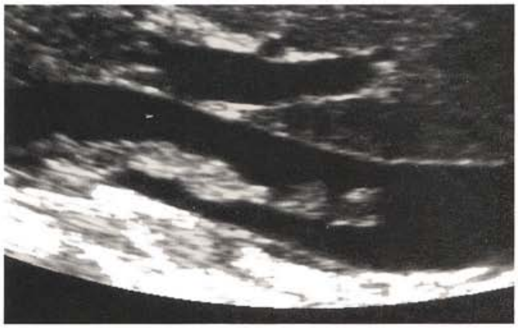
TECHNIQUES OF VENOUS IMAGING



TECHNIQUES OF VENOUS IMAGING

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CONTENTS

THROMBUS IDENTIFICATION AND CHARACTERIZATION

Steven R. Talbot, RVT

The two main goals in diagnosing venous thrombosis are to determine (1) the presence or absence of intraluminal thrombus and (2) the relative risk of embolization. Venous imaging is uniquely suited to both of these tasks. This chapter explains how to differentiate thrombus-free veins from veins containing thrombus. In addition, it emphasizes the importance of observing such things as degree of attachment to the vein wall, echogenicity, and texture of the thrombus. Attention to these characteristics can help in assessing the potential risk of embolization. Finally, this chapter discusses pitfalls and how to avoid them.

IMAGING NORMAL, THROMBUS-FREE VEINS

First, we will discuss the on-screen appearance of normal veins, referring to the vessels as they are visualized from a transverse plane.

The deep veins are located alongside a corresponding artery. This artery can be used as a landmark to find the vein. The artery is a thicker-walled but typically smaller structure, and it is visibly pulsatile. In contrast, the vein has thin walls that are held open only by the pressure of the blood within it (i.e., the transmural pressure).[1] This is an important point, because the size and appearance of the vein vary greatly depending on the pressure within the venous system.

Many factors may affect the caliber of the vein during ultrasonographic examination, the most common being patient positioning. The extremity under examination must be below the level of the

VENOUS IMAGING TECHNIQUE

Steven R. Talbot, RVT

On occasion I have heard people say how easy venous imaging is. I often wonder if we are talking about the same procedure. I have found venous imaging, especially imaging the deep calf veins, to be extremely challenging. Many people have attempted to image veins without formal instruction, only to fail miserably. One of my colleagues had such difficulty that she called venous imaging "imaging in vain."

The best way to avoid this frustration is to have hands-on instruction from an experienced venous imager. Unfortunately, such a person is not always available. Still, anyone getting started in venous imaging should do everything possible to obtain this kind of instruction; doing so takes several months off an already lengthy learning curve.

This chapter is designed to walk the examiner through a complete venous imaging examination, step by step. Exactly how the examination is done in day-to-day practice may vary slightly from examiner to examiner, sometimes because of variations in equipment or personal preference. However, too much variation from the techniques described here may adversely effect the accuracy of your study.

There are three factors for success:

1. Equipment selection.
2. Environment and patient positioning.
3. Proper examination technique.

Venous examinations will be successful if attention is paid to these important factors.

EQUIPMENT SELECTION

The ultrasound equipment itself greatly influences the quality of the study. One should select a high-resolution imager, preferably with an integrated, pulsed, range-gated Doppler.

Special consideration should be given to selecting an imager with excellent resolution in all fields of view. This is important because many of the structures to be examined are very small and may move quickly from a very superficial position to a deep field. Some imagers without variable focusing capabilities do well with vessels in the mid field, but are unable to clearly resolve targets in the near or far fields.

Emphasis also should be placed on obtaining an imager with excellent gray scale. The combination of high resolution and excellent gray scale makes it possible to identify lightly echogenic thrombi that may be missed by imagers without these qualities.

The imager should be able to penetrate to a depth of five to six centimeters. In the design and selection of probes, there is always a conflict—and therefore a compromise—between penetration and image quality. Recently, several manufacturers have addressed this problem quite well, producing probes (usually operating between 8 and 5 MHz) that allow visualization even into difficult areas like the adductor canal and the deep calf while still providing excellent image quality. Color is advantageous, but not necessary for good-quality venous imaging (see Chapter 7).

ENVIRONMENT AND PATIENT POSITIONING

Proper set-up for this examination is extremely important. Neglecting these simple preparations can greatly complicate the examination and even lead to erroneous results.

