COMPREHENSIVE MOCK EXAM 5

Supplemental to: Clinical Ultrasound Board Review 2026-2027

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ARDMS SPI (Sonography Principles and Instrumentation) Examination, Inteleos -- 110 questions, single-best-answer, four options (A-D), domain-weighted per official ARDMS SPI Content Outline v17.3

Board-Review Questions

1. A facility's ultrasound units display real-time Mechanical Index (MI) and Thermal Index (TI) values during every exam. This on-screen indicator system, mandated for machines operating above certain acoustic output limits, is known by which term?

A. AIUM Statement on Prudent Use

B. Track 3 labeling requirement

C. As Low As Reasonably Achievable protocol

D. Output Display Standard (ODS)

2. A sonographer is asked to explain the mechanical bioeffect of ultrasound, as opposed to the thermal effect. Which process describes the formation, growth, and potentially violent collapse of gas-filled microbubbles in tissue due to the pressure fluctuations of the sound wave?

A. Streaming

B. Radiation force

C. Cavitation

D. Rarefaction

3. Which mechanism is primarily responsible for the thermal bioeffect of diagnostic ultrasound on tissue?

A. Mechanical shearing of the cell membrane by pressure gradients

B. Absorption of acoustic energy by tissue, converted to heat

C. Reflection of sound at tissue interfaces generating friction

D. Constructive interference of the transmitted and reflected wave

4. During a first-trimester transvaginal exam, the sonographer switches from 2D imaging to spectral Doppler to assess embryonic cardiac activity. From a prudent-use standpoint, why does this switch warrant particular caution?

A. Spectral Doppler cannot be performed transvaginally in the first trimester

B. Doppler imaging always exceeds the FDA output limit for obstetric use

C. B-mode TI limits do not apply in the same way to transvaginal transducer use

D. Spectral Doppler typically produces a higher TI than B-mode imaging, so exposure time should be minimized

5. Between routine abdominal exams on different patients, a surface (non-critical) transducer that only contacted intact skin is cleaned using a disinfectant wipe. Under the Spaulding classification, what level of disinfection is appropriate for this transducer use?

A. Sterilization

B. Low-level disinfection

C. High-level disinfection

D. Intermediate-level disinfection with a tuberculocidal agent

6. A department pursues AIUM/ACR practice accreditation for its ultrasound lab. What is the primary purpose of this accreditation process?

A. To individually certify sonographers as registered, credentialed professionals

B. To approve new transducer purchases before they are placed into clinical use

C. To verify the facility meets established standards for equipment performance, image quality, and personnel qualifications

D. To set the facility's reimbursement rate for billed ultrasound procedures

7. Immediately before beginning a scan, the sonographer confirms the patient's name and date of birth against the order, and verbally confirms the exam being requested. This practice is best described as which of the following?

A. ALARA compliance documentation

B. Informed consent documentation process

C. HIPAA privacy verification step

D. Patient identification / time-out protocol

8. Between patients, in addition to disinfecting the transducer, the sonographer wipes down the keyboard and bed, and performs hand hygiene. This broad set of practices, applied to every patient regardless of known infection status, is called what?

A. Contact isolation

B. Spaulding classification

C. Standard precautions

D. Reverse isolation

9. A patient asks the sonographer, mid-exam, whether the mass seen on screen is cancer. What is the most appropriate response, given the sonographer's scope of practice?

A. Give the patient a preliminary reassurance that the mass is likely benign in nature

B. Describe the mass's exact size, shape, and echogenicity in detail to the patient

C. Explain that the images will be reviewed by the interpreting physician, who will discuss findings with them

D. Compare the mass directly to prior imaging to answer the patient's specific question

10. During an ultrasound-guided liver biopsy, the sonographer adjusts the transducer angle so the needle shaft produces a strong specular reflection back to the transducer. Which needle-guidance principle does this describe?

A. Aligning the needle as close to perpendicular to the beam as the approach allows, to maximize needle-shaft visibility

B. Using a steeper, more parallel needle angle to increase the depth of field

C. Increasing transmit frequency specifically to improve needle-tip visualization

D. Switching to color Doppler instead of B-mode to track the needle tip position

11. Shortly after intravenous administration of an ultrasound contrast agent, a patient develops hives, wheezing, and hypotension. What is the sonographer's immediate priority?

A. Stop the exam, alert the supervising physician/emergency team, and initiate the facility's anaphylaxis protocol

B. Reduce the mechanical index and continue imaging to confirm the reaction

C. Administer a second, smaller contrast dose to verify the reaction is agent-related

D. Complete the exam quickly so the patient can be discharged

12. A transducer element vibrates at 5 MHz. If the period of one cycle is 0.2 microseconds, which relationship correctly describes period and frequency?

A. Period equals frequency multiplied by propagation speed

B. Period and frequency are unrelated for piezoelectric elements

C. Period is the reciprocal of frequency ($T = 1/f$)

D. Period increases as frequency increases, in direct proportion

13. Two tissues have the same density, but one is stiffer (higher bulk modulus) than the other. Based on the physics relating propagation speed to a medium's properties, what happens to propagation speed in the stiffer tissue?

A. Speed decreases in the stiffer tissue, since stiffness impedes particle motion

B. Speed increases, since propagation speed rises with increasing stiffness (and falls with increasing density)

C. Speed is unaffected by stiffness of the medium, only by its density

D. Speed becomes unpredictable in the stiffer tissue without also knowing frequency

14. Ranking average propagation speed from fastest to slowest, which sequence is correct for bone, soft tissue, fat, and air?

A. Bone > soft tissue > fat > air

B. Air > fat > soft tissue > bone

C. Soft tissue > bone > air > fat

D. Bone > air > soft tissue > fat

15. On a pressure-versus-time plot of a sound wave, which parameter is defined as the maximum variation of a variable (such as pressure) from its average, undisturbed value?

A. Wavelength

B. Amplitude

C. Period

D. Duty factor

16. A machine's TGC curve is described in dB rather than a linear scale. Why is decibel notation used to express relative changes in intensity or power in ultrasound?

A. Because decibel values are always positive numbers, unlike ordinary linear ratios

B. Because it converts intensity directly into a distance measurement unit

C. Because ultrasound systems cannot process linear ratios electronically at all

D. Because it is a logarithmic scale that compactly expresses the very large range of intensity ratios encountered clinically

17. Which quantity is defined as power divided by the area over which that power is distributed?

A. Intensity

B. Amplitude

C. Impedance

D. Attenuation coefficient

18. A physicist describes the depth at which a beam's intensity has been reduced to half its original value as the beam travels through tissue. What is this depth called?

A. Focal depth

B. Near-zone length

C. Penetration depth (maximum imaging depth)

D. Half-value layer

19. A system operates with a pulse repetition frequency (PRF) of 5,000 Hz. What is the correct relationship between pulse repetition period (PRP) and PRF?

A. PRP equals PRF multiplied by the propagation speed of sound in soft tissue itself

B. PRP and PRF are simply the same measurement, just expressed in different units entirely

C. PRP is the reciprocal of PRF (PRP = 1/PRF), representing the time from the start of one pulse to the start of the next

D. PRP is always exactly 1,000 times smaller than PRF, by strict definition

20. An imaging pulse consists of 3 cycles at a wavelength of 0.3 mm. Using the standard formula, what is the spatial pulse length (SPL)?

A. 0.9 mm (SPL = number of cycles x wavelength)

B. 0.1 mm (SPL = wavelength divided by number of cycles)

C. 3.3 mm (SPL = wavelength plus number of cycles)

D. 0.3 mm (SPL equals wavelength regardless of cycle count)

21. A transducer produces pulses with very few cycles per pulse (a low Q-factor). What imaging characteristic does this design favor?

A. Broadband operation, supporting a short spatial pulse length and good axial resolution

B. Narrowband operation, supporting the highest possible Doppler sensitivity

C. Elimination of attenuation effects entirely

D. A fixed, single operating frequency with no bandwidth

22. Using the commonly applied clinical rule of thumb for soft tissue attenuation (approximately 0.5 dB/cm/MHz), how does the attenuation coefficient change as transmitted frequency increases?

A. It decreases proportionally as the transmitted frequency increases

B. It remains constant and unchanging regardless of transmitted frequency

C. It depends only on imaging depth, not on transmitted frequency at all

D. It increases proportionally as frequency increases, so higher-frequency beams attenuate more per centimeter

23. For a given transducer aperture, increasing the operating frequency has what effect on the length of the near zone (Fresnel zone)?

A. The near zone shortens noticeably as transmitted frequency increases

B. The near zone is completely unaffected by frequency, only by aperture size

C. The near zone disappears entirely once frequency rises high enough

D. The near zone lengthens as frequency rises, since it is proportional to aperture squared and frequency

24. Beyond the near zone, the ultrasound beam enters the far zone (Fraunhofer zone). What characterizes beam behavior in this region?

A. The beam remains perfectly parallel-sided and non-diverging throughout the far zone

B. The beam progressively diverges (spreads out), reducing lateral resolution with depth

C. The beam narrows continuously to a single point at every depth in the far zone

D. The beam reflects entirely back toward the transducer once it enters the far zone

25. A system's ability to distinguish between two adjacent structures that differ only in echo strength (displayed as different shades of gray), rather than by their spatial separation, is best described by which term?

A. Contrast resolution

B. Axial resolution

C. Temporal resolution

D. Elevational resolution

26. Two overlapping sound waves arrive at a point exactly in phase, crest aligning with crest. What is this interaction called, and what is its effect on the resultant amplitude?

