Functional diagnosis in venous disease

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In the current presentation, venous disease is defined as deep venous thrombosis (DVT) and chronic lower extremity venous insufficiency (CVI). These conditions are interlinked, as CVI often is a consequence of DVT that occurred years earlier, defined as postthrombotic syndrome (PTS). The reported incidence of PTS varies in the literature between 40 and 75% of those with previous DVT.

Deep venous thrombosis

A large fraction of the DVT-episodes are clinically silent. Screening studies have shown that more than 90% of calf vein thrombi are asymptomatic (Carter 1994). Twenty percent of these may migrate to the femoropopliteal segment, where 40-50% becomes symptomatic. Early detection of DVT is essential to limit the fraction of patients developing valvular reflux (Markel et al. 1992).

The clinical signs of DVT, including increased skin temperature, redness, oedema, tenderness and positive Homan's sign, are unreliable, and warrant objective examinations. The diagnostic tests can separately be considered as *anatomic* or *functional* procedures.

Anatomic tests. The anatomic tests include contrast phlebography, ultrasound B-mode scanning, isotope scanning, thermography, and not so frequently used magnetic resonance imaging and computed tomography. These tests are those performed according to a rigid protocol and require minimal operator decision making.

Functional tests. The functional tests include Doppler ultrasound examination, colour-flow ultrasound scanning and plethysmography. In general, subjective testing is more versatile, and requires maximal operator input to obtain the greatest amount of accurate information. The operator frequently modifies the test protocol during the procedure according to knowledge of anatomy, physiology, pathophysiology, hemodynamics, physics, and instrumentation.

Combined tests. Colour-flow duplex (CD) scanning combines direct ultrasound image data with indirect Doppler-derived flow data. Direct image requires actual visualisation of the thrombus. Indirect image test consists of absence of normal venous wall movements during the respiratory cycle or with external pressure. The Doppler flow data are considered positive for DVT in the absence of normal venous flow pattern. These include flow synchrony with respiration and flow augmentation at distal compression.

In an increasing number of centres, CD scanning has replaced contrast phlebography as the primary technique. Several authors claim that CD constitute the new "golden standard", at least proximal to the knee. CD scanning has an overall accuracy of 96-100%

in detecting symptomatic DVT in the femoropopliteal veins. The detection of isolated calf veins is less accurate, but nevertheless approaches 90% in experiences hands. Visualisation of the iliac veins is often impaired because of overlying bowel gas and measurement depth. Consequently, the patency of iliac veins often has to be inferred from the flow pattern in the femoral vein. Continuous, non-phasic flow associated with poor augmentation at distal compression implies obstruction in the iliac vein or vena cava.

Plethysmographic recording of maximal venous outflow may also be used to detect outflow obstruction proximal to the knee level. In our experience, a two-phase emptying curve is typical for iliac or vena cava thrombosis.

Chronic venous insufficiency

CVI is defined as an abnormally functioning venous system caused by venous valve incompetence with or without associated venous outflow obstruction. It may affect the superficial venous system, the deep venous system, or both. CVI is a common condition, with prevalence of 30-47%, according to the literature. The most severe state, including leg ulcers has a reported prevalence of 0.3-4%.

There are many methods available for assessing CVI, the most important is still based on careful history and detailed clinical examination including continuous wave (CW) Doppler examination, primarily of the superficial veins. This is usually the diagnostic set-up for simple, primary varicose veins. However, at recurrent varicose veins, presence of dystrophic skin changes, ulceration or clinical evidence of deep venous disease, more extensive examinations should be performed. The most common methods are:

- CD scanning
- Venous pressure measurements
- Plethysmography
- Contrast phlebography

CW Doppler examination

CW Doppler examination is best performed standing without weight bearing of the investigated leg. Segments suitable for Doppler assessment are sapheno-femoral junction, femoral vein, great saphenous vein and popliteal vein. Investigation is always accompanied by provocation procedures to identify reflux in that segment (Valsalva manoeuvre, release of distal compression, proximal compression). Doppler assessment improves the accuracy of clinical examination, but should be interpreted with caution. CW Dopplers implies no control of measurement depth, and signals interpreted as superficial may originate from underlying deep veins, and vice versa. The advantages of CW Doppler are it is relatively cheap, easy to use, readily available, and well suited for outpatient clinics.

CD scanning

CD scanning overcomes the shortcomings of CW Doppler in that it directly identifies the site of measurement (pulsed wave Doppler mode). In addition, the colour-flow mode

speeds up the investigation by rapid identification of arteries and veins, as well as patency of the veins. As in CW Doppler examination CD scanning always include provocation procedures. A reflux time exceeding 0.5 s (some centres use cut-off time 1.0 s) is considered pathological. Because of a very good agreement between CD scanning and both contrast phlebography and peroperative findings, the technique has the potential of replacing phlebography as the primary diagnostic tool for CVI. In many centres it already has. The disadvantage is, however, that the technique requires considerable operator skills and understanding of hemodynamics and the great variability of venous anatomy and function.

Venous pressure measurements
Venous pressure measurements is by several regarded as the "golden standard" for assessing the venous function in CVI, because venous hypertension is the main factor predisposing venous stasis and leg ulcers. The test is performed standing, with and without walking on the spot (or tiptoeing), with and without manual or tourniquet compression of the superficial veins to simulate superficial vein exclusion. The venous pressure, which is normally reduced during ambulation, and the time from stop of walking until pressure reaches its pre-walking level (recovery time) are the diagnostic criteria. Most studies perform pressure recording in a dorsal foot vein. This should be avoided, because patent vein valves in the ankle region may mask proximal pathology. This potential error could explain the lack of agreement between pressure recordings and clinical examination, as found in some investigations.

Plethysmography
The plethysmographic techniques detect volume changes of an extremity. Different recording techniques are available, including mercury strain gauge (SGP), airfilled, waterfilled, impedance or photo (PPG) plethysmographs. The assessment of maximal venous outflow by using these techniques (except PPG) provides objective information on the presence and amount of venous obstructions. Plethysmography are also used in conjunction with specific manoeuvres to evaluate the vein muscle pump system and to detect venous reflux. PPG has been used extensively to mimic vein pressure recordings, especially the recovery time.

Contrast phlebography
Ascending phlebography is used to assess deep and superficial venous anatomy and to identify perforator veins. Descending phlebography is more invasive and primarily used to assess reflux in deep veins and long saphenous veins. If proximal valves are patent, however, the technique may be falsely negative. Furthermore, isolated segmental reflux is generally missed.

Suggested reading

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