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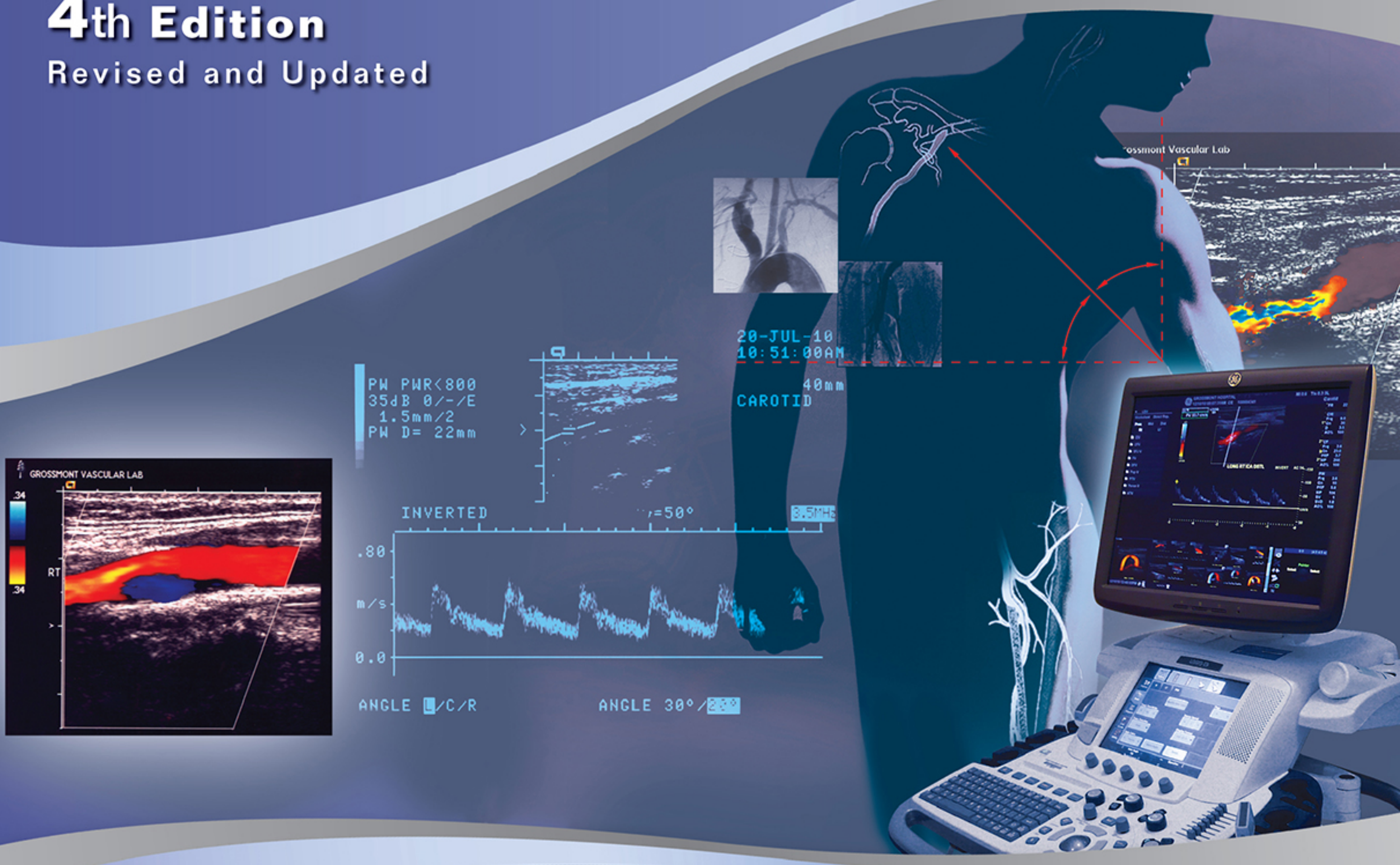
Introduction to Vascular Scanning

A Guide for the Complete Beginner

4th Edition

Revised and Updated



Continuing Education Activity

Approved for 18 Hours' CME Credit

DONALD P. RIDGWAY

GETTING STUCK: A WORD ABOUT THE FLOP SWEATS

When you begin scanning in the real world, on real patients with real disease and for real reading physicians who expect you to come up with really useful information, you will be nervous. You will feel that you have been let loose on an unsuspecting world to cause all kinds of damage. The patient will have tortuous vessels that go to Chicago and back, and there is absolutely no evidence of an external branch anywhere in the patient's body. Another patient is due in five minutes. Your patient is getting restless and has a stiff neck. And you haven't yet acquired any images for your report.

Is that what's troubling you, kiddo?

Stop. Take three slow breaths. (You can pretend to continue scanning while you do this.) Think about what you'll have for lunch; think about mountain lakes, sunny beaches, the water slides at the Family Fun Center. Meanwhile,

UNCLE DON SAYS

DON'T FORGET TO BREATHE!

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Donald P. Ridgway, RVT

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Pasadena, California 91105-1961
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www.daviespublishing.com

Michael Davies, Publisher
Satori Design Group, Inc., Design
Charlene Locke, Production Manager
Christina J. Moose, Editorial Director
Janet Heard, Manuscript Management
Daniel Liota, Digital Media
Stephen Beebe, Illustration
Denise Eggman, Illustration

Library of Congress Cataloging-in-Publication Data

Ridgway, Donald P., 1948- author.
Introduction to vascular scanning : a guide for the complete beginner / Donald P. Ridgway. — 4th edition.
p. ; cm.
Vascular scanning
Includes bibliographical references and index.
ISBN-13: 978-0-941022-83-5 (alk. paper)
ISBN-10: 0-941022-83-8 (alk. paper)
I. Title. II. Title: Vascular scanning.
[DNLM: 1. Blood Vessels—ultrasonography. 2. Ultrasonography, Doppler—methods. WG 500]
RC691.6.U47
616.1'307543—dc23
2013036489

Printed and bound in China

ISBN 978-0-941022-83-5

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CHAPTER

2

Basic Terminology, Jargon, and Buzzwords

"When I use a word," Humpty Dumpty said, in a rather scornful tone,"it means just what I choose it to mean—neither more nor less."
"The question is," said Alice, "whether you can make words mean so many different things."
"The question is," said Humpty Dumpty, "which is to be master—that's all."
—Lewis Carroll, *Through the Looking-Glass*

Talk. . . . It's only talk. . . .
Clichés, commentary, controversy, chit-chat. . . .
—Adrian Bellew (of King Crimson), *"Elephant Talk"*

One thing I tell my students often is that the medical professions are largely about words. If you know the vocabulary, you are a long way toward competence already. If you don't, you are groping in the dark.

Here is something I saw in the newspaper. It's from the "Aces on Bridge" column by Bobby Wolff. I didn't make this up.

> *Dear Mr. Wolff:* My RHO opened one club and I doubled for takeout. Partner cue-bid two clubs and I bid two spades, which partner passed. Doesn't the cue-bidder promise at least one more bid in this situation?
>
> *Answer:* Yes, the cue-bidder does promise another bid after his forcing action. This does not preclude doubler from making a stronger response than minimum if he has values in excess of a routine takeout double.

What on earth are they talking about? You could write this kind of thing with a random-word generator. Obviously this nonsense means something to the folks who play bridge, and so these narrowly defined terms are useful in the narrow context.

And of course it's the same for us in the medical professions: We have to know the talk. Here are some of the terms and concepts used in this guide and in medical imaging generally. Some of these terms are explained more fully in later chapters.

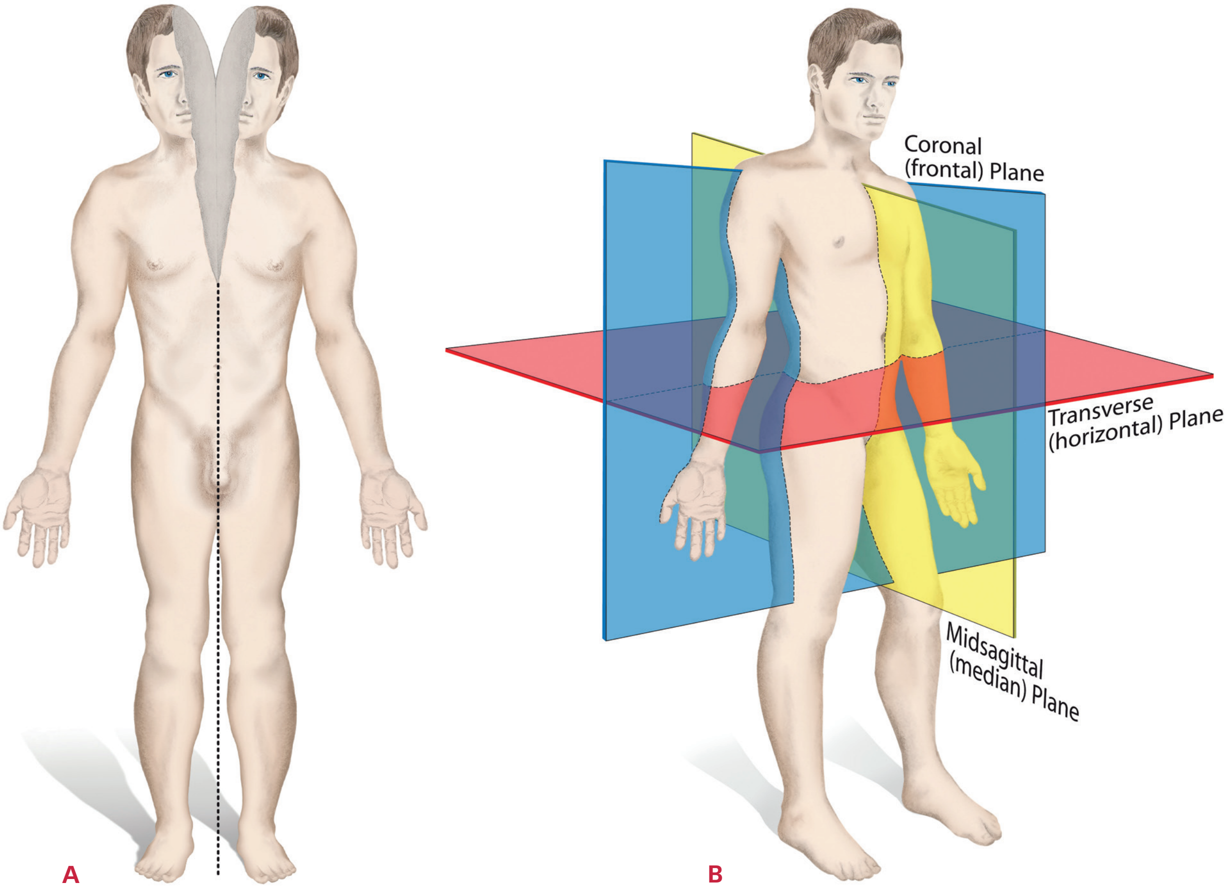
SCAN PLANES

The planes are defined as if you were to make cuts through the body with a buzz saw (Figure 2-1). It helps in remembering them to think of the ultrasound beam as a sort of bloodless buzz saw that divides the body parts into sections as described below.

Transverse This plane divides the body cross-sectionally into top and bottom (superior and inferior) sections. In vascular scanning, *transverse* is often used interchangeably with *short axis*, and that usually works, since most of the vessels we scan run superior-inferior. For the exceptions, it is best to stick with *short axis* when we want to indicate a cross-sectional view.

Sagittal This plane divides the body into right and left sections. *Sagittal* is often used interchangeably with *longitudinal* or *long axis*. As noted with transverse/short axis, it usually works to use those terms interchangeably, but be alert for the exceptions, in which case stick with *longitudinal* or *long axis*.

Figure 2-1. **A** *This poor fellow is being divided along a sagittal plane, in this case the midsagittal plane since it's down the middle.* **B** *Transverse, midsagittal, and coronal (frontal) body planes. Any plane angled differently from those illustrated here is an oblique plane.*



It's best to remember the difference between *long axis* and *sagittal*: The first is suitable for any structure, whether it is a vessel or, say, a kidney. The second should be used strictly for that body plane.

Frontal or **coronal** This plane divides the body into front and back (anterior and posterior) sections.

Oblique This is any plane that is not transverse, longitudinal, or coronal. Returning to the buzz-saw illustration, suppose your victim is lashed to a log lengthwise. (If you are squeamish, perhaps you should read the rest of this paragraph with your eyes closed.) Then he will be divided in a sagittal plane. If he is lashed to the log crosswise, with hands and feet tied together, he will be divided in a transverse plane. And if the victim twists around under the ropes so that the saw divides him, say, from the right shoulder to the left hip, he will have been divided in an oblique plane.

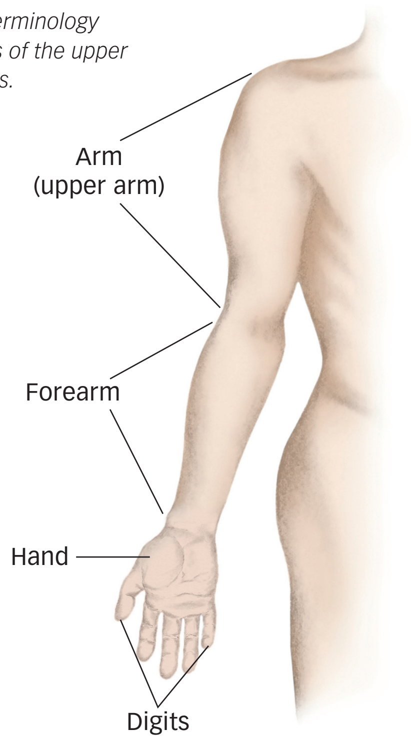


Figure 2-2. *Terminology for and locations of the upper extremity regions.*

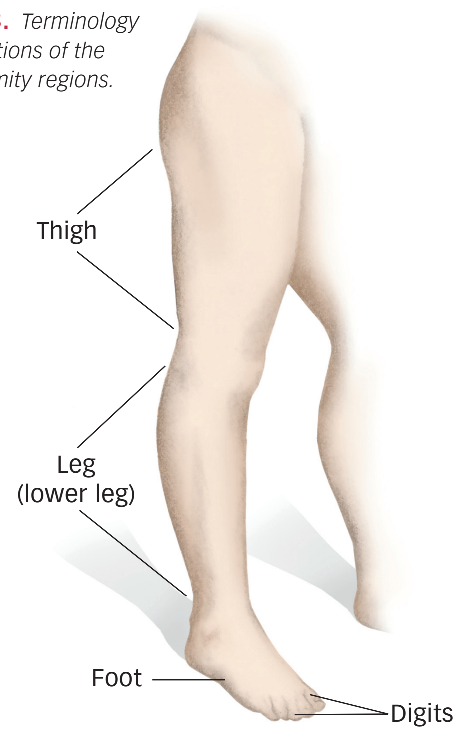


Figure 2-3. *Terminology for and locations of the lower extremity regions.*

We should take a moment to clarify the proper medical terminology for the, ahem, arms and legs. In medical-speak, *arm* actually refers to just the segment from shoulder to elbow; *forearm* refers to the segment from elbow to wrist (Figure 2-2). The whole limb is the *upper extremity*, even though nonmedical usage uses *arm* to refer to the whole thing. I recommend using *upper arm* rather than just *arm*, to prevent any confusion whatsoever.

And in medical-speak, the leg is actually the *lower extremity*. *Thigh* refers to the segment from groin or hip to knee, and *leg* refers to the segment from knee to ankle (Figure 2-3). Again, to eliminate confusion, I recommend *lower leg* instead of just *leg*.

BODY ORIENTATIONS

Medial Toward the center line of the body.

Lateral Away from the center line of the body.

These terms also can be used to indicate the location of one structure in relation to another structure; e.g., *The thyroid is* medial *to the common carotid artery, or the cephalic vein is* lateral *to the basilic vein in the arm*. See Figure 2-4.