Ensure a Warm Environment

The first consideration is ambient temperature: If at all possible, the examination room should be warm. A cold environment causes the veins to contract, making small veins even smaller. A thermostat in the examination room is optimal, but most examination rooms are not so equipped, and many studies are done at the bedside where room temperature is not controlled by the examiner. One solution is to provide the patient a warmed blanket whenever the room temperature is cooler than desired. We also do this whenever the patient complains of being cold. This practice helps us not only to obtain better views by enlarging the veins, but also to build rapport with the patient by demonstrating sensitivity to his or her needs.

Tilt the Bed

To examine the lower extremities, the legs of the patient must be well below the level of the heart so that blood pools in the legs, thus enlarging the veins. This is of great benefit when imaging the calf veins. *Omission of this preparatory maneuver is the most common reason for inadequate identification of the deep calf veins.*

The best way to accomplish this goal is to place the patient in a reversed Trendelenburg's position (Figure 6-1). The bed or table remains flat, so the patient is not bent in the middle, but the entire surface is tilted so the head of the patient is elevated. As a general rule, the more elevation, the better the result. A 10–20 degree tilt is usually sufficient.

Another way to achieve dilatation of the veins is to have the patient sit up on the edge of the bed and dangle both legs. The examiner sits in a chair and rests the foot of the leg not being examined in his or her lap (Figure 6-2). This technique can be most helpful when the veins under examination are poorly visualized because of their small diameter. The technique may be quite clumsy, however, if the probe being used has a large scanhead or if the

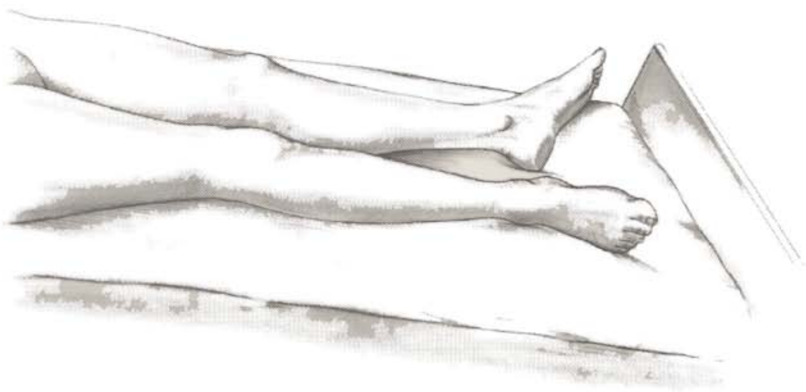

Figure 6-1. Patient in the reversed Trendelenburg's position. The bed is tilted 10–20 degrees with the head elevated to enhance venous filling of the lower extremities.

Figure 6-2. An alternate imaging position that can be used on selected patients. The patient sits on the edge of the examination table with the legs apart. The examiner is seated, facing the patient.

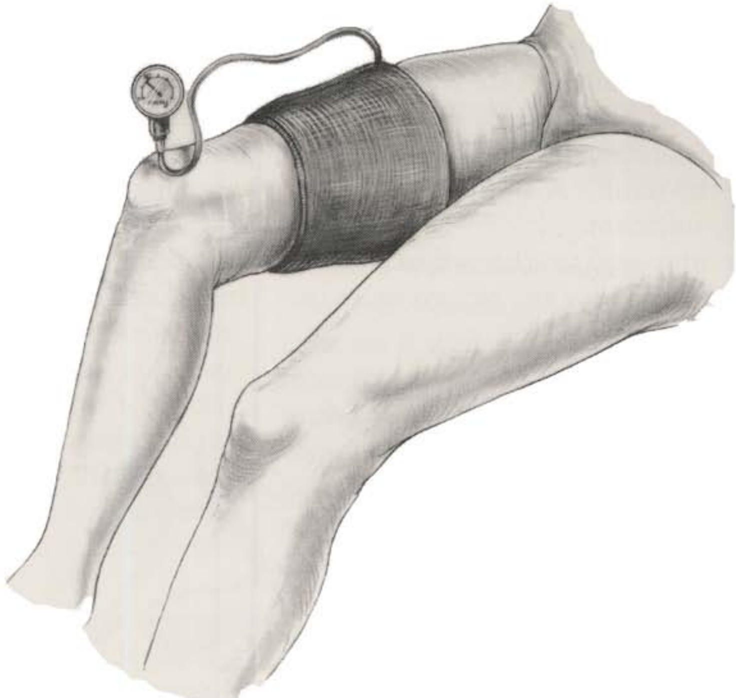

Figure 6-3. *An extreme measure that can be taken to increase the size of the veins being examined involves placing a blood pressure cuff around the thigh and inflating it 30–50 mmHg.*

scanhead has a long handle. Some examiners who have equipment with small scanheads use this position on all patients who can sit up.

