PART 1 OF 2

SCROTAL ULTRASOUND

Focusing on the principles and practice

By Bruce R. Gilbert, MD, PhD

An understanding of the testicular anatomy and the fundamental principles of ultrasound are prerequisites of an optimal scrotal exam. These essentials and a systematic scanning protocol ensure patient safety and guide the urologist in selecting the best transducer and optimizing image quality.

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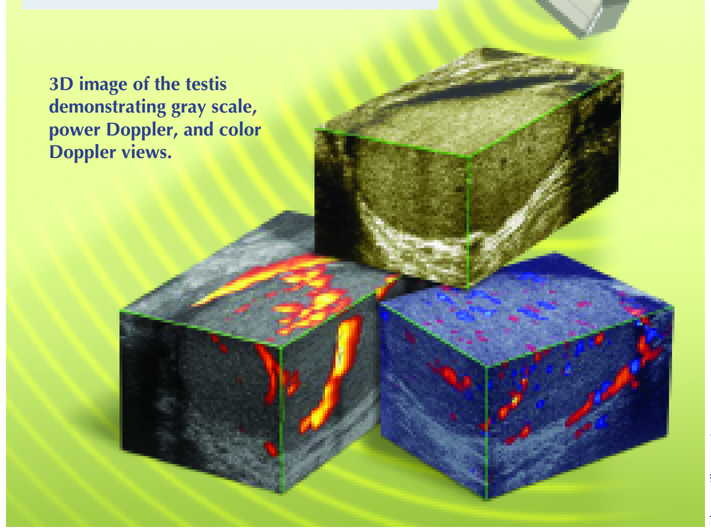


3D image of the testis demonstrating gray scale, power Doppler, and color Doppler views.

Photo illustration George Baquero.

Scrotal ultrasound (US) is a routine—and often essential component—of the evaluation of the male patient presenting with scrotal symptoms. This noninvasive procedure provides urologists with real-time information that is often invaluable in providing a rapid and accurate diagnosis. When performed in a urologist's office, it can save patients time and money.

Urologists are uniquely qualified by training and experience to perform, interpret, and document scrotal US studies, and should maintain a high degree of proficiency in these skills. The primary goal of this article is to provide practicing urologists with an overview of the principles and practice of office scrotal US. Initial proficiency in scrotal US requires "hands-on" training under the mentorship of an experienced sonographer, which often occurs during residency. Classes for maintaining and updating these skills are available through the American Urological Association (AUA), various academic training programs, and US equipment manufacturers. In addition, many excellent educational resources are available online.

RELEVANT EMBRYOLOGY AND ANATOMY

A basic understanding of the embryologic development of the scrotal structures and the scrotal blood supply helps guide the interpretation of certain abnormalities in scrotal US.

Developmental anatomy. In the 3-week-old embryo, primordial germ cells in the wall of the yolk sac close to the attachment of the allantois migrate along the wall of the hindgut and the dorsal mesentery into the genital ridge. In the 5-week-old embryo, the 2 excretory organs (the pronephros and mesonephros systems) regress, leaving only the mesonephric duct. The metanephros (adult kidney) forms from the metanephric diverticulum (ureteric bud) and the metanephric mass of mesoderm. The ureteric bud develops as a dorsal bud of the mesonephric duct near its insertion into the cloaca.

At 7 weeks, the indifferent embryo has 2 parallel pairs of genital ducts: the mesonephric (Wolffian) and the paramesonephric (Müllerian). By week 8, the developing fetal testis produces at least 2 hormones. The first, known as Müllerian-inhibiting substance or factor (MIS, MIF) or anti-Müllerian hormone (AMH), is produced by the fetal sertoli cells and suppresses unilateral development of the paramesonephric duct. The other, testosterone, stimulates development of the mesonephric duct into the male genital tract. Vestigial remnants (Figure 1) often can be visualized sonographically. The appendix of the testis persists as a vestigial remnant of the paramesonephric duct, while the appendix of the epididymis persists as a vestigial remnant of the mesonephric duct.

In the 7-week-old embryo, the testes are positioned in the dorsal abdominal wall. At about 28 weeks, the process vaginalis and testis begin to pass through the inguinal canal with facial coverings from the abdominal wall. These coverings become the coverings of the spermatic cord and testis. The scrotum contains 2 compartments divided by a septum with multiple facial layers beneath the skin and dartos facia. The primary components of each compartment include a testis, an epididymis, and a spermatic cord (Figure 2). The latter contains the ductus deferens and arterial and venous vessels (pampiniform plexus). Each testis is covered by a thick, fibrous, connective tissue layer (tunica albuginea) and 2 thinner connective tissue layers formed when the process vaginalis closes—a visceral layer and the parietal tunica vaginalis—creating a cavity that normally contains a small amount of fluid. When this cavity contains more than the physiologic amount of fluid (1-2 mL), a hydrocele is present. When blood collects in this cavity or in areas outside the parietal vaginalis, it constitutes a hematocele.

The scrotal blood supply. The scrotal structures receive their blood supply from 3 principal sources:

- the testicular artery (arising from the aorta and supplying the testis),
- the cremasteric artery (a branch of the inferior epigastric artery supplying the scrotal sac and coverings of the spermatic cord), and
- the deferential artery (arising from the superior vesical artery and supplying the vas deferens and epididymis).

The veins draining the testis exit at the mediastinum, where they join the veins draining the epididymis to form the pampiniform plexus. The cremasteric plexis, which drains blood primarily from extratesticular structures, lies posterior to the pampiniform plexus at the superior portion of the testis. The right testicular vein joins the inferior vena cava below the level of the right renal vein, while the left testicular vein drains into the left renal vein.