A. Constructive interference; the resultant amplitude is increased

B. Destructive interference; the resultant amplitude is increased

C. Constructive interference; the resultant amplitude is canceled to zero

D. Refraction; the resultant amplitude is unchanged

27. A sound beam strikes a surface that is small relative to its wavelength (such as red blood cells), compared to a beam striking a large, smooth interface (such as a diaphragm). How do the resulting echo patterns differ?

A. Both surfaces produce identical specular echoes, regardless of their relative size

B. The small surface produces a strong specular echo; the large one produces weak scatter

C. Neither surface type produces a detectable echo without added contrast enhancement

D. The small surface scatters weakly and diffusely; the large, smooth surface produces a strong, mirror-like specular reflection

28. A transducer is inadvertently exposed to excessive heat during autoclave sterilization and permanently loses its ability to convert between electrical and mechanical energy. Above what property is this failure explained by?

A. The transducer's fractional bandwidth specification was exceeded during use

B. The matching layer degraded chemically from repeated disinfectant exposure

C. The piezoelectric material was heated above its Curie point, permanently depoling it

D. The backing material simply absorbed too much acoustic energy over time

29. Most diagnostic ultrasound transducer elements are manufactured from a synthetic ceramic engineered for a strong piezoelectric response. Which material is most commonly used for this purpose?

A. Quartz crystal

B. Barium titanate exclusively

C. Silicon dioxide

D. Lead zirconate titanate (PZT)

30. A transducer fires its elements sequentially across the array, without electronic steering, producing an image whose width at the skin surface equals the transducer's physical footprint. Which array type does this describe?

A. Linear sequential array (rectangular field of view)

B. Phased array (sector field of view)

C. Annular array (single-element, mechanically focused)

D. Vector array (curved sector field of view)

31. A transducer has a curved footprint like a curvilinear probe, but steers and focuses its beams electronically using timed element firing, similar to a phased array, producing a sector-shaped image from a convex contact surface. Which array design does this describe?

A. Vector array (curved footprint, phased-style electronic steering)

B. Linear sequential array (rectangular, no steering)

C. Mechanical sector (wobbler) transducer

D. 1.5D array (limited elevational rows)

32. An older ultrasound system produces a sector image using a single transducer element (or small element group) that is physically oscillated back and forth by a motor within the probe housing, rather than steering the beam electronically. What is this transducer type called?

A. Vector array, using electronic phased-array steering

B. 2D matrix array, using full electronic steering

C. Mechanical sector (wobbler) transducer

D. Micro-convex array, a small curved electronic array

33. A transducer design uses a single element divided into concentric ring-shaped sub-elements, allowing the beam to be focused symmetrically in both the scan plane and the elevational plane, though it requires mechanical steering to form an image. What is this design called?

A. Linear array

B. Annular array

C. Vector array

D. Full matrix (2D) array

34. A standard 1D linear array transducer achieves focusing in the elevational (slice-thickness) plane using which fixed component, since the array itself cannot electronically steer or focus in that dimension?

A. An acoustic lens bonded to the face of the array

B. A second row of piezoelectric elements

C. An additional matching layer tuned to a lower frequency

D. A mechanically rotating mirror

35. All else being equal, how does increasing the number of individual elements (channels) in a 1D array generally affect image quality and capability?

A. It has no meaningful effect on lateral resolution or steering, only on frame rate

B. It degrades lateral resolution, because each element must transmit weaker pulses

C. It improves lateral resolution and steering/focusing capability, since finer element spacing allows more precise beam shaping

D. It eliminates the need for electronic focusing across the array altogether

36. A system deliberately reduces the drive amplitude of the outermost elements in the active aperture relative to the central elements, tapering the excitation across the aperture. What is this technique called, and what is its main purpose?

A. Dynamic focusing; its main purpose is to improve frame rate

B. Apodization; its main purpose is to increase penetration depth

C. Apodization; it reduces side-lobe artifact by tapering the aperture's edge excitation

D. Beam steering; its main purpose is to change the scan-line angle

37. As the receive focus moves to progressively deeper depths during a single scan line, the system widens the number of active elements contributing to that focal zone. What is this technique called?

A. Dynamic aperture

B. Apodization

C. Harmonic filtering

D. Spatial compounding

38. Some transducers intended for both 2D imaging and continuous-wave Doppler contain a dedicated pair of separate, always-transmitting and always-receiving piezoelectric elements built alongside the standard imaging array. What describes this probe configuration?

A. A duplex (combination) probe with dedicated CW Doppler crystals integrated alongside the imaging array

B. A single-crystal, pulsed-wave-only probe with no separate CW element

C. An annular array probe with concentric ring elements and mechanical steering

D. A matrix array probe with no dedicated CW Doppler capability

39. Certain transducers are constructed with materials (housing, cabling, lens) rated to withstand ethylene oxide (EtO) gas sterilization, while most standard transducers are only rated for high-level liquid disinfection. What determines which method may be used on a given probe?

A. The frequency of the transducer alone, regardless of its housing materials

B. Whether the probe is used for Doppler imaging or B-mode imaging that day

C. The manufacturer-specified material compatibility and sterilization rating of that specific transducer model

D. The hospital's general infection-control policy, regardless of the probe's own rating

40. An older-generation 3D/4D transducer produces a volume dataset by mechanically tilting or rotating a standard 1D array element inside the probe housing to sweep through a series of 2D planes. How does this differ from a true 2D matrix array system?

A. They are functionally identical technologies that simply carry different marketing names despite different designs

B. The mechanical system by itself cannot produce any true 3D dataset at all, only a flat 2D image

C. The mechanical system relies on electronic beam steering in all three dimensions simultaneously, with no moving parts

D. The mechanical system sweeps a conventional 1D array through sequential planes; a true matrix array instead steers electronically in both planes, with no moving parts

41. A small-footprint curved array transducer, designed to fit intercostal spaces or be used in neonatal/pediatric imaging where a standard curvilinear probe's footprint is too large, is best described as which transducer type?

A. Linear array

B. Annular array

C. Micro-convex array

D. 1.5D array

42. An endocavity transducer has its active array elements positioned at the very tip of the probe, so the beam fires straight off the end of the shaft. This design, as opposed to one where elements are positioned along the side of the shaft, is described as which configuration?

A. Endfire configuration

B. Sidefire configuration

C. Biplane configuration

D. Annular configuration

43. A transducer engineered with a very wide bandwidth (low Q-factor) generally exhibits which tradeoff compared to a narrowband, high-Q transducer operating at its resonant frequency?

A. Improved penetration at every frequency within its range, with essentially no drawback

B. Somewhat lower sensitivity at any single frequency, traded for effective operation across a broader frequency range

C. Complete elimination of attenuation-related signal loss across the whole range

D. A fixed, single, unchangeable center frequency with no usable bandwidth

44. As part of routine transducer preventive maintenance, a biomedical technician regularly inspects the cable and connector housing for cracks, fraying, or bent pins, separate from any image-based element testing. What is the primary purpose of this specific check?

A. To catch mechanical/electrical damage to the cable and connector before it causes intermittent signal loss or a safety hazard

B. To measure and precisely record the transducer's exact center operating frequency value

C. To verify the Curie point temperature rating of the transducer's piezoelectric material

D. To calibrate the ultrasound system's overall TGC curve settings for that day

45. When scanning a very superficial structure, the sonographer places a gel standoff pad between the transducer face and the skin. What is the primary imaging benefit of this technique?

A. It increases the transducer's operating frequency setting during the exam itself

B. It shifts the structure of interest farther from the transducer, out of the near-field artifact region

C. It eliminates the need for a matching layer inside the transducer housing

D. It converts a standard linear array transducer directly into a curvilinear array

46. A system uses 128 scan lines to build each frame, with a pulse repetition frequency of 6,400 Hz. Using the standard relationship among these variables, what is the resulting frame rate?

A. 50 frames/second (frame rate = PRF divided by lines per frame)

B. 800 frames/second (frame rate = PRF multiplied by lines per frame)

C. 6,272 frames/second (frame rate = PRF minus lines per frame)

D. 12,800 frames/second (frame rate = PRF multiplied by 2)

47. An operator increases the number of scan lines used to construct each frame, without changing depth. What is the expected trade-off?

A. Lateral resolution worsens overall while frame rate simultaneously improves

B. Lateral resolution improves (finer line sampling) but frame rate decreases, since more lines must be acquired per frame

C. Both lateral resolution and frame rate improve simultaneously, with no trade-off

D. Neither lateral resolution nor frame rate is affected by scan-line density at all

48. A gray-scale mapping curve is adjusted after an image has already been frozen and stored, changing how echo amplitudes are displayed without re-scanning the patient. Which category of image processing does this represent?

A. Postprocessing (applied to already-stored data)

B. Preprocessing (applied before storage occurs)

C. Beamforming step during transmit

D. Apodization step during transmit

49. A look-up table (LUT) assigns each digitized echo-amplitude value to a specific shade of gray for display. When can this assignment be adjusted without needing to rescan the patient?

A. Only during the initial beamforming stage, before any digitization occurs

B. Only by physically replacing the transducer with a different model

C. Never; gray-scale assignment is fixed permanently at the factory

D. After image acquisition, since the LUT is a postprocessing function applied to already-stored digital data

50. Before an echo signal can be digitally processed and stored, it must be converted from a continuously varying voltage into discrete numeric values. What is this conversion process called?

A. Beamforming process step

B. Demodulation process step

C. Analog-to-digital conversion (ADC)

D. Rectification process step

51. When digitizing the returning analog echo signal, the sampling rate must satisfy a minimum requirement relative to the highest frequency component present, or the digital reconstruction will be inaccurate. What principle governs this minimum sampling rate?