One word of caution: The more elevation, the harder it is to compress the veins. The examiner must keep this fact in mind when performing maneuvers that enlarge the veins. For example, an extreme measure to aid in the dilatation of the calf veins is to inflate a blood pressure cuff around the thigh to between 30 and 50 mmHg (Figure 6-3). This traps venous blood in the calf, causing maximum dilatation of even the smallest calf veins. Although this technique is quite effective, it stops the blood in the veins so completely that they may appear to be filled with thrombus. The stagnant flow can become brightly echogenic and can be distinguished from thrombus only by compressing the vein. Because the venous outflow has been occluded by the cuff, these veins are quite resistant to compression. Much more force is needed to compress them. Inexperienced examiners may mistake these difficult-to-compress vessels for veins that are filled with thrombus. For this reason, those who choose to use this thigh-cuff method should inflate the cuff for only a moment or two to allow vessel identification, and then slowly bleed off the pressure in the cuff while imaging. In this way the venous outflow is restored

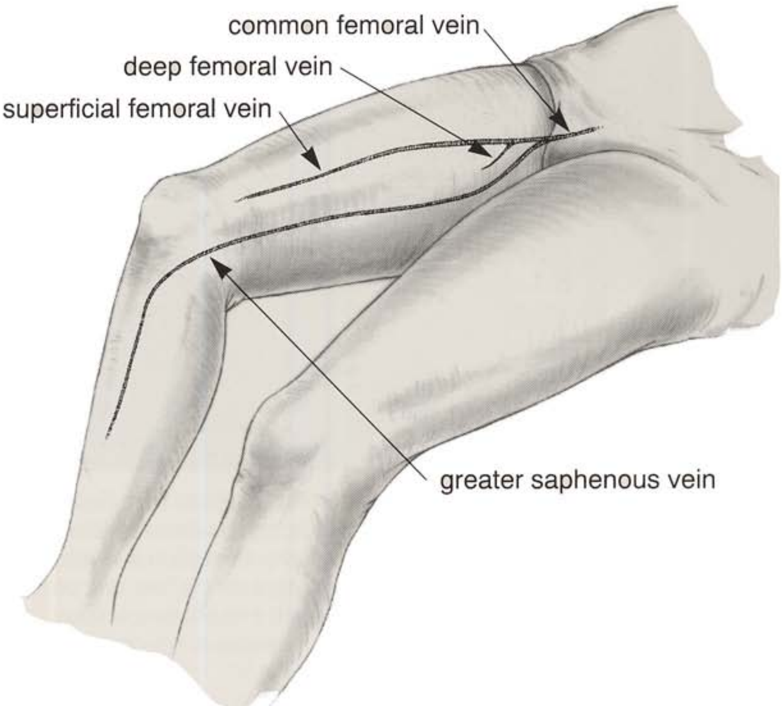

Figure 6-4. *To examine the common femoral, superficial femoral, deep femoral (profunda femoris), and greater saphenous veins, the knee is bent slightly and the hip is slightly rotated externally. For simplicity of presentation, the illustrations in this chapter focus on the right extremity; for the left extremity, imagine a mirror image.*

quickly and the veins can be compressed more readily. This thigh-cuff procedure should be used only after the thigh and popliteal areas have been scanned and found to be thrombus-free.

Begin with the Patient in a Supine Position

With the bed in the reversed Trendelenburg's position, the patient is placed in the supine position to begin the examination. The examiner should inform the patient that the examination will involve no injections. This often calms the anxious patient and allows for better cooperation during the procedure.

Externally Rotate the Leg

The leg being examined should be positioned with the knee slightly bent and with slight external rotation of the hip (Figure 6-4). This is accomplished by so instructing the patient and then carefully guiding the leg until it is in the desired position. Some patients may not be able to externally rotate the hip comfortably unless they move slightly onto their side. Other patients, including those with recent hip replacements, may not be able to do this at all. But if this position can be achieved comfortably and safely, it will make examination of the groin and thigh areas much easier.