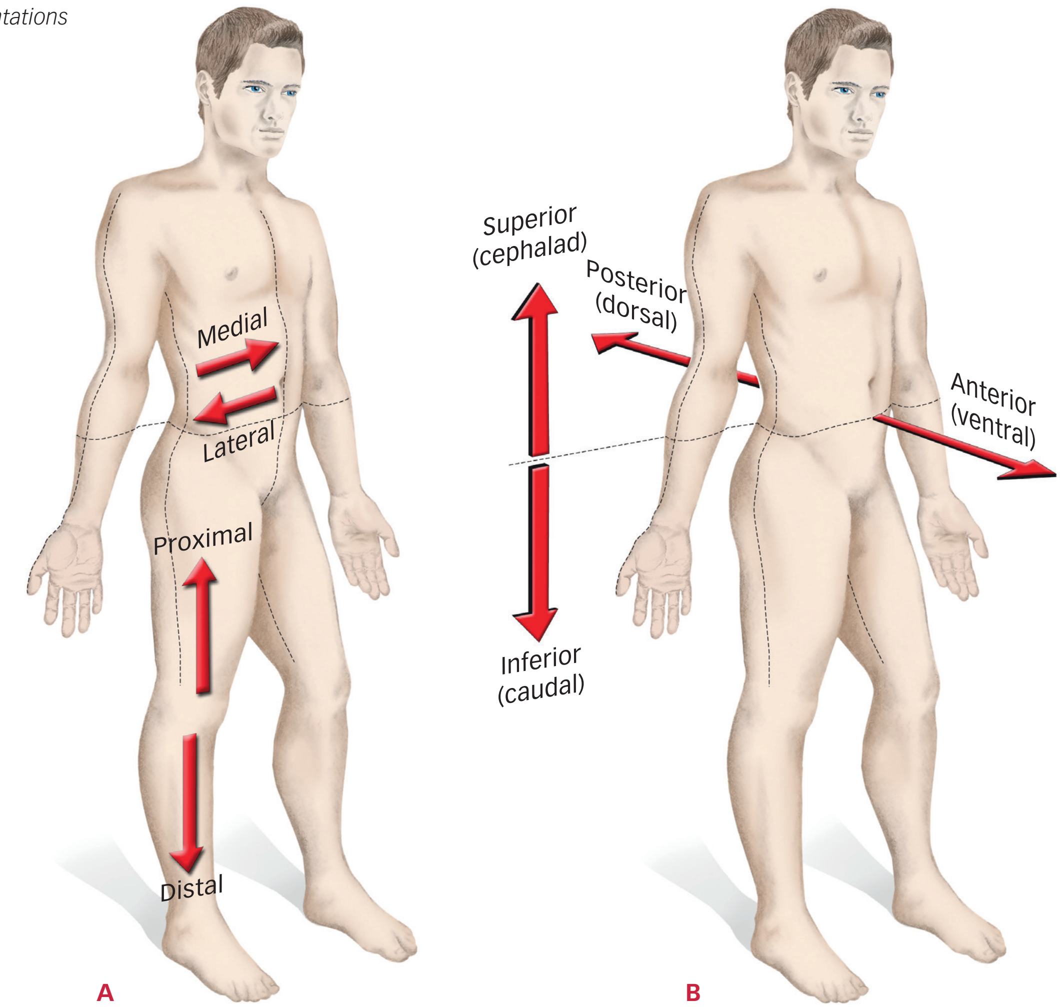


Figure 2-4. A *and* **B** *Orientations and directions on the body.*

Proximal Closer to the point of attachment, the point of origin, the central circulation, the heart, and so forth.

Distal Farther away from the point of attachment, etc.

These are relative terms. For example, *The common femoral artery is in the* proximal *thigh. The carotid bifurcation is at the* distal *end of the common carotid artery*. How about this: *The* distal *common carotid artery is* proximal *to the* proximal *internal carotid artery*. Note that in that last sentence, the terms are used two ways:

- To designate a particular location on a structure (e.g., *distal* common carotid artery)
- To suggest direction relative to some other location (e.g., *proximal* to the origin of the internal carotid artery)

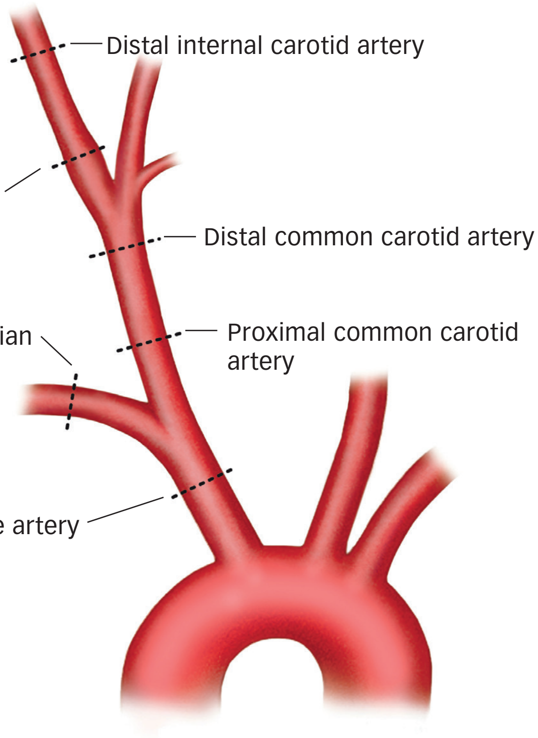


Figure 2-5. *An exercise in proximal/distal relationships. Be sure you really understand these as you look at the illustration:*

- *The* distal innominate artery *is proximal to the* proximal common carotid artery.
- *The* proximal common carotid artery *is distal to the* distal innominate artery.
- *The* proximal subclavian artery *is distal to the* distal innominate artery.
- *The* distal common carotid artery *is distal to the* proximal common carotid artery.
- *The* proximal internal carotid artery *is distal to the* distal common carotid artery, *but it is proximal to the* distal internal carotid artery.
- *To get from the* proximal common carotid artery *to the* proximal internal carotid artery, *you must move distally.*
- *To get from the* distal common carotid artery *to the* distal innominate artery, *you must move proximally.*

And so forth.

You can make up confusing descriptions, too. See Figure 2-5.

Cephalad Toward the head.

Caudal Toward the feet (literally, toward the tail). *Cephalad* and *caudal* are often used interchangeably with *superior* and *inferior*, but this becomes a bit of a problem in the lower extremities, since *toward the tail* would no longer be the same as inferior. It's probably best to stick with *superior/inferior* for most purposes. The usual screen orientation in the sagittal plane is with cephalad to the left, caudal to the right.

From the proximal common carotid artery, you move the probe cephalad *to the carotid bifurcation*.

Superior Above; toward the head; generally interchangeable with *cephalad*.

Inferior Below; toward the feet.

The carotid bifurcation is superior *to the clavicle.*

The bifurcation of the internal and external iliac arteries is inferior *to the aortic bifurcation.*

Superficial Closer to the surface/skin.

Deep Farther down from the surface/skin.

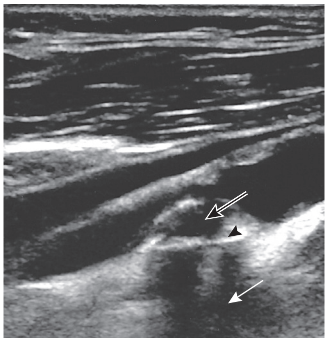


Figure 2-9. *Intraplaque hemorrhage (probable), demonstrating a typical anechoic appearance (black arrow). Note the acoustic shadowing (white arrow) deep to the bright calcific plaque (black arrowhead).*

are being careful not to draw diagnostic conclusions (for legal reasons, since the reading physician handles that), you point out "echogenic material within the venous lumen" rather than call it thrombus. This can be a relative term, as when characterizing thrombus—there, I said it—as to age: Fresh thrombus is generally faintly echogenic (very dark echoes), while older clot is more brightly echodense.

Hypoechoic, anechoic Producing few or no echoes, respectively. A Baker's cyst usually appears as a hypoechoic space in the medial popliteal area. Intraplaque hemorrhage (Figure 2-9) also appears hypoechoic (although you must be certain that the dark area is not caused by acoustic shadowing from calcific plaque). Vessels appear anechoic because moving blood does not bounce back the ultrasound (except for slow-moving venous flow, where red blood cell aggregates can show up on the gray-scale image).

Suboptimal A very useful term. It usually means "crummy," as in *Our image of the bifurcation is* suboptimal *with this approach*. There are useful variations: e.g., *Imaging was* less than optimal *due to pronounced postoperative edema*, or *This study was* somewhat less than optimal *due to patient confusion and restlessness*. Another handy word that conveys pretty much the same thing is *nondiagnostic*.

Within normal limits A hedge against an unequivocal *normal*. Often abbreviated as *WNL*, it carries the connotation of there being established "limits" or guidelines for assessing the system in question, where just saying *normal* may have implications that are broader than you want.

Essentially One of many useful qualifying terms, especially when used with WNL: *Imaging was less than optimal due to pronounced postsurgical edema; however, the Doppler signals and spectral analysis are* essentially *within normal limits*, or *There is mild turbulence in the internal carotid artery, possibly due to the tortuosity, but the Doppler here is* essentially *within normal limits*.

Appreciate Used in medicine to mean to "discern" or "distinguish," rather than the more common meaning of "admire" or "be thankful for." For example, *In the more posterior approach, we can better* appreciate *the crater-like formation at the origin of the internal carotid*.

Proximal limit/distal limit Farthest possible point toward or away from the heart or point of origin, respectively. *This is the* distal limit *of useful imaging in the internal carotid artery*. Reassures the reader that you are attempting to pursue the vessel as far proximally or distally as possible.

Characterizing Atheromatous Lesions

Plaque, atheroma, atheromata, areas of atheroma, areas of calcification, atheromatous development, etc. Atherosclerotic lesions of the arteries. *Plaque* is usually used in the singular, as a commodity, as in *There is extensive* plaque *in this vessel*. *Atheroma* is from a Greek word meaning "porridge," and it is so called because of its consistency. It is also used like *plaque*: *There is extensive* atheroma *in this vessel*.

Calcific, dense Characteristic features of certain types of plaque. (See Chapter 17, "Recommended Reading and Other Resources," for discussion of plaque types.) Both calcific and dense plaque show up as bright echoes in the lumen (Figure 2-10A). In the sense that many professionals use these terms, dense plaque may not create acoustic shadowing, while calcific plaque certainly would. Others may use the two terms interchangeably.

Soft, fibrous Characteristic features of certain types of plaque. Soft, fibrous plaque (Figure 2-10B) produces darker echoes than the dense or calcific varieties of plaque. Modifying adjectives can be appropriate here, as in *somewhat soft* or *fairly dense*.

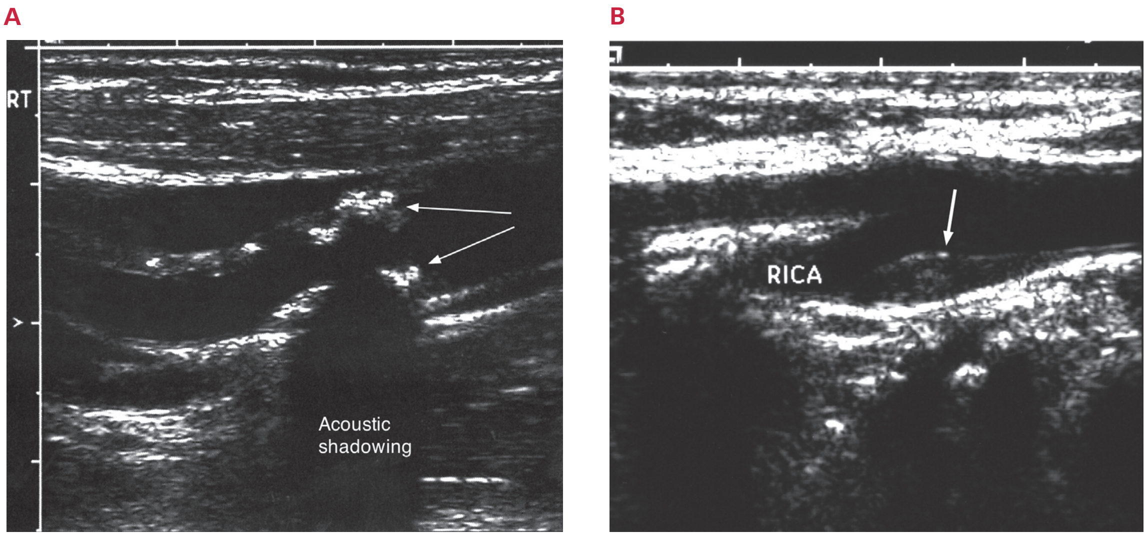


Figure 2-10. **A** *Calcific plaque. Note acoustic shadowing (arrows).* **B** *Soft (a.k.a. fibrous or fibrofatty) plaque (arrow). RICA = right internal carotid artery.*

Intimal thickening Thickened walls along the artery, looking a bit like very minimal atheroma (Figure 2-11).

Minimal, mild, moderate, moderately severe, severe Gradations of carotid stenosis. There are different systems for grading carotid stenosis, but most use these categories. You can often characterize plaque as appearing minimal, mild, or moderate, having first checked the Doppler to rule out significant velocity increases. Characterizing the latter two categories is best done with the Doppler.

Circumferential Around the entire circumference of the vessel, as opposed to plaque that lies on one side of the wall. You must see this in transverse, obviously.

Extensive Plaque along a lengthy segment of the artery; often used not quite accurately to describe a plaque that has created severe stenosis, in which case *pronounced*, *severe*, or simply *large* is better.

Scattered, diffuse Plaque found at several levels in the artery.

True lumen vs. **residual lumen** The actual wall of the vessel versus the remaining opening through which blood continues to flow.

Homogeneous vs. **heterogeneous** All of one consistency versus having different consistencies or materials (Figure 2-12); used to describe plaque. Plaque with both soft and dense areas—*heterogeneous* plaque—is widely regarded as more likely to have

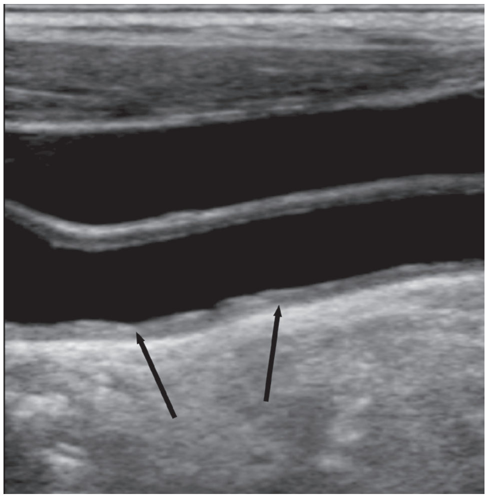


Figure 2-11. *Intimal thickening. Courtesy of GE Ultrasound.*

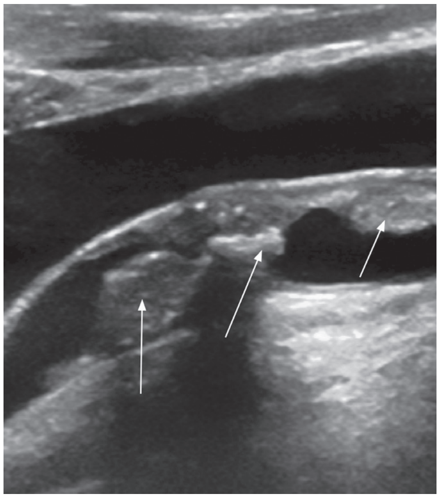


Figure 2-12. *Heterogeneous plaque: softer and denser areas.*

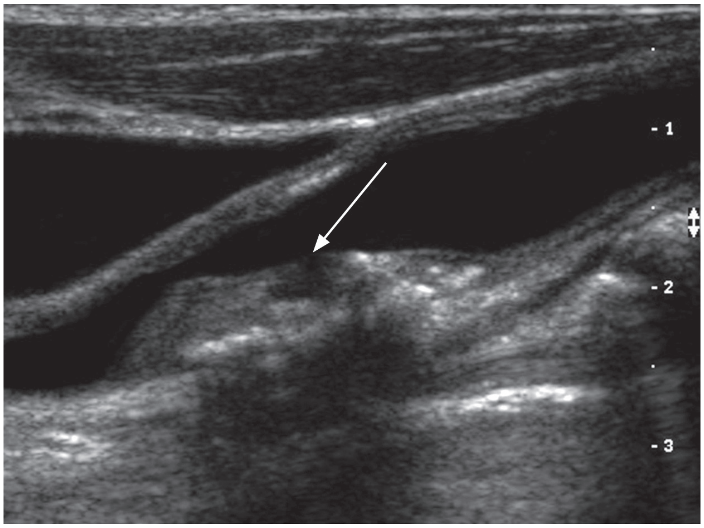


Figure 2-13. *Crater, scooped-out appearance, suggesting probable ulcer.*

ulcerative activity than *homogeneous* plaque. Similarly, thrombus in a vein might be characterized as homogeneous when it is acute versus heterogeneous when it is chronic.

