

# Techniques for Venous Reflux Disease Evaluation

Patient positioning, imaging, and clinical exam methods for accurate diagnosis.

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Venous return is attained through a complex interaction of valves, muscle pumps, and pressure gradients and is greatly influenced by position. In the upright position, gravity is counteracted by the valve-pump system; however, in the supine position, hydrostatic pressure disappears, and pressure gradients effect flow. Duplex ultrasound (DUS) technology uses sound to provide relatively limited information about this complex physiologic system. The physician must therefore rely mostly on clinical skills when treating patients with venous disease.

## EVALUATING VENOUS DISEASE

The clinical features of chronic venous disease (CVD) involve a combination of historical, physical, and diagnostic findings. The venous examination is best done with the patient standing in a room that is warm and comfortable to ensure that the veins will be less prone to spasm, allowing for any mapping to be completed. Height and weight must be included because the impact of a potential standing column of blood in the lower extremity is directly proportional to venous pressure. A clinical classification called CEAP is widely used (see *CEAP Classification of Chronic Venous Disease*).<sup>1</sup> The designation stands for (C) classification, (E) etiology, (A) anatomy, which includes up to 247 venous segments in the lower limbs, and (P) pathophysiology. The Venous Clinical Severity Score (VCSS) is a useful measure of disease severity, and it provides a method for serial assessment postintervention. Various disease-specific quality-of-life questionnaires provide additional insight into the burden of illness from the patient perspective.

The complexity of venous disease insists on the combining of multiple pieces of information not solely from one

## CEAP CLASSIFICATION OF CHRONIC VENOUS DISEASE

C0	No visible or palpable signs of venous disease
C1	Telangiectasias or reticular veins
C2	Varicose veins
C3	Edema
C4a	Pigmentation or eczema
C4b	Lipodermatosclerosis or atrophie blanche
C5	Healed venous ulcer
C6	Active venous ulcer

source of information, such as DUS. When patients present with CEAP classification 2 through 6, the lower limbs must be inspected for varicosities, scars from previous trauma or surgery, and areas of skin discoloration. Patients with C1 disease rarely need DUS examinations because the disease is localized to the skin. Physicians should anticipate the ultrasound findings based on their clinical findings. Patients with C2 pathology will likely have an incompetent superficial truncal vein with a normal deep system. Those with C4 through C6 would have some postthrombotic changes in the deep system in addition to the superficial changes that may cause deep reflux, obstruction, or both.

## PROPER PATIENT POSITIONING

The standing position has been advocated as the best physiologic position for the DUS reflux examination because this position brings on symptoms in patients with

CVD (Figure 1). In the upright position, venous flow is dominated by the effects of hydrostatic pressure, which is derived from the weight of the column of blood below the right atrium. A typical dorsal foot vein pressure of 95 mm Hg measured in the standing position is derived from 80 mm Hg of hydrostatic pressure and 15 mm Hg of dynamic pressure (from arterial perfusion across the capillary bed). When the hydrostatic pressure column is lost, the dorsal foot vein pressure falls to 15 mm Hg in the same supine patient (0 mm Hg, hydrostatic and 15 mm Hg, dynamic). *Venous reflux* refers to reversal of vein flow, which can be seen in both physiologic and pathologic conditions.

### OTHER EXAM TIPS AND TECHNIQUES

Venous reflux may be elicited by imaging the vein while applying compression to the limb with one of the following methods: release after a calf squeeze for proximal veins or a foot squeeze for calf veins, manual compression of vein clusters, pneumatic calf cuff inflation-deflation, active foot dorsiflexion and relaxation, or the Valsalva maneuver. Compression with release (augmentation) distal to the point of insonation is a reliable method of evaluating for venous valvular incompetence (reflux). Compression is abruptly removed, and the presence and duration of reflux are observed. With compression, vein flow is initially increased as the blood is pushed in the normal direction of flow in a distal-to-proximal direction. Once the pressure is released, blood flow reverses momentarily. Examinations may be conducted in various positions such as supine, different degrees of reverse Trendelenburg, or fully erect. To achieve standardization, measurements can be obtained with pneumatic cuffs with automated inflation and deflation; however, they are not commonly used. The Valsalva maneuver is mainly useful for evaluation of valves in the groin because competent valves proximally will limit its usefulness in the distal part of the lower extremity.

### REFLUX PARAMETERS AND TECHNIQUES IN THE LITERATURE

Masuda et al<sup>2</sup> studied two testing techniques, Valsalva and rapid cuff deflation, performed in two positions: 15° reverse Trendelenburg (RT-15) and standing.