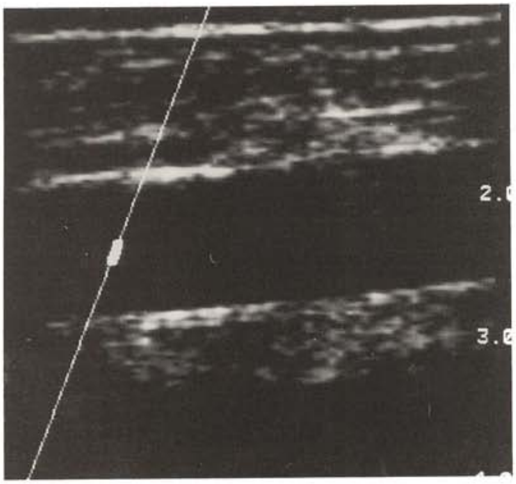

Figure 6-5. *Placement of the Doppler cursor within the lumen of the vein in preparation for pulsed Doppler interrogation of venous flow.*

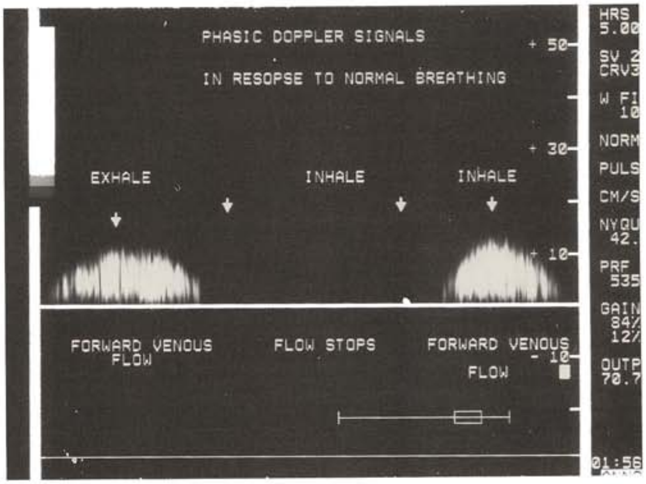

Figure 6-6. *Normal venous flow in phase with respiration. Spectral display of the Doppler signals demonstrates that forward venous flow stops during inspiration and resumes with expiration. This finding suggests that the venous system above the sample site is patent. In this example flow displayed above the baseline represents flow toward the heart.*

Interrogate the Major Deep Veins with Doppler Ultrasound

A generous amount of ultrasound gel is applied to the medial surface of the thigh from the groin to the knee approximating the course of the femoral and saphenous veins. In our laboratory, we perform a continuous-wave Doppler examination of the common femoral, superficial femoral, popliteal, and posterior tibial veins before we begin the duplex examination,[1,2] although pulsed-Doppler interrogation can be performed during the imaging study if so desired (Figure 6-5).

At each major vessel, the examiner should listen for good phasic venous flow signals, i.e., flow that stops during inspiration and returns during expiration (Figure 6-6). The absence of phasic flow or the presence of continuous flow may suggest thrombosis above the level under examination. Once phasic flow is determined, the examiner should squeeze below the area being examined (at the thigh and calf, for example, when listening at the level of the common femoral vein). Augmentation of the flow signal with distal compression suggests patent vessels between the level of the squeeze and the level at which the Doppler signal is obtained (Figure 6-7). Poor augmentation or no augmentation of venous flow during this procedure suggests venous obstruction. Importantly, nonobstructive thrombus

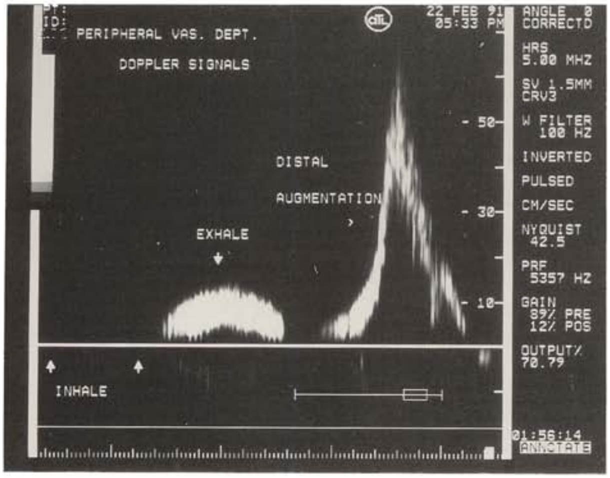

Figure 6-7. A dramatic increase in forward venous flow as a result of manual compression below the site of Doppler examination suggests that the segment of vein between the point of compression and the sample site is patent. The normal finding in this example suggests patency between the point of calf compression and the sample site in the femoral vein.

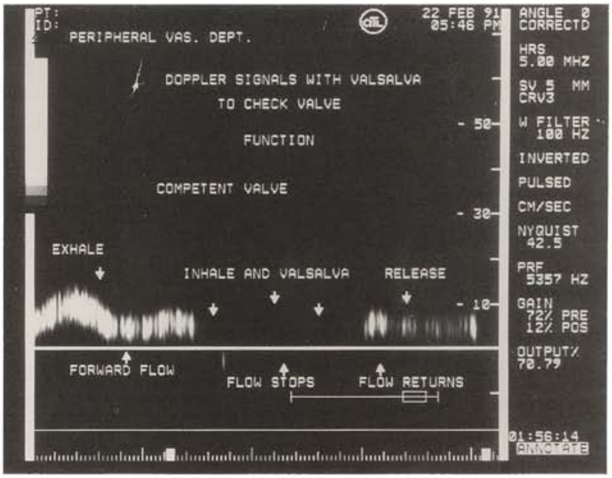

Figure 6-8. An abrupt cessation of venous flow in response to a Valsalva maneuver suggests the competency of the venous valves at the level of examination. Note how forward flow ceases with Valsalva's maneuver and then resumes upon release.

may be missed completely during the Doppler examination.[3]

Competency of the valves can be determined by having the patient perform a Valsalva maneuver, during which the venous flow signal should stop (Figure 6-8). If flow continues or increases during a sustained Valsalva maneuver, the valves in the area under examination are incompetent (Figure 6-9).

If the imager allows the examiner actually to visualize blood flow on the gray-scale image, the venous imaging procedure can be an even more sensitive means of identifying incompetent valves. Here normal flow is observed with passive respiration. Then the patient is asked to

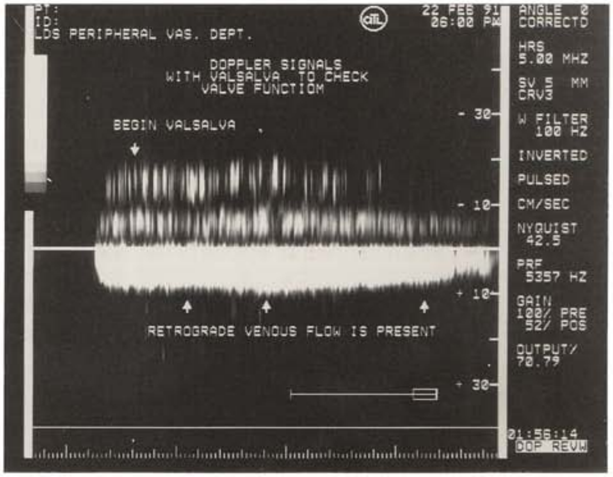

Figure 6-9. Retrograde venous flow during a sustained Valsalva maneuver indicates incompetent venous valves. In this example flow displayed above the baseline represents flow toward the heart.

perform a Valsalva maneuver by straining with the abdominal muscles. If the valves are competent, flow stops; if they are incompetent, flow reverses. This technique often can be used while actually observing the valve at the same time (see Chapter 5). Color flow imaging is also quite helpful in checking for incompetent valves (see Chapter 7).

IMAGING TECHNIQUE: LOWER EXTREMITY

To illustrate the techniques of venous imaging as clearly and as meaningfully as possible, the figures in the remainder of this chapter are presented in three parts:

1. An anatomic illustration of the extremity under examination showing patient position, venous anatomy, and scan sequence.
2. Schematic illustrations of transverse anatomy in standard format (i.e., skin line at top of screen) at key points in the scan sequence. These illustrations represent the ultrasonographically imaged tranverse anatomy as it appears on the screen.
3. Ultrasonographic images taken at the same key points in the scan sequence. These images are in standard format; i.e., the skin line is at the top of the screen.

For simplicity of presentation, all of the illustrations in this chapter focus on the right extremity; for the left extremity, imagine a mirror image if you always keep the orientation notch on the transducer pointed toward you. If, on the other hand, you reverse the orientation notch when imaging the left leg, the vessel orientation will appear the same as for the right leg. For the convenience of readers who are learning or practicing venous imaging techniques, the Appendix presents these illustrated protocols in abbreviated, quick-reference format.