A. The Doppler shift equation itself, unrelated to sampling rate

B. Snell's Law of refraction, unrelated to sampling rate

C. The ALARA operating principle, unrelated to sampling rate

D. The Nyquist sampling theorem (sample at least 2x the highest frequency)

52. A digital ultrasound image is displayed as a grid of individual picture elements. How does increasing the pixel density (matrix size) of that grid, for a fixed field of view, affect the digital image?

A. It has no effect on spatial resolution, only on frame rate

B. It decreases spatial resolution, since more pixels dilute the available echo data

C. It changes only the color palette, not spatial detail

D. It improves the digital spatial resolution, since each pixel represents a smaller area of the image

53. A system displays 256 distinct shades of gray. What is the minimum bit depth per pixel required to represent that many discrete gray levels?

A. 4 bits total (16 levels)

B. 6 bits total (64 levels)

C. 8 bits (2^8 = 256 levels)

D. 16 bits total (65,536 levels)

54. After freezing an image, the sonographer scrolls backward through the most recently acquired frames to select the best still image for a measurement. Which system function allows this?

A. Spatial compounding function

B. Cine loop (image buffer review)

C. Coded excitation function

D. Persistence (frame averaging) function

55. Pressing a specific control immediately halts real-time scanning and displays only the single most recent frame, allowing measurements to be taken on a motionless image. What is this function called?

A. Cine loop

B. Freeze-frame

C. Write zoom

D. Read zoom

56. To measure the length of a structure on a frozen image, the sonographer places two cursors on the image using a physical input device and reads out the distance between them. Which instrumentation component enables this?

A. TGC slide control panel

B. Apodization array setting

C. Trackball with electronic calipers

D. Duty factor selector switch

57. A sonographer displays a real-time B-mode image on the left half of the monitor and a simultaneous, synchronized real-time color Doppler image on the right half, both updating together. What display mode is this?

A. Cine loop review

B. M-mode

C. Split-screen (dual-image) display

D. Panoramic (extended field of view) display

58. During an ultrasound-guided procedure, the system overlays a fixed dashed line on the image corresponding to the expected path of the needle when inserted through a needle guide attached to the transducer. What is this feature called?

A. Biopsy guide-line

B. TGC curve overlay

C. Spatial compounding overlay

D. Elevational focus indicator

59. Some systems offer a software feature that electronically steers a subset of scan lines at an angle closer to perpendicular with an inserted needle, specifically to strengthen the needle's specular reflection during a guided procedure. What is this feature generally called?

A. Needle-enhancement (needle-steering) imaging feature

B. Harmonic imaging technique for contrast

C. Spatial compounding technique for borders

D. Coded excitation technique for penetration

60. A cardiac sonographer freezes a single frame to review anatomy, as opposed to continuously updating the display during live scanning. What distinguishes these two acquisition states?

A. There is no meaningful difference at all between these two acquisition states ever

B. Static imaging always has a higher frame rate than real-time imaging does

C. Real-time imaging cannot use B-mode at all in this system, only Doppler modes

D. Real-time imaging continuously refreshes with new pulse-echo data; static imaging shows one fixed frame with no new data

61. A small notch or ridge on one edge of the transducer corresponds to a marker (such as a dot) displayed on one side of the on-screen image. What is the purpose of correlating these two features?

A. To indicate which array type the transducer is (linear vs curvilinear)

B. To establish and maintain a consistent, known image orientation relative to the patient

C. To indicate battery charge status on wireless probes

D. To activate harmonic imaging automatically

62. When storing ultrasound images to a PACS archive, a facility must choose between a compression method that reduces file size with no loss of image data and one that reduces file size further but discards some data permanently. What describes this trade-off?

A. Lossless compression (no data discarded, larger file) versus lossy compression (some data discarded, smaller file)

B. Preprocessing versus postprocessing of the acquired image signal data

C. Analog storage versus digital storage of the acquired image data files

D. Cine loop review versus freeze-frame review of the acquired image data files

63. Before color Doppler information can be overlaid on a B-mode image, the operator must position and size a box on the image indicating where color processing should be applied. What is this box called?

A. TGC window setting

B. Region of interest (color box)

C. Biopsy guide overlay line

D. Cine loop boundary marker

64. A sonographer presses a single control, and the system automatically adjusts overall gain and TGC settings based on the average echo signal received, without the operator manually adjusting each control. What best describes this feature?

A. Automatic image-optimization ("one-touch") algorithm

B. Apodization amplitude-weighting setting

C. Dynamic aperture sizing setting

D. Spatial compounding averaging setting

65. An ultrasound system automatically populates a scheduled patient's name, ID, and ordered exam from the hospital's scheduling system, rather than requiring manual entry at the machine. What describes this integration?

A. PACS long-term image archival function

B. Modality worklist integration with the RIS/HIS system

C. DICOM lossy compression setting

D. Cine loop synchronization function

66. A control allows the operator to selectively boost or reduce gain on the left versus the right side of the image, independent of depth, to correct for an asymmetric image appearance across the field of view. How does this differ from standard TGC?

A. It is functionally identical to TGC and simply duplicates that existing depth control

B. It adjusts gain only in the far field of the image, exactly like standard TGC does

C. It has no real effect on brightness at all, only on the assigned color pixel value

D. It adjusts gain uniformly across depth at a lateral position, whereas TGC adjusts by depth, not lateral position

67. A small anechoic cyst appears to contain low-level internal echoes on the image, even though it is truly fluid-filled, because the finite width of the ultrasound beam simultaneously samples adjacent solid tissue at the same depth. What artifact does this describe?

A. Mirror-image artifact from a strong reflector

B. Range ambiguity artifact from excessive PRF

C. Grating lobe artifact from element spacing

D. Beam-width (partial volume/section-thickness) artifact

68. A well-defined, clean anechoic band appears directly posterior to a densely calcified gallstone, with no internal echoes visible within the band. What artifact does this represent?

A. Dirty shadowing pattern typically seen arising from overlying bowel gas collections

B. Clean posterior shadowing from the strongly attenuating calcified structure

C. Posterior acoustic enhancement pattern, the opposite finding

D. Ring-down comet-tail artifact pattern, usually from gas

69. Low-level echoes appear layered within a normally anechoic gallbladder lumen, mimicking sludge, even though no true sludge is present, because structures outside the true scan plane but within the finite elevational beam thickness are being included in the image. What artifact does this describe?

A. Speckle texture pattern within tissue

B. Comet-tail artifact pattern from close reflectors

C. Reverberation artifact pattern from parallel reflectors

D. Section-thickness (slice-thickness) pseudo-sludge artifact

70. A structure is displayed in an anatomically incorrect location because the returning echo traveled along an indirect path, reflecting off a second strong interface before returning to the transducer, so the system's straight-line assumption places it incorrectly. What artifact does this describe?

A. Grating lobe artifact

B. Speckle

C. Multipath artifact

D. Range ambiguity artifact

71. Which image-quality metric specifically describes a system's ability to distinguish a true anatomic signal (such as a small lesion) from background image noise, rather than describing its ability to distinguish two adjacent gray shades from each other?

A. Contrast resolution

B. Axial resolution

C. Temporal resolution

D. Contrast-to-noise ratio

72. A postprocessing algorithm analyzes the random, granular pattern produced by coherent interference within a uniform tissue and selectively smooths it, without requiring the transmission of multiple beam angles the way spatial compounding does. What describes this technique?

A. Spatial compounding beam-angle technique

B. Coded excitation transmit technique

C. Adaptive speckle-reduction (noise-reduction) filtering

D. Harmonic imaging contrast technique

73. Two adjacent soft-tissue structures with similar overall composition appear as different shades of gray on an image, one brighter than the other. What underlying physical property primarily accounts for this difference in relative echogenicity?

A. Their distance from the transducer face alone, uncompensated

B. Their propagation speed value alone, a minor factor

C. Their pixel density on the display screen alone

D. Differences in backscatter and reflectivity between the two tissue types

74. An ultrasound image is built by acquiring and displaying data one scan line at a time, in sequence, until an entire frame is complete. What is this fundamental method of image construction called?

A. Spatial compounding method

B. Raster (line-by-line) scan reconstruction

C. Coded excitation method

D. Harmonic reconstruction method

75. A quality-control phantom's shallowest calibrated target cannot be resolved as a discrete structure, appearing instead as a bright, undifferentiated echo band immediately adjacent to the transducer face. What zone does this represent?

A. The far zone of the beam, well beyond the transducer

B. The dead zone, a near-field ring-down region next to the transducer

C. The focal zone of the beam, at the point of narrowest width

D. The Fraunhofer zone of the beam, far from the transducer

76. On color Doppler imaging, a rough, strongly reflective structure such as a kidney stone or surgical clip produces a rapidly alternating mix of color pixels directly at its surface, in the absence of any true blood flow. What artifact does this describe?

A. Flash artifact from patient motion

B. Aliasing

C. Blooming artifact

D. Twinkling artifact

77. Blood flowing through a straight, unobstructed vessel segment moves fastest at the center of the lumen and progressively slower toward the vessel wall, forming a smooth, orderly velocity profile. What is this normal flow pattern called?

A. Turbulent flow pattern, chaotic and disorganized

B. Laminar flow, with a smooth parabolic velocity profile

C. Plug flow pattern, flat and uniform

D. Retrograde flow pattern, simply reversed

78. Just distal to a significant arterial stenosis, blood cells move chaotically with multiple velocities and directions within the same small region, rather than in organized parallel streamlines. What is this flow pattern called?

A. Turbulent flow

B. Laminar flow

C. Plug flow

D. Phasic flow

79. A dimensionless value, incorporating vessel diameter, flow velocity, and fluid viscosity, is used to predict whether flow through a given vessel segment is likely to remain laminar or become turbulent. What is this value called?

A. Resistive index

B. Pulsatility index

C. Reynolds number

D. Nyquist limit

80. As blood flows through a significant narrowing in a vessel, its velocity increases at the narrowing while the pressure within that segment drops. What fluid-dynamics principle explains this inverse relationship between velocity and pressure?

A. The continuity equation alone, unrelated to pressure

B. The Bernoulli principle (velocity up, pressure down across a narrowing)

C. The Doppler equation alone, unrelated to pressure

D. Reynolds number alone, unrelated to pressure

81. In an incompressible fluid system, the product of cross-sectional area and velocity at one point in a vessel must equal that same product at another point along the same vessel, assuming no branching. Which principle is this, and what is it commonly used to calculate?

A. The continuity equation (Area1 x Velocity1 = Area2 x Velocity2), used to estimate an unknown area, such as valve area

B. The Bernoulli principle, used only to estimate pressure gradients across a stenosis

C. The Reynolds number, used only to predict the likelihood of turbulence

D. The Doppler equation, used only to calculate flow direction, not area

82. To estimate the true volume of blood passing through a vessel per unit time (not just a velocity measurement), which calculation is required?

A. Peak systolic velocity alone, with no other measurement needed at all

B. Resistive index multiplied simply by the vessel's measured diameter value

C. The Doppler shift value divided by the cosine of the Doppler angle alone

D. Cross-sectional area of the vessel multiplied by the time-averaged mean velocity (and, for a given interval, time)

83. When calculating volume flow rate, which velocity measurement should be used rather than the single highest velocity recorded in the cardiac cycle?

A. The time-averaged (mean) velocity across the full waveform, not the peak systolic velocity alone

B. The peak systolic velocity alone, since it is the single easiest value to measure

C. The end-diastolic velocity alone, taken at the very end of each cardiac cycle

D. The Nyquist limit for the current sample depth and settings

84. Immediately downstream of a hemodynamically significant stenosis, a focal area of high-velocity, disorganized flow is typically seen on color and spectral Doppler. What is this localized finding called?

A. Venous augmentation response

B. Tardus parvus waveform pattern

C. Poststenotic jet/turbulence

D. Respiratory phasicity pattern

85. Doppler interrogation of a normal lower-extremity vein shows flow velocity that rises and falls in coordination with the patient's breathing cycle. What is this normal finding called?

A. Spectral broadening pattern

B. Pulsatility index value

C. Aliasing artifact pattern

D. Respiratory phasicity

86. During a venous duplex exam, the sonographer manually squeezes the calf distal to the transducer and observes a brisk increase in venous flow velocity toward the heart. What is this maneuver and finding called?

A. Augmentation (distal compression augmentation), confirming venous patency

B. Tardus parvus response pattern, seen distal to stenosis

C. Poststenotic turbulence pattern, seen just past a stenosis

D. Valsalva maneuver, which instead produces flow cessation

87. On an arterial spectral waveform, the interval measured from the very onset of systolic upstroke to the point of peak systolic velocity is used as a diagnostic parameter in certain vascular exams. What is this interval called?

A. Pulse repetition period

B. Pulsatility index

C. Resistive index

D. Acceleration time

88. During spectral Doppler interrogation, the operator hears an audible signal through the system's speakers whose pitch rises and falls with the waveform. What do the pitch and loudness of this audible signal primarily correspond to?

A. Pitch corresponds to the Doppler shift magnitude (velocity); loudness corresponds to signal strength

B. Pitch corresponds to vessel diameter; loudness corresponds to imaging depth

C. Pitch and loudness both correspond only to the Doppler angle of insonation

D. Pitch corresponds to overall gain; loudness corresponds to PRF setting

89. A system displays real-time B-mode imaging together with a simultaneously updating spectral Doppler waveform, but without a color overlay. What term describes this combined imaging configuration, and how does it differ from a system that also adds color?

A. Triplex (B-mode plus spectral Doppler); a duplex system additionally requires color

B. Duplex (B-mode plus spectral Doppler); adding a simultaneous color overlay would make it a triplex system

C. Duplex and triplex are interchangeable terms for the same configuration

D. This describes M-mode combined with B-mode, unrelated to Doppler terminology

90. To accurately estimate flow velocity, the operator manually positions an on-screen line so that it lies parallel to the presumed direction of blood flow within the vessel. What is this line/technique called?

A. The angle-correction cursor, aligned parallel to the vessel wall/flow direction

B. The sample volume gate marker, defining interrogation depth

C. The wall filter cursor setting, removing clutter

D. The baseline shift control knob, repositioning zero velocity

91. When scanning a superficial vessel that runs parallel to the skin surface with a linear array, obtaining an adequate Doppler angle can be difficult with the probe held straight. Which transducer feature allows the operator to electronically angle the transmitted Doppler beam without physically tilting the probe as much?

A. Apodization amplitude setting

B. Dynamic aperture sizing setting

C. Electronic beam steering (steer angle) feature

D. Harmonic filtering frequency setting

92. To measure very high velocities that would otherwise exceed the Nyquist limit for a given sample depth, some systems offer a mode that fires multiple pulses simultaneously along the beam at range intervals, deliberately introducing more than one active sample gate along the beam path. What is this mode called, and what is its trade-off?

A. Color M-mode; its main trade-off is loss of live B-mode imaging

B. High-PRF (HPRF) mode; its trade-off is range ambiguity from multiple active sample gates

C. Power Doppler; its main trade-off is loss of flow-direction information

D. CW Doppler; its main trade-off is complete loss of range resolution

93. A system displays color flow information along a single, fixed scan line plotted continuously over time, similar in format to conventional M-mode but with color-encoded velocity information added. What is this display mode called?

A. Triplex mode

B. Color M-mode

C. HPRF mode

D. Power Doppler

94. A variant of power Doppler adds limited flow-direction information to the otherwise amplitude-based, non-directional power Doppler display. What is this variant called?

A. Color velocity mode

B. Spectral Doppler

C. Tissue Doppler

D. Directional power Doppler

95. Unlike conventional color Doppler, which encodes mean velocity, power Doppler signal strength primarily reflects which underlying factor?

A. The Doppler angle of insonation exclusively, nothing else

B. The peak velocity of only the fastest-moving red blood cells

C. RBC concentration/amplitude of the returning signal, largely independent of velocity

D. The wall filter setting exclusively, and nothing else in the signal

96. In grading the severity of an arterial stenosis, which single spectral Doppler measurement is most commonly used as the primary velocity-based criterion?

A. Peak systolic velocity (PSV) at the site of stenosis

B. End-diastolic velocity proximal to the site of stenosis

C. Mean venous velocity in an adjacent vein

D. Pulse repetition period at the current setting

97. To help correct for a patient's overall elevated baseline velocities (which could otherwise overestimate stenosis severity), some grading criteria use a ratio comparing velocity at the stenosis to velocity in a normal segment. What is this ratio called?

A. Velocity ratio (stenotic PSV divided by proximal PSV)

B. Pulsatility index value, a different waveform ratio

C. Reynolds number value, unrelated to this ratio

D. Resistive index value, a different waveform ratio

98. In a vessel that is nearly, but not completely, occluded by thrombus, Doppler interrogation may reveal only a faint, minimal, barely detectable flow signal along a thin residual channel. What descriptive term is used for this finding?

A. Augmentation response

B. Tardus parvus waveform

C. Poststenotic turbulence pattern

D. String sign (trickle flow)

99. Distal to a significant, more proximal arterial stenosis, the spectral waveform shows a delayed and blunted systolic upstroke with a lower-than-expected peak velocity. What is this waveform pattern called?

A. Triphasic waveform

B. To-and-fro waveform

C. Monophasic augmentation

D. Tardus parvus waveform

100. Doppler interrogation of the neck of a suspected pseudoaneurysm shows flow moving into the sac during systole and then reversing back out of the sac during diastole. What is this characteristic biphasic pattern called?

A. Tardus parvus waveform

B. To-and-fro waveform

C. Venous augmentation

D. String sign

101. Given a measured Doppler shift, a known transmitted frequency, a known Doppler angle, and the propagation speed of sound in soft tissue, the Doppler equation can be algebraically rearranged to directly solve for which unknown quantity?

A. Vessel diameter

B. Pulse repetition frequency

C. Attenuation coefficient

D. Flow (blood) velocity

102. On an obstetric umbilical artery Doppler waveform, the complete absence of forward flow, or frank reversal of flow, during diastole is considered a marker of which underlying condition?

A. A technically inadequate Doppler angle during the exam

B. Normal, expected third-trimester placental function

C. Maternal, rather than fetal, circulation being sampled

D. Increased placental vascular resistance (a sign of placental insufficiency)

103. Doppler interrogation of a normal hepatic vein typically shows a waveform with three distinct phasic components reflecting the cardiac cycle, rather than the waveform pattern typical of a peripheral artery. What is this normal hepatic vein pattern called?

A. Triphasic waveform, reflecting transmitted right atrial pressure

B. Tardus parvus waveform, a delayed arterial pattern

C. Monophasic waveform, a continuous flat pattern

D. To-and-fro waveform, a bidirectional pattern

104. Doppler interrogation of the main portal vein in a healthy patient typically shows flow moving in which direction, and with what general character?

A. Away from the liver (hepatofugal), with a sharply triphasic pattern

B. Absent flow under normal fasting conditions

C. Toward the liver (hepatopetal), continuous with only mild respiratory undulation

D. Bidirectional, alternating every cardiac cycle

105. During a carotid duplex exam, the sonographer needs to confirm which of two adjacent vessels is the internal carotid artery. Tapping gently on the ipsilateral superficial temporal artery while watching the spectral waveform is a technique used to help make this distinction. What does this maneuver rely on?

A. The maneuver is used only to measure resistive index, not to identify which vessel is which

B. Both vessels always show identical waveform oscillation, so it cannot distinguish between them at all

C. Only the internal carotid artery responds at all to this particular temporal tap maneuver

D. The external carotid (supplying the temporal artery via branches) shows a transient oscillation to the tap; the internal carotid does not

106. In a patient with a significant stenosis proximal to the origin of the vertebral artery on one side, Doppler of that vertebral artery may show flow reversed in direction, away from the brain. What is this finding called?

A. Subclavian steal: reversed vertebral flow from a proximal subclavian stenosis

B. Poststenotic turbulence pattern, seen just past a stenosis

C. Venous augmentation response, a distinct venous finding

D. Tardus parvus waveform, a distinct arterial pattern

107. Doppler evaluation of the feeding artery to a surgically created arteriovenous (AV) fistula for dialysis access typically shows unusually low resistance with markedly elevated diastolic flow, compared to a normal peripheral artery. What does this waveform pattern indicate?

A. Low-resistance runoff into the venous system via the AV shunt, consistent with a patent fistula

B. Normal resting peripheral arterial flow, with no shunt present at all

C. Fistula thrombosis or complete occlusion of the vascular access

D. A technically inadequate Doppler angle used during this particular exam

108. In a patient with clinically suspected testicular torsion, which Doppler finding on the affected side is the key diagnostic indicator?

A. Increased, hyperemic arterial and venous flow compared to the unaffected side

B. A normal triphasic waveform pattern identical to the unaffected side

C. Absent or markedly diminished arterial and venous flow on the affected side versus the normal side

D. Isolated venous flow reversal with preserved normal arterial flow

109. For a patient with a renal transplant, the resistive index is measured on serial ultrasound exams over the following weeks and months, rather than on a single exam alone. What is the primary purpose of tracking this value serially over time?

A. A single RI value is always sufficient on its own, so serial tracking adds nothing

B. A rising RI trend over serial exams can be an early indicator of a developing complication, such as rejection

C. To measure vessel diameter change over the transplant's follow-up period

D. To calibrate the ultrasound system's TGC for that specific patient

110. Distal to a severe, longstanding proximal arterial occlusion, a lower-extremity spectral waveform may lose its normal triphasic pattern entirely, showing only continuous forward flow throughout the cardiac cycle with no diastolic reversal component. What is this waveform pattern called?

A. Triphasic waveform

B. To-and-fro waveform

C. String sign

D. Monophasic waveform

Answers

1. D. The Output Display Standard requires real-time on-screen display of the Thermal Index (TI) and Mechanical Index (MI) on systems capable of exceeding specific output thresholds, so operators can monitor and minimize bioeffect risk in real time. AIUM's Statement on Prudent Use is a practice guideline, not the display system itself; Track 3 refers to an FDA output-labeling tier for the equipment's regulatory approval pathway, not the live on-screen readout; ALARA is the operating principle the display supports, not the display standard itself.

2. C. Cavitation is the mechanical bioeffect in which gas bodies (bubbles) oscillate, grow, and can collapse under the pressure swings of the sound field, potentially causing local tissue damage; it is the basis for the Mechanical Index. Streaming is fluid motion induced by the sound field, a related but distinct mechanical phenomenon. Radiation force is a steady force from momentum transfer, not bubble collapse. Rarefaction is simply the low-pressure half of the sound wave cycle, not a bioeffect.

3. B. Thermal bioeffects arise when tissue absorbs acoustic energy and converts it to heat, with the degree of heating estimated by the Thermal Index. Mechanical shearing relates to mechanical, not thermal, bioeffects. Reflection at interfaces does not itself generate clinically significant heat. Constructive interference describes wave interaction, not the tissue-heating mechanism.

4. D. Spectral (pulsed-wave) Doppler uses a much higher duty factor than B-mode, concentrating more acoustic energy at the sample volume and typically producing a higher TI; prudent use calls for minimizing dwell time when switching into Doppler modes, especially early in pregnancy. Spectral Doppler can be performed transvaginally when clinically indicated. Doppler output does not automatically exceed FDA limits. TI display standards apply to all modes including transvaginal transducers.

5. B. Under the Spaulding classification, devices contacting only intact skin are non-critical and require only low-level disinfection. High-level disinfection is reserved for semicritical devices (e.g., endocavity probes contacting mucous membranes). Sterilization is reserved for critical devices entering sterile tissue or the vascular system. Intermediate-level with a tuberculocidal agent is a stricter standard than intact-skin contact requires.

6. C. AIUM/ACR practice accreditation evaluates a facility's equipment performance, image quality, protocols, and personnel qualifications against established standards, functioning as an external quality-assurance check. It does not individually certify sonographers (that is registry credentialing, e.g., ARDMS), does not approve individual equipment purchases, and does not set reimbursement rates.

7. D. Verbally confirming patient identity and the ordered exam immediately before scanning is the patient identification/time-out protocol, intended to prevent wrong-patient or wrong-exam errors. ALARA concerns acoustic output minimization. Informed consent documentation is a separate, typically written, process. HIPAA verification concerns privacy/records access, not exam confirmation.

8. C. Standard precautions are infection-control practices (hand hygiene, surface disinfection, PPE as indicated) applied to every patient encounter regardless of known infection status. Contact isolation is an additional, patient-specific precaution used when a known transmissible organism is present. The Spaulding classification governs device disinfection level, not general workplace hygiene. Reverse isolation protects immunocompromised patients from external exposure, a different, patient-specific concept.

9. C. Sonographers perform image acquisition but do not render diagnoses; the appropriate response redirects the patient to the interpreting physician while remaining honest and professional. Offering reassurance or a diagnostic impression, or volunteering interpretive detail, exceeds the sonographer's scope of practice and can mislead the patient before formal interpretation.

10. A. Needle-shaft echogenicity (specular reflection) is maximized when the needle is oriented as close to perpendicular to the ultrasound beam as the clinical approach allows, improving visualization of the shaft during guidance. A steeper (more parallel) angle reduces specular reflection and visibility. Frequency changes affect resolution but are not the primary technique for needle-angle visibility. Color Doppler can help localize the needle tip motion but is not the core angle-optimization principle described.

11. A. Signs of anaphylaxis after contrast administration constitute a medical emergency; the sonographer must stop the exam and activate the facility's emergency/anaphylaxis response immediately. Continuing to image, or giving further contrast to 'confirm' the reaction, endangers the patient. Rushing to finish the exam delays necessary emergency care.

12. C. Period (T) and frequency (f) are reciprocals: $T = 1/f$. They are not related through propagation speed, and period decreases (not increases) as frequency increases, since more cycles occur per second.

13. B. Propagation speed rises with increasing stiffness and falls with increasing density (c is proportional to the square root of stiffness divided by density). With density held equal, the stiffer medium transmits sound faster, not slower, and stiffness is very much a determinant of speed, not irrelevant.

14. A. Average propagation speeds increase with tissue rigidity/density arrangement: bone (~4080 m/s) is fastest, followed by average soft tissue (~1540 m/s), then fat (~1450 m/s), with air (~330 m/s) slowest of the four, since gas is highly compressible.

15. B. Amplitude is the maximum variation of a variable (pressure, density, etc.) from its undisturbed (average) value. Wavelength is a distance measure, period is a time measure, and duty factor is the fraction of time the system is actively transmitting -- none describe the magnitude of variation itself.

16. D. The decibel is a logarithmic ratio, which compresses the enormous range of intensity/power ratios encountered in ultrasound (spanning many orders of magnitude) into a manageable, clinically usable

scale. dB values can be negative (representing a decrease), it is not a distance unit, and systems can and do process linear values internally before conversion.

17. A. Intensity is defined as power per unit area (W/cm^2). Amplitude is a measure of variable magnitude, impedance is density times propagation speed, and the attenuation coefficient describes energy loss per unit distance/frequency, none of which is a power-per-area quantity.

18. D. The half-value layer is the tissue depth over which beam intensity is reduced to 50% of its starting value due to attenuation. Focal depth relates to beam focusing, near-zone length relates to beam geometry near the transducer, and maximum imaging depth is a broader, application-based limit rather than this specific attenuation-defined depth.

19. C. PRP is the reciprocal of PRF (PRP = 1/PRF) and represents the total time from the beginning of one pulse to the beginning of the next, including both transmit and listening time. PRP is not derived by multiplying PRF by propagation speed, the two are not merely unit variants of one measurement, and there is no fixed 1,000x relationship between them.

20. A. Spatial pulse length equals the number of cycles in the pulse multiplied by the wavelength: 3 cycles x 0.3 mm = 0.9 mm. Dividing wavelength by cycle count, adding the two values, or ignoring cycle count entirely all misapply the formula.

21. A. Few cycles per pulse corresponds to a low Q-factor (damped, broadband) transducer, which produces a short spatial pulse length and therefore good axial resolution -- the standard design goal for imaging transducers. High-Q, narrowband designs are favored for Doppler sensitivity, not few-cycle imaging pulses; attenuation is unaffected by pulse cycle count, and broadband transducers still have a defined center frequency, just with a wider bandwidth around it.

22. D. Attenuation is frequency-dependent: using the approximate 0.5 dB/cm/MHz soft-tissue rule, higher-frequency beams lose more energy per centimeter of travel than lower-frequency beams, which is the physical basis for the resolution-versus-penetration tradeoff. Attenuation does not decrease with frequency, is not frequency-independent, and depends on both depth and frequency, not depth alone.

23. D. Near-zone length is proportional to the aperture (diameter) squared and to frequency (and inversely related to propagation speed), so increasing frequency, with aperture held constant, lengthens the near zone. It does not shorten the near zone, is not independent of frequency, and does not disappear at higher frequencies.

24. B. In the far zone, the ultrasound beam diverges (spreads) with increasing depth, which degrades lateral resolution farther from the transducer. The beam is not parallel-sided in the far zone, does not narrow to a point, and is not reflected back toward the transducer simply by virtue of being in the far field.

25. A. Contrast resolution is the ability to differentiate between echoes of different strength (displayed as different gray-scale shades), independent of spatial separation. Axial resolution concerns minimum

separable distance along the beam axis, temporal resolution concerns frame rate/time, and elevational resolution concerns slice-thickness direction -- none address gray-shade differentiation.

26. A. When waves arrive in phase (crest aligning with crest), their amplitudes sum, producing constructive interference with an increased resultant amplitude. Destructive interference (out-of-phase waves reducing or canceling amplitude) is the opposite case, and refraction is an unrelated phenomenon concerning a change in beam direction at an interface.

27. D. When a reflecting surface is small relative to the wavelength (e.g., red blood cells), it scatters sound weakly and diffusely in many directions (Rayleigh-type scattering); a large, smooth surface relative to wavelength (e.g., the diaphragm) produces a strong specular, mirror-like reflection. The other options invert or misstate this size-dependent relationship.

28. C. The Curie point is the temperature above which a piezoelectric ceramic permanently loses its polarization and therefore its piezoelectric properties -- a real risk with improper heat sterilization. Fractional bandwidth, matching-layer chemistry, and backing-material absorption are unrelated to this specific heat-induced depoling failure.

29. D. Lead zirconate titanate (PZT) is the synthetic ceramic most widely used in diagnostic transducer elements for its strong, tunable piezoelectric response. Natural quartz was used historically but is far less common now; barium titanate is an older piezoelectric ceramic largely superseded by PZT; silicon dioxide (quartz's chemical form) is not the standard modern imaging element material.

30. A. A linear sequential array fires groups of elements in sequence without electronic steering, producing a rectangular image whose width matches the probe's physical footprint. Phased and vector arrays use electronic steering to produce a sector image narrower than the footprint; an annular array is mechanically steered, not sequentially fired without steering.

31. A. A vector array combines a curved (convex) footprint with phased-array-style electronic steering and focusing, producing a sector image from a curved contact surface -- distinct from a standard curvilinear array, which does not use phased-array electronic steering to the same degree. A mechanical sector transducer uses physical motion, not electronic steering; a 1.5D array adds limited elevational elements but is not defined by a curved sector footprint.

32. C. A mechanical sector (wobbler) transducer generates its sector image by physically oscillating one or a few elements with a motor, rather than steering electronically. Vector and matrix arrays use electronic steering; a micro-convex array is a curved electronic array, not a mechanically moved single element.

33. B. An annular array uses concentric ring-shaped elements that allow symmetric focusing in both the scan and elevational planes, but because the rings are concentric (not laid out linearly), the array must be mechanically steered/swept to build an image. Linear and vector arrays steer electronically in the scan plane; a full matrix array focuses electronically in both planes without mechanical steering.

34. A. A conventional 1D array can only electronically focus in the scan-plane (azimuthal) direction; elevational (slice-thickness) focusing is provided by a fixed acoustic lens bonded to the array face. There is no second row of elements in a true 1D array, an extra matching layer does not provide elevational focusing, and there is no rotating mirror involved.

35. C. More individual elements (finer element pitch across the same aperture) allow more precise control of the beam's shape, timing, and steering, generally improving lateral resolution and steering/focusing capability. Element count does affect resolution (not just frame rate), does not degrade lateral resolution, and does not eliminate the need for electronic focusing.

36. C. Apodization tapers the drive amplitude across the aperture (typically reducing amplitude toward the edges) specifically to reduce side-lobe artifact by softening the sharp aperture edge. It is not a focusing technique (dynamic focusing) nor primarily aimed at penetration, and it does not change scan-line steering angle, which is a separate beam-steering function.

37. A. Dynamic aperture progressively widens the number of active elements as the receive focal depth increases, helping maintain more consistent focal characteristics (such as a constant f-number) with depth. Apodization tapers amplitude across a fixed aperture rather than changing aperture size; harmonic filtering and spatial compounding are unrelated processing techniques.

38. A. This describes a duplex/combination probe: a standard imaging array paired with a dedicated, separate CW Doppler element pair that continuously transmits and receives, allowing true CW Doppler (unlimited velocity range) alongside conventional imaging. It is not a PW-only probe (PW imaging arrays do not continuously transmit/receive), not an annular array, and by definition it does include CW capability.

39. C. Whether a transducer can undergo gas (EtO) sterilization versus only high-level liquid disinfection is determined by that specific probe's manufacturer-rated material compatibility -- not by its operating frequency, its imaging mode, or a blanket hospital policy that ignores probe-specific ratings.

40. D. Mechanical 3D/4D probes physically sweep (tilt or rotate) a conventional 1D array to acquire a stack of sequential 2D planes that are then reconstructed into a volume, whereas a true 2D matrix array electronically steers and focuses in both azimuth and elevation with no moving parts, generally enabling faster real-time (4D) volume acquisition. The two technologies are not identical, the mechanical system does produce a genuine 3D dataset, and it does not steer electronically in all three dimensions.

41. C. A micro-convex array is a small-footprint curved array purpose-built for situations where a standard curvilinear probe's footprint is too large, such as intercostal or neonatal/pediatric imaging. Linear arrays have a flat, not curved, footprint; annular arrays are mechanically steered single/ring-element designs; a 1.5D array refers to limited elevational element rows, not footprint size.

42. A. In an endfire endocavity probe, the array is positioned at the tip so the beam projects off the end of the shaft (common in transvaginal probes); a sidefire configuration positions elements along the side of the shaft instead. Biplane and annular are unrelated configuration terms for this context.

43. B. A wide-bandwidth (low-Q) transducer trades some sensitivity/efficiency at any single frequency for the ability to operate effectively across a broader frequency range (useful for harmonic and multi-frequency imaging). It does not improve penetration at every frequency with no drawback, does not eliminate attenuation, and by definition has a broad, not fixed single, operating range.

44. A. Cable and connector inspection is aimed at catching mechanical or electrical damage (cracked cable jacket, bent connector pins) before it causes intermittent signal dropout or creates an electrical safety hazard -- a maintenance check distinct from image-based element dropout testing. It does not measure center frequency, Curie point, or calibrate TGC.

45. B. A standoff pad increases the distance between the transducer face and the structure of interest, moving very superficial structures out of the near-field/near-zone region (where beam geometry and artifact can degrade image quality), improving visualization. It does not change operating frequency, does not remove the need for a matching layer (an internal transducer component), and does not convert one array geometry into another.

46. A. Frame rate equals PRF divided by the number of lines per frame: 6,400 / 128 = 50 frames/second. Multiplying, subtracting, or doubling PRF do not represent this standard relationship.

47. B. More scan lines per frame improve lateral (line) sampling density and therefore lateral resolution, but since each additional line requires additional pulse-echo listening time, frame rate decreases proportionally. There is a genuine trade-off; the two do not improve together, and line density does meaningfully affect both parameters.

48. A. Postprocessing is applied to data that has already been acquired and stored (e.g., adjusting a gray-scale curve on a frozen image), without needing to rescan the patient. Preprocessing occurs before storage, during initial signal handling; beamforming and apodization are transmit/receive beam-shaping steps, not display adjustments made after storage.

49. D. A look-up table (LUT) is a postprocessing tool, so its gray-scale assignment can be changed on already-acquired, stored digital data without rescanning. It is not fixed at beamforming, is unrelated to transducer replacement, and is not permanently fixed at the factory.

50. C. Analog-to-digital conversion (ADC) is the process of sampling a continuous analog voltage signal and converting it into discrete digital values for storage and processing. Beamforming shapes/steers the beam, demodulation extracts amplitude information from the RF signal, and rectification is a step in envelope detection -- none describe the analog-to-digital sampling step itself.

51. D. The Nyquist sampling theorem requires the sampling rate to be at least twice the highest frequency component present in the signal being digitized, to avoid inaccurate reconstruction (a form of aliasing). The Doppler equation, Snell's Law, and ALARA are unrelated physical/practice principles.

52. D. For a fixed field of view, a higher pixel density means each pixel represents a smaller physical area, improving the digital image's spatial resolution. Pixel density is a spatial-resolution factor, not merely a frame-rate or color-palette parameter, and more pixels does not dilute or worsen resolution.

53. C. An 8-bit pixel can represent 2^8 = 256 discrete values, matching 256 gray shades. 4 bits would allow only 16 shades, 6 bits only 64 shades, and 16 bits would allow far more (65,536) than needed for 256 shades.

54. B. The cine loop is an image buffer that retains a rolling sequence of the most recently acquired frames, allowing the operator to scroll backward and select the optimal still frame. Spatial compounding blends multiple beam angles into one frame, coded excitation is a transmit-pulse encoding technique, and persistence is real-time frame averaging -- none provide backward frame-by-frame review.

55. B. Freeze-frame immediately halts real-time acquisition and displays a single static frame for measurement or review. Cine loop reviews a buffered sequence of prior frames rather than simply halting on the current one; write zoom and read zoom are magnification functions, not freeze functions.

56. C. Electronic calipers, positioned via a trackball (or similar pointing device), allow the operator to place cursors on a frozen image and read out the distance between them. TGC adjusts depth-based gain, apodization tapers aperture amplitude, and the duty factor selector is not a real user control for linear measurement.

57. C. Split-screen (dual-image) display simultaneously shows two synchronized real-time images side by side, such as B-mode and color Doppler. Cine loop review is single-image frame-by-frame playback, M-mode shows motion-over-time along a single scan line, and panoramic imaging stitches sequential frames into one extended static image, none of which describe simultaneous side-by-side live display.

58. A. The biopsy guide-line is a fixed overlay showing the predicted needle path through an attached needle guide, helping the operator align the needle trajectory with the target before insertion. Spatial compounding and TGC overlays are unrelated processing features, and elevational focus is a transducer-lens property, not an on-screen overlay.

59. A. Needle-enhancement (needle-steering) software selectively angles a subset of scan lines closer to perpendicular with the expected needle trajectory, strengthening the needle's specular reflection and improving its visibility during guided procedures. Harmonic imaging, spatial compounding, and coded excitation address different image-quality goals (contrast/near-field clutter, border definition, and signal-to-noise/penetration, respectively), not needle-specific visualization.

60. D. Real-time imaging continuously acquires and displays new pulse-echo data frame after frame, while a static (frozen) image displays one fixed frame with no further data acquisition until unfrozen.

Static imaging has no frame rate at all (it is not updating), and both real-time and static states can occur in any imaging mode, including B-mode.

61. B. Correlating the transducer's physical orientation marker with the on-screen indicator establishes and maintains a consistent, predictable image orientation relative to the patient's anatomy, which is essential for correct interpretation. It does not indicate array type, battery status, or trigger harmonic imaging.

62. A. Lossless compression preserves all original image data while reducing file size somewhat; lossy compression achieves greater file-size reduction by permanently discarding some data, with a corresponding risk to image fidelity, which is why diagnostic archives often restrict or avoid lossy compression. This trade-off is distinct from preprocessing/postprocessing, analog/digital storage, or cine loop/freeze-frame concepts.

63. B. The region of interest, or color box, defines the specific area of the B-mode image within which color Doppler processing is applied and displayed; color information outside the box is not shown. A TGC window, biopsy overlay, and cine loop boundary are unrelated features.

64. A. An automatic image-optimization ("one-touch") algorithm analyzes the received echo signal and automatically adjusts gain/TGC settings to a target image appearance, reducing the need for manual adjustment. Apodization tapers aperture amplitude, dynamic aperture changes active element count with depth, and spatial compounding blends multiple beam angles -- none of these describe automatic gain optimization.

65. B. Modality worklist integration pulls scheduled patient demographic and exam-order information directly from the RIS/HIS into the ultrasound system, avoiding manual re-entry and reducing labeling errors. PACS archival, DICOM compression, and cine loop synchronization are related but distinct digital-imaging functions that do not describe this specific scheduling integration.

66. D. This lateral gain control adjusts brightness uniformly with depth but varies by lateral position across the image, correcting side-to-side asymmetry; standard TGC instead adjusts gain based on depth, applied uniformly across the image width at each depth. The two controls address different, complementary sources of image non-uniformity, so they are not duplicates or identical in function.

67. D. Beam-width (partial-volume/section-thickness) artifact occurs because the ultrasound beam has finite width; when a small anechoic structure does not completely fill the beam's cross-section at a given depth, echoes from adjacent solid tissue are also captured and displayed within the structure, creating false internal echoes. Mirror-image, range ambiguity, and grating lobe artifacts arise from different mechanisms (reflection off a strong interface, PRF-depth mismatch, and off-axis grating lobe energy, respectively).

68. B. Clean posterior acoustic shadowing occurs when a strongly attenuating or reflecting structure (such as a densely calcified stone) blocks nearly all sound transmission beyond it, producing a well-

defined, echo-free band posteriorly. Dirty shadowing from gas is typically less well-defined due to reverberation; posterior enhancement is the opposite effect (increased, not absent, echoes) seen behind weakly attenuating fluid; ring-down is a distinct comet-tail-type artifact usually associated with gas.

69. D. Section-thickness (slice-thickness) artifact arises when the finite elevational beam width samples tissue outside the intended thin scan plane, causing structures adjacent to a fluid-filled organ to be superimposed within it, mimicking sludge. Speckle is a diffuse granular texture from coherent interference within tissue itself, and comet-tail/reverberation artifacts arise from a different mechanism (sound bouncing repeatedly between closely spaced reflectors).

70. C. Multipath artifact occurs when the returning echo travels an indirect, multi-bounce path back to the transducer; because the system assumes a straight round-trip path, it places the resulting echo at an incorrect location, often deeper than the true structure. Grating lobe artifact arises from off-axis energy due to element spacing, not from multi-bounce path length; speckle and range ambiguity are unrelated mechanisms.

71. D. Contrast-to-noise ratio specifically quantifies how well a true signal (such as a lesion) stands out against background noise, whereas contrast resolution concerns distinguishing between two genuine gray-scale echo levels from each other, independent of noise. Axial and temporal resolution address spatial-along-beam and time-based performance, not signal-versus-noise discrimination.

72. C. Adaptive speckle-reduction filtering is a postprocessing algorithm that smooths the granular speckle pattern using signal-processing techniques on a single acquired dataset, distinct from spatial compounding, which reduces speckle and improves border definition by physically transmitting and averaging multiple beam angles. Coded excitation and harmonic imaging address penetration/signal-to-noise and near-field clutter/contrast, respectively, not speckle texture directly.

73. D. Relative echogenicity between similar tissues primarily reflects differences in backscatter and reflectivity at the microscopic and macroscopic level, producing different returned echo amplitudes that are displayed as different gray shades. Distance from the transducer is compensated by TGC rather than being the source of true echogenicity differences, propagation speed differences are typically too small to explain this, and pixel density is a display property, not a tissue property.

74. B. Raster (line-by-line) scanning builds the image by acquiring and displaying one scan line's worth of data at a time in sequence until a full frame is assembled, the fundamental method underlying conventional real-time B-mode image formation. Spatial compounding, coded excitation, and harmonic reconstruction are additional processing techniques applied on top of, not substitutes for, this basic line-by-line construction method.

75. B. The dead zone is the near-field region immediately adjacent to the transducer face where ring-down and pulse duration effects prevent accurate resolution of discrete targets, verified on QC phantom testing using its shallowest calibrated target. The far zone, focal zone, and Fraunhofer zone all refer to beam behavior farther from the transducer face, not this specific near-field limitation.

76. D. Twinkling artifact appears as a rapidly alternating mosaic of color pixels directly at the surface of a rough, strongly reflective structure (such as a stone or surgical clip) in the absence of true flow, thought to result from intrinsic machine noise interacting with the irregular, highly reflective surface. Flash artifact results from gross patient/tissue motion, aliasing is a velocity-related color-wraparound phenomenon, and blooming is excess color bleeding from over-gained true flow -- distinct mechanisms from twinkling.

77. B. Laminar flow is the normal, orderly flow pattern in a straight vessel, with fastest velocity at the center and slowest near the wall, producing a parabolic profile. Turbulent flow is disorganized with multiple velocities/directions in the same region; plug flow is a nearly flat, uniform-velocity profile seen very early in a vessel; retrograde flow simply means reversed-direction flow, not a description of the velocity profile shape.

78. A. Turbulent flow is characterized by chaotic, multidirectional velocities within a localized region, classically occurring just distal to a significant stenosis. Laminar flow is the normal orderly pattern; plug flow is a flat, near-uniform profile; phasic flow describes cyclic variation (e.g., with respiration or the cardiac cycle), not disorganization.

79. C. The Reynolds number is a dimensionless value combining vessel diameter, flow velocity, fluid density, and viscosity to predict whether flow will remain laminar or transition to turbulent; higher values favor turbulence. Resistive and pulsatility indices are waveform-shape measures unrelated to this prediction, and the Nyquist limit concerns maximum unambiguously detectable Doppler shift, not turbulence prediction.

80. B. The Bernoulli principle describes how, in a narrowed segment, flow velocity must increase to maintain volume flow, and this velocity increase is accompanied by a corresponding pressure drop across the narrowing -- the physical basis for estimating pressure gradients in stenosis. The continuity equation relates area and velocity without directly addressing pressure; the Doppler equation relates frequency shift to velocity; Reynolds number predicts turbulence, not pressure.

81. A. The continuity equation states that Area1 x Velocity1 = Area2 x Velocity2 in a non-branching, incompressible flow system, and is commonly used clinically to calculate an unknown cross-sectional area (such as valve area) when the other three variables are known. The Bernoulli principle addresses pressure-velocity relationships, Reynolds number addresses turbulence likelihood, and the Doppler equation addresses frequency shift and velocity, not area.

82. D. Volume flow rate requires multiplying the vessel's cross-sectional area by the time-averaged mean velocity (and, to get a total volume over an interval, by time), since neither area nor velocity alone captures the actual volume passing per unit time. Peak systolic velocity alone, RI x diameter, and Doppler shift/cosine calculations do not, by themselves, yield a volume flow rate.

83. A. Volume flow rate calculations require the time-averaged (mean) velocity across the entire cardiac cycle, not just the peak systolic velocity, because using only the peak would substantially overestimate

the true average volume moving through the vessel over time. End-diastolic velocity alone underestimates flow, and the Nyquist limit is an unrelated sampling-rate concept.

84. C. A poststenotic jet with associated turbulence is the localized, high-velocity, disorganized flow pattern seen immediately downstream of a significant stenosis. Venous augmentation is a distinct venous-compression finding, tardus parvus describes a delayed/blunted waveform seen farther downstream, and phasicity describes normal respiratory or cardiac-cycle-related variation, not this focal poststenotic finding.

85. D. Respiratory phasicity is the normal variation in venous flow velocity that rises and falls with the patient's breathing (due to changing intrathoracic/intra-abdominal pressure), and its presence is a reassuring sign of unobstructed venous flow. Pulsatility describes cardiac-cycle-related arterial variation, aliasing is a Doppler sampling artifact, and spectral broadening reflects turbulence, none of which describe this respiratory-linked venous finding.

86. A. Augmentation is the expected brisk increase in venous flow velocity toward the heart following manual distal compression, confirming that the venous segment between the compression site and the transducer is patent. A Valsalva maneuver instead typically causes flow to transiently cease or reverse; tardus parvus and poststenotic turbulence are arterial, not venous compression-related, findings.

87. D. Acceleration time is the interval from the start of systolic upstroke to the point of peak systolic velocity, and a prolonged acceleration time can indicate proximal arterial narrowing. Pulsatility and resistive indices are calculated from peak, minimum, and mean velocities rather than this specific timing interval, and pulse repetition period is an unrelated PRF-based instrumentation term.

88. A. In audible Doppler output, pitch corresponds to the magnitude of the Doppler frequency shift (and therefore velocity), while loudness (volume) corresponds to the strength/amplitude of the returned signal. Vessel diameter, depth, gain, and PRF are not what the pitch and loudness of the audio signal directly represent.

89. B. A duplex system combines real-time B-mode imaging with spectral Doppler simultaneously; adding a simultaneous color flow overlay to that combination defines a triplex system. The terms are not interchangeable, and this configuration is unrelated to M-mode, which is a distinct single-line-over-time display.

90. A. The angle-correction cursor is manually aligned by the operator parallel to the vessel wall (presumed flow direction) so the system can accurately calculate the Doppler angle used in the velocity equation. The wall filter removes low-frequency clutter, the sample volume gate defines the interrogation location/size, and the baseline shift control repositions the zero-velocity line on the display -- none perform angle alignment.

91. C. Electronic beam steering allows the system to angle the transmitted Doppler beam relative to the linear array's face without requiring as much physical probe tilt, helping achieve an adequate Doppler

angle on vessels running parallel to the skin. Apodization tapers aperture amplitude, dynamic aperture changes active element width with depth, and harmonic filtering isolates harmonic frequencies -- none address beam angle for Doppler.

92. B. High-PRF (HPRF) mode fires additional pulses so that more than one range gate is active along the beam simultaneously, allowing measurement of higher velocities than the standard single-gate PW Nyquist limit would permit, at the cost of not knowing with certainty from which of the active gates a given signal originated (range ambiguity). Color M-mode, power Doppler, and CW Doppler describe different display/acquisition modes with different trade-offs.

93. B. Color M-mode overlays color-encoded velocity information onto a conventional M-mode display, showing flow along a single fixed scan line plotted continuously over time. Triplex mode combines B-mode, spectral, and color simultaneously in real time (not a single-line-over-time format); power Doppler and HPRF describe different acquisition characteristics, not this specific single-line temporal display.

94. D. Directional power Doppler adds limited flow-direction information on top of the amplitude-based power Doppler display, which is otherwise non-directional. Color velocity mode is simply standard (non-power) color Doppler terminology, spectral Doppler is a waveform display rather than a color mode, and tissue Doppler measures myocardial wall motion, not blood flow direction.

95. C. Power Doppler signal strength primarily reflects the amplitude of the returned signal, which correlates with the number/concentration of moving red blood cells contributing echoes, largely independent of how fast they are moving -- which is why power Doppler is highly sensitive to slow, low-volume flow. It is not based on peak velocity of the fastest cells, the Doppler angle alone, or the wall filter setting alone.

96. A. Peak systolic velocity at the stenosis is the primary, most widely used velocity criterion for grading arterial stenosis severity in standard vascular protocols. End-diastolic velocity proximal to the stenosis, mean venous velocity, and pulse repetition period are not the primary grading criteria used for this purpose.

97. A. The velocity ratio compares peak systolic velocity at the stenosis to peak systolic velocity in a normal proximal segment, helping correct for a patient's overall elevated baseline velocities that could otherwise cause the stenosis to appear more severe than it truly is using an absolute PSV threshold alone. Resistive index, pulsatility index, and Reynolds number are distinct calculations not used for this specific correction.

98. D. String sign (trickle flow) describes the minimal, thread-like residual flow signal detectable in a vessel that is nearly, but not completely, occluded by thrombus. Augmentation is a venous compression-response finding, tardus parvus is a delayed downstream arterial waveform pattern, and poststenotic turbulence is a distinct focal high-velocity disorganized-flow finding, none of which describe this near-occlusion trickle pattern.

99. D. Tardus parvus describes a waveform with a delayed, blunted systolic upstroke and reduced peak velocity, typically seen distal to a significant, more proximal stenosis. A triphasic waveform is the normal high-resistance pattern, monophasic augmentation is not a standard descriptive term, and a to-and-fro waveform describes bidirectional flow, not a delayed upstroke.

100. B. A to-and-fro waveform, with flow entering the pseudoaneurysm sac during systole and exiting back through the same neck during diastole, is the characteristic Doppler finding at a pseudoaneurysm neck. Tardus parvus and string sign describe unrelated findings distal to stenosis or near-occlusion, and venous augmentation is a distinct venous compression-response finding.

101. D. With Doppler shift, transmitted frequency, angle, and propagation speed known, the Doppler equation is algebraically rearranged to solve for the unknown flow (blood) velocity -- the entire clinical purpose of performing a Doppler velocity measurement. Vessel diameter, PRF, and the attenuation coefficient are not variables solved for using this rearranged equation.

102. D. Absent or reversed end-diastolic flow in the umbilical artery reflects increased downstream placental vascular resistance and is a recognized marker of placental insufficiency requiring close fetal surveillance. It is not a normal third-trimester finding, does not represent maternal circulation, and is not simply explained away as a technically inadequate angle, since umbilical artery Doppler angle correction is not typically required given the near-axial approach used.

103. A. The normal hepatic vein waveform is triphasic, reflecting transmitted right atrial pressure changes through the cardiac cycle, unlike the resistance-based triphasic pattern of a peripheral artery. A monophasic pattern, tardus parvus, and to-and-fro patterns are abnormal or unrelated findings in other vascular beds, not the normal hepatic vein appearance.

104. C. Normal main portal vein flow is hepatopetal (toward the liver) and continuous, with only mild undulation related to respiration and cardiac activity, rather than sharply phasic or pulsatile. Hepatofugal flow, absent flow, and cardiac-cycle-linked bidirectional alternation are all abnormal or incorrect descriptions of the normal portal venous pattern.

105. D. Tapping the temporal artery transiently disturbs flow in the external carotid artery's branch, producing a visible oscillation/artifact on the external carotid waveform, while the internal carotid artery (which has no cervical branches and supplies the temporal artery only indirectly) shows no such response -- allowing the two vessels to be distinguished when anatomy alone is ambiguous. The maneuver does not affect both vessels identically, does not selectively affect the internal carotid, and is unrelated to resistive index measurement.

106. A. Subclavian steal describes reversed (retrograde) flow in the vertebral artery, away from the brain, resulting from a significant stenosis or occlusion proximal to the vertebral artery's origin on the subclavian artery, which creates a pressure gradient that 'steals' flow from the vertebrobasilar system. Poststenotic turbulence, venous augmentation, and tardus parvus describe different, unrelated findings.

107. A. A low-resistance waveform with markedly elevated diastolic flow in the feeding artery reflects low-resistance runoff into the venous system through a patent, functioning AV shunt -- the expected finding in a working dialysis fistula. Thrombosis/occlusion would instead show absent or minimal flow, a normal peripheral artery without a shunt would show a higher-resistance pattern, and this finding is not explained by a technical angle error.

108. C. Absent or markedly diminished arterial and venous flow on the affected side, compared to a normal contralateral testicle, is the key diagnostic Doppler finding in testicular torsion, reflecting compromised blood supply from cord twisting. Increased hyperemic flow is more typical of epididymo-orchitis (an inflammatory process), a normal symmetric waveform argues against torsion, and isolated venous reversal with preserved arterial flow is not the classic torsion pattern.

109. B. Tracking resistive index serially over time allows a rising trend to be identified as an early indicator of a developing transplant complication (such as rejection, obstruction, or vascular compromise), information a single isolated measurement cannot provide on its own. Serial tracking is not merely redundant, is unrelated to TGC calibration, and is not primarily used to track vessel diameter change.

110. D. A monophasic waveform shows only continuous forward flow throughout the cardiac cycle, with loss of the normal diastolic reversal component, typically reflecting severe, longstanding proximal arterial disease with collateralized, low-resistance distal flow. A triphasic waveform is the normal pattern, a to-and-fro waveform describes bidirectional flow at a pseudoaneurysm neck, and string sign describes minimal trickle flow through a near-total occlusion, not this loss-of-reversal pattern.