Smooth vs. **irregular** Used to characterize the surface appearance of plaque in an effort to indicate possible areas of ulceration.

Crater; crater-like in appearance The shape that is most suggestive of ulceration of plaque; scooped-out in appearance, especially if there are shelf-like projections over the crater (Figure 2-13).

Occlusion Complete blockage. This term is best used with *total* to distinguish it from *obstruction*, which may be partial and not total: *Note axial thrusting of the vessel, apparent filling of the vessel with heterogeneous material, and atrophied appearance of the distal vessel, all compatible with* total occlusion. Possibly also best used with the word *probable*, since duplex scanning cannot absolutely rule out a tiny "string" residual lumen with flow too slow for the Doppler to pick up.

Characterizing Doppler Findings

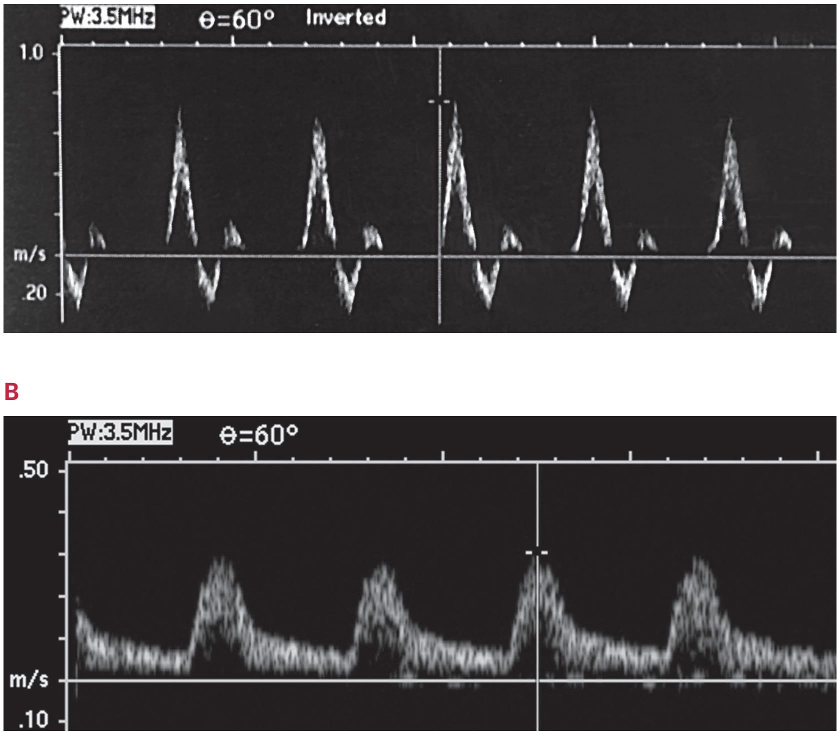
Laminar Orderly, nonturbulent flow. *Doppler here appears to be* laminar *and within normal limits*.

Sharp vs. **damped** Used to characterize the sound of the Doppler signals as well as the shape of the waveforms (swift versus sluggish up- and downstrokes, sharp versus rounded peak). See Figure 2-14A.

Figure 2-14. **A** *Normal lower extremity arterial analog Doppler waveform: sharp and multiphasic (a.k.a. triphasic)—forward, reversed, second forward components.* **B** *Damped, monophasic lower extremity arterial Doppler waveform distal to arterial occlusion.*

A

B



Multiphasic vs. **monophasic** An issue in the extremity arteries. Normal peripheral arterial flow is multiphasic (Figure 2-14A), as described in Chapter 5. Monophasic Doppler signals (Figure 2-14B) suggest that a great deal of energy has been damped out of the flow.

Antegrade vs. **retrograde** Flow in the expected direction versus flow in the opposite direction (Figure 2-15). An issue mainly in the vertebral arteries, although occasionally you will find unusual flow patterns elsewhere, as when the common carotid artery is totally occluded and retrograde flow in the external carotid provides flow to the internal carotid artery.

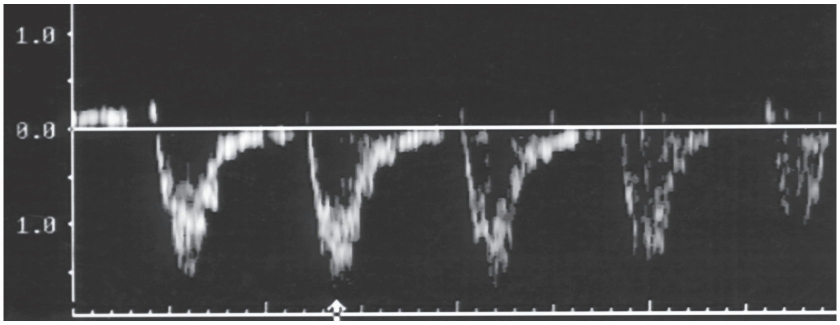
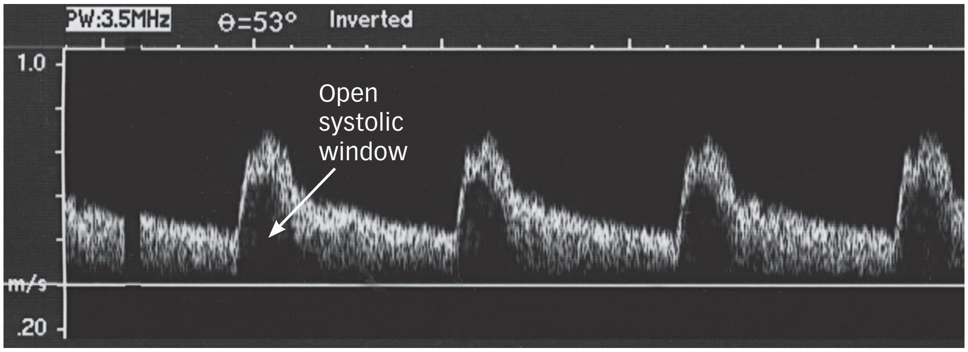


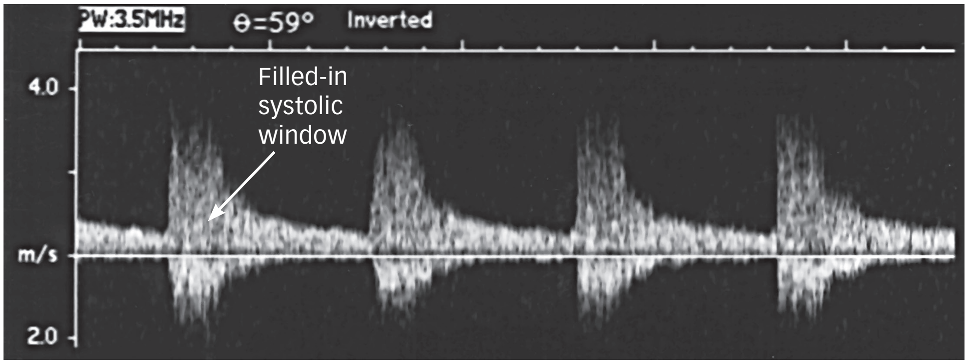
Figure 2-15. *Retrograde flow in a left vertebral artery.*

Figure 2-16. **A** *Normal, nonturbulent (laminar) flow character in internal carotid artery.* **B** *Turbulent flow on spectral analysis. Note filled-in systolic window, flow below baseline—many velocities, many directions.*

A



B



Turbulence, spectral broadening, disturbed flow, window filling, gross turbulence All used to characterize various degrees of flow disturbance as reflected in the spectral analysis (Figure 2-16).

Elevated velocities (peak systolic and end-diastolic), accelerated flow through stenosis Used to describe flow through a hemodynamically significant lesion.

Aliasing The wrapping-around of the spectral waveform that can result from high-velocity blood flow (Figure 2-17). When the frequency shifts exceed the Nyquist limit (half the PRF, or pulse repetition frequency, of the Doppler), the scanner displays the higher frequencies as coming up from below the baseline. For a complete discussion of this phenomenon, see the physics references in Chapter 17, "Recommended Reading and Other Resources." In most cases, the mere presence of aliasing suggests fairly severe stenosis.

Compatible with A very useful phrase that again allows you to suggest an impression without being more definite than you

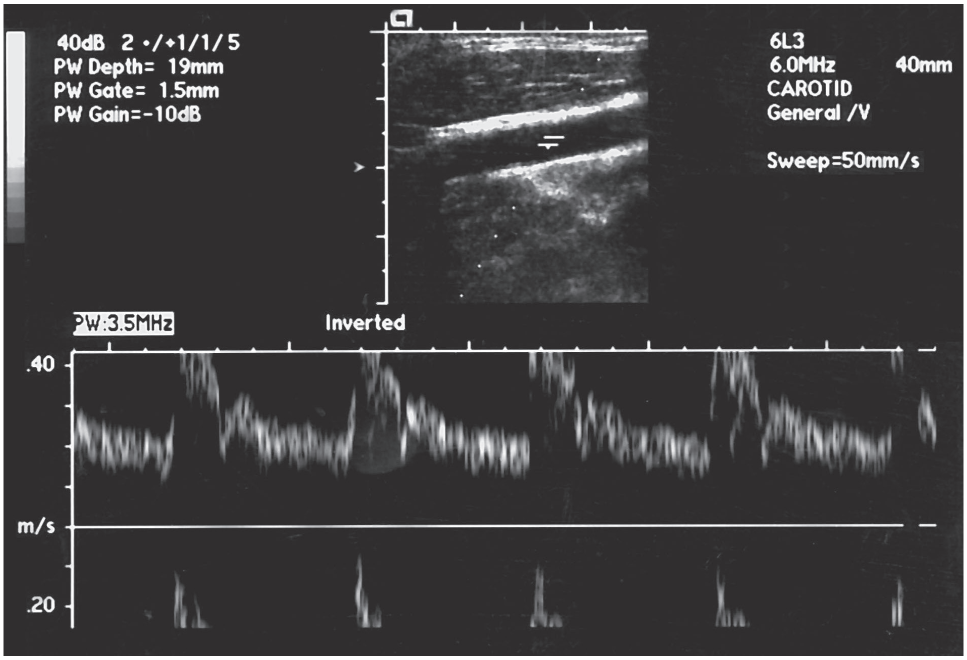


Figure 2-17. *Aliasing spectral waveform, with the peak cut off and wrapping around from below baseline.*

should be. *These markedly elevated peak systolic and end-diastolic velocities, and complete window-filling, are* compatible with *greater than 80% stenosis*. Other similarly useful phrases are *suggestive of* and *strongly suggestive of*.

Characterizing Venous Images

Patent and compressible (with light/moderate probe pressure) Characteristics of normal veins.

Coapt To meet or join. *The walls of the veins* coapt *with gentle probe pressure*.

Document To establish on the record, whether by video or photography, as in *The vein is the deeper of the two vessels; we'll* document *with Doppler*, and *This signal is from the external carotid artery; we'll* document *with temporal percussion*.

Chronic vs. **acute thrombosis** Old versus new thrombus. Or, to put it in terms of ultrasonographic appearance, brightly echodense, heterogeneous, striated echoes versus softly echogenic, homogeneous, lightly speckled echoes. Also small or atrophied-appearing versus distended vein. See Chapter 5. *This is a judgment you must be cautious about making, but these signs are compatible with* chronic *or* acute thrombosis.

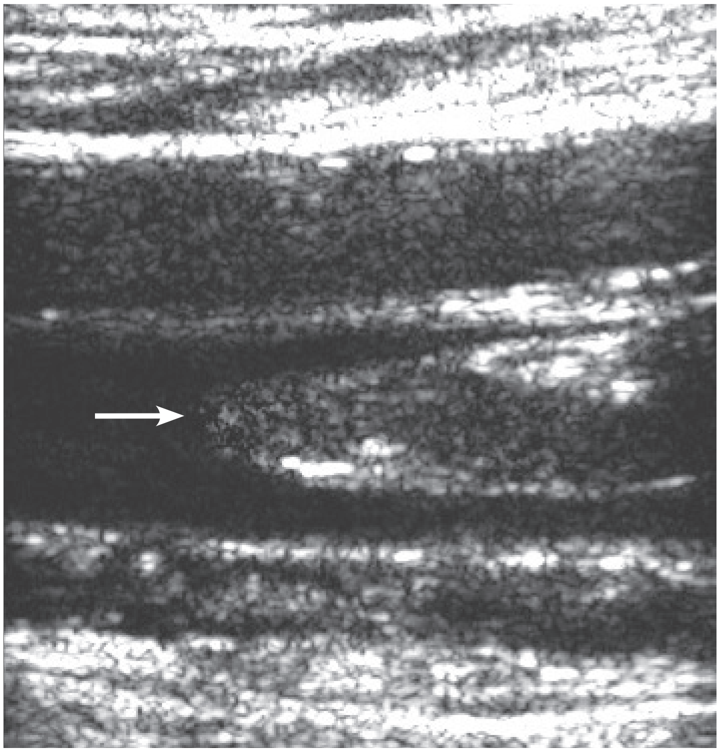


Figure 2-18. *Venous thrombosis. Note poorly attached "tail" (arrow), suggesting acute rather than chronic thrombosis. (More on this in Chapter 5.)*

Recanalized Having formed a channel of flow through a thrombus. Recanalization is suggestive of older (chronic) clot. Recanalization may be partial, with a very small residual lumen and irregular walls, or nearly complete, with just a brightly echodense flap left behind.

Tail The free-floating proximal end of a thrombus, suggesting that it is poorly attached to the wall and therefore probably acute rather than chronic (Figure 2-18). (Avoid too much compression here; you don't want the thrombus to break off and travel.) Sometimes difficult to differentiate from recanalizing clot.

Nonocclusive Obstructed but not totally blocked. Applied in cases of venous thrombosis, it means that the clot does not completely fill the lumen. Nonocclusive thrombus is often seen in cancer patients, especially in the area of the saphenofemoral junction, and it is often very localized.

No evidence of DVT A useful phrase for writing temporary (or permanent) reports. It means exactly what it says: *There is no evidence of deep vein thrombosis from your test*. It is safer than saying "This patient has no DVT."

CHAPTER 11

Abdominal Doppler

God grant me patience; I need it NOW!
—Unknown. Maybe me.

This chapter comes pretty late, because scanning arteries in the abdomen is one of the more challenging skills you will have to learn. It's not difficult to learn the anatomy and scan a slender patient. Unfortunately your average patient will not be slender.

There are a couple of things that make abdominal scanning more difficult (or, to use positive spin, more challenging) than studies of the neck, legs, and arms. First, the vessels are deeper than those in necks and extremities, making it more difficult to locate and assess them. Second, the abdomen often has serious obstacles to good ultrasound:

- Adipose tissue

  and

- Bowel gas

As I hinted just now, more and more of our patients are obese. Adipose tissue tends to scatter ultrasound, making it tougher to image anything beyond it. And of course obesity makes everything lots deeper.