Along the length of the spermatic cord, the vascular supply is covered by the cremasteric muscle and loose connective tissue, and is in close approximation to nerves, lymphatics, and the vas deferens.

HOW US WORKS

Attenuation, resolution, and the biologic effects of US are all related to the physical principles of the sound wave. Sound waves are considered longitudinal pressure waves

FIGURE 1
Vestigial remnants of the male genital tract

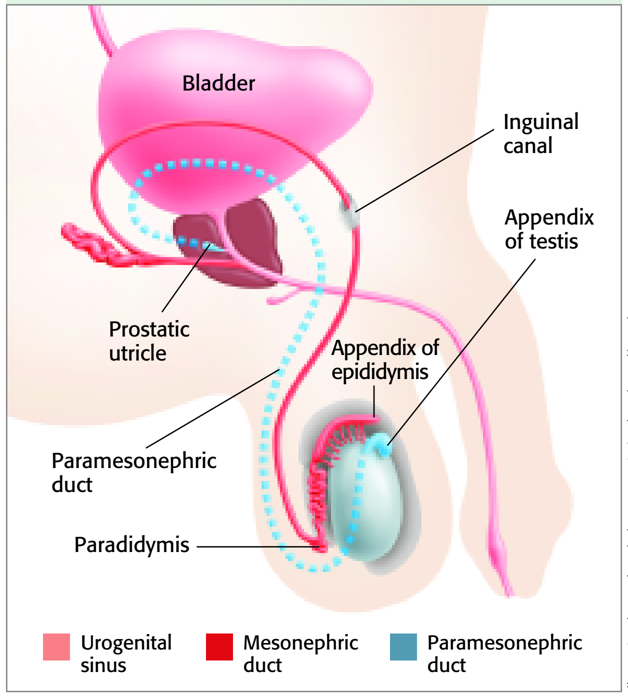


Illustration by Joel and Sharon Harris/Deborah Wolfe Ltd.

FIGURE 2
Coverings of the spermatic cord and testis

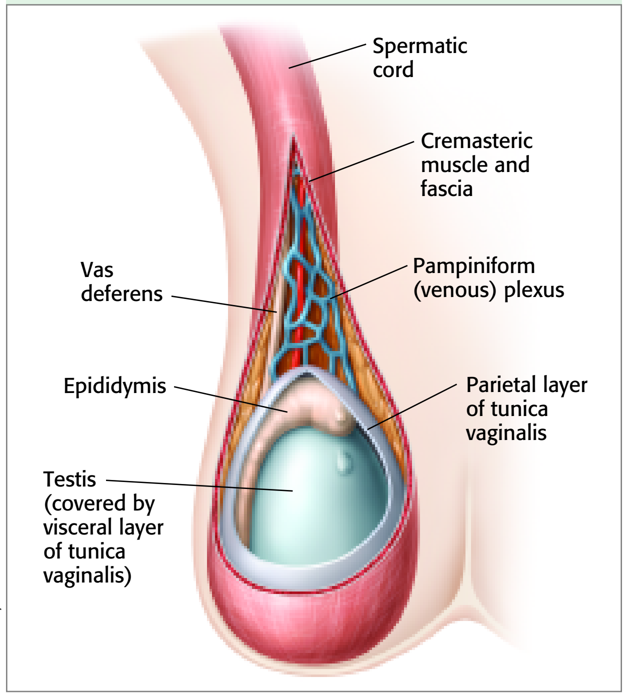


Illustration by Joel and Sharon Harris/Deborah Wolfe Ltd.

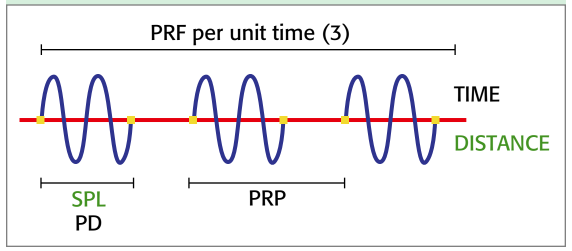
because the particles in the medium move in the same direction that the sound is traveling. Because the particles vibrate back and forth, the wave is also considered mechanical in nature. These concepts are important when considering the movement of a sound wave through tissue.

Although human hearing is in the frequency range of 20 Hz to 20,000 Hz (cycles/second), imaging transducers for US typically operate in the range of 2 to 15 MHz (million cycles/second). It is important to keep in mind that frequency and wavelength are inversely related through their relationship with velocity (wherein Velocity = Frequency × Wavelength).

Two types of US waves can be generated:

- *Continuous wave US* uses 2 transducers—1 for transmitting and 1 for receiving—and is "on" all the time. It is not practical for imaging but is very useful for determining the speed and direction, but not the depth, of blood flow.
- *Pulsed wave US*, used for imaging, uses a single transducer to generate and receive. After a few cycles are generated, the transmission stops and waits for the signal to intercept a tissue "reflector" and return a portion of the sound wave to the transducer. The transducer then receives and analyzes the returning signal (echo).

FIGURE 3
Ultrasound waveform descriptors



DOCUMENTATION AND BENCHMARKS

Proper documentation of scrotal US findings requires correct orientation of the testis and appropriate labeling of the images. The common terms used in scrotal US in the longitudinal (sagittal) orientation include anterior, posterior, superior, and inferior; in the transverse orientation, the terms anterior, posterior, medial, and lateral are used.

Echogenicity. For most US studies, the liver is typically used as the benchmark for echogenicity. In scrotal US, however, it is also important to compare the echogenicity of the 2 testes.

