COMPREHENSIVE MOCK EXAM 9

Supplemental to: Ultrasound Physics Board Review 2026-2027

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ARDMS SPI (Sonography Principles & 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 sonographer is instructed that a leakage current far smaller than what would cause a surface burn can still be lethal if it has a direct low-resistance pathway to the heart (e.g., through an invasive catheter). This describes which electrical-safety hazard?

A. Micro-shock -- a small current delivered directly to or near the myocardium

B. Macro-shock -- a larger current delivered through intact skin

C. Ground-fault leakage exceeding the device's rated limit

D. Electromagnetic interference from an adjacent RF source

2. A sonographer who repeatedly performs obstetric exams with poor fetal outcomes reports emotional exhaustion, reduced empathy, and dread before certain encounters, despite no direct threat to their own physical safety. This is best described as:

A. Burnout from excessive scheduling volume alone

B. Compassion fatigue / secondary traumatic stress

C. Malingering related to job dissatisfaction

D. An occupational musculoskeletal disorder

3. A department wants an authoritative document defining the minimum elements, indications, and documentation requirements for a specific type of ultrasound examination. Which document should they consult?

A. The AIUM Prudent Use Statement

B. An AIUM Practice Parameter for that examination type

C. The manufacturer's Declaration of Conformity

D. The department's internal Quality Improvement charter

4. During contrast-enhanced ultrasound, the sonographer notices localized swelling and discomfort at the IV site rather than any systemic reaction. This is most consistent with:

A. Extravasation of contrast agent into surrounding soft tissue

B. An anaphylactoid reaction to the contrast agent

C. Vasovagal response to venipuncture

D. Nephrotoxic reaction to the contrast agent

5. During a routine exam, the system intermittently loses image feed from one array without any error message. What is the appropriate next step?

A. Continue scanning and note it informally in the patient's chart

B. Restart the system between patients and keep using it if the issue doesn't recur

C. Wait for the next scheduled preventive-maintenance visit to mention it

D. Take the system out of service and report the malfunction through the incident system

6. During an ultrasound-guided percutaneous biopsy, which practice is essential to maintaining the sterile field around the needle path?

A. Using a low-level-disinfected transducer cover instead of a sterile one

B. Using a sterile transducer cover and sterile gel for the needle pathway

C. Cleaning the transducer with alcohol wipes between passes

D. Wearing clean, non-sterile gloves throughout the procedure

7. A department wants staff to report near-miss errors without fear of automatic punitive action, so systemic causes can be identified and corrected. This reporting philosophy is known as:

A. Zero-tolerance policy

B. Peer review program

C. Just Culture, a non-punitive approach

D. Mandatory incident escalation protocol

8. Before a newly purchased ultrasound system is placed into clinical use, which step verifies baseline performance and documents staff training on the new equipment?

A. Routine daily QA phantom testing

B. The vendor's standard warranty registration

C. The department's annual comprehensive PM review

D. Acceptance testing and documented in-service training

9. A language barrier prevents fully explaining an upcoming procedure to a patient, and no staff interpreter is immediately available. What is the appropriate course of action?

A. Proceed using gestures and hope for adequate understanding

B. Cancel the exam entirely with no further action taken

C. Use a qualified interpreter service, such as phone or video interpretation, before proceeding

D. Ask a bilingual coworker informally, regardless of interpretation training

10. A patient becomes agitated and verbally hostile during a lengthy exam due to pain and anxiety. Which approach is most appropriate for the sonographer to de-escalate while completing the exam?

A. Match the patient's tone to assert authority and finish quickly

B. Ignore the behavior and proceed silently without acknowledgment

C. Immediately terminate the exam and leave the room

D. Acknowledge the patient's distress calmly, explain each step, and offer brief breaks

11. A sonographer identifies pediatric imaging findings inconsistent with the reported history, raising concern for non-accidental injury. What is the sonographer's obligation?

A. Document the finding but say nothing unless directly asked

B. Discuss concerns privately with the family before any reporting

C. Report the concern through mandated-reporter channels per facility/state law

D. Wait for the interpreting physician to independently notice the same finding

12. If the pressure amplitude of an ultrasound wave is doubled while all other factors remain constant, the intensity of the wave increases by a factor of:

A. 4

B. 2

C. 8

D. 16

13. As an ultrasound pulse crosses a boundary into a medium with a different propagation speed, which quantity remains unchanged while wavelength adjusts accordingly?

A. Propagation speed of the medium

B. Frequency, set by the source

C. Wavelength within the medium

D. Amplitude of the wave

14. For a fixed true flow velocity, angle, and operating frequency, increasing the system's PRF (velocity scale) setting will:

A. Increase the calculated Doppler shift value

B. Decrease the calculated Doppler shift value

C. Not change the shift value, only raise the Nyquist limit

D. Convert the displayed signal to power Doppler automatically

15. Two coherent wavefronts with a wavelength of 0.6 mm interfere constructively where their path lengths differ by a whole-number multiple of the wavelength. If the path-length difference at a point is 1.8 mm, what is the relationship?

A. Destructive interference, since the difference is not a multiple of the wavelength

B. Constructive interference, since 1.8 mm equals 3 whole wavelengths

C. Constructive interference, since 1.8 mm equals 2.5 wavelengths

D. Cannot determine without knowing the amplitude

16. A beam's spatial peak temporal average intensity (ISPTA) is substantially higher than its spatial average temporal average intensity (ISATA) across the beam's cross-section. This relationship is best described by:

A. The duty factor of the pulse

B. The beam uniformity ratio

C. The Q-factor of the transducer

D. The attenuation coefficient of the medium

17. Purely from the cosine term in the Doppler equation, at what angle between the beam and flow direction does the calculated frequency shift become zero, regardless of true velocity?

A. 0 degrees

B. 45 degrees

C. 90 degrees

D. 180 degrees

18. For a fixed blood flow velocity and fixed insonation angle, using a higher-frequency transducer for Doppler interrogation will:

A. Decrease the resulting Doppler shift frequency

B. Have no effect on the resulting Doppler shift frequency

C. Increase the resulting Doppler shift frequency

D. Only affect the shift if the vessel is deep

19. Assuming a propagation speed of 1,510 m/s in amniotic fluid and an operating frequency of 5 MHz, the wavelength is closest to:

A. 0.15 mm

B. 0.30 mm

C. 0.60 mm

D. 1.50 mm

20. Sound travels through 2 cm of fat (attenuation ~0.6 dB/cm/MHz) then 3 cm of liver (attenuation ~0.5 dB/cm/MHz) at 5 MHz, one-way. What is the approximate total one-way attenuation?

A. 13.5 dB

B. 6 dB

C. 7.5 dB

D. 27 dB

21. Sound traveling at 1,540 m/s strikes a boundary at a 20-degree angle of incidence and enters a medium with a propagation speed of 1,600 m/s. Using Snell's law, the sound will refract:

A. Toward the normal, at an angle less than 20 degrees

B. Along the boundary, parallel to the interface

C. Straight through, undeviated, at exactly 20 degrees

D. Away from the normal, at an angle greater than 20 degrees

22. A system uses a PRF of 5,000 Hz. Assuming a propagation speed of 1,540 m/s, what is the approximate maximum imaging depth before range ambiguity occurs?