Imaging is begun at the groin crease (Figure 6-10). A transverse scanning plane is used. The transverse view is used instead of a longitudinal view because it allows for a more complete anatomic survey, making it easier to identify and track vessels. This is extremely important, because during venous imaging several vessels must be tracked simultaneously. The transverse view also allows more accurate assessment of vein-wall compressibility.[4]

The Common Femoral Vein

At the level of the inguinal ligament only two vessels will be seen, the common femoral artery and vein (Figure 6-10A). If more than two vessels are visualized when the probe is first placed over this region, the examiner should slowly move the probe higher in the groin until the vessels converge into two large vessels. Once these two structures have been identified, light probe pressure is exerted. If the common femoral vein is thrombus free, it should compress completely (see Chapter 5 for details about the appearance of normal versus thrombotic veins). The structure that does not compress should be the common femoral artery. The artery can be compressed as well, but only with much more probe pressure. This response to

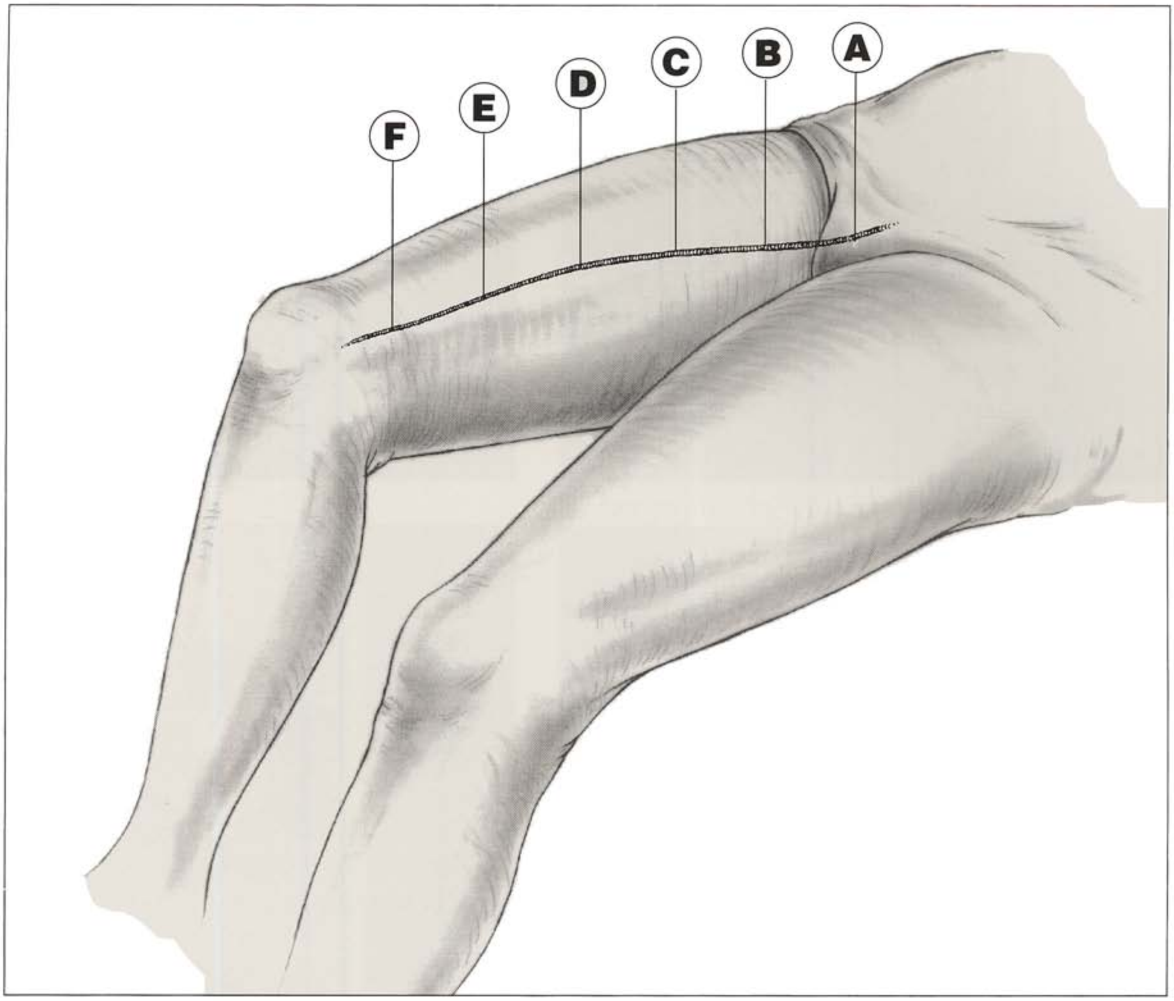

Figure 6-10. *Probe position sequence for examining the common femoral and superficial femoral veins.*