A variety of terms are used to describe the relative echogenicity of the testis as compared with that of the reference, including *hypoechoic* (darker and black on US), *hyperechoic* (brighter and white on US), and *isoechoic* (similar to the reference on US). High water content makes tissue appear hypoechoic, while high fat content makes tissue appear hyperechoic. Additional qualifiers like *anechoic* (without echo), *homogeneous* (of uniform echogenicity), and *heterogeneous* (of mixed echogenicity) are used to convey additional qualitative information about the composition of the structure being imaged.

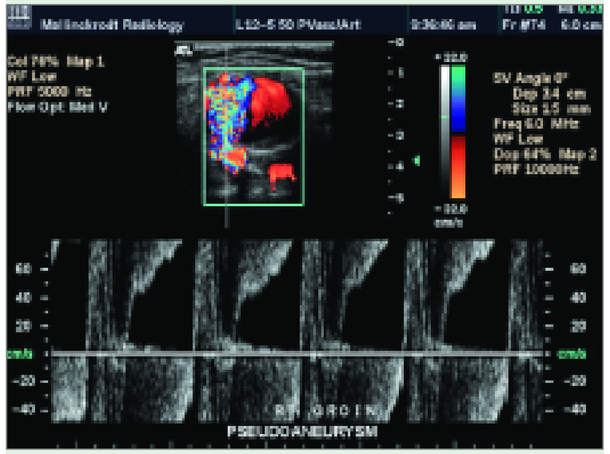
SIGNAL TERMINOLOGY IS KEY

It is important to understand the variety of terms used to describe the transmitted signal (Figure 3) because these variables can often be adjusted by the sonographer to improve the quality and reliability of the image.

Pulse repetition frequency (PRF). The PRF is the number of pulses occurring in 1 second (expressed in kHz). In clinical practice, the PRF is the most important variable to understand, especially when using color Doppler (CD) US. At a given PRF, the maximum Doppler frequency that can be measured (without distortion) is equal to 1/2 the PRF (also known as the Nyquist limit). This is a fundamental limitation of all pulse-wave systems. If the velocity of the blood flow and the beam/flow angle combine to give a Doppler frequency exceeding 1/2 the PRF, aliasing (Figure 4) will occur.

In a pulsed Doppler system, there must be a sufficient time interval for the sampling pulse to reach the reflector and make its way back to the transducer before a second pulse is generated. If the second pulse is generated before the first pulse is received, the 2 pulses are unable to be differentiated and ambiguity occurs. Also, as the depth of the reflector increases, a longer time interval is also required before the second pulse is generated. Therefore, the maximum Doppler frequency that can be measured decreases with increasing depth.

FIGURE 4
Aliasing



This artifact occurs when Doppler frequency exceeds 1/2 the PRF (the Nyquist limit).

Low PRFs are used to study low flow velocities (such as venous flow, varicoceles with Valsalva) and high PRFs are used to examine high flow velocities. When using low PRFs, aliasing will occur when high flows are encountered. Conversely, low flow velocities may be misrepresented when high PRFs are being used.[1]

TABLE 1
Speed of US through various body tissues

Air	330 m/sec (0.33 mm/µs)
Lung	500 m/sec (0.50 mm/µs)
Fat	1,450 m/sec (1.45 mm/µs)
Brain	1,520 m/sec (1.52 mm/µs)
Liver	1,550 m/sec (1.55 mm/µs)
Kidney	1,560 m/sec (1.56 mm/µs)
Muscle	1,580 m/sec (1.58 mm/µs)
Bone	4,000 m/sec (4.00 mm/µs)

Pulse repetition period (PRP). The PRP is the time from the start of 1 pulse to the start of the next (expressed in ms).

Spatial pulse length (SPL). The SPL is the space occupied by 1 pulse (the wavelength times the number of cycles in the pulse, expressed in mm).

Pulse duration (PD). The PD is the time it takes for 1 pulse to occur (expressed in µs).

Amplitude. The size of the sound wave (expressed in units of pressure, Mpa).

Intensity. This is the concentration of energy in the sound wave (equal to the square of the amplitude, expressed in mW/cm^2).

Propagation speed. This is the speed at which the US wave moves through tissues in the body. When US systems measure the time it takes for an echo to return (to calculate the depth of the object of interest), they *assume* a constant propagation speed of 1,540 m/second. However, because propagation speed actually varies with tissue density (Table 1), a misregistration artifact occurs, producing a US image that fails to represent the actual anatomy.

RESOLUTION, IMPEDANCE, AND REFLECTION

The terms resolution, impedance, and reflection are important in describing image quality, understanding why resolution changes with transducer frequency, and how the sonographer can improve the quality of the image by making adjustments in equipment settings.

Resolution. Spatial (or detail) resolution includes axial (longitudinal), lateral, and elevation resolution.

- *Axial resolution* is the ability to separately identify 2 objects, one in front of the other, in the direction of the propagating sound wave. Because the axial resolution is equal to 1/2 the SPL, axial resolution increases as the SPL is reduced (by reducing the wavelength and/or the number of cycles in the pulse). A reduction in the wavelength (by increasing the frequency) or the PRF therefore results in improved axial resolution.
- *Lateral resolution* is the ability to discriminate between 2 objects that are next to each other (side-by-side). Because lateral resolution is determined by the width of the beam in the direction of sound wave propagation, image quality is the best at the focal zone (the narrowest point of the beam).
- *Elevation resolution* is determined by the width of the beam perpendicular to the direction of motion. Because the perpendicular direction is deep to the scan plane, a slice thickness artifact can occur. A good example is when echos are seen in an anechoic structure (such as a cyst) because the width of the perpendicular beam is greater than that of the structure of interest.
- *Temporal resolution*, the ability to identify the position of a moving structure at a particular point in time, is directly related to the number of images generated by the US system per second (the frame rate). The goal is to optimize the frame rate to maximize temporal resolution.