A. 15.4 cm

B. 7.7 cm

C. 30.8 cm

D. 1.54 cm

23. A pulse contains 4 cycles at a wavelength of 0.4 mm. What is the spatial pulse length, and what is the best achievable axial resolution?

A. SPL = 1.6 mm; axial resolution = 3.2 mm

B. SPL = 1.6 mm; axial resolution = 0.8 mm

C. SPL = 0.8 mm; axial resolution = 1.6 mm

D. SPL = 1.6 mm; axial resolution = 1.6 mm

24. The propagation speed of sound through a medium is fundamentally determined by which relationship?

A. Speed equals the square root of bulk modulus divided by density

B. Speed equals frequency times density

C. Speed equals wavelength divided by bulk modulus

D. Speed depends only on the transducer's operating frequency

25. At the focal zone, a transducer's beam width is 2 mm; well beyond the focal zone, the beam has diverged to 6 mm. How does lateral resolution compare at these two depths?

A. Lateral resolution is the same at both depths

B. Lateral resolution is best, finest, at the focal zone

C. Lateral resolution is best in the far field, where the beam is widest

D. Lateral resolution cannot be determined from beam width alone

26. Tissue A has a higher density but a lower propagation speed than Tissue B; Tissue A's calculated acoustic impedance turns out to be higher than Tissue B's. This is possible because impedance depends on:

A. Density alone

B. The product of density and propagation speed

C. Propagation speed alone

D. Impedance cannot differ if speed is lower, regardless of density

27. An echo signal is reported as having lost 20 dB of intensity relative to the transmitted pulse. Approximately what fraction of the original intensity remains?

A. 1/2

B. 1/10

C. 1/100

D. 1/1000

28. The piezoelectric 'd' constant of a crystal material describes:

A. The crystal's electrical impedance at resonance

B. The crystal's physical thickness relationship to frequency

C. How strain relates to applied voltage or pressure

D. The crystal's Curie temperature threshold

29. A transducer that can switch between several discrete, pre-set center frequencies (e.g., 5/7.5/10 MHz) rather than operating across one continuous broadband range is best described as:

A. A broadband agile-frequency imaging probe

B. A CW dedicated Doppler-only probe

C. An annular array ring-element probe

D. A multi-frequency, discrete-preset transducer

30. Regulatory/safety standards for diagnostic ultrasound transducers set a maximum allowable continuous surface (contact) temperature to prevent thermal injury, generally around:

A. 30 degrees C

B. 37 degrees C

C. 43 degrees C

D. 50 degrees C

31. Compared to a rigid epoxy lens, a soft silicone rubber acoustic lens on a transducer face is generally chosen for:

A. Higher resonant frequency stability

B. Reduced manufacturing cost only

C. Better acoustic coupling and patient comfort

D. Increased electrical shielding

32. Unwanted acoustic/electrical coupling between adjacent transducer elements ('crosstalk'), which can degrade beam quality, is minimized primarily by:

A. Increasing the operating frequency

B. Using a larger element pitch only

C. Increasing transmit power

D. Kerf cuts filled with acoustic damping material

33. A linear-array transducer produces a field of view that is best described as:

A. Sector-shaped, narrow near the skin and wide at depth

B. Trapezoidal, wider than the footprint at depth

C. Rectangular, constant width at all depths

D. Circular in shape

34. An element's 'fill factor' refers to:

A. How full the coupling gel reservoir is during a scan

B. The percentage of scan lines filled per frame

C. The ratio of active elements to inactive elements in an array

D. The proportion of active piezoelectric material versus kerf/spacing

35. A continuous-wave (CW) Doppler pencil probe cannot generate a B-mode image because:

A. It lacks a piezoelectric element altogether

B. Its operating frequency is too low for imaging

C. It transmits and receives continuously with no timing gate

D. Its beam cannot be focused

36. For a phased-array transducer to accurately steer and focus its beam electronically, the timing of each element's firing must be controlled with precision on the order of:

A. On the order of nanoseconds

B. Milliseconds

C. Microseconds only, never finer

D. Timing precision does not affect steering accuracy

37. A dedicated CW pencil (non-imaging) probe is most appropriately used for which clinical application, where continuous high-velocity flow detection matters more than 2D image guidance?

A. Routine abdominal organ survey imaging

B. Standard obstetric anatomy screening exam

C. Musculoskeletal tendon evaluation imaging

D. Transcranial or umbilical Doppler assessment of high velocities

38. A manufacturer specifies a maximum number of high-level disinfection cycles for a reusable endocavity probe component. Exceeding this limit primarily risks:

A. Material degradation and reduced probe cover seal integrity

B. Immediate electrical failure with no prior warning

C. Automatic frequency drift requiring recalibration

D. Voiding only the extended warranty, with no functional risk

39. Manufacturers intentionally design imaging transducers with wide (broadband) frequency response primarily because:

A. Wider bandwidth reduces manufacturing cost

B. A wider bandwidth allows a shorter transmitted pulse

C. Wider bandwidth increases penetration depth

D. Wider bandwidth eliminates the need for a matching layer

40. Some ultrasound systems use an optical barcode or QR label on the transducer connector housing, scanned at connection, primarily to:

A. Encrypt patient data during transmission

B. Replace the need for acoustic output testing

C. Identify the transducer for correct presets and tracking

D. Measure the transducer's surface temperature

41. A manufacturer's published drop/impact-resistance rating for a transducer describes:

A. The system's software crash-recovery capability

B. The tested drop height/conditions the probe survives without damage

C. The maximum acceptable patient body weight for probe pressure during scanning

D. The probe's resistance to disinfectant chemical damage

42. Choosing a more heavily damped backing material for a transducer element primarily has which trade-off?

A. Improves sensitivity while degrading axial resolution

B. Has no measurable effect on pulse characteristics

C. Shortens ring-down time, improving axial resolution, less sensitivity

D. Increases penetration depth without any resolution trade-off

43. In transducer terminology, 'sensitivity' most precisely refers to:

A. The frequency range the transducer can operate across

B. The physical fragility of the piezoelectric crystal

C. The transducer's resistance to electrical interference

D. The strength of signal received for a given output

44. At equivalent imaging depth and line density, a curved (convex) array typically achieves a lower frame rate than a comparable linear array primarily because:

A. Curved arrays always operate at a lower frequency

B. Curved arrays require twice the pulse repetition period

C. Curved arrays cannot use parallel beamforming

D. A wider diverging FOV at depth requiring more scan lines

45. A transducer may physically contain more piezoelectric elements than the ultrasound system has dedicated receive channels. This is significant because:

A. It means the transducer is defective

B. It has no practical significance to image quality or system design

C. Channel count is often the pricier, limiting design factor, needing multiplexing

D. It means every element must fire simultaneously regardless of imaging mode

46. Pulse inversion harmonic imaging improves image quality primarily by:

A. Increasing the pulse repetition frequency

B. Doubling the number of receive channels

C. Using two identical pulses transmitted at different depths

D. Transmitting inverted-polarity pulse pairs and summing echoes

47. Increasing the acquired volume size (larger region) in real-time 4D imaging, all else equal, will:

A. Increase the volume rate (faster updates)

B. Decrease the volume rate substantially

C. Have no effect on volume rate

D. Only affect volume rate if color Doppler is also active

48. For an out-of-plane needle approach, which software feature specifically helps confirm needle-tip location?

A. Standard in-plane beam steering toward the needle shaft

B. A crossed-beam/multi-plane technique confirming the tip

C. Increasing overall system gain

D. Switching to M-mode display

49. An automated Doppler angle-correction feature on modern systems primarily functions by:

A. Software auto-aligning the cursor to detected vessel orientation

B. Physically rotating the transducer housing

C. Automatically switching from PW to CW mode

D. Increasing the pulse repetition frequency to avoid aliasing

50. A system's cine-loop buffer continuously stores the most recent several seconds of imaging in the background, even before freeze is pressed. This allows the operator to:

A. Increase the maximum acoustic output

B. Automatically generate a structured report

C. Retrospectively capture an event just before freeze

D. Bypass the need for a DICOM archive

51. During fusion imaging, if the system detects the patient has moved enough to misalign the real-time ultrasound with the pre-loaded CT/MRI dataset, an automated re-registration prompt will:

A. Permanently disable fusion mode for that exam

B. Automatically increase the ultrasound frequency

C. Silently continue with the original (now misaligned) registration

D. Alert the operator to re-register for accurate alignment

52. A biopsy needle with a specially textured or dimpled 'echogenic' tip coating improves ultrasound visualization primarily by:

A. Increasing the needle's electrical conductivity

B. Making the needle radiopaque for later X-ray confirmation

C. Creating extra reflective facets that scatter more echo back

D. Reducing the needle's overall diameter

53. Live overlay of real-time ultrasound imaging onto a simultaneously displayed fluoroscopic image, used in some interventional procedures, primarily provides:

A. Elimination of all radiation exposure to the patient

B. Automatic needle-path calculation without operator input

C. Combined soft-tissue and bony/contrast spatial guidance

D. Replacement of the need for pre-procedure imaging

54. Compared to the traditional ellipsoid-formula method for estimating prostate volume, an AI-based automated boundary-segmentation approach differs primarily in that it:

A. Requires manual entry of all three dimensions before calculating

B. Traces the actual gland contour to calculate volume directly

C. Can only be used with endocavity transducers

D. Produces a volume estimate that is always identical to the formula-based method

55. A real-time AI feature that alerts the sonographer DURING acquisition, not after the exam, that the current view appears technically inadequate is best described as:

A. A static post-exam image-quality score

B. Live, in-scan guidance prompting immediate correction

C. An automated measurement-outlier flag

D. A DICOM compliance/metadata check

56. A system control that averages several consecutive frames together to reduce random image noise, at the cost of some temporal resolution, most broadly describes:

A. Frame averaging, a temporal-noise trade-off

B. Spatial compounding, angle-based

C. Harmonic imaging technique

D. Coded excitation technique

57. An automated renal cortical thickness measurement that compares the result against an age-adjusted normal range is clinically useful because:

A. It replaces the need to evaluate renal length entirely

B. It only functions in pediatric patients

C. Cortical thinning can signal early chronic kidney disease

D. It automatically diagnoses the underlying cause of any thinning found

58. A linear-array transducer's default perpendicular beam orientation is a poor Doppler angle for a vessel running parallel to the skin surface. Which feature specifically compensates for this?

A. Increasing the color gain

B. Switching to a curvilinear probe automatically

C. Reducing the pulse repetition frequency

D. Electronic beam steering

59. A 'snap-to-edge' auto-caliper feature assists the sonographer by:

A. Auto-adjusting caliper placement to the nearest strong edge

B. Automatically calculating gestational age from any two calipers

C. Preventing the operator from placing calipers manually at all

D. Only functioning on Doppler spectral traces

60. A technique that simultaneously transmits two different frequencies to exploit their differing tissue interaction characteristics for improved tissue differentiation is best described as:

A. Dual-frequency simultaneous transmission

B. Standard second-harmonic imaging

C. Simple frequency-agile switching between exams

D. Coded excitation technique

61. A live 'quad-view' display simultaneously showing B-mode, color Doppler, spectral Doppler trace, and M-mode from the same anatomic location is primarily useful for:

A. Reducing the total exam time to under one minute

B. Eliminating the need for a written report

C. Automatically calculating cardiac output

D. A comprehensive, correlated view of anatomy, flow, and motion

62. An automated protocol-compliance checklist that prompts the sonographer in real time if a required standard view has not yet been captured is designed primarily to:

A. Replace the sonographer's clinical judgment entirely

B. Ensure all required standard views are captured

C. Automatically interpret the images for diagnosis

D. Increase the total radiation dose tracked for the exam

63. Automated aortic annulus diameter measurement software, used in pre-procedural planning for transcatheter aortic valve replacement (TAVR), is primarily valuable because:

A. It replaces the need for any cross-sectional imaging in TAVR planning

B. It only works with a phased-array cardiac probe

C. Accurate sizing affects valve selection; automation improves reproducibility

D. It automatically selects the correct valve brand for the case

64. An automated feature that graphs fetal heart rate trends captured at multiple points throughout a single extended exam session, rather than a single spot measurement, is primarily useful for:

A. Identifying transient decelerations a single spot-check would miss

B. Replacing the need for any fetal heart rate measurement

C. Calculating estimated fetal weight

D. Automatically diagnosing fetal arrhythmia without physician review

65. Multi-planar reformatting (MPR) navigation, used when reviewing a previously acquired 3D ultrasound volume dataset, allows the reviewer to:

A. Reconstruct any arbitrary 2D plane without rescanning

B. Only view the original acquisition plane

C. Automatically calculate organ volume without any manual input

D. Convert the 3D dataset into a live real-time scan

66. A 'region-growing' automated segmentation tool estimates the volume of an irregularly shaped mass by:

A. Assuming the mass is a perfect sphere and applying a simple formula

B. Requiring the operator to trace the entire boundary manually, point by point

C. Starting from a seed point and expanding by similar intensity

D. Measuring only the single longest diameter of the mass

67. During a therapeutic HIFU procedure, a live on-screen readout of the applied acoustic power output percentage primarily allows the operator to:

A. Convert the display to standard diagnostic B-mode automatically

B. Titrate and monitor delivered treatment energy

C. Calculate the patient's total radiation dose

D. Automatically stop the procedure once a fixed time has elapsed

68. Automated software that flags a suspected parathyroid gland based on size and location criteria near the thyroid is primarily intended to:

A. Replace the need for any nuclear medicine localization study

B. Confirm the diagnosis of hyperparathyroidism independently

C. Only function during a thyroid-specific exam, never a neck survey

D. Prompt further correlation, since glands are small and easily overlooked

69. A structured hanging-protocol feature that automatically arranges captured images/clips into a standardized layout matching the facility's reporting template is primarily intended to:

A. Streamline the physician's review with a consistent layout

B. Automatically generate the diagnostic interpretation

C. Replace the need for a PACS system

D. Improve the transducer's acoustic output stability

70. A live side-by-side display showing the current real-time image alongside a static reference diagram of normal anatomy is primarily intended to:

A. Automatically measure the deviation from normal anatomy

B. Replace the sonographer's anatomic knowledge

C. Function only in obstetric exams

D. A visual orientation aid correlating the image with landmarks

71. Automated quantification of B-lines (vertical reverberation artifacts) in lung ultrasound is used clinically to help assess:

A. Skeletal bone density

B. Gallbladder wall thickness

C. Pulmonary interstitial fluid/edema

D. Renal cortical thickness

72. During an extended field-of-view (panoramic) sweep, real-time gain normalization across the stitched image is important primarily to prevent:

A. Aliasing artifact pattern

B. Range ambiguity error

C. Banding at the stitch seams

D. Grating lobe artifact effect

73. Serial trending of splenic vein diameter over time is most clinically useful in the context of:

A. Routine appendicitis evaluation

B. Monitoring portal hypertension progression

C. Thyroid nodule surveillance

D. Testicular torsion follow-up

74. A live audible chime that automatically sounds when a measurement crosses a pre-set critical-value threshold during scanning, in addition to any visual on-screen flag, is designed primarily to:

A. Replace the need for any visual flagging system

B. A redundant sensory alert if visual attention is elsewhere

C. Automatically page the interpreting physician

D. Adjust the transducer's acoustic output automatically

75. Quantitative ultrasound-based hepatic fat fraction measurement, compared to traditional qualitative echogenicity-based steatosis grading, primarily offers:

A. A completely different, non-overlapping diagnostic purpose

B. Elimination of any need for liver biopsy in all cases

C. A numeric, reproducible measurement trackable over time

D. Function only with contrast agent administration

76. Automated color Doppler-assisted detection flagging a possible umbilical cord nuchal loop is intended to:

A. Automatically confirm fetal distress requiring immediate delivery

B. Replace grayscale visualization of the cord entirely

C. Only function in the third trimester

D. Prompt evaluation and documentation of a nuchal cord finding

77. Using the Doppler equation, calculate the frequency shift for: operating frequency 5 MHz, flow velocity 60 cm/s, propagation speed 1,540 m/s, and Doppler angle 60 degrees (cosine 60 = 0.5).

A. Approximately 975 Hz

B. Approximately 3,900 Hz

C. Approximately 2,750 Hz

D. Approximately 1,950 Hz

78. A system's PRF is 6,000 Hz. What is the Nyquist limit (maximum unambiguous Doppler shift frequency) for this PRF?

A. 3,000 Hz

B. 6,000 Hz

C. 12,000 Hz

D. 1,500 Hz

79. A spectral waveform shows a peak systolic velocity (PSV) of 80 cm/s and an end-diastolic velocity (EDV) of 20 cm/s. Calculate the resistive index, RI = (PSV-EDV)/PSV.

A. 0.25

B. 0.40

C. 0.60

D. 0.75

80. For a waveform with PSV 90 cm/s, EDV 10 cm/s, and a calculated mean velocity of 40 cm/s, calculate the pulsatility index, PI = (PSV-EDV)/mean velocity.

A. 2.0

B. 1.0

C. 0.8

D. 2.5

81. A vessel has a cross-sectional area of 0.5 cm squared and a time-averaged mean velocity (TAV) of 20 cm/s. Calculate the volume flow rate, Volume flow = Area x TAV.

A. 5 mL/min

B. 600 mL/min

C. 60 mL/min

D. 1,200 mL/min

82. Pre-stenotic PSV is 40 cm/s and the PSV within the stenosis is 320 cm/s. Calculate the velocity ratio (stenotic PSV / pre-stenotic PSV) used for grading.

A. 2:1

B. 4:1

C. 6:1

D. 8:1

83. An umbilical artery waveform shows a systolic peak of 45 cm/s and an end-diastolic value of 15 cm/s. Calculate the S/D ratio.

A. 2.0

B. 3.0

C. 4.5

D. 0.33

84. A normal peripheral arterial spectral waveform typically shows a clear 'window,' a relatively echo-free space, under the systolic peak. This clear window reflects:

A. Laminar flow, with RBCs moving at a narrow velocity range

B. Turbulent flow filling the entire velocity range

C. An artifact from excessive wall filter setting

D. Aliasing artifact at the baseline

85. The recommended technique for setting spectral Doppler gain is to increase it until background noise just appears throughout the display, then:

A. Continue increasing gain further for a brighter trace

B. Switch to color Doppler instead

C. Reduce gain slightly until noise just disappears

D. Reduce gain to the lowest possible setting to eliminate all noise

86. Compared to conventional color Doppler, power Doppler's greater sensitivity to slow/low-volume flow comes at the cost of:

A. Reduced spatial resolution overall

B. Increased frame rate significantly

C. Loss of directional and velocity information

D. Increased susceptibility to aliasing artifact

87. A spectral Doppler trace shows a thick band of low-frequency noise near the baseline, obscuring the true waveform, caused by tissue/vessel wall motion. This is most likely due to:

A. Wall filter set too high

B. Wall filter set too low

C. PRF set too high

D. Color gain set too low

88. A high-velocity, purely unidirectional jet is displayed, but the peak keeps cutting off at the top of the spectral display even though the scale (PRF) is already at maximum. The most appropriate adjustment is to:

A. Increase the wall filter setting further

B. Shift the baseline for more display range

C. Switch to power Doppler mode

D. Reduce the sample volume size setting

89. A spectral Doppler tracing over several cardiac cycles shows irregular, beat-to-beat variation in peak velocity and waveform shape rather than a consistent repeating pattern. This finding is most suggestive of:

A. A technically inadequate Doppler angle

B. Aliasing artifact pattern

C. Excessive wall filter setting

D. Underlying cardiac arrhythmia affecting filling

90. Near a strong specular reflector, a spectral Doppler tracing may show a symmetric, duplicated waveform appearing on the opposite side of the baseline. This artifact is best explained by:

A. Reflection off a strong interface mirroring the trace

B. True bidirectional flow within the vessel

C. Aliasing due to insufficient PRF

D. Excessive spectral broadening from turbulence

91. A waveform's systolic upstroke begins at time 0 and reaches peak systolic velocity at 120 milliseconds. If the total cardiac cycle length is 800 milliseconds, calculate the acceleration time as a percentage of the cycle.

A. 5%

B. 10%

C. 15%

D. 25%

92. A jet velocity of 4 m/s is measured across a valve. Using the modified Bernoulli equation, pressure gradient = 4V squared, calculate the estimated peak pressure gradient.