Duplex examinations of 22 extremities in 19 patients with moderate to severe CVD symptoms were compared with duplex scanning of 21 limbs in 11 normal, healthy volunteers. The duration of retrograde flow and peak velocity were measured in 247 venous segments. All extremities were studied in four ways: RT-15 Valsalva, standing Valsalva, RT-15 cuff, and standing cuff. Reflux was defined as the duration of retrograde flow or reflux time > 0.5 seconds. Six venous segments were examined: common femoral, femo-



Figure 1. A patient being evaluated in the upright position by DUS.

ral, deep femoral, and great saphenous in the upper thigh, popliteal, and posterior tibial (at the ankle). The results of testing the Valsalva technique and the cuff in both the RT-15 and standing, nonweight-bearing positions indicate that the Valsalva method is best performed in the RT-15 position as opposed to standing, whereas the cuff technique is more effective in the standing position.

In symptomatic limbs, the RT-15 Valsalva method showed similar proportion of reflux in the upper thigh when compared with the standing cuff method (common femoral, 90% vs 67%; femoral, 81% vs 71%; great saphenous, 88% vs 59%; and deep femoral veins, 30% vs 15%). In the popliteal vein, the standing cuff test showed similar proportion of reflux (77%) as compared with the RT-15 Valsalva test (68%); however, analysis identified a large amount of variability between techniques.

Examination of the posterior tibial veins by all methods produced inconsistencies and a low yield of reflux in symptomatic limbs. In the common femoral vein, RT-15 Valsalva testing produced reflux times of up to 1.5 seconds in normal limbs and represented physiologic reflux. There was no recognizable effect of iliac vein valves on testing distal venous segments by the Valsalva maneuver. The investigators concluded that reflux in the upper thigh veins (eg, com-

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mon femoral, femoral, deep femoral, and great saphenous) is similarly demonstrated in both normal and symptomatic states by cuff deflation and RT-15 Valsalva techniques. In the popliteal vein, discrepancies between these two techniques were identified in patients with CVD, and tibial vein reflux is not well demonstrated by either technique.

Lurie et al<sup>3</sup> conducted a prospective multicenter investigation to define the repeatability of DUS venous reflux and parameters affecting the reproducibility of the test. The study enrolled 17 healthy volunteers and 57 patients with primary CVD. Repeatability of reflux time measurements in *deep veins* did not significantly differ with the time of day, the patient's position, or the reflux-provoking maneuver. Reflux measurements in the *superficial veins* were more repeatable ( $P < .05$ ) when performed in the morning with the patient standing. Interpretations agreed in 93.4% of the replicated measurements when a 0.5-second cut point was selected. Facilitated reproducibility was studied by training vascular technologists from participating laboratories in a standardization course to measure the effect of training on reproducibility. The training intervention improved the frequency of agreement to 94.4%. The investigators concluded that alternations of the time of the duplex scan, the patient's position, and the reflux-provoking maneuver significantly decreased reliability.

### CHOOSING THE RIGHT TOOLS

We are just beginning to scratch the surface of venous reflux evaluation. Because venous DUS examinations are not standardized and are operator dependent, results may become difficult to interpret. As previously described, technique, position, and defined protocols affect the accuracy of the DUS examination in vascular laboratories. In addition, choosing the right transducer is important because axial resolution and tissue penetration are inversely related. A 4- to 7-MHz linear-array transducer is optimal for assessing most veins, which are usually found 1 to 5 cm below the skin. Deep abdominal veins are best assessed using lower-frequency curvilinear transducers for deeper penetration. The focal point should be set at the far wall (in relation to the skin) to achieve better lateral resolution. The lumen of the vein should be set to appear dark in the

absence of stasis and thrombosis. Time-gain compensation (increasing amplification of ultrasound echoes with depth to compensate for their progressive attenuation) is set according to the echogenicity and location of the examined tissues. The weaker the signal seen with increasing depth, the higher the time-gain compensation that will be required. Venous flow is slow, and so the pulse repetition frequency (the number of pulses transmitted per second) is set at 1,500 Hz or lower. Because most veins run parallel to the skin, an insonation angle of 45° to 60° should be used to achieve the optimum Doppler waveform. The character of the pulsed Doppler waveform during retrograde flow (reflux) is quite variable. The size and extent of the refluxing conduit (saphenous trunk) as it empties into a venous reservoir of varying capacitance can affect the tracing. For example, a large-diameter incompetent vein emptying into a small capacitor will yield high peak velocities of short duration. On the contrary, a small-diameter refluxing vein emptying into large capacitor will yield low-velocity tracings of long duration, which re-emphasizes the importance of an active hydrostatic column in the standing position—the capacitor (varicosities) should be full of blood.

We do not currently have a venous Holter monitor and thus cannot measure venous changes through a typical 24-hour day. Ideally, an examination should inform the physician about venous performance during daytime ambulation, evening exercise, and sleep while supine. For the time being, venous clinical examination may be guided by the CEAP classification system combined with noninvasive or more advanced investigations. The ultrasound exam should be performed in the standing position and tailored to the clinical findings.

### CONCLUSION

With an accurate diagnosis and classification, appropriate therapy can be planned. The outcome of therapy can be continuously evaluated using tools such as the Venous Clinical Severity Score. Finally, quality-of-life questionnaires give valuable subjective data to the vascular physician about the real effects of CVD on the patient. ■

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