Bowel gas reflects all the ultrasound and lets none through. It is just as bad as if the abdomen had several bones in the way, as the chest does—sort of like clouds moving in and blocking the sun (Figure 11-1). Here is a quick ultrasound physics review to explain this fact:

Question: What makes an echo?

Answer: A difference in *acoustic impedance*. The difference in impedance between soft tissue and gas is nearly as big as the difference between soft tissue and bone. Either way, a big difference means a big echo, with essentially no sound getting beyond that big difference.

A third stumbling block is the tendency for some abdominal vessels, or segments of them, to travel at awkward angles, making it difficult to produce the desired 50°–60° Doppler beam angle relative to flow. Solving this problem calls for some careful maneuvering.

And yet another tricky bit here is that patients have a frustrating tendency to breathe. That moves things around in there, often making it difficult to produce consistent Doppler waveforms. There will be times when snagging just one good beat of Doppler makes your day. You'll want to establish a working relationship with the

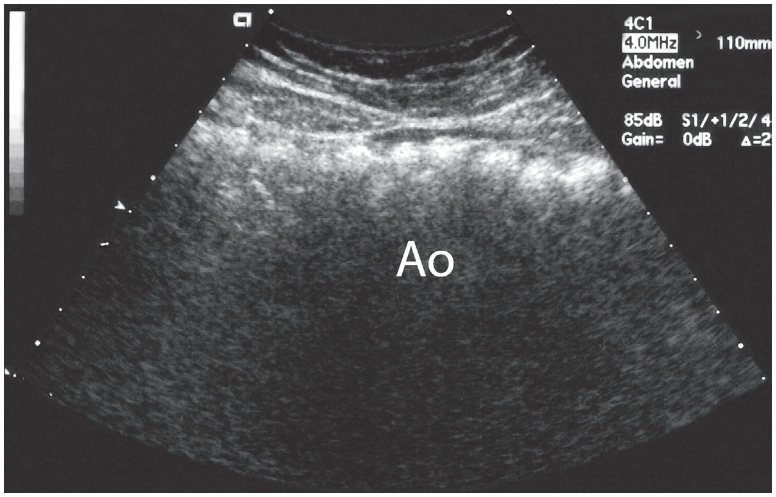


Figure 11-1. *The clouds roll in: bowel gas.*

ANATOMY REVIEW

Time to remember where the vessels are (Figure 11-2A). Compare the drawing to the spiral CT (computed tomography) scan of the abdominal arteries (Figure 11-2B).

The abdominal aorta begins at the diaphragm and bifurcates at roughly the level of the navel into the right and left common iliac arteries. Each of the common iliac arteries bifurcates into the internal iliac and external iliac arteries, right and left, about halfway between the aortic bifurcation and the inguinal ligament. (The internal iliac is sometimes also called the "hypogastric artery.") The external iliac arteries become the common femoral arteries as they pass beneath the inguinal ligament. The inferior vena cava lies to the right of the aorta.

The first branch off the abdominal aorta is the celiac trunk (or celiac axis), which takes off from the anterior aorta. It branches very soon into the common hepatic artery on the right and the splenic artery on the left. (The left gastric artery comes off the distal celiac trunk as well, but we generally don't see that one with ultrasound.)

The next abdominal aortic branch is the superior mesenteric artery (SMA), which arises from the anterior aorta usually very

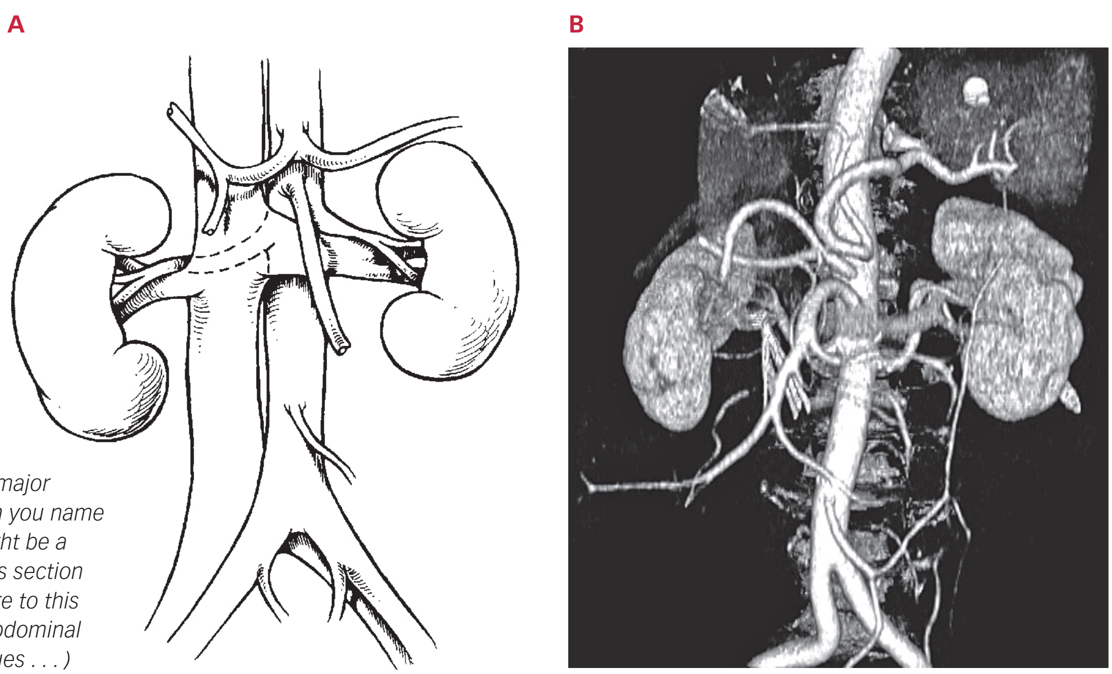
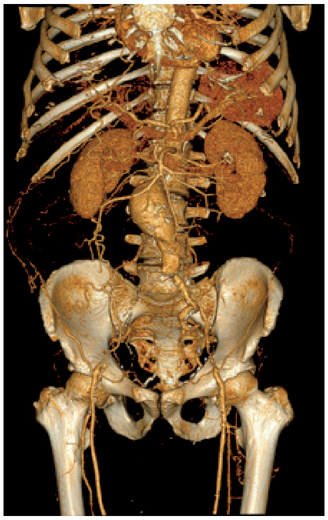


Figure 11-2. **A** *The major abdominal arteries. Can you name these readily? Now might be a good time to review this section in Chapter 3.* **B** *Compare to this lovely CT scan of the abdominal arteries. (Figure continues . . .)*



Courtesy of Philips.

close to the celiac trunk. A variant is the celiac and SMA arising from the aorta together. The superior mesenteric artery turns immediately to run inferior parallel to the aorta, with multiple branches coming off to perfuse the intestine.

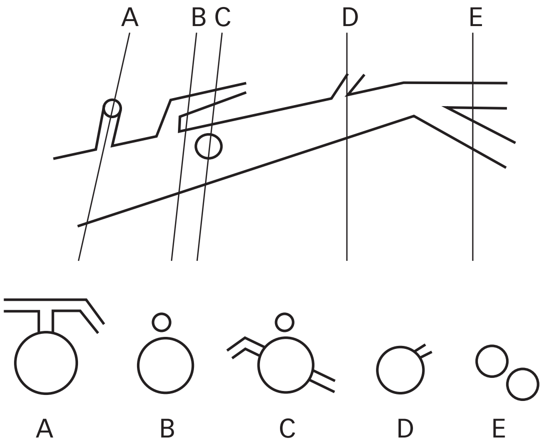
Just distal to the superior mesenteric artery is the left renal vein, crossing over the aorta to empty into the inferior vena cava. This is a useful landmark when searching for the renal arteries, which lie just deep to this vein.

The left renal artery tends to be a bit *postero*lateral, making it usually the more difficult of the two to image and to interrogate with Doppler. The right renal artery takes off from the aorta slightly *antero*laterally, so it is usually easier to image. Additionally, you have help on this side from the liver, which provides an acoustic window.

The inferior mesenteric artery is the last major aortic branch before the iliac bifurcation, coming off anterolaterally toward patient's left.

Figure 11-2C is a schematic diagram of the sagittal aorta and branches, along with the corresponding transverse images at the different levels. The color-enhanced CT (Figure 11-2D) demonstrates the celiac trunk (CT) and the hepatic (HEP), right and left renal (RRA/LRA), splenic (SP), and superior mesenteric (SMA) arteries. Check back with this one as you work through the various views.

C



D

Figure 11-2, continued. **C** *Schematic diagram of the abdominal arteries, comparing sagittal to transverse views.* **D** *Color-enhanced CT of the abdominal arteries. Courtesy of Philips.*

PATIENT POSITION AND YOUR POSITION

The Patient

The two basic patient positions for abdominal scanning are the midline approach (on the back) and the flank approach (on the side).

There are two basic patient positions for abdominal scanning: on the back for the midline approach (see Figure 11-3) or on the side for the flank approach. (Could be right or left side, so maybe that makes it three positions.) Our initial scanning will be with the patient supine, on the back, head raised a bit. (Don't let your patient put his or her arms behind the head because this tightens the abdomen. Arms at the sides.) Later we'll flatten the bed and ask the patient to turn onto the right or left side to look at the kidneys, get Doppler from the distal renal arteries, and possibly track renal arteries back centrally to the aorta.

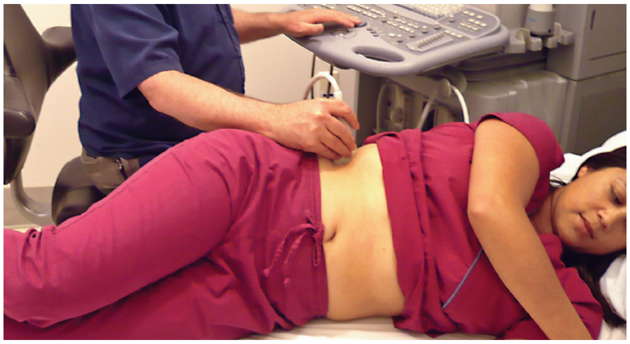
You

As for you, Figure 11-4 demonstrates a good way to do yourself lasting damage if you persist in scanning this way. The arm is straight, the shoulder is elevated, the body is twisted, and the patient is too far away from the dingbat sonographer—other than that, the positioning is just perfect.

Figure 11-3. **A** *Scan position for the midline approach.* **B** *Scan position for the flank approach.*

A

B



A B

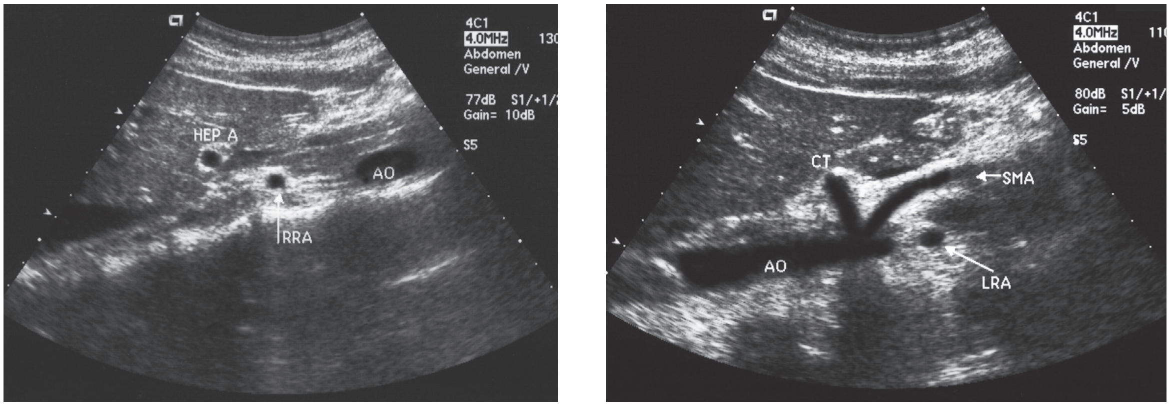


Figure 11-13. *Locating the short-axis renal origins from the sagittal plane by angling slightly right and left of the aorta itself.* **A** *Right renal artery origin.* **B** *Left renal artery origin.*

This little trick might help you to find these arteries for Doppler purposes later; get the short-axis renal artery, then keep it on the screen and rotate to elongate it.

Move carefully distal, keeping the aortic image clear as with any longitudinal structure: constant tiny adjustments of angle (to keep walls clear) and rotation (to keep ends open).

In real life, you will pay careful attention to the size of the aorta as you move along. Abdominal aortic aneurysm (AAA) is a significant cause of death, especially in older male smokers, so we automatically check for any suggestion of dilatation while we're here. If you were to see the aorta widen, you would measure in two planes, but the longitudinal plane is preferred to be sure of getting a true diameter and not an oblique measurement (Figure 11-14).

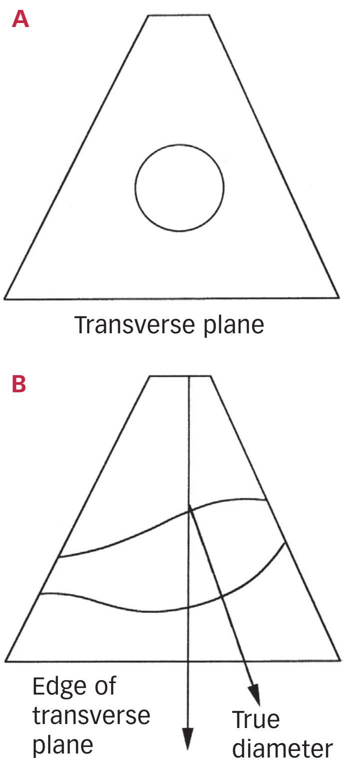
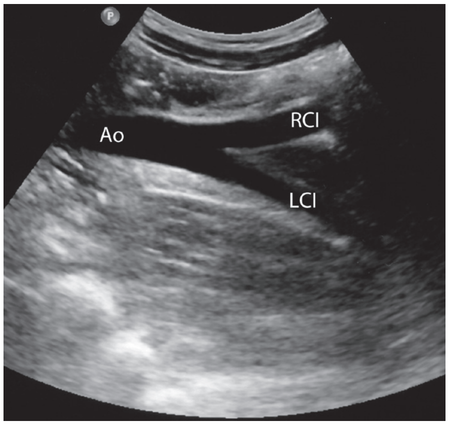


Figure 11-14. *Drawings of the aorta in short (**A**) and long axis (**B**) demonstrating that measuring in long axis is probably more accurate for true diameter. Measuring in short axis might actually be oblique.*

Before long, at the most distal and superficial level of the aorta, as you approach the patient's umbilicus (okay, belly button), you should notice a change of shape or direction. This is where the aorta bifurcates into right and left common iliac arteries. With some probe adjustments you can do a modified bifurcation maneuver, keeping the aorta at the left of the screen while moving from the left to the right common iliac. Note that the left one tends to dive more quickly than the right one.

You can often profile this bifurcation by moving the probe somewhat to the patient's right, angling the beam back toward patient's left (Figure 11-15). Press the side of the probe into the abdomen while continuing to aim toward the patient's left. This allows you

A



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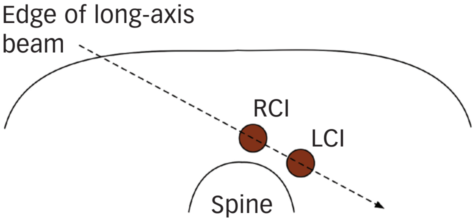


Figure 11-15. **A** *Profiling the iliac bifurcation by moving to the patient's right and laying the probe down to aim medial.* **B** *Drawing shows why this usually works: The left common iliac artery dives sooner, so the beam can angle through both with a right-side approach. This also shows why the left common iliac artery dives sooner than the right: Note the position of the spinal column.*

to aim through the rectus abdominis muscle for a nice aortic tuning fork view—in other words, you can see both common iliac arteries on the same plane. Since the left common iliac artery is the diving one, and because it is farther from the probe, it appears deeper in the field. This can be a nice view for getting Doppler, especially from the left common iliac artery.