A. 16 mmHg

B. 64 mmHg

C. 32 mmHg

D. 8 mmHg

93. Following a transradial approach for cardiac catheterization, the radial artery distal to the access site shows absent Doppler flow, with the hand remaining well-perfused via collateral ulnar artery flow. This is most consistent with:

A. Asymptomatic radial occlusion, tolerated via ulnar collateral supply

B. Acute hand ischemia requiring emergent intervention

C. A normal post-procedure finding requiring no documentation

D. Radial artery pseudoaneurysm

94. A gestational sac is identified eccentrically in the fundal region, surrounded by a thin (<5 mm) myometrial mantle, lateral to the interstitial portion of the fallopian tube, with a vascular ring on color Doppler. This is most consistent with:

A. A normal eccentric intrauterine pregnancy

B. A cervical ectopic pregnancy

C. A cesarean scar ectopic pregnancy

D. An interstitial (cornual) ectopic pregnancy

95. A well-circumscribed, solid, hypoechoic mass is identified within the placental parenchyma near the cord insertion, showing prominent internal vascularity on color Doppler with a feeding vessel from the fetal circulation. This is most consistent with:

A. A placental infarct finding

B. A subchorionic hematoma collection

C. A placental chorioangioma, a vascular tumor

D. A simple placental cyst structure

96. A blind-ending, thick-walled bowel loop is identified in the right lower quadrant, distinct from the appendix, showing increased wall vascularity on color Doppler in a patient with painless rectal bleeding. This is most suggestive of:

A. Acute appendicitis presentation

B. Inflamed Meckel's diverticulum, painless bleeding

C. Crohn's disease terminal ileitis

D. Intussusception with target sign

97. Persistent bilateral uterine artery diastolic notching identified on Doppler in the third trimester is most associated with:

A. A normal finding at this gestational age, requiring no further action

B. Confirmation of fetal well-being

C. A technical artifact from incorrect angle correction

D. Increased pre-eclampsia/growth-restriction risk from elevated resistance

98. Numerous tiny (1-3mm) echogenic, non-shadowing foci are diffusely scattered throughout both testes, without an associated mass, in an asymptomatic patient. Color Doppler shows no associated abnormal vascularity. This is most consistent with:

A. A testicular malignancy requiring immediate biopsy

B. Testicular microlithiasis, low malignancy risk when isolated

C. Segmental testicular infarction area

D. Scrotal wall calcification unrelated to the testicle

99. During an abdominal Doppler exam, a vascular structure is identified coursing along the LEFT side of the aorta, connecting to the left renal vein rather than directly to the IVC, with normal venous flow confirmed by Doppler. The IVC itself is not visualized on the right in its expected location. This is most consistent with:

A. IVC thrombosis with echogenic material

B. A retroaortic left renal vein

C. An acquired venous collateral from portal hypertension

D. A congenital left-sided/duplicated IVC variant

100. Following a renal transplant, a new anechoic fluid collection adjacent to the transplant is identified, and the transplant renal vein now shows increased peak velocity with turbulence where it courses near the collection. This suggests:

A. A normal postoperative seroma with no hemodynamic significance

B. Acute transplant rejection findings

C. A lymphocele causing extrinsic venous compression

D. Transplant renal artery stenosis

101. The umbilical cord is observed to insert at the edge of the placental disc rather than centrally, with the vessels remaining protected within Wharton's jelly at the insertion site. This finding is best described as:

A. Marginal cord insertion, a benign variant

B. Vasa previa, a distinct risk

C. Placenta previa location

D. Velamentous cord insertion pattern

102. Transcranial venous Doppler in a patient with severe headache and papilledema shows absent flow signal in the expected location of the superior sagittal sinus, with collateral venous flow patterns elsewhere. This raises concern for:

A. Normal variant sinus anatomy pattern

B. Arterial vasospasm of the circle of Willis

C. A middle cerebral artery aneurysm finding

D. Cerebral venous sinus thrombosis with raised ICP signs

103. In a lower-extremity vein, using a 5 MHz probe, a Doppler angle of 45 degrees (cosine = 0.707), a propagation speed of 1,540 m/s, and a measured shift of 1,000 Hz, solve for the venous flow velocity.

A. Approximately 15 cm/s

B. Approximately 22 cm/s

C. Approximately 44 cm/s

D. Approximately 11 cm/s

104. An intratesticular artery shows a PSV of 15 cm/s and an EDV of 6 cm/s. Calculate the resistive index.

A. 0.60

B. 0.40

C. 0.90

D. 0.25

105. A vessel's diameter is measured at 0.8 cm, and the time-averaged mean velocity is 15 cm/s. First calculate the cross-sectional area (Area = pi x radius squared), then the volume flow rate.

A. Approximately 283 mL/min

B. Approximately 150 mL/min

C. Approximately 452 mL/min

D. Approximately 50 mL/min

106. A high-velocity regurgitant jet through a cardiac valve appears as a mosaic pattern with rapid color reversal (aliasing) on color Doppler, even though the true flow is unidirectional. The most likely explanation and correction is:

A. The color gain is set too high; reduce color gain

B. The color scale is set too low; increase the scale

C. The wall filter is set too low; increase the wall filter

D. The transducer frequency is too high; switch to a lower-frequency probe

107. During adrenal vein sampling for suspected primary aldosteronism, intraprocedural Doppler assessment of the sampling catheter tip position within the adrenal vein is used primarily to:

A. Measure adrenal gland volume

B. Diagnose adrenal malignancy

C. Replace the need for cortisol-level confirmation of catheter position

D. Confirm catheter position and flow in real time

108. Following microsurgical free-flap reconstruction, postoperative Doppler monitoring of the vascular pedicle (arterial and venous anastomoses) is performed primarily to:

A. Measure the flap's final cosmetic outcome

B. Detect early anastomotic thrombosis or compromise

C. Replace clinical (capillary refill, color, temperature) flap assessment entirely

D. Only assess arterial inflow, since venous outflow cannot be evaluated with Doppler

109. At a prior low-transverse cesarean scar site, a wedge-shaped hypoechoic defect (niche) is identified in the anterior lower uterine segment in a non-pregnant patient, with mild peripheral vascularity on color Doppler and no gestational sac. This is most consistent with:

A. A cesarean scar ectopic pregnancy finding

B. Retained products of conception tissue

C. A uterine arteriovenous malformation pattern

D. A cesarean scar niche, no gestational sac present

110. A spectral tracing shows PSV 100 cm/s, EDV 25 cm/s, and mean velocity 50 cm/s. Calculate RI, PI, and S/D ratio together.

A. RI=0.75, PI=1.50, S/D=4.0

B. RI=0.25, PI=1.50, S/D=4.0

C. RI=0.75, PI=2.50, S/D=4.0

D. RI=0.75, PI=1.50, S/D=0.25

Answers

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1. A. Micro-shock refers to a very small current that becomes dangerous only when it has a direct, low-resistance path to or near the heart, bypassing the skin's normal resistance -- exactly the scenario described. Macro-shock requires a much larger current through intact skin and is the more familiar hazard, which is why it's tempting, but the direct-cardiac-pathway detail specifically defines micro-shock. Ground-fault leakage describes a device malfunction, not the hazard mechanism itself. EMI affects image quality, not electrical safety.

