Optimal Imaging for Varicose Vein Procedures

Which modalities to use and why.

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Since the beginning of time, man has sought tools that allow him to optimize his work. Growth of any field will be stifled if the ideal tools to perform the required tasks are inadequate. Chronic venous disease management has undergone dramatic changes during the past decade as a result of technological developments. Just 2 decades ago, fluoroscopic invasive contrast venography was the gold standard to image venous problems; however, it was by no means ideal. Fluoroscopy generates images by delivering ionizing radiation to patients and requires intravenous injection of an iodine-based solution for visualization of the venous system. The potential for radiation-induced and/or contrast-induced toxicity makes fluoroscopy unattractive to both patients and doctors.

Fluoroscopy, with contrast venography, remains useful for selected cases, but is no longer the workhorse for diagnosis and treatment of venous disease. Fortunately, for patients with varicose veins, the ideal imaging tool was invented, is currently in everyday use, and is known as *color-flow duplex imaging* (CFDI). CFDI transmits sound waves from a transducer, which in turn contact a target, and subsequently generate reflected waves back to the delivery source for interpretation. CFDI consists of three components: grayscale (B-mode), pulsed-wave doppler, and color flow. For this reason, some investigators refer to it as *triplex ultrasound imaging*. CFDI is noninvasive and nontoxic. Formerly only available as large, heavy, expensive devices confined to the hospital arena, portable units have been available in a laptop-style platform since 2002.

Ultrasound technology continues to advance. Recently, devices with tissue harmonics and crossbeam technology were released, resulting in images with incredible resolution. Conventional ultrasound imaging sends out a fundamental beam and receives essentially the same frequency range back as an echo. The sound wave becomes distorted as the tissue expands and compresses in response to the wave. When a certain energy level is reached, this distortion results in the generation of additional frequencies, called *harmonics*, due to acoustic noise that occurs when the ultrasound beam is reflected from the tissues surrounding the targeted area. Although the harmonic signals are weaker than the fundamental beam, they are more pure because they have only to travel one direction. Modern ultrasound units were developed to isolate harmonic frequencies, and subsequently, to enhance contrast and gray-tone differentiation. Another recent breakthrough is crossbeam software, which enhances image clarity by defining continuous boundaries of anatomy and improving overall image resolution. Therefore, ultrasound seems to be the ideal system to image the small structures inherent to varicose vein surgery, and further enhancements are possible with continued technological advancement.

Figure 1. Ultrasound-guided percutaneous venous access.

CFDI FOR VARICOSE VEIN MANAGEMENT

Referable to the field of varicose vein treatment, the most important feature of CFDI is its value preoperatively, intraoperatively, and postoperatively. CFDI is required for diagnosis and treatment planning, for venous access and positioning of devices intraluminally, and for follow-up in the short and long term. It cannot be overstated how CFDI has changed the landscape of venous disease.

Pre-Duplex Ultrasound Era

Before the introduction of CFDI imaging, surgeons would diagnose great saphenous vein (GSV) incompetence solely from the physical examination (ie, a bulging vein in the calf).

The patient would then go to the operating room for surgical stripping of the GSV and phlebectomy of varicose clusters. In the operating room, after opening the groin, a stripping device would be passed "blindly" down the thigh and retrieved from a remote incision distally in the leg. It should come as no surprise that recurrence rates were unacceptably high, largely because of improper preoperative diagnosis and absent intraoperative imaging.

Post-Duplex Ultrasound Era

Today, we know from duplex ultrasound imaging that the GSV is often not the refluxing vessel causing varicosities. Accessory saphenous veins, circumflex veins, or even small groin veins, such as epigastric veins, can be the source. If a surgeon identifies the correct vein before treatment, be it surgical stripping or endovenous ablation, the immediate recurrence rate is extremely low. Recurrences, in contemporary series, come from neovascularization and/or progression of disease and not from improper diagnosis and treatment. It should be emphasized that ultrasound technicians are unfamiliar with superficial venous anatomy and its many variations. The treating physician must therefore be self-sufficient with regard to handling an ultrasound probe and recognizing the nuances of venous anatomy. The goal of the examination is simple: to generate a detailed deep and superficial venous map.