Now we can look at the flow in those arteries.

Abdominal Arterial Doppler

Assessing the Main Arteries of the Abdomen

The character of the aortic Doppler signal changes distal to the renal arteries.

Let's begin the Doppler assessment with the proximal aorta. Usually this waveform and velocity measurement is made at the level of the SMA origin. Go to the longitudinal view and position the sample volume. The waveform will be fairly sharp, somewhat like an arterial signal, but at this level you won't expect a reverse-flow component as you would in a leg artery (Figure 11-16). That's because you are above the level of the renal arteries, which take around 25% of the cardiac output and therefore contribute a large

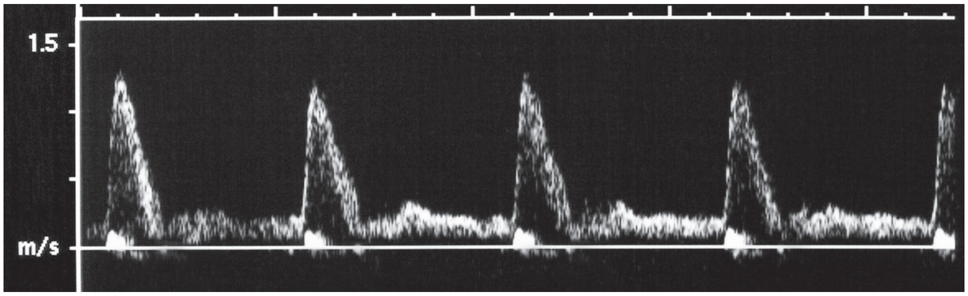


Figure 11-16. *Normal spectral Doppler of the suprarenal aorta. Note the absence of flow reversal due to the lower-resistance distal vascular bed.*

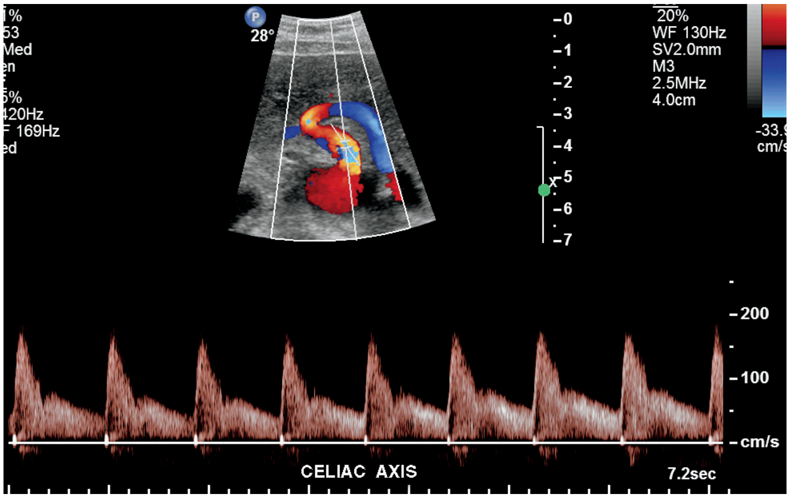


Figure 11-20. *Spectral Doppler of the celiac trunk. Courtesy of Philips.*

for the splenic artery, which turns and dives as it courses to the patient's left. The hepatic artery, though, typically stays fairly level in the field, and you will have to maneuver to create an acceptable Doppler angle. Again, try to get it toward the edge of your field of view, and then do some rocking. And don't forget to get your patient's help by asking him to suspend the breathing for a few seconds.

A stenotic and turbulent celiac trunk occurs more often in a female than a male patient.

In real-world work, you will occasionally find a celiac trunk that sounds pretty stenotic and turbulent, most likely in a female patient (Figure 11-21). This usually turns out to be a compression syndrome due to the celiac trunk being caught under the median arcuate ligament (possible registry-exam question alert). The

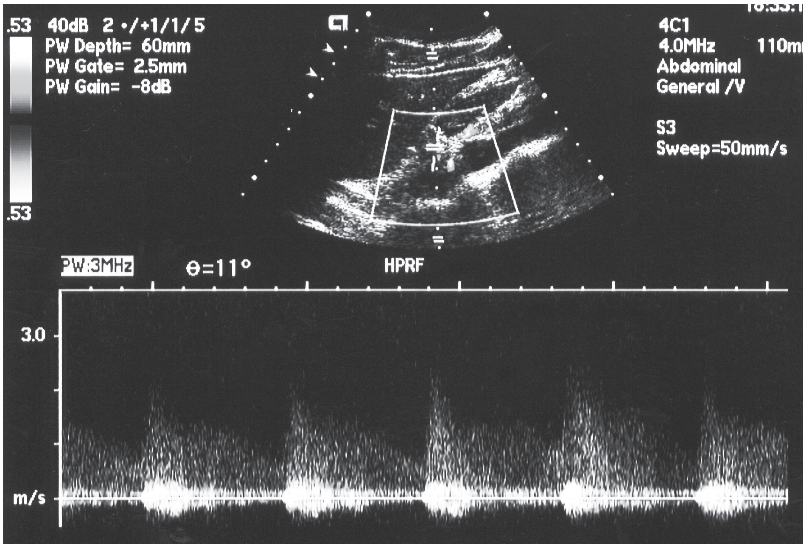


Figure 11-21. *Stenotic, turbulent celiac spectral Doppler in a patient with celiac compression syndrome, seen most often in thin female patients. The compression is reduced on inspiration.*

compression is relieved when the patient breathes in, giving you reduced velocities and turbulence; then the compression resumes at the end of expiration, and the stenotic-sounding flow returns. This is a normal variant, occasionally symptomatic but more often benign. It is worth noting, though, as it can explain an abdominal bruit.

Okay, now turn from short- to long-axis aorta and get that image of the superior mesenteric artery coming off the top and then turning to course above the aorta. The proximal superior mesenteric artery should be easy to Doppler with a good angle (Figure 11-22); you might have to rock the probe a bit to keep it at 60° for more distal segments.

Note that the superior mesenteric artery does not always run directly above the aorta. In some patients it will course a bit to the right or left of the aorta, so you won't have the classic view with both arteries showing clearly; priority goes to the one you're trying to assess. A different approach from right or left might lay it out more neatly.

A

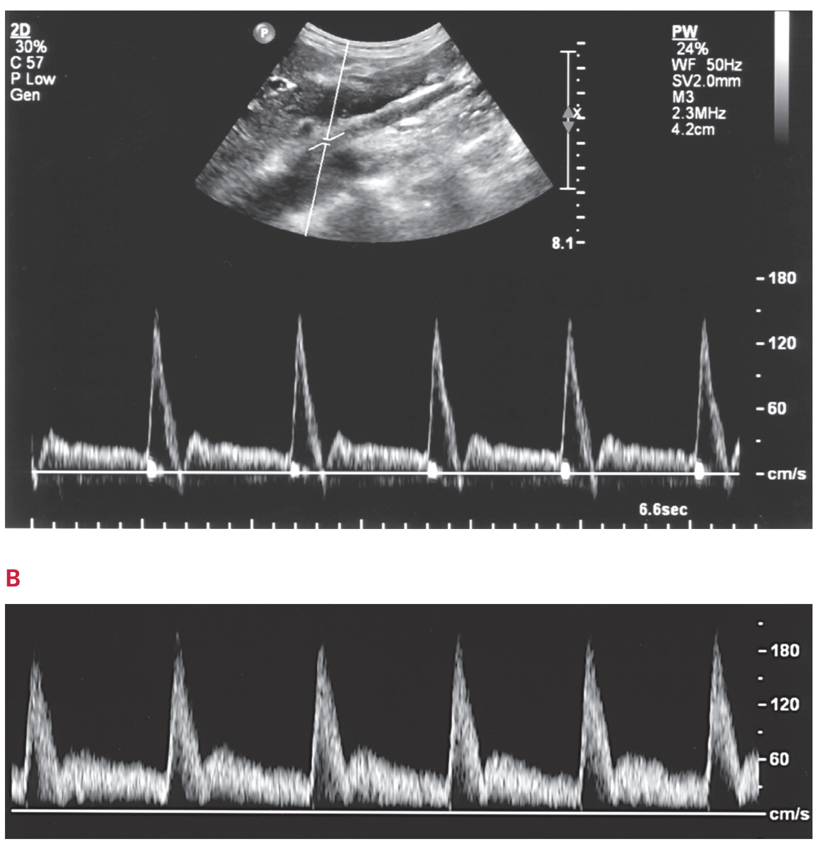


Figure 11-22. *Spectral Doppler from the superior mesenteric artery.* **A** *The waveform from a fasting patient is more resistive in character, having less diastolic flow.* **B** *The waveform from a postprandial patient (post-burrito in this case) has significantly more diastolic flow.*

Assessing the Renal Arteries from the Midline Approach

Now it's time for the renal arteries. Far and away the most common reason for you to evaluate the abdominal arteries is to look for renal artery stenosis, which might cause renovascular hypertension, as noted in Chapter 5.

The most common reason to scan the abdominal arteries is to look for renal artery stenosis, a cause of renovascular hypertension.

Starting Out Go back to the transverse plane. Image the aorta right where the superior mesenteric artery comes off, then nudge distal to look for the renal artery origins. As we saw earlier, the right renal artery (RRA) comes off a bit anterolaterally, at the ten o'clock position, while the left renal artery (LRA) is usually at or near the four o'clock position (Figure 11-23). You can't insist on getting both at once, but if you happen to be lucky this time in your choice of patient, congratulations.

Having trouble finding one or both? Go back to the superior mesenteric artery origin and start again, methodically. The left renal vein crosses over the top of the aorta to empty into the inferior vena cava (you can see a bit of it above the left renal artery in Figure 11-23), and this can be a helpful landmark too.

The most common site of renal artery stenosis is right at the origin, so you'll want to sample flow very proximally in the renal arteries. Starting with the right one, note its usual course going slightly up in the field from its origin off the aorta, then ducking to go deep under the inferior vena cava (Figure 11-24).

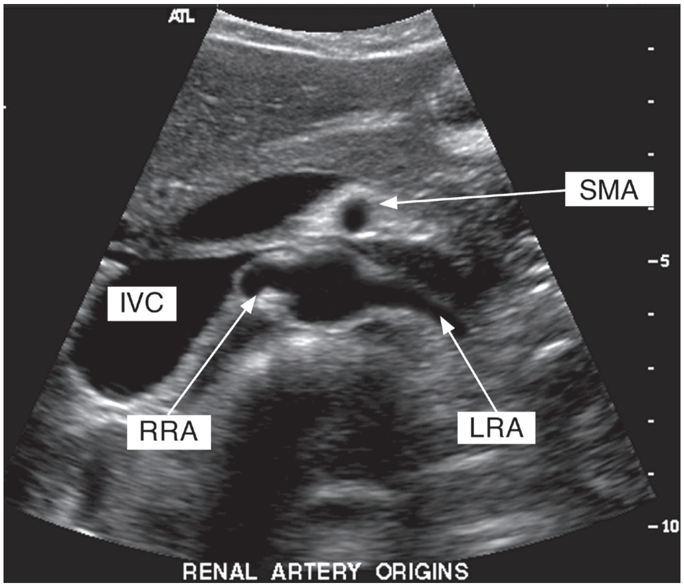


Figure 11-23. *The renal arteries coming off the lateral aorta, right and left. A bit of the left renal vein is visible above the left renal artery. IVC = inferior vena cava, SMA = superior mesenteric artery, RRA = right renal artery, LRA = left renal artery. Courtesy of Philips.*

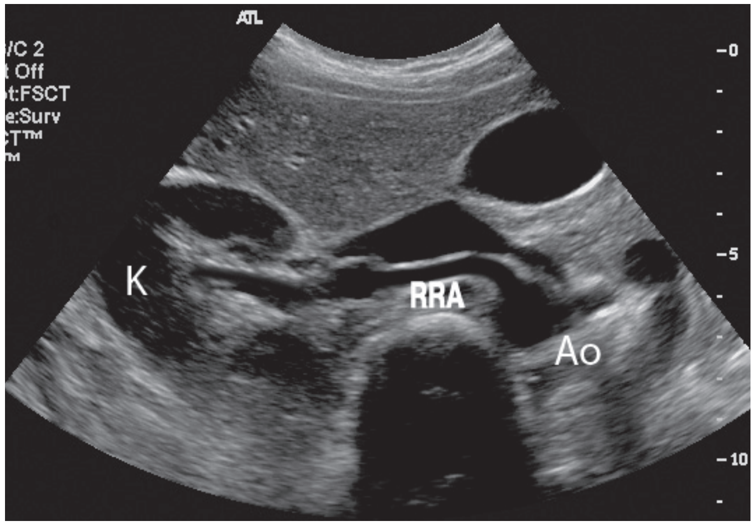


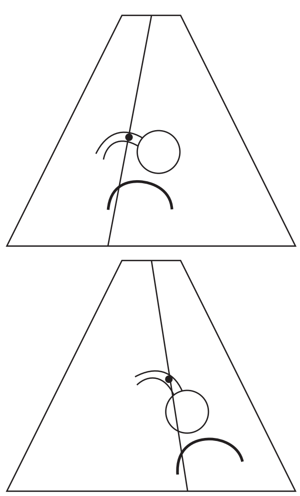
Figure 11-24. *Here, with the probe in a right anterolateral position, we can see the whole length of the right renal artery (RRA) from aorta (Ao) to kidney (K), passing beneath the inferior vena cava. One doesn't expect to produce this very nice view in most patients. Courtesy of Philips.*

Don't settle for a bad angle; rocking will change the artery direction and sliding will move the desired spot elsewhere in the image.

Angling for Doppler Getting Doppler with a good angle from right at the right renal artery origin can be especially difficult, given the geometry. The artery comes off the aorta at about the ten o'clock position, as noted, moves superiorly a bit, then turns to dive. Figure 11-25 demonstrates the angle problem here: kind of perpendicular. Don't settle for crummy angles.

Two things can help, here and elsewhere: *rocking* to change the artery direction and *sliding* to move the desired spot elsewhere in the image. In this case, we slide a bit to the patient's right, putting the aorta and renal artery toward the left side of the screen, and rock to change the direction of the renal artery origin. You have to be creative; experience will help you to visualize solutions to these angle conundrums.

A



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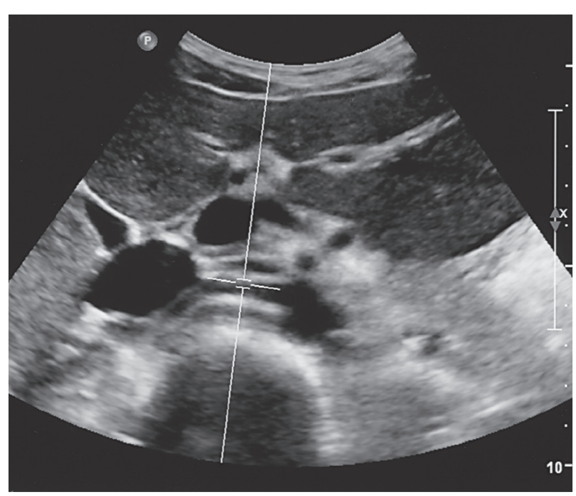
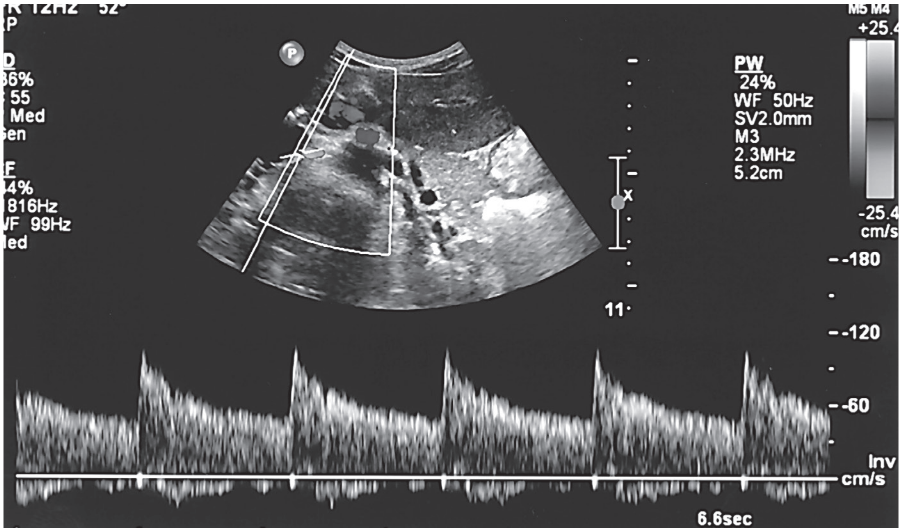


Figure 11-25. *Maneuvering to create a better Doppler angle at that awkward right renal artery (RRA) origin.* **A** *The drawing at top shows the suboptimal angle using the midline approach, then (bottom) moving the approach to the patient's right side to put the aorta and RRA origin toward the left of the field.* **B** *Bad Doppler angle at proximal RRA. (Figure continues . . .)*

Figure 11-25, continued.
C *Better Doppler angle, obtained this time by moving to the patient's left.*

C



You never know which modality, color versus gray-scale, is going to make life easier. Don't be afraid to toggle back and forth.