2. B. Compassion fatigue describes the cumulative emotional toll of repeatedly witnessing patients' traumatic experiences, distinct from general workload burnout, which lacks the empathy-specific, trauma-exposure component described. Malingering is unrelated. A musculoskeletal disorder is physical, not emotional.

3. B. AIUM Practice Parameters are exam-specific documents defining required elements, technique, and documentation. The Prudent Use Statement addresses bioeffects/output philosophy broadly, not exam-specific content, making it a tempting but wrong choice. A Declaration of Conformity is a manufacturing document unrelated to exam content. An internal QI charter is facility-specific, not an authoritative external standard.

4. A. Localized swelling and pain confined to the injection site, without systemic signs, is the classic presentation of extravasation. Anaphylactoid reaction produces systemic signs, not just local swelling. Vasovagal response presents with hypotension/bradycardia/syncope. Ultrasound contrast agents are not renally excreted the way iodinated CT contrast is, so nephrotoxicity doesn't apply here.

5. D. An intermittent malfunction should be reported immediately and the equipment taken out of service until evaluated, since continuing to use potentially malfunctioning equipment risks patient safety and diagnostic accuracy. Continuing to scan with an informal note doesn't address the risk. Restarting and hoping the issue doesn't recur ignores an unresolved hardware problem. Waiting for the next scheduled PM visit delays a report that should be immediate.

6. B. A true sterile field for an invasive procedure requires a sterile probe cover and sterile coupling gel over the needle pathway. Low-level disinfection is insufficient for a sterile field. Alcohol-wiping between passes does not substitute for a sterile barrier. Clean, non-sterile gloves break sterile technique for an invasive procedure.

7. C. Just Culture balances accountability with a non-punitive approach to honest reporting, encouraging disclosure so systemic causes can be fixed. Zero-tolerance is essentially the opposite. Peer review is a retrospective case-accuracy audit, not a reporting-culture philosophy. Mandatory escalation describes a pathway/requirement, not the underlying philosophy.

8. D. Acceptance testing establishes the new system's baseline performance, and documented in-service training ensures staff competency, both at installation. Routine daily QA assumes an already-established baseline. Warranty registration is administrative. The annual comprehensive PM review is a recurring maintenance activity, not the initial installation step.

9. C. Best practice, and often a regulatory requirement, is to use a qualified interpreter service for informed consent and instructions, since untrained family members or coworkers can introduce translation errors, bias, or confidentiality issues. Gestures alone cannot reliably convey risk/benefit information. Canceling with no further action skips an available, appropriate solution. An untrained bilingual coworker is not a substitute for a qualified interpreter.

10. D. De-escalation relies on calm acknowledgment, clear explanation, and offering control to reduce anxiety-driven agitation, while completing a necessary exam. Matching tone tends to escalate conflict. Ignoring the behavior fails to address the distress. Terminating the exam immediately is premature as a first response and abandons a needed study without trying a lower-intensity approach first.

11. C. Healthcare workers, including sonographers, are mandated reporters for suspected child abuse in essentially all jurisdictions; findings inconsistent with the history must be escalated through the facility's mandated-reporting channel. Silent documentation fails that duty. Discussing concerns with the family first can compromise the child's safety and any investigation. Waiting for the physician to notice independently improperly shifts a personal legal obligation.

12. A. Intensity is proportional to the square of amplitude (I is proportional to A squared), so doubling amplitude quadruples intensity. Option B reflects the common mistake of treating intensity as linearly proportional to amplitude. C and D reflect miscalculated exponents, not the correct squared relationship.

13. B. Frequency is set by the source and does not change crossing into a new medium; since v=f times lambda and v changes with the medium, wavelength adjusts to keep frequency fixed. Propagation speed is exactly the quantity that DOES change. Wavelength is also a changing quantity. Amplitude changes due to attenuation, unrelated to this boundary relationship.

14. C. The Doppler shift itself is determined by true velocity, angle, and operating frequency, not by PRF; PRF only sets the Nyquist limit, the maximum shift displayable before aliasing. Raising PRF lets a higher true shift be displayed without wraparound, but doesn't alter the actual shift value. Options A and B both incorrectly assume PRF changes the underlying shift. Mode switching to power Doppler is a separate, manual operator choice, not an automatic consequence of a PRF change.

15. B. 1.8 mm divided by 0.6 mm equals exactly 3, a whole-number multiple, the condition for constructive interference. Option A misapplies the condition despite the numbers satisfying it. Option C miscalculates the ratio. Option D is a distractor -- amplitude affects the resulting magnitude, not whether the interference condition itself is met.

16. B. The beam uniformity ratio compares spatial peak intensity to spatial average intensity across the beam's cross-section; a high peak-to-average ratio reflects a high beam uniformity ratio value. Duty factor relates pulse duration to pulse repetition period, a temporal concept, making it a tempting but wrong distractor. Q-factor describes bandwidth/damping, unrelated to spatial distribution. Attenuation coefficient describes energy loss with distance, not the peak-vs-average relationship within one cross-section.

17. C. Cosine of 90 degrees equals zero, so the calculated shift is zero at a perpendicular beam-to-flow angle regardless of true velocity. 0 degrees gives cosine=1, the maximum shift. 45 degrees gives cosine of about 0.707, a reduced but non-zero shift. 180 degrees gives cosine=-1, the maximum magnitude in the opposite direction.

18. C. The Doppler shift equation shows the shift is directly proportional to operating frequency, so a higher frequency produces a proportionally larger shift for the same velocity and angle. Option A reverses the relationship. Option B ignores frequency's direct presence in the equation. Option D introduces depth as an irrelevant factor to this specific proportional relationship.

19. B. Wavelength = speed/frequency = 1,510/5,000,000 is approximately 0.30 mm. Option A is roughly half the correct value. Option C is roughly double. Option D reflects a decimal-placement error, off by roughly a factor of 5.

20. A. Each segment's attenuation (path length times coefficient times frequency) is summed since dB values are additive along a path: fat contributes 6 dB, liver contributes 7.5 dB, totaling 13.5 dB. B and C

are each just one segment's contribution alone. D roughly doubles the correct total, a plausible round-trip-confusion error when the question specifically asks for one-way attenuation.

21. D. Snell's law shows that entering a medium with a HIGHER propagation speed refracts sound away from the normal, at an angle greater than the angle of incidence. Option A describes the opposite scenario. Option B would only occur exactly at the critical angle. Option C would only be true if the two speeds were equal.

22. A. PRP = 1/5000 = 200 microseconds; maximum unambiguous depth = (1540 m/s x 0.0002 s)/2, approximately 15.4 cm. Option B is exactly half the correct value. Option C is double, from omitting the divide-by-2 for round-trip travel. Option D is off by a factor of ten.

23. B. SPL = cycles x wavelength = 4 x 0.4 = 1.6 mm; axial resolution equals half the SPL, so 0.8 mm. Option A doubles the SPL for the resolution figure instead of halving. Option C miscalculates the SPL itself. Option D fails to divide by 2 at all.