DEEP VENOUS SYSTEM ASSESSMENT

The surgeon needs several pieces of information describing the status of the deep venous system before proceeding with varicose vein treatment: (1) presence or absence of thrombus, (2) status of valve competency, (3) areas of stenosis/obstruction, and (4) anatomic variability. We recommend that the subject be studied on a flat examining table in which the lower extremities may be placed in the dependent position at approximately 15°. This slight angle dilates the deep system, which makes the identification of veins easier and improves the velocity signals. The examination proceeds from the inguinal ligament to the ankles and includes the common femoral, deep femoral, femoral, popliteal, and tibial veins. Anatomic variability, such as duplication and atresia, should also be documented in the report.

The ability to fully compress the vein walls confirms vein patency and absence of thrombus formation. Acute thrombi are characterized by vein dilatation and noncompressible echolucent intraluminal material. Chronic thrombi take on a speckled echogenic ultrasonic appearance. Areas of obstruction/stenosis are documented; however, there are no criteria yet available to accurately quantify the degree of stenosis in the venous system. Continuous flow in a common femoral vein during interrogation with pulsed-wave Doppler is a clue to proximal obstruction. Reflux is determined at locations of interest by adjusting the color box in the measurement location and adjusting the velocity scale (maximum 25 cm/s). While a signal is being obtained, the technician compresses the calf (below the probe) in a brisk manner. The vein highlighted in the color box should demonstrate an increase in velocity toward the heart with compression. On release, the vein should demonstrate no velocity or minimal velocity away from the heart. Reflux (venous flow away from the heart after release) lasting between 0.5 to 2 seconds is mild; reflux is severe if present for >2 seconds.

Figure 2. Endovenous ablation of complex anatomy with intraoperative duplex imaging.

SUPERFICIAL VENOUS SYSTEM ASSESSMENT

In contrast to the deep system, the superficial assessment is carried out in the erect position. With the subject properly positioned, the technician moves the probe to the inguinal ligament and focuses on the GSV. The normal GSV extends from the saphenofemoral junction to the distal calf and is surrounded by superficial fascia above and muscular fascia below. As a minimum, we record diameter measurements in millimeters and the presence of reflux (positive or negative) at three locations in the GSV: the saphenofemoral junction, midthigh, and below the knee. The same evaluation is repeated for the small saphenous vein. This vein originates in the distal calf and can terminate in the upper thigh. Multiple levels may be assessed; however, we generally record a characteristic small saphenous vein diameter (in millimeters) and assess reflux in the most diseased location.

The lower extremity has some common perforators that play significant roles in venous insufficiency. Hunterian perforating veins are located in the midthigh. Dodd perforating veins are located at the distal thigh. The Boyd perforating vein is located below the knee at the upper/medial calf. Finally, Cockett No. 1, 2, and 3 perforating veins are located respectively between the ankle and the lower calf. If present, perforators should be assessed regarding diameter, degree of reflux, and extension to other superficial structures.

INTRAOPERATIVE AND POSTOPERATIVE IMAGING

B-mode ultrasound is used for real-time percutaneous access of the saphenous vein (Figure 1), positioning of wires and catheters (Figure 2), and delivery of perivenous local anesthesia.

Further, it is useful during ultrasound-guided sclerotherapy of venous structures below the skin. In general, color-flow and pulsed-wave Doppler are not required for these actions.

Postoperatively, all three components of color-flow duplex ultrasound are used for determining the adequacy of target vein closure and presence or absence of deep vein thrombosis. Areas of venous recanalization and their need for further treatment with ultrasound-guided sclerotherapy can be monitored with CFDI.

VARICOSE VEINS OF THE PERINEUM

Multiparous women presenting with perineal varicosities are a unique subgroup. Often, the varicosities coursing down the thigh are the result of pelvic congestion syndrome or ovarian vein reflux. CFDI is not the best modality to identify these defects. Instead, magnetic resonance venography or contrast venography may be more suitable.

CONCLUSION

We emphasize that CFDI is not only a diagnostic tool, but it also plays crucial roles in endovenous ablation, ultrasound-guided sclerotherapy, and monitoring the success of vein closure procedures. Contrast venography remains useful to detect pelvic vein incompetence. Since the advent of harmonics and crossbeam technology, we can now identify small structures, such as venous valve leaflets, with satisfactory resolution. Such fine structures were not visible with ultrasound just a few years ago. We expect that progress in the treatment of varicose veins will closely parallel the progress made in ultrasound technology. ■

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