This is a place where the color flow can help, but also can be confusing. The left renal vein will course in the same direction as the right renal artery in order to get to the inferior vena cava. What color will the vein be? The same as the right renal artery. If the color scale is set properly, you can usually distinguish the pulsatile flow character of the artery, but sometimes the color just makes things harder. Don't be afraid to turn it off and just look for walls; you never know which modality (color versus gray-scale) is going to make life easier.

If you can follow it under the inferior vena cava, get another waveform farther along the right renal artery. How to line up as much of the artery as possible? It's the same as with any longitudinal structure: *angle and rotate, rotate and angle, angle and rotate, etc*. You constantly do these two probe movements to find the plane that lines up with as much of the artery as possible. *Slide* around a bit and mess with your approach in little increments. And *rock* the beam to be sure you can get echoes back from the walls.

If you are really lucky, you can follow it to (or nearly to) the kidney (Figure 11-26) and get a distal waveform. If not, don't feel bad—you will usually have to go to the flank approach (coming soon) to get mid to distal waveforms.

The left renal artery is usually easier to get with 60° (Figure 11-27). Again, chase that artery as far along as you can. In real life, you will want to try to obtain at least proximal, mid, and distal renal

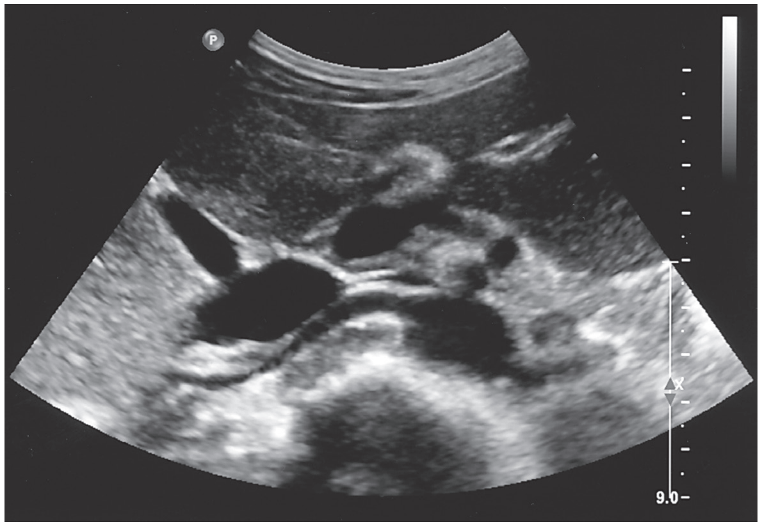


Figure 11-26. *Laying out the right renal artery along most of its length.*

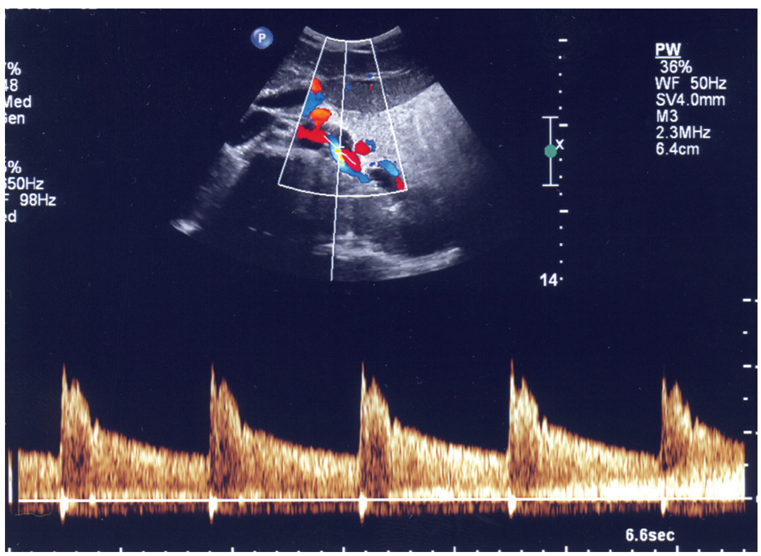


Figure 11-27. *Spectral Doppler from the proximal left renal artery. Courtesy of Philips.*

artery waveforms bilaterally, along with any other levels that look stenotic, using the color flow to help spot these areas. (And yet again I will exhort you to work on gray-scale skills a while before hitting that color flow button.)

If you have trouble getting the renal artery waveform near the origins, it is possible to stray a bit into the aorta. Now you are so grateful to get any kind of waveform that you measure it and move on—but it's not the renal artery. Be sure your waveform *looks* like a renal artery: lots of diastolic flow. The aorta will have little or no diastolic flow. In addition, the renal artery is probably running *away* from the beam, while the aorta (which angles up

A good maneuver for real-life assessment of the renal artery origins: Move the sample volume from the aorta through the origin into the renal artery, looking for stenotic acceleration.

superficial as it goes distal, remember?) will flow *toward* the beam. Check the "invert" status on the Doppler display. Don't be fooled. It might be a good idea to move the sample intentionally a bit into the aorta, then back to the renal artery, just to be sure about the difference in flow character and flow direction.

Before moving to the flank, take one more careful look along the aorta (using color flow to help). From 15% to 25% of people have duplicate renal arteries, although they are often tough to spot; some are larger, some quite small. With as many as a one-quarter of your patients having an alternate supply to the kidney, you want to be alert for that possibility.

Assessing the Kidneys from the Flank Approach

Now we go out to the patient's flank to look directly at the kidney and the distal renal artery. First it will help to recall the basic anatomy of the kidney (Figure 11-28).

The renal arteries divide into (usually) five *segmental arteries* as they approach the kidneys. The region where they enter the kidney itself is called the *hilum* (Latin: the point of attachment of a stem to a bean). These branches move within the kidney toward the renal *pyramids*, where they divide into the *interlobar* arteries to pass between the pyramids.

The interlobars further divide into *arcuate arteries* arching over the pyramids. And then finally come *interlobular arteries* (not to be confused with interlobar arteries) to the nephrons, the structures that do the work of the kidney.

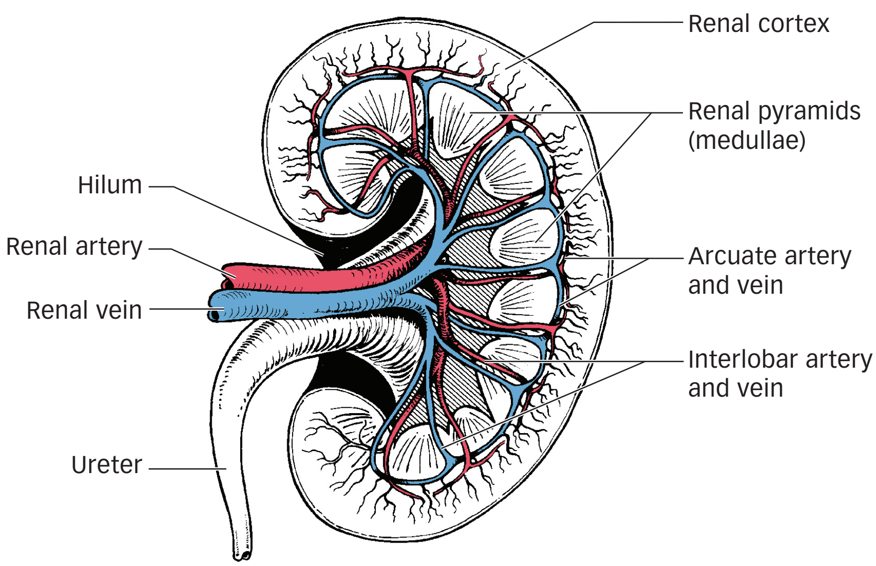


Figure 11-28. *Kidney anatomy.*

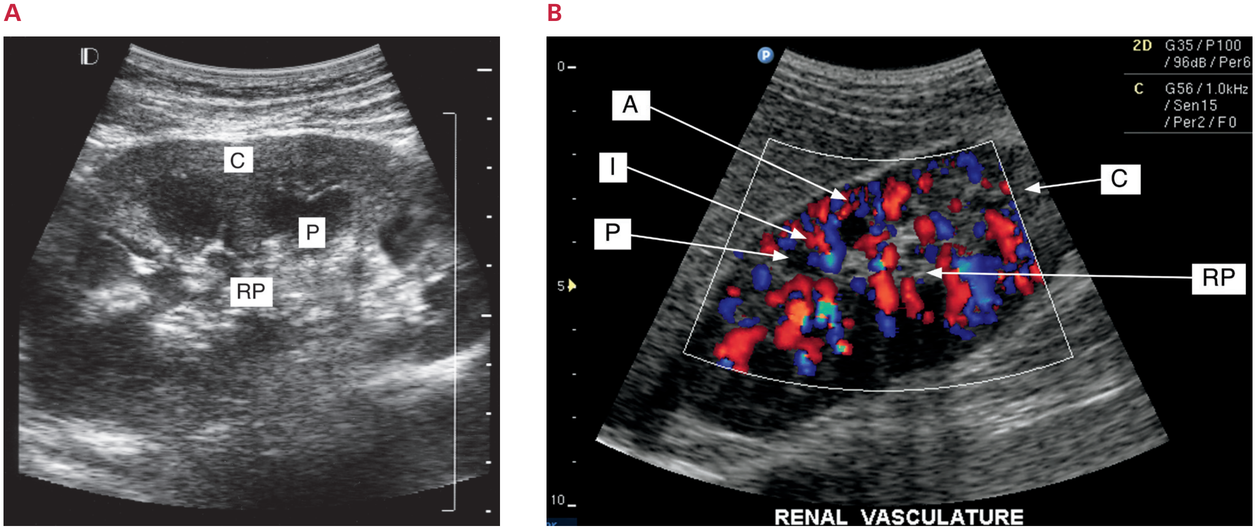


Figure 11-29. *Compare these to Figure 11-28.* **A** *Gray-scale image of the kidney. RP = renal pelvis, P = renal pyramid, C = renal cortex.* **B** *Color flow in the kidney: P = renal pyramid (medulla), I = interlobar artery and vein, A = arcuate artery flow (on top of pyramid), C = renal cortex, RP = renal pelvis (brighter echoes).*

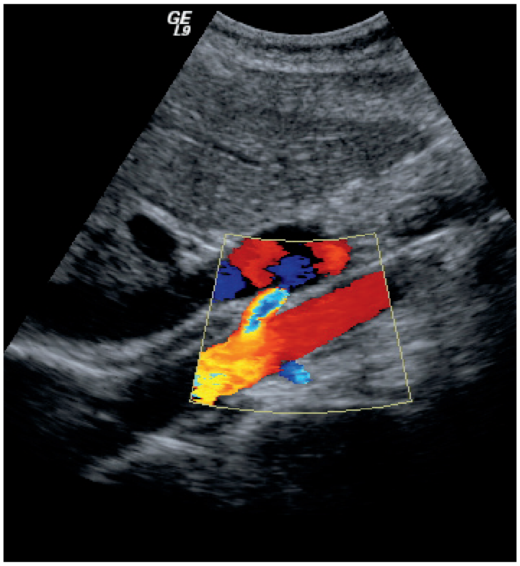
If you get a crystal-clear image of the kidney, the central portion (pelvis and calyces) will appear fairly bright, the pyramids will be quite dark (hypoechoic), and the cortex will also be fairly dark (Figure 11-29). Not all kidneys will look this clearly detailed, but you know that stuff is there.

You can begin a bit posterolateral or anterolateral or just plain lateral to start with a long-axis image of the kidney. Because the kidneys usually lie somewhat oblique to the superior/inferior plane, you will want to rotate the superior end of the beam a bit posterior to line up with the long axis. As with any long-axis structure, you will angle and rotate, rotate and angle until you find the longest-axis image. You may need to alter your approach to find the best window. You can ask your patient to take a big breath and hold it; sometimes that will push the kidney down a bit and give you a better shot.

Good ergonomics: Don't reach halfway across the room for your scanning. Get the patient close to you and work relaxed (see Figure 11-30).

Another possible strategy for scanning the kidneys: the patient-seated position, with patient facing away from you. Every strategy helps.

The Patient-Sitting Position And I will mention here that some sonographers swear by the patient-sitting position for imaging kidneys (assuming the patient can do that for you), which they say makes the kidneys drop into a more accessible position. The patient sits on the exam bed facing away from you. Have the patient put the left hand on the bed and lean left; this will help to lift the right rib cage and give you better access to the right kidney, A



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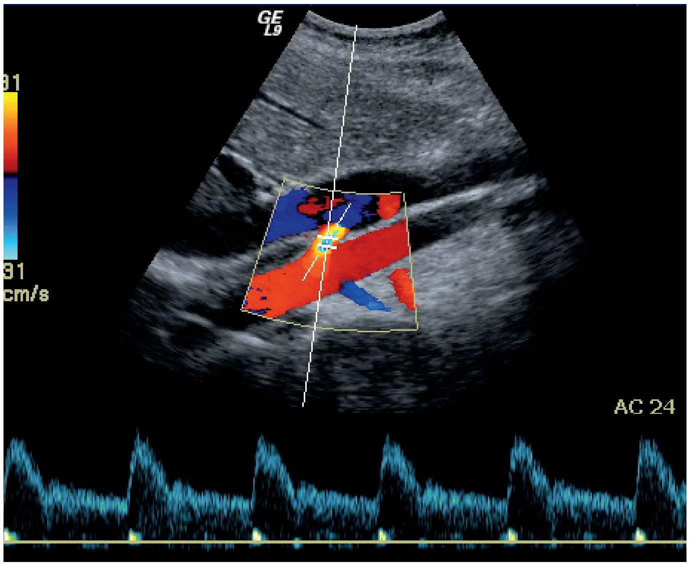


Figure 11-34. **A** *The banana peel view of the aorta with renal origins (color flow image).* **B** *You're getting the banana peel view from the right side, and this is spectral Doppler from the top artery, so is it the right or left renal artery? Images courtesy of GE Ultrasound.*

right and left renal origins, as in Figure 11-34. The aorta will angle upward going from left to right, the right renal artery will come off the top of the aorta (being closer to the probe), and the left renal artery off the bottom (being farther from the probe).

This is often called the "banana peel view." Why does it work, and why with this approach? Remember the way the renal arteries come off the aorta in the midline short-axis view: the right renal artery a bit more anterior, the left renal artery a bit more posterior (the ten and four o'clock positions, give or take a bit on different patients). That means the anterolateral approach on the right sends the beam through both origins (Figure 11-35).

You will not be able to achieve this view in all patients, but in many it may help you to get at the renal artery origins (where, as noted earlier, stenosis most often appears) when the midline approach is gassed out or otherwise nondiagnostic.