Impedance and reflection. The quality of the echoes produced by an US wave reflecting off of a tissue interface is based on the *acoustic impedance* of the tissues (their resistance to sound waves, related to the density of the tissues and the propagation speeds of the wave), *the angle of incidence* (the angle between the sound wave and the tissue interface), and the character of the tissue interface (smooth or rough). A large impedance difference with a perpendicular angle of incidence against a smooth interface is termed a *specular reflector*. However, no echo is produced when tissue impedance is equal, even with a *perpendicular reflector.*

Most tissue interfaces are *nonspecular reflectors*, in which there are irregular or uneven boundaries with tissues of unequal impedance and an angle of incidence that is not perpendicular. While the scattering that occurs in these instances is helpful (because it insures that at least a portion of the beam will return to the transducer), it is also detrimental to image quality, providing an engineering challenge.

PRACTICAL APPLICATIONS

An understanding of these concepts allows urologists to vary machine settings ("knobology") to optimize image quality, select the best transducer for the application, and ensure patient safety.

Because higher frequencies are absorbed more than lower frequencies, imaging depth is limited with higher frequency transducers. However, higher frequency transducers produce better image quality than low frequency transducers because of their greater axial resolution. Therefore, a higher frequency transducer should be used for structures located close to the transducer (such as the testis and prostate) and a lower frequency transducer used for deeper structures (such

TABLE 2
Artifacts in 2D US

DISTORTION
• Geometric (ghost, split)
• Signal intensity (edge shadow)
DISPLACEMENT
• Misregistration
• Range ambiguity
• Refraction (ghost, split)
• Multipath reflection
• Beam geometry (blurring, slice thickness)
SHADOWING
• Angle of incidence
• Refraction (edge shadowing)
• Reflection (diffuse, edge shadow, specular)
• Attenuation
REVERBERATION
• Comet tail/ring down
• System noise
• Mirror image
• Pseudomass
• Reflection

TABLE 3
Artifacts in color flow US

ALIASING
• Wrap around
• Color
FLOW DETECTION
• Directional ambiguity
• False color modulation
FLOW VELOCITY
• Wall filter
• Spectral broadening (gate size, angle of incidence)
GAIN SETTING
MOTION
• Vascular
• Flash
COLOR MODULATION
• Uniform
• Color gap
• Color noise
REVERBERATION
DISPLACEMENT
RANGE AMBIGUITY

as the bladder and kidneys). Also, because the strongest echo returns to the transducer from perpendicular or specular reflectors, the sonographer may need to adjust the angle of incidence (how the transducer is angled) throughout the examination to get the best image.

Advancements in technology—including multiple bandwidth transducers and electronic focusing—have greatly simplified "knobology" and limited the need for multiple machine adjustments and for repositioning the probe during US exams.

WHY AND WHEN ARTIFACTS OCCUR

A US artifact occurs when an anatomic structure is incorrectly represented by the image—there is either an error in the location, the echogenicity, or the movement of the object of interest that may cloud image interpretation. Artifacts are not necessarily the result of sonographer or equipment malfunction, but are often related to assumptions made regarding the physical laws of sound—which may not always hold true. These include the beliefs that:
• a specular (perpendicular) reflector is always present;
• scattering does not occur;
• the beam width is always equal to the diameter of the object of interest; and
• sound travels at 1,540 m/second in all tissue.

Several artifacts commonly seen in scrotal US actually aid in diagnosis. Common artifacts that arise with 2D (real-time) US are listed in Table 2, and those that occur with CD US are listed in Table 3.

Acoustic shadowing is seen when a structure strongly attenuates or reflects, causing a decrease in the amplitude of echoes behind the structure. Testicular calcifications such as those occasionally seen with microlithiasis (Figure 5) can produce this artifact, although it is better visualized with larger calcific densities.

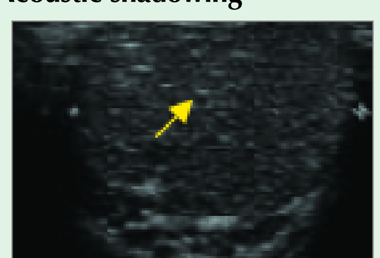
Acoustic enhancement is seen when a structure poorly attenuates or reflects, causing an increase in the amplitude of echoes behind the structure. Benign cystic structures such as epididymal cysts (Figure 6) produce this artifact. In fact, acoustic enhancement, a smooth circumscribed outer boundary, and an anechoic center are the diagnostic criteria for such cysts.

Reverberation artifact occurs when the partial reflection of a returning echo at the transducer due to a strong reflector produces a second, a third, or additional echoes that appear deeper on the display where, in fact, there are no additional reflectors. This occurs, for example, when imaging a testicular prosthesis (Figure 7).

An edge artifact is identified by a linear anechoic band, which is produced by phase cancellation effects at curved interfaces. This is often seen when imaging the caput epididymis (Figure 8).

