (6). Multimodality imaging of venous compression syndromes with evolving techniques, such as magnetic resonance venography is the focus of the paper by Zucker and colleagues (7). In the manuscript from Farrell *et al.* post-thrombotic syndrome is approached comprehensively including clinical aspects, diagnostic work-up and endovascular management (8). Ghandour *et al.* are describing the embryologic basis and clinical implications of inferior vena cava anomalies (9). In the paper from Karuppasam the value of cone-beam computed tomography combined with digital subtraction angiography for the assessment of the porto-spleno-mesenteric venous system is clearly demonstrated (10). Endovascular thermal ablation and ultrasound guided sclerotherapy are evolving minimal invasive therapeutic options for the treatment of perforator venous insufficiency as elaborated on by Kuyumcu and colleagues (11). The pathophysiology and role of imaging in lower extremity venous reflux is discussed in the paper from Baliyan *et al.* (12). A major application of blood pool contrast agents in magnetic resonance imaging is for the depiction of the venous system as shown by Oliveira and colleagues (13). Recent developments in non-invasive DVT imaging are approached in the manuscript of Karande *et al.* (14). Madan and colleagues are talking in their paper about the increasing use of novel anticoagulants in the clinical arena for venous thromboembolism treatment based on the current evidence (15). Catheter-directed thrombolysis as treatment option for PE is currently an exciting topic as discussed in the mini-review from Zarghouni and colleagues (16).

The research paper from Joseph *et al.* is dealing with real-time magnetic resonance imaging of exercise induced deep venous blood flow (17). Finally, the multidisciplinary PE response team at Massachusetts General Hospital is described on a case-based approach by Monteleone and colleagues (18).

This is an exciting collection of articles focusing on recent advancements in the field of venous imaging and venous interventions. We hope that the readers of the journal will enjoy this high quality collection of manuscripts as we did as editors during preparation of the Focused Issue for *Cardiovascular Diagnosis and Therapy*.

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