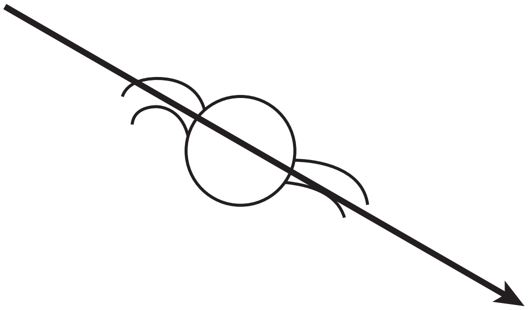


Figure 11-35. *Why the right side works to produce the banana peel view.*

Doppler Waveforms from the Flank Approach (Color On!)

Now you will use color flow to help you to produce Doppler waveforms at three levels:

1. The distal renal artery
2. The hilum
3. The renal parenchyma

(1) **The Distal Renal Artery** Be sure the color flow controls are set for lower velocities (low pulse repetition frequency [PRF]/scale) and perhaps boost the gain a bit to light up parenchymal flow.

Doppler color flow will help you produce waveforms at three levels: the distal renal artery, the hilum, and the renal parenchyma.

You can use any beam orientation to locate the distal renal artery as it approaches the kidney, but usually it works best to rotate to a short-axis image of the kidney, center on the artery as it joins the kidney, then maneuver to follow it back proximally toward the midline of the body. On a good day with a good patient, you can chase the artery all the way back to the aorta, as in Figure 11-36. This is often your best (or only) bet when the midline approach is not feasible, gassed out or whatever.

Screen orientation! The short-axis view of the kidney will look like Figure 11-33 on the right side if you turn the probe counterclockwise from the correctly oriented long-axis plane. Start in the long axis, use the color flow to get all the vessels to converge on the hilar area, then keep those vessels centered on the screen as you rotate. As we saw earlier, the short-axis kidney has a C shape on the patient's right side. Now medial/anterior is at the right of the screen, while lateral/posterior is at the left.

A

B

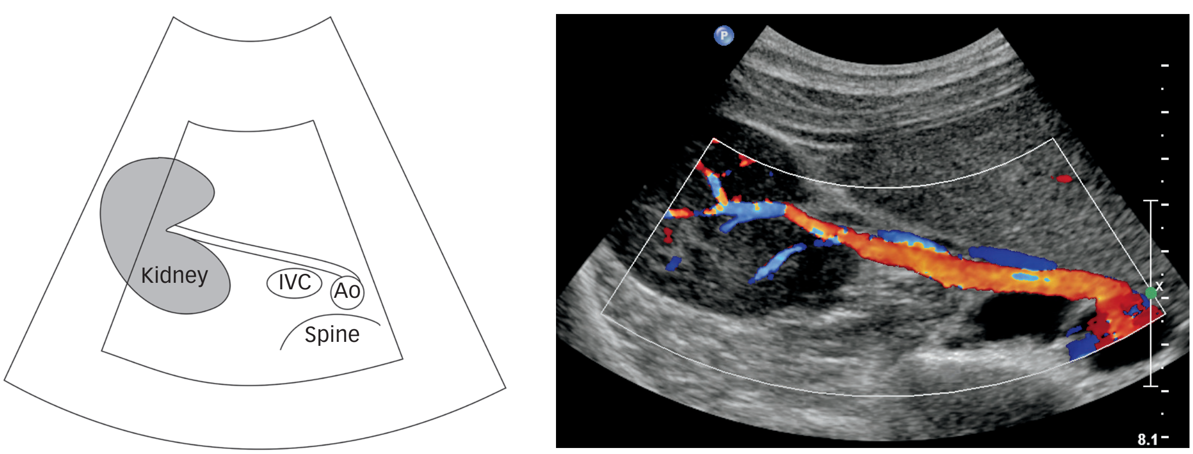


Figure 11-36. *Kidney to aorta.* **A** *Drawing of image obtained from patient's anterolateral abdomen.* **B** *With some maneuvering, this can work. On a good day. Courtesy of Philips.*

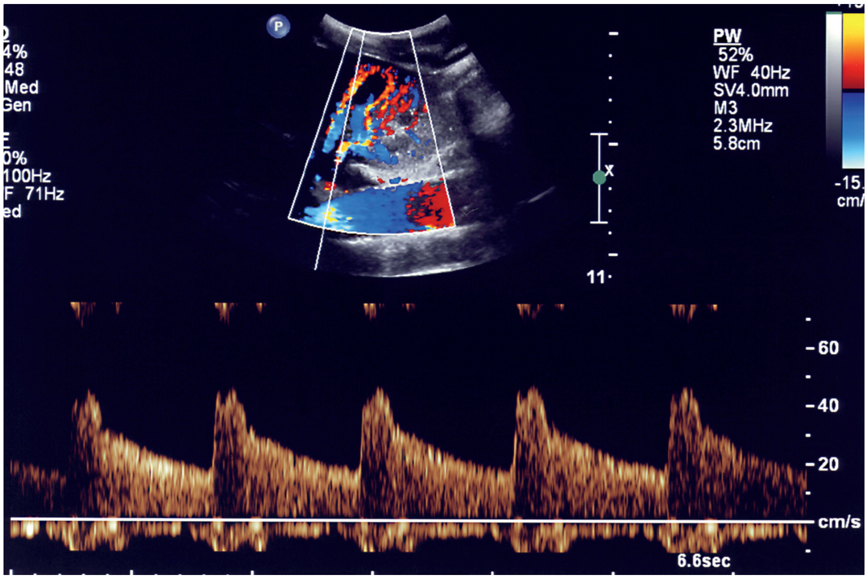


Figure 11-37. *Acquiring spectral Doppler from the distal right renal artery.*

For the left kidney, start with the long-axis view and rotate counterclockwise as before, and the short-axis view will look like a backward C. This time medial/anterior is at the left of the screen, while lateral/posterior is at the right.

Use small angle-and-rotate probe adjustments to line up the renal artery with the kidney. With further angle/rotate adjustments you can line up a lot of, most of, or even all of the renal artery on the screen. (Again, the color flow is your friend here.)

One way to try for the entire length of renal artery is to get the kidney image, then use the spinal column as a landmark to help to find the short-axis aorta. (Use the inferior vena cava as a landmark as well.) Now angle-rotate-angle-rotate and try to connect the kidney and aorta. If you cannot capture the entire length in one view, at least you can get Doppler from the segments.

Take a Doppler waveform in the renal artery a centimeter or two from the kidney (Figure 11-37), using good angle correction, then (if possible) 2 or 3 cm proximal to that. Measure peak systolic velocity.

(2) **The Hilum** Now, in the same short-axis kidney position, note where the artery joins the kidney. As we see in Figure 11-38, it looks in this view as though the kidney appears to be sort of wrapping around the vessels. This is the level called the *hilum*, the entry point of the vessels into the kidney. When we produce waveforms from this level it is called *hilar Doppler*.

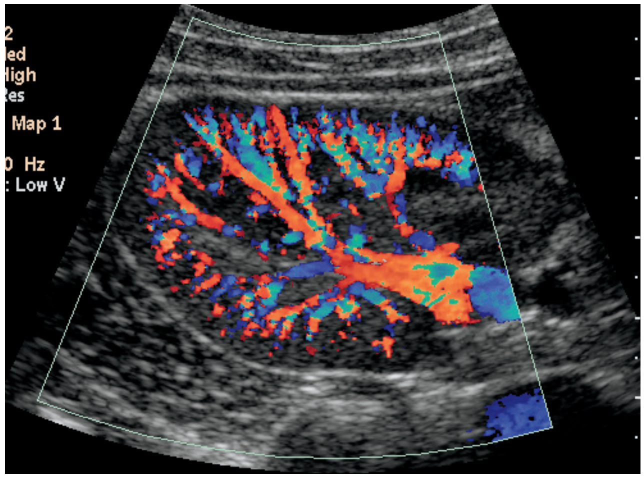


Figure 11-38. *Short-axis kidney with color flow. Get all that flow to converge at the hilum. Courtesy of Philips.*

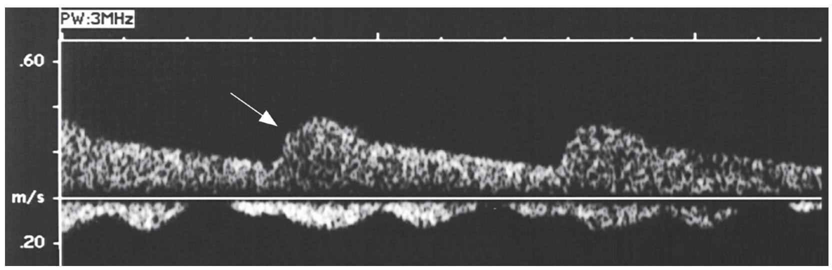


Figure 11-39. *Hilar Doppler. The sweep speed is doubled, making it look spread out horizontally for better measurement of acceleration time. The shoulder of the early systolic peak (ESP) is best seen in the middle waveform.*

Place your sample volume there and take a Doppler waveform. At this and all other levels, get your patient to help out by suspending breathing when you say "Stop." At this level we will assume a 0° angle; just turn the angle correction off. We look for a couple of characteristics in the hilar Doppler waveforms: They exhibit an *early systolic peak* (often abbreviated ESP), due to the compliance of the renal artery, and they have a rapid acceleration time (Figure 11-39).

To measure this acceleration time, sometimes called the rise time, you will change the sweep speed. Usually the sweep speed for the Doppler spectral display is something like 50 mm/sec, which results in a clear waveform to assess for flow character and to measure velocities with. You have already adjusted the scale (a.k.a. PRF) to make the waveforms as big as possible without going off the top of the display; that allows you to make a precise measurement on the y-axis, the *vertical* axis, for velocity (really the frequency shift, translated to velocity).

But now you want to measure time, on the x-axis of the display, so you will increase the sweep speed to 100 mm/sec. This will

When the portal vein is assessed after TIPS deployment, the flow should be hepatopetal—in the direction of the low resistance offered by that pathway. If the TIPS occludes, flow is again hepatofugal.

The sonographer might be asked to look at liver circulation for two main reasons, then: portal hypertension, and TIPS evaluation to see if it is still flowing properly. The liver being a very complex organ, there are many other reasons to scan here, which is again why you must learn much more than the brief introduction in this book.

Anatomy Review

The portal-vein system carries blood from the intestine and related organs to the liver, so that whatever we take in gets screened for toxins before it gets into the systemic circulation. *Portal* can be taken to mean "gatekeeper" in this context.

The main portal vein (MPV) angles upward to the patient's right as it heads toward the liver. Figure 11-43A is a venerable *Gray's Anatomy* illustration courtesy of Wiki Commons. It gives a good idea of the relationship of the portal system to the digestive organs. Figure 11-43B is a drawing of the portal-hepatic veins

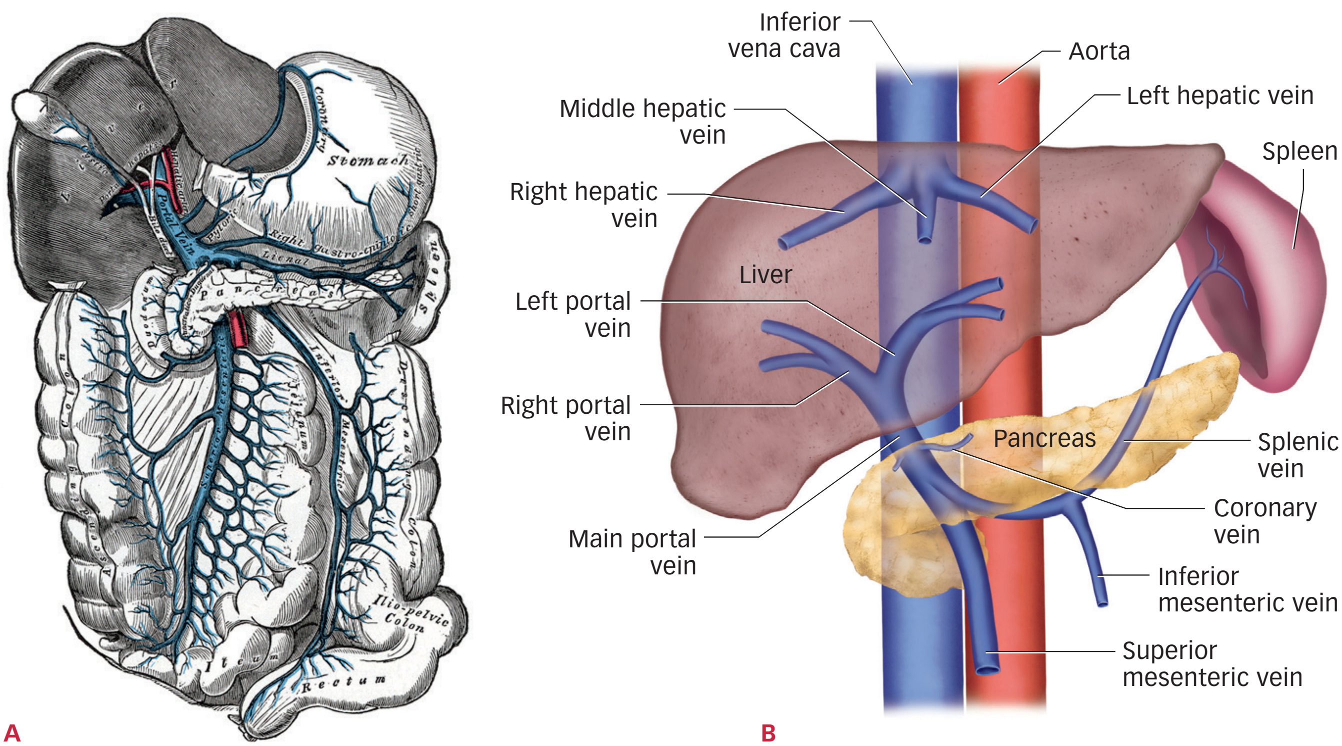


Figure 11-43. *The portal system.* **A** Gray's Anatomy *portal system.* **B** *Main components of the portal system, courtesy of Denise Eggman.*

along with their tributaries. The main portal vein receives blood from the major gastrointestinal veins; here you see the superior mesenteric and splenic veins joining to form the proximal end of the main portal vein. The inferior mesenteric vein empties into the splenic vein a bit before this junction.

One other branch vein—the coronary vein (also called the left gastric vein)—is sometimes clinically significant. It joins the main portal vein, bringing blood from the stomach and esophagus. In the patient with portal hypertension, excess venous pressure may back up into this vein and its tributaries to cause varices and potentially fatal bleeding.

Just before entering the liver, the main portal vein divides into the right and left portal veins. These veins further divide, eventually arriving at the capillary level, where the liver does its work. Then the capillaries begin converging into venules and small veins, finally flowing into the right, middle, and left hepatic veins. These are the outflow vessels from the liver to the inferior vena cava, just a bit below the level of the right atrium.

Patient Position

Most of this is done with the patient supine, but a modified flank approach can be useful for some views.

Probe(s)

Start with a curved-linear probe at around 3.5 MHz. A smaller-footprint phased array of similar frequency can be useful for shooting between ribs.

Scanning

Begin with the probe transverse just below the xyphoid process, as when starting an abdominal arterial scan. Identify the aorta and inferior vena cava. Put the inferior vena cava in the center of the screen, and then rotate on it to obtain a longitudinal view.