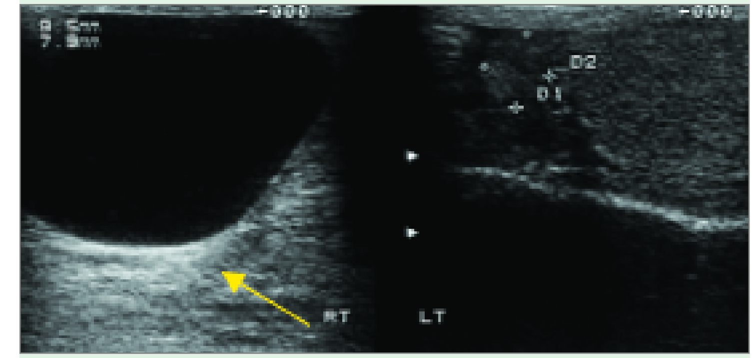
The slice thickness artifact occurs when the width of the beam perpendicular to the scan plane is larger than the structure of interest. Echoes outside the structure are therefore included in the image. This is often seen in patients with a large hydrocele, when echoes are produced in an anechoic structure (Figure 9). This artifact can often be reduced by narrowing or refocusing the beam.

FIGURE 5
Acoustic shadowing



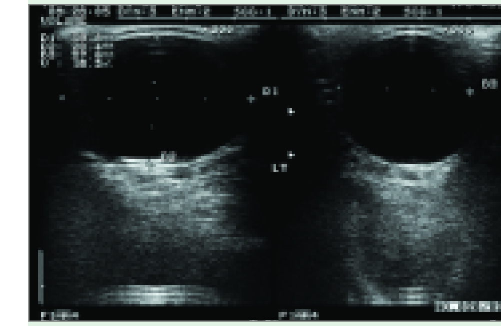
This artifact occurs when a structure (in this case, testicular microcalcifications) strongly attenuates or reflects, causing a decrease in the amplitude of echoes behind the structure.

FIGURE 6
Acoustic enhancement



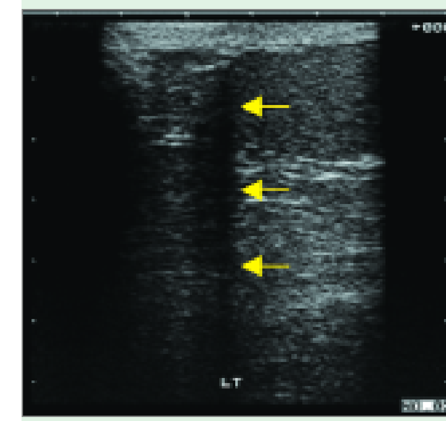
This artifact occurs when a structure (in this case, an epididymal cyst) poorly attenuates or reflects, causing an increase in the amplitude of echoes behind the structure.

FIGURE 7
Reverberation artifact



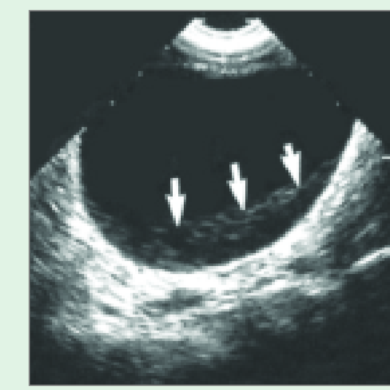
This artifact occurs when a strong reflector (such as this testicular prosthesis) causes a partial reflection of the returning echo at the transducer, producing additional (phantom) echoes.

FIGURE 8
Edge artifact



This linear anechoic band, often seen when imaging the caput epididymis, is produced at curved interfaces by phase cancellation effects.

FIGURE 9
Slice thickness artifact



This artifact, often seen in patients with a large hydrocele, occurs when the width of the beam perpendicular to the scan plane is larger than the structure of interest so that echoes outside the structure are included.

DOPPLER US

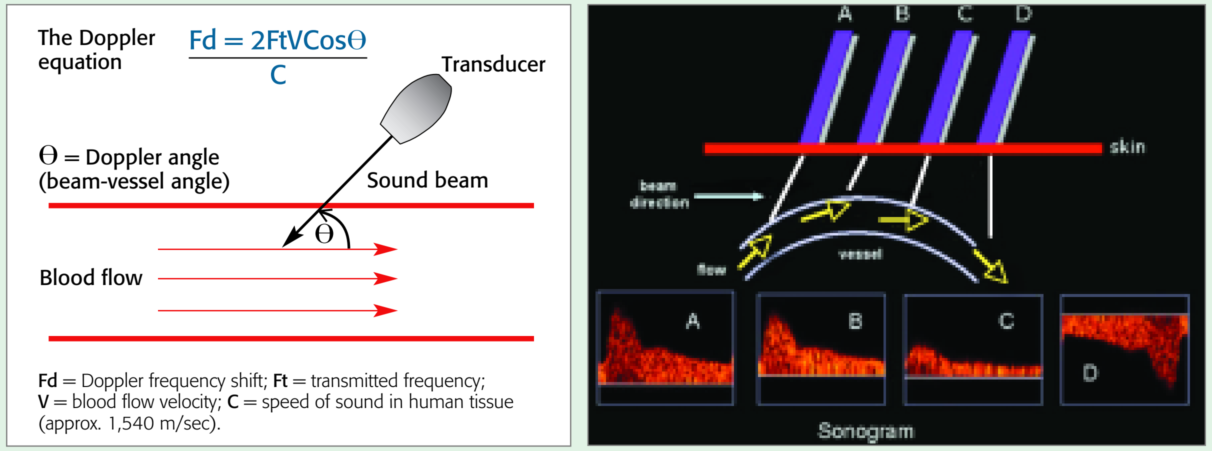
This modality has evolved to become an important component of the scrotal US examination. The physical principle of interest in color flow US (which uses the Doppler principle to characterize "blood flow") is that of the Doppler shift—the change in frequency caused by motion between the US beam and the receiver.

The angle of incidence between the US beam and the estimated direction of flow (Figure 10, left) is known as the Doppler angle. Doppler US accurately measures velocity (the speed and direction of movement) only at Doppler angles of 0° and 180°. Angles between 60° and 120° produce too large an error in velocity and should not be used. Therefore, to obtain the best images of blood flow of scrotal structures, the transducer must be properly aligned (manually or electronically) with the vessel of interest (Figure 10, right).

Doppler US equipment incorporates filters that eliminate any high amplitude, low frequency signals that are routinely caused by tissue movement. Since vessel wall movement is the primary cause of motion artifact, the term "wall" filter has been used. Unfortunately, this filter can also limit the ability to measure low flow velocities. Thus, the sonographer may need to adjust the filter settings. There are several types of Doppler US (Figure 11):

Continuous wave Doppler (CWD) uses 2 crystals (1 receives and 1 transmits). Although it can measure high velocities, the position (or depth) at which the velocity is measured is unknown. It cannot be used to produce color flow images. CWD is not used for scrotal imaging, but is sometimes

FIGURE 10
The importance of the Doppler angle



Left: The angle of incidence between the US beam and the estimated flow direction is known as the Doppler angle. *Right:* Doppler accurately measures velocity (speed and direction of movement) only at Doppler angles of 0° and 180°.

used in adult cardiac scanners to measure high velocities in the aorta.

Pulsed wave Doppler (PWD) allows the operator to position a sample gate (an electronically steerable box or guide) within a vessel where Doppler shifts and velocity information can be obtained. PWD is used to provide data for CD, color power Doppler, and spectral Doppler.

Color Doppler (CD) converts Doppler shifts into colors and then superimposes them on a 2D image. CD involves many sample gates positioned at several depths along multiple scan lines. CD gives velocity information (speed and direction). Flow moving towards the scan head is represented at the top of the color bar, while flow away from the scan head is represented at the bottom of the color bar. CD has several limitations (Table 3):[2]

- There is a tendency for noise to overwhelm the flow signal if the gain is too high or the threshold too low. This can muddle the image, making it difficult to interpret.
- Results are dependent on proper alignment of the transducer.
- Aliasing is a common artifact with pulsed wave Doppler, in which high velocity signals appear negative (Figure 9).

Color power Doppler (CPD) encodes the power in the Doppler signal in color by displaying the total integrated signal instead of the mean Doppler frequency shift.[3] The major limitation of CPD is that it does not provide directional information. However, it is often more sensitive than CD in detecting lower blood flow speeds.

Spectral Doppler (SD), which examines flow at a single site, is often used in combination with CD. It provides superb temporal resolution allowing for detailed analysis of the waveform including the calculation of velocities and indices.

The Resistive Index (RI) is a frequently used CD index. It is easily calculated from measurements of the peak systolic velocity (PSV) and the end diastolic velocity (EDV), where RI = (PSV-EDV) ÷ PSV.

RI values of 0.7 and 0.5 are considered normal in the spermatochord and intratesticular arteries, respectively. A lowered RI in testicular arteries has been associated with impaired histology.[4] In addition, both epididymal and testicular artery RI have been noted to be lower than normal in patients with epididymo-orchitis.[5] Alternately, intratesticular RI increased from 0.5 to 0.6 (21%) in patients with a hydrocele.[6]

PATIENT SAFETY

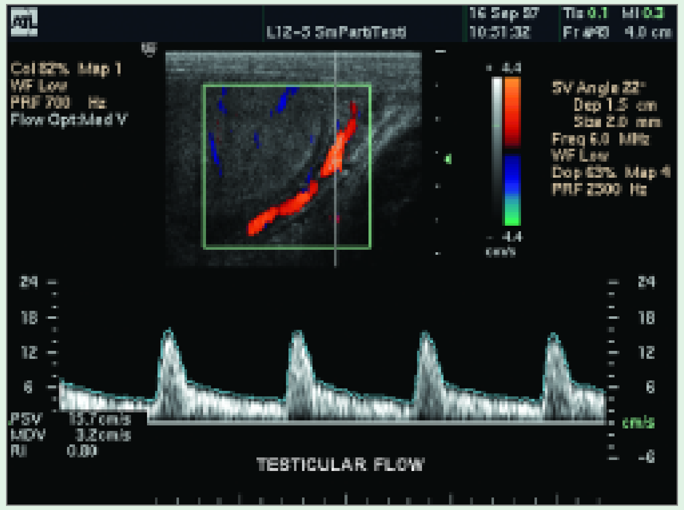
US has an excellent safety record. The American Institute of Ultrasound in Medicine has stated and reaffirmed that "No confirmed biological effects on patients or instrument operators caused by exposure at intensities typical of present diagnostic US instruments have ever been reported." However, because US propagates through tissue, there is the *potential* for tissue damage through thermal heating and nonthermal phenomena (such as cavitation).

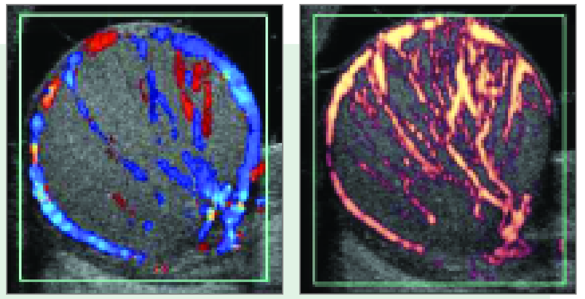
The acronym ALARA (As Low As Reasonably Achievable) is often used in association with imaging modalities. During US, this is accomplished by using procedures and equipment designed to limit the mechanical and thermal effects of US, including:

- use of the lowest power setting possible;
- limiting the time the transducer is active;
- proper transducer selection (higher frequency transducers require greater intensity to "see" at greater depth); and
- implementing "knobology" to appropriately adjust the PRF, focus, power, and pulse length.

It is also extremely important that all equipment receives routine mainte-

FIGURE 11
Types of Doppler US

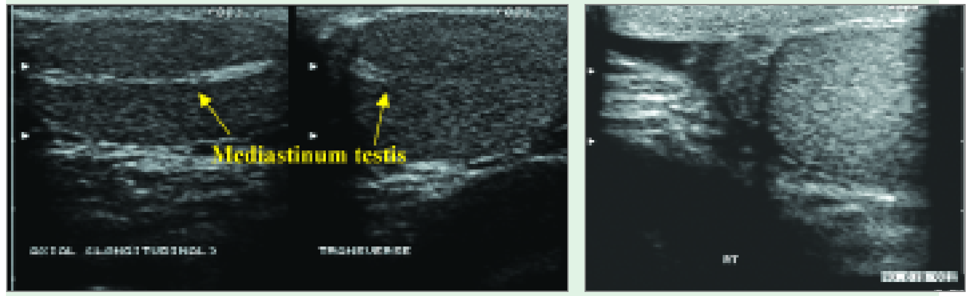


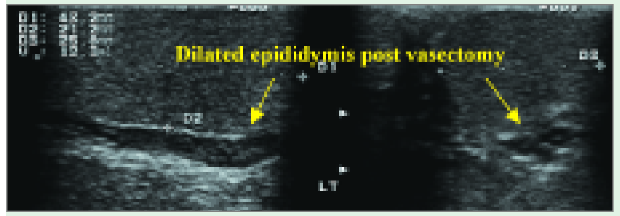


Left: Duplex Doppler presents 2 images: color flow Doppler and a spectral Doppler (presentation of the blood flow as a waveform). *Center:* Color flow Doppler presents flow direction by varying colors. It is necessary to check the color bar on the image (shown in left image) to identify flow coming towards the transducer (the top colors) from flow moving away from the transducer (the lower colors on the color bar). *Right:* Color power Doppler quantifies the amount of flow but gives no directional information.

nance and that transducers are disinfected before and after use. Each office should develop a standard operating procedure manual that states the policy and the documentation required to insure compliance. Manufacturers' guidelines must be followed. Any patient complications or equipment malfunctions should be documented and follow-up actions recorded.

FIGURE 12
Common scrotal US exam findings





Top left: normal mediastinum testis.

Top right: normal caput epididymis.

Bottom: dilated epididymis postvasectomy.

PHYSICAL ENVIRONMENT… THE FENG SHUI OF US

The US exam room should provide comfort and privacy for the patient. Simple measures, such as providing a space heater to warm the room and using a gel warmer, are greatly appreciated by patients and can even improve the quality of the exam. The room should be spacious enough for the patient and all necessary equipment. It is important that there be adequate room for interpreting and documenting the images and for secure storage of permanent images and written reports. Electronic medical record systems can easily store images, facilitating the documentation of US exams.

THE NORMAL SCROTAL US EXAM

The adult testis is approximately 4 to 5 cm long, 3 cm wide, 2 to 3 cm in the anterior-posterior (AP) dimension, and typically between 20 and 30 mL in volume. It is a smooth ovoid gland that exhibits homogeneous echogenicity. The 250 conical lobules, composed of seminiferous tubules, converge at the mediastinum to form the rete testis. From 8 to 12 efferent ductules connect the rete testis to the head (caput or globus major) of the epididymis, forming a single ductus epididymis. The septa and mediastinum testes may appear as linear echogenic areas on US (Figure 12, top left).

The adult epididymis is 6 to 7 cm long and courses posteriolateral to the testis with the head (caput) measuring 10 to 12 mm, the body (corpus) measuring 2 to 4 mm, and the tail (cauda) about 2 to 5 mm in greatest dimen-

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TABLE 4

Suggested images for office scrotal US

The following images should be saved as part of the permanent record:

Longitudinal (sagittal) view of left mid-testis
- Width and AP measurement
- Measurement of body of epididymis

Longitudinal (sagittal) view of right mid-testis
- Width and AP measurement
- Measurement of body of epididymis

Longitudinal (sagittal) view of caput epididymis (split-screen image of right and left sides)
- Comparison of echogenicity
- Measurement of width

Longitudinal (sagittal) view of cauda epididymis (split-screen image of right and left sides)
- Comparison of echogenicity
- Measurement of width

Transverse view of both testes (either single split-screen image or image of each side individually)
- Compare echogenicity (split-screen view is ideal)
- Width and AP measurement

Color Doppler evaluation (longitudinal [sagittal] and/or transverse view) of both testes
- Parenchymal blood flow evaluation
- Measurement of varicocele size in mid-sagittal and/or mid-transverse view

sion. The caput epididymis is often, but not always, more echogenic than the testis and coarser in appearance (Figure 12, top right). The smaller corpus epididymis can be seen as a hypoechic structure containing multiple echogenic linear structures representing the coiled epididymal tubule.[7] In men who have undergone a vasectomy or who are experiencing epididymitis, it is often less echogenic than the testis (Figure 12, bottom).

SCANNING PROTOCOL: TIPS AND TECHNIQUE

The key to performing a complete and thorough scrotal exam is to develop a protocol and follow it—on every scan. My approach, presented here, provides a foundation that others may vary according to their experience and preferences.

Patient preparation. The patient's scrotum should be supported. While towels or drapes are often used, having the patient place his legs together actually provides the best support. A towel or drape should be placed over the phallus. The patient can be asked to hold the tip of his phallus to prevent it from obscuring the field.

Transducer selection. A high frequency (7.5-10 MHz) transducer should be used for scrotal scanning. Broad bandwidth transducers allow for multiple focal zones, eliminating the need for adjustment during the examination. Multiple frequency transducers allow the transducer to be set at one of several distinct frequencies. A linear array probe with a "footprint" able to measure the longitudinal length of testis is ideal. While a curved array probe can be used for a large testis and to compare the testes, the frequency is usually lower, resulting in a less detailed image. Color and spectral Doppler are becoming essential elements of scrotal US because they provide documentation of normal testicular blood flow and paratesticular findings.

Survey scan. The images that should be obtained are listed in Table 4. Begin with a longitudinal survey scan of the scrotum, progressing medial to lateral to get an overall impression of the testis and paratesticular structure. The standard orientation of the image should be with the superior pole to the left and the inferior pole to the right. If the testis is larger than the footprint of the transducer, be sure to get views of the superior and inferior portions of the testis including the epididymis in those regions. Measure the long axis at the mid-testis together with the AP measurement.

Now switch to the transverse view by rotating the transducer 90°. The standard orientation for the right testis is to have the lateral aspect to the left and the medial aspect to the right. Conversely, for the left testis, the lateral aspect should be to the right and the medial aspect to the left. Using the mid-testis as a starting point of the survey scan, proceed first towards the superior pole then back to the to mid-testis before scanning to the inferior pole. Measurements of width and AP dimensions are taken and documented at the mid-testis. If the equipment being used has split-screen capabilities, comparative views of echogenicity and blood flow can easily be made and documented.

The use of CD imaging should be considered an integral part of the scrotal US exam. Many inflammatory, neoplastic, and benign conditions have characteristic flow patterns that can assist in diagnosis. Several of these

text continues on page 22

FIGURE 13

SCROTAL US REPORT

Patient: ______ Patient age: ______ Date: ______

Indications: ______ Physician ordering test: ______

Sonographer: ______ US machine: ______ Transducer(s): ______

SPECIFIC FINDINGS:

RIGHT TESTIS	LEFT TESTIS
Measurements	***Measurements***
Length (cm):	Length (cm):
AP (cm):	AP (cm):
Width (cm):	Width (cm):
Volume (cm^3):	Volume (cm^3):
Comment (right testis general):	Comment (left testis general):
Comparative testis size:	Comparative testis size:
Intratesticular findings	***Intratesticular findings***
Homogeneous echogenicity: yes/no	Homogeneous echogenicity: yes/no
Comment (testis echogenicity):	Comment (testis echogenicity):
Comparative testis echogenicity:	Comparative testis echogenicity:
Flow pattern (right testis):	Flow pattern (left testis):
Microlithiasis: yes/no	Microlithiasis: yes/no
Quantification: comment	Quantification: comment
Mass: yes/no	Mass: yes/no
Mass size: length (cm), AP (cm), width (cm):	Mass size: length (cm), AP (cm), width (cm):
Mass location:	Mass location:
Mass flow: increased, decreased, absent	Mass flow: increased, decreased, absent
Comment (right intratesticular):	Comment (left intratesticular):
Paratesticular findings	***Paratesticular findings***
Right epididymis: Normal/abnormal	**Left epididymis:** Normal/abnormal
Caput size: AP (cm): width (cm):	Caput size: AP (cm): width (cm):
Body width (cm):	Body width (cm):
Cauda width (cm):	Cauda width (cm):
Comment (epi size):	Comment (epi size):
Comparative epididymal size:	Comparative epididymal size:
Homogeneous echogenicity: yes/no	Homogeneous echogenicity: yes/no
Comparative epididymal echogenicity:	Comparative epididymal echogenicity:
Cyst present: yes/no	Cyst present: yes/no
Cyst location(s):	Cyst location(s):
Comment (epididymal echogenicity):	Comment (epididymal echogenicity):
Right varicocele present: yes/no	**Left varicocele present:** yes/no
(must be confirmed by color Doppler)	(must be confirmed by color Doppler)
Varicocele size (largest vein diameter):	Varicocele size (largest vein diameter):
Varicocele decreases in supine position: yes/no	Varicocele decreases in supine position: yes/no
Comparative varicocele size:	Comparative varicocele size:
Scrotal wall: normal/abnormal	***Scrotal wall:*** normal/abnormal
Comments:	Comments:

CLINICAL DIAGNOSIS ______

COMMENTS AND RECOMMENDATIONS ______

Physician signature and date ______

Modified after Resnick M, Fulgham P. Sample Scrotal Ultrasound Data Collection Tool. *Recommendations for Urologic Ultrasound*, AUA.

will be detailed in the section on indications (Part 2, July 2007).

PROPER DOCUMENTATION

The written report and archived images are a reflection of the quality of the examination. The old adage "If it's not documented, it wasn't done" should guide the sonographer in developing a quality report. The static images obtained during the evolving US exam should represent the sonographer's impression of the findings. If electronic storage space is available and the equipment allows, video clips, which better represent findings, can be saved. A quality report can aid in diagnosis, and is therefore in the best interest of our patients.

Figure 13 provides an example of a report form for scrotal US. In addition to the measurements and anatomic findings of the exam, it is essential to include patient identification information, the exam date, and the indications for performing the exam. The report should be signed by the physician who performed the exam.

Images should be attached to the report. Each image should include the date, the time, patient identification, and the transducer used and its frequency. The area of interest should be clearly identified. The orientation and measurements should be clearly labeled along with the pertinent anatomy and any abnormalities. CU

Part 2 of this article, which will appear in our **July issue**, will focus on the wide variety of indications for performing scrotal ultrasound. Sample images will provide guidance on how to differentiate normal and abnormal conditions. In addition, it will provide information on reimbursement and guidance on what to look for when purchasing a US system.

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