24. A. Propagation speed is derived from v = square root of (bulk modulus/density); higher stiffness increases speed while higher density decreases it. Option B invents an incorrect formula combining unrelated variables. Option C similarly misapplies wavelength, a derived quantity. Option D is a common misconception -- propagation speed is a property of the medium, independent of the transducer.

25. B. Lateral resolution is directly determined by beam width -- the narrower the beam, the finer the lateral resolution -- so the focal zone provides the best lateral resolution. Option A ignores the direct dependence. Option C reverses the relationship. Option D is incorrect since beam width is, in fact, the primary determinant of lateral resolution at a given depth.

26. B. Acoustic impedance is the product of density and propagation speed; if Tissue A's density advantage proportionally outweighs its speed disadvantage, its overall impedance can still exceed Tissue B's. Option A ignores the speed component entirely. Option C ignores the density component. Option D incorrectly asserts speed alone controls the ranking, contradicted by the scenario itself.

27. C. A 10 dB change corresponds to a 10-fold intensity change, so 20 dB corresponds to 10x10, a 100-fold decrease, leaving 1/100 of the original. Option A reflects the misconception that dB changes are linear rather than logarithmic. Option B is the correct fraction for a 10 dB loss, one decade short. Option D would correspond to a 30 dB loss, one decade too many.

28. C. The piezoelectric strain constant quantifies how efficiently a material converts electrical energy to mechanical strain and vice versa. Electrical impedance at resonance is a separate electrical property. Physical thickness relationship to frequency describes the half-wavelength resonance rule, a different concept. Curie temperature describes the depolarization threshold, unrelated to the strain constant.

29. D. A multi-frequency transducer offers several discrete selectable center frequencies rather than one continuous band, letting the operator pick the best depth/resolution trade-off for the exam. A broadband agile probe instead sweeps continuously across a range rather than switching between fixed discrete

presets. A CW probe has no imaging capability. Annular arrays are defined by their ring-element geometry, not frequency-switching capability.

30. C. Recognized standards cap the continuous patient-contact surface temperature at approximately 43 degrees C, a threshold chosen because tissue damage risk rises meaningfully above this point with sustained contact. 30 degrees C is below normal body temperature and unrealistically low as a safety ceiling. 37 degrees C is simply normal body temperature, with no margin. 50 degrees C would risk thermal injury with prolonged contact.

31. C. A softer, more compliant lens conforms better to irregular body surfaces, improving acoustic coupling and comfort. Resonant frequency stability is governed primarily by the piezoelectric element, not the lens material. Manufacturing cost is a secondary consideration. Electrical shielding is unrelated to the acoustic lens's function.

32. D. Crosstalk is minimized by physically isolating adjacent elements with kerf cuts filled with a damping material that absorbs stray vibrational/acoustic energy before it couples into neighboring elements. Frequency, pitch alone, and transmit power don't directly address the coupling mechanism.

33. C. A linear array fires parallel scan lines straight down, producing a rectangular image whose width at any depth equals the active footprint width. Sector shape describes phased/mechanical sector probes. Trapezoidal describes a curvilinear or virtual-convex/extended linear scanning mode, a different probe/mode. Circular does not describe any standard 2D field of view shape.

34. D. Fill factor describes what fraction of the element's total area is active piezoelectric material rather than the inactive kerf or spacer material between elements. Coupling gel reservoir fullness is unrelated and fabricated. Scan-line fill percentage per frame is not what fill factor refers to. Active-vs-inactive ELEMENT ratio is a plausible but distinct concept from a single element's own composition.

35. C. Because a CW probe transmits and receives simultaneously and continuously, there is no pulse-timing information available to calculate echo depth via time-of-flight, the fundamental requirement for building a 2D image. It does have piezoelectric elements, just used differently. Its frequency isn't inherently too low for imaging. Beam focusing is possible to some degree with CW probes, but focusing alone doesn't provide depth/timing information.

36. A. Because sound travels roughly 1.54 mm per microsecond in tissue, achieving fine spatial steering and focus demands firing-delay control at the nanosecond level. Milliseconds is far too coarse by several orders of magnitude. Microsecond-only precision is generally too coarse for fine steering accuracy at typical element spacings. Timing precision is fundamental to steering accuracy, so option D is incorrect.

37. D. CW Doppler has no theoretical velocity ceiling because it lacks a Nyquist constraint, making it ideal for very high-velocity flow (transcranial Doppler, certain fetal/umbilical circulations) where pulsed-wave systems would alias. Routine abdominal survey, obstetric anatomy screening, and MSK tendon evaluation all require 2D anatomic imaging, which a non-imaging CW probe cannot provide.

38. A. Repeated chemical disinfection cycles can gradually degrade housing and seal materials, increasing the risk of compromised barrier integrity if the manufacturer's cycle limit is exceeded -- a real functional/safety risk, not merely a warranty issue. Electrical failure isn't typically immediate or the primary described risk. Frequency drift is not directly caused by disinfection cycle count. It is not simply a warranty-only concern.

39. B. There is an inverse relationship between pulse duration and bandwidth -- a shorter pulse requires a wider frequency bandwidth, and shorter pulses directly improve axial resolution. Manufacturing cost is not the driving technical rationale. Penetration depth is primarily governed by operating frequency, not bandwidth. A matching layer is still required regardless of bandwidth.

40. C. An optical barcode/QR identifier lets the system automatically recognize which transducer is connected, enabling correct default presets and asset tracking without manual entry. It has no role in patient-data encryption. It does not substitute for acoustic output testing. It provides no temperature-sensing function.

41. B. A drop/impact-resistance rating is a mechanical durability specification describing tested conditions under which the probe remains functional. Software crash-recovery is unrelated. Patient body weight tolerance is not addressed by this rating. Disinfectant chemical resistance is a separate materials-compatibility specification.

42. C. Heavier damping absorbs vibrational energy faster, shortening how long the element continues to ring, producing a shorter pulse and better axial resolution, at the cost of reduced sensitivity. Option A reverses the trade-off. Option B denies a well-established effect. Option D falsely claims a free improvement with no trade-off.

43. D. Sensitivity describes the transducer's efficiency at converting a returning echo into a detectable electrical signal for a given transmit strength. Frequency range describes bandwidth, a related but distinct specification. Physical fragility is a durability characteristic. Electrical interference resistance is a shielding/EMI characteristic, unrelated to sensitivity.

44. D. Because a curved array's beams diverge to cover a progressively wider field of view at depth, achieving the same line density across that wider area requires more total scan lines per frame than a linear array's constant-width rectangular FOV, directly reducing frame rate for a given PRF. Curved arrays are not inherently restricted to lower frequencies. Parallel beamforming can be applied to curved arrays too. There's no fixed rule requiring curved arrays to use double the PRP.

45. C. Because dedicated receive channels are costly, systems often have fewer channels than the transducer's total element count, requiring multiplexing schemes. This mismatch is a normal, intentional design choice, not a defect. It has real practical significance for image quality, cost, and frame rate. Simultaneous firing of every element regardless of mode is not required or accurate.