Look for a dark circle above the inferior vena cava, roughly 1 cm in diameter: That should be the main portal vein (Figure 11-44A). Put the main portal vein in center screen and rotate on it (taking the beam-edge indicator to the patient's right to maintain orientation), and voilà: main portal vein, angling sort of west by northwest in the field of view (Figures 11-44B and C). If you fish

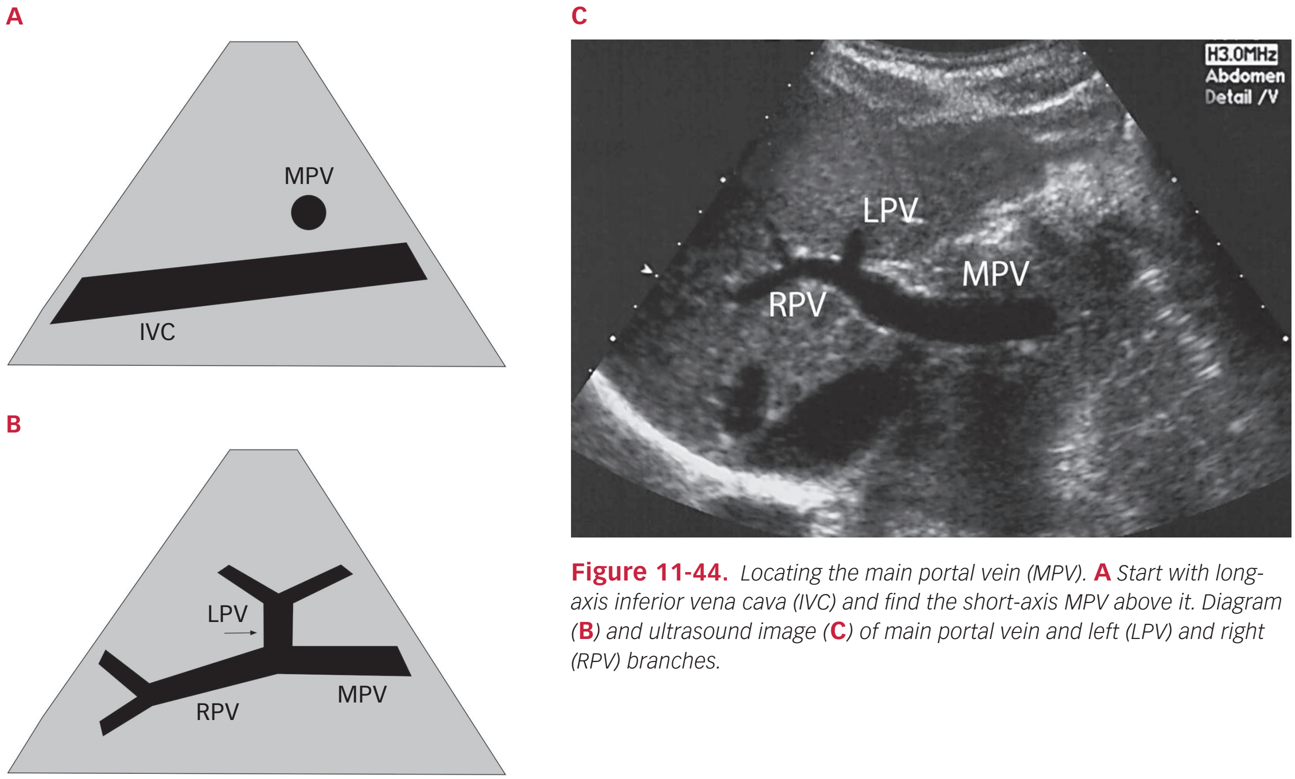


Figure 11-44. *Locating the main portal vein (MPV).* **A** *Start with long-axis inferior vena cava (IVC) and find the short-axis MPV above it. Diagram (***B***) and ultrasound image (***C***) of main portal vein and left (LPV) and right (RPV) branches.*

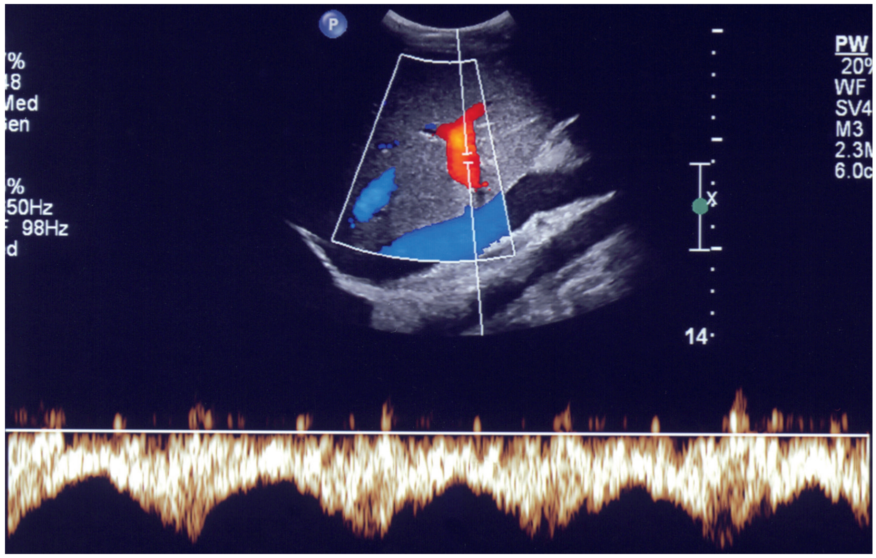
around using the angle and rotate maneuvers, you may be able to lay out the main portal vein with its right and left branches.

Possibly more useful than that midline approach is the right coronal oblique approach. Starting in transverse at the midline, move at the same level to the patient's right, aiming the beam medially between the ribs (good reason to have a small-footprint phased array probe available). Rotate to about halfway between the transverse and sagittal planes to lay out the main portal vein.

If this doesn't work for you in gray scale, by all means turn on the color flow and try it that way, but give the gray-scale image a chance first.

You should look for a noticeable difference between the main portal vein and the hepatic veins: Portal-vein walls are thicker and more echodense, while hepatic vein walls are thinner and essentially invisible on the scan. The portal veins are carrying potentially toxic stuff from the digestive system, like that birdbath margarita you just had at Casa de Bandini. So it makes sense that the walls here would be thicker and more protective until the liver has had a chance to deal with the bad stuff you insist on ingesting.

Figure 11-45. *Spectral Doppler from the main portal vein.*



Get a spectral waveform from the main portal vein. It should be semicontinuous, with perhaps a bit of pulsatility, not much (Figure 11-45). Pronounced pulsatility would be an abnormal finding, suggesting portal hypertension.

Now go back to the basic subxyphoid transverse position. Angle the beam superiorly, tracking the inferior vena cava, and look for the three hepatic veins: right, middle, and left (Figure 11-46). They drain the right, middle, and left regions of the liver into the inferior vena cava (IVC). It is often not possible to image all three on the same scan plane, so you may have to visualize two of them, then look for the third.

Doppler from these veins is normally very pulsatile in character because of their proximity to the right atrium (Figure 11-47).

A **B** **C**

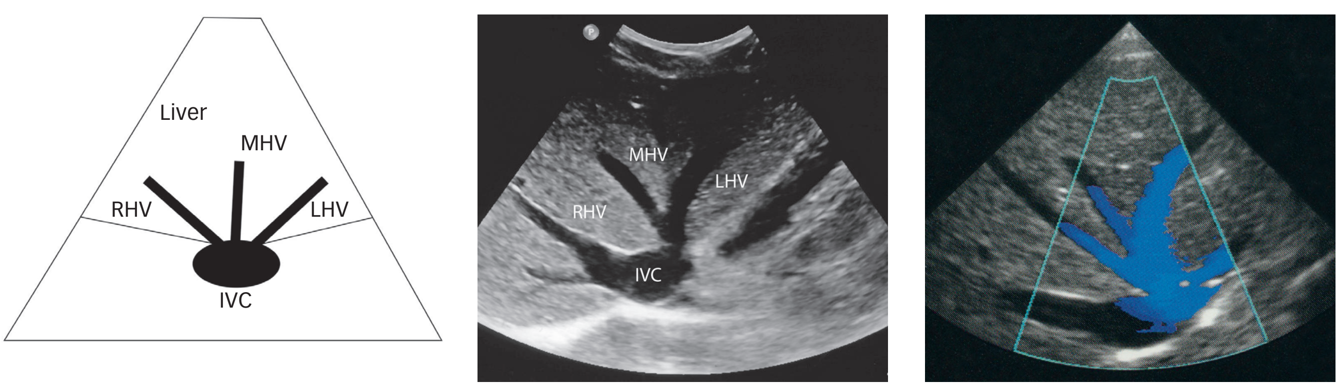


Figure 11-46. **A** *Configuration of hepatic veins and inferior vena cava.* **B** *Ultrasound image of hepatic veins and inferior vena cava.* **C** *Color flow image. Courtesy of Philips.*

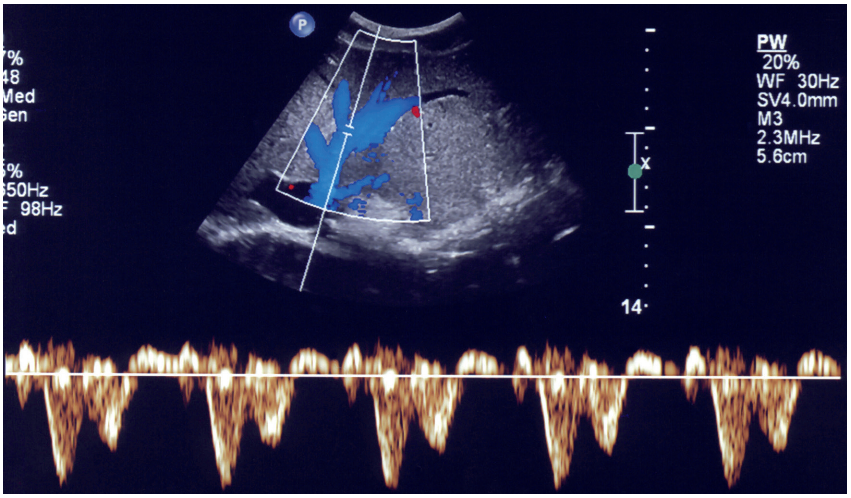


Figure 11-47. *Highly pulsatile spectral Doppler from hepatic vein.*

THE LEARNING CURVE

Having tried some of this, you are saying to me now, "It's all very well for you to tell me, do this, do that. I don't see a thing." You should be aware that the learning curve for performing competent abdominal Doppler studies is estimated variously as being from six months to as long as two years. Since you are bright enough and motivated enough to be reading this book, you can use the lower figure if you like, but that still means a long period of practice and hand-and-eye training before you can expect to perform good studies. This is a good time to recall the musical-instrument metaphor from the introduction: Try to enjoy the practicing and don't insist on immediate gratification; soon you will realize that you can perform. In other words, don't watch the pot too closely, or it will seem never to boil.

SUGGESTED SEQUENCE OF IMAGE STORES FOR GENERIC ABDOMINAL STUDY

Gray Scale

(You may have to do some or all of these with color flow, but only if the study is difficult.)

1. Long-axis proximal abdominal aorta, with celiac and SMA if possible
2. Long-axis distal aorta, possibly with common iliac bifurcation profiled

Abbreviations

AAA = abdominal aortic aneurysm
ABI = ankle/brachial index
ACA = anterior cerebral artery
ACoA = anterior communicating artery
AK = above knee
Ao = aorta
AP = anatomic position
APG = air plethysmography
AT = anterior tibial
ATA = anterior tibial artery
ATV = anterior tibial vein
AV = arteriovenous *or* axillary vein
AVF = arteriovenous fistula
AVM = arteriovenous malformation
Ax = axillary artery *or* vein
BA = brachial artery *or* basilar artery
BK = below knee
BPG = bypass graft
Br = brachial artery
BV = basilic vein
CABG = coronary artery bypass graft
CCA = common carotid artery
CFA = common femoral artery
CFV = common femoral vein
CHF = congestive heart failure
CIA = common iliac artery
C.O. = cardiac output
CSA = cross-sectional area
CT = celiac trunk *or* computed tomography
CV = cephalic vein
CVA = cerebrovascular accident
CVI = chronic venous insufficiency
CW = continuous wave
DF = deep fascia
DFA = deep femoral artery
DFV = deep femoral vein
DGC = depth gain compensation
DICOM = digital imaging and communications
DPA = deep palmar arch *or* dorsalis pedis artery
DSA = digital subtraction angiography
DVT = deep venous thrombosis
ECA = external carotid artery
ECG = electrocardiogram
EDV = end-diastolic velocity
EIA = external iliac artery
EKG = electrocardiogram
fem-fem = femorofemoral
fem-pop = femoropopliteal
fem-tib = femorotibial
FFT = fast Fourier transform
FM = foramen magnum
FV = femoral vein (*not* superficial femoral vein)
GSV = great (*formerly* greater *or* long) saphenous vein
HA = hepatic artery
HT = high thigh
HV = hepatic vein
IA = innominate artery
ICA = internal carotid artery
IIA = internal iliac artery
IJ = internal jugular vein
IMA = inferior mesenteric artery *or* internal mammary artery
IMS = intermuscular septum
IPG = impedance plethysmography
IV= innominate vein
IVC = inferior vena cava
LRA = left renal artery
LRV = left renal vein
LSA = left subclavian artery
LSV = lesser saphenous vein (no longer current; *now* small saphenous vein)
LT = low thigh
MAV = median antecubital vein
MCA = middle cerebral artery
MCV = median cubital vein
MI = myocardial infarction
MPV = main portal vein
MRI = magnetic resonance imaging/image
MSI = musculoskeletal injury
OA = ophthalmic artery
OPG = ocular plethysmography *or* oculoplethysmography
PA = peroneal artery *or* pulmonary artery
PCA = posterior cerebral artery
PCoA = posterior communicating artery
PE = pulmonary embolism *or* embolus
PerA = peroneal artery
PerV = peroneal vein
PFA = profunda femoris artery
PFV = profunda femoris vein
PI = pulsatility index
PICA = posterior inferior cerebellar artery
POD = periorbital Doppler
PopA *or* Pop a. = popliteal artery
pop-tib = popliteal-tibial graft
PopV *or* Pop v. = popliteal vein
PPG = photoplethysmography
PRF = pulse repetition frequency
PRG = phleborheography
PSV = peak systolic velocity
PT = posterior tibial *or* prothrombin time
PTA = posterior tibial artery
PTFE = polytetrafluoroethylene
PTT = partial thromboplastin time
PTV = posterior tibial vein
PV = peroneal vein *or* pulmonary vein
PVR = pulse-volume recording
PW = pulsed wave
RA = radial artery *or* renal artery *or* right atrium
RAR = renal/aortic ratio
RBC = red blood cell
RI = resistivity (*or* resistive) index
RIND = resolving (*or* reversible) ischemic neurologic deficit
ROA = right ophthalmic artery
RRA = right renal artery
SCM = sternocleidomastoid muscle
SF = superficial fascia
SFA = superficial femoral artery
SFJ = saphenofemoral junction
SMA = superior mesenteric artery
SMV = superior mesenteric vein
SPA = superficial palmar arch
SPG = strain-gauge plethysmography
SPJ = saphenopopliteal junction
SSV = small (*formerly* lesser) saphenous vein
STA = superficial temporal artery
Sub = subclavian artery or vein
SV = subclavian vein
SVC = superior vena cava
TCD = transcranial Doppler
TCI = transcranial imaging
$TcPO_2$ = transcutaneous partial pressure of oxygen
TGC = time gain compensation
TIA = transient ischemic attack
TIPS = transjugular intrahepatic portosystemic shunt
TO = total occlusion
TP = tibioperoneal
TPA = tibioperoneal trunk artery (*not* tPA, the lysing agent)
TPT = tibioperoneal trunk
TPV = tibioperoneal trunk vein
UA = ulnar artery
VA = vertebral artery
VPR = volume-pulse recording
WNL = within normal limits

Introduction to Vascular Scanning

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Donald P. Ridgway, RVT

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As a practicing vascular technologist and Professor (now Emeritus) in the vascular technology program at Grossmont College in California, Don Ridgway was responsible for seeing that program become the first vascular technology curriculum to receive American Medical Association/CAAHEP accreditation. Don brings teaching skills from several different disciplines and areas of expertise. He has taught both writing and fencing (swords, not chain-link) at San Diego State University, and for ten years he played and taught bluegrass banjo, mandolin, guitar, and Dobro—skills that inform his lessons on getting the best beam angles and protecting your hands.

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ISBN 978-0-941022-83-5

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