46. D. Pulse inversion transmits a pulse and its exact polarity-inverted twin; summing the returning echoes cancels the linear (fundamental) component while the nonlinear harmonic component is reinforced. PRF increase is unrelated to this mechanism. Doubling receive channels is a hardware concept unrelated to this signal-processing technique. Transmitting at different depths misdescribes the technique.

47. B. A larger acquired volume requires more scan lines/planes per full volume, directly reducing volume rate, mirroring the familiar 2D trade-off between FOV/line density and frame rate. Option A reverses the relationship. Option C ignores the real data-acquisition burden. This trade-off applies regardless of color Doppler activation, though color adds its own additional burden.

48. B. Because an out-of-plane needle only briefly intersects a single 2D plane, specialized crossed-beam or biplane techniques localize where the needle tip crosses that plane; standard in-plane shaft-enhancement software is not designed for this, since that technique assumes the needle lies within the visible plane. Increasing gain doesn't address the localization problem. M-mode shows motion along a single line over time, not spatial needle-tip localization.

49. A. Automated angle-correction software analyzes the image to detect vessel wall orientation and automatically positions the angle-correction cursor parallel to presumed flow direction. It does not physically move the transducer. It doesn't switch Doppler modes. Increasing PRF addresses aliasing, an unrelated function.

50. C. A continuously running retrospective buffer captures imaging even before the freeze command, letting the sonographer rewind to capture a transient finding otherwise missed. It has no relationship to acoustic output settings. It doesn't generate reports. It doesn't replace the DICOM archive, which remains the permanent storage system.

51. D. Detected motion-related misalignment triggers a prompt guiding rapid re-registration to restore accurate spatial correspondence, since continuing with stale registration would misguide targeting. Permanently disabling fusion is an overreaction not typical of this feature. Frequency changes are unrelated to registration accuracy. Silently continuing with a known misalignment is precisely the failure the prompt is designed to prevent.

52. C. The textured surface creates numerous small reflective facets that scatter sound in multiple directions, increasing energy returned toward the transducer compared to a smooth needle, improving conspicuity. Electrical conductivity is irrelevant to ultrasound visualization. Radiopacity for X-ray is a different-modality concept. Needle diameter is a separate physical characteristic unrelated to the coating's mechanism.

53. C. Combining ultrasound's soft-tissue detail with fluoroscopy's bony/contrast visualization in one overlaid display gives complementary spatial guidance neither modality provides alone. It does not eliminate radiation exposure, since fluoroscopy still uses ionizing radiation. It doesn't automate needle-path planning. It doesn't replace pre-procedure imaging, which still serves its own planning purpose.

54. B. AI-based segmentation traces the gland's actual irregular contour to compute volume from the real segmented shape, rather than assuming an ellipsoid. Manual dimension entry describes the traditional formula method, the opposite approach. It isn't restricted to endocavity transducers specifically. It does not always match the formula-based estimate, since the methods use different underlying assumptions.

55. B. This feature's defining characteristic is operating DURING active scanning, giving the operator an immediate opportunity to correct technique -- a real-time guidance function rather than a retrospective one. A static post-exam score is explicitly the opposite timing. An outlier flag addresses measurement values, not acquisition technique. A DICOM compliance check addresses file-format/metadata standards.

56. A. Frame averaging blends data across consecutive TIME points to smooth random noise, trading temporal resolution for smoothness -- distinct from spatial compounding, which blends multiple simultaneous beam-steering angles at essentially one moment. Spatial compounding is exactly this different, time-independent mechanism. Harmonic imaging uses nonlinear frequency content, unrelated. Coded excitation is a pulse-encoding scheme, not a frame-blending technique.

57. C. Renal cortical thinning is a recognized sign of chronic parenchymal disease, but normal cortical thickness naturally decreases with age, so age-adjusted comparison avoids over-flagging normal age-related change while still catching pathologic thinning. It doesn't replace renal length assessment, a separate complementary measurement. It isn't restricted to pediatric patients; age-adjustment applies across the lifespan. It flags a finding for correlation, not an automated diagnosis of cause.

58. D. Electronic beam steering allows a linear array to angle its beam obliquely, creating a workable non-90-degree angle relative to a superficial vessel, where the default perpendicular orientation would produce a near-zero shift. Increasing color gain doesn't change beam geometry. The probe doesn't automatically switch type; this remains a steering choice on the same linear probe. Reducing PRF affects the velocity scale, not the beam angle.

59. A. Snap-to-edge assistance detects a nearby strong echo boundary and fine-tunes the operator's approximate click to the true anatomic edge, improving precision over purely manual placement. It doesn't specifically calculate gestational age; that's a separate downstream calculation. It assists rather than replaces manual placement. It isn't restricted to spectral traces; it commonly applies to B-mode anatomic measurements too.

60. A. This describes a technique using two simultaneously transmitted frequencies, rather than switching or relying on harmonic generation from a single transmit frequency, to leverage each frequency's tissue-interaction behavior. Standard harmonic imaging relies on nonlinear propagation of a SINGLE transmitted frequency, a related but distinct mechanism. Frequency-agile switching changes frequency between separate exams, not simultaneously. Coded excitation uses a frequency-swept single pulse for SNR improvement, a different technique.

61. D. Presenting all four modes together lets the clinician correlate anatomic structure, flow presence/pattern, spectral characteristics, and motion at the same location and moment, valuable for complex diagnostic questions. It doesn't shorten exam time; displaying more information typically requires more acquisition and review time. It doesn't eliminate reporting. It does not itself calculate cardiac output automatically, though displayed measurements could feed into a separate calculation.

62. B. This feature functions as a real-time safeguard against incomplete exams by tracking required views and prompting if something is missing before the study is considered complete. It supports, rather than replaces, the sonographer's judgment. It does not interpret images diagnostically. Ultrasound involves no ionizing radiation, so a radiation-dose tracking function is not applicable and a clear distractor.

63. C. Correct annulus sizing is critical to selecting an appropriately sized prosthetic valve, and automated measurement tools improve reproducibility compared to fully manual caliper placement, though echo typically complements rather than replaces cross-sectional imaging in most TAVR planning protocols. It is not restricted to a single probe type. It supports sizing, not brand selection, which remains a clinical/procedural decision.

64. A. A trend graph built from multiple measurements can reveal transient patterns that a single isolated spot-check would completely miss, providing more clinically useful information over the session's duration. It doesn't eliminate heart rate measurement; it's built from multiple heart-rate measurements. It's unrelated to weight estimation. It generates a trend for physician review, not an automated diagnosis.

65. A. MPR navigation allows retrospective reconstruction and scrolling through any desired 2D plane, including oblique planes never directly acquired, from the already-captured volume dataset without the patient present. It provides MORE than just the original acquisition plane, which is precisely the limitation MPR overcomes. It does not automatically calculate volume without input, a separate feature. A stored dataset cannot be converted into a live real-time scan.

66. C. Region-growing segmentation starts from one seed point and automatically expands outward, including adjacent pixels/voxels sharing similar intensity, to delineate an irregular mass's true boundary. It specifically avoids the sphere-formula assumption. It reduces, rather than requires, full manual point-by-point tracing. It produces a full volumetric estimate, not just a single longest-diameter measurement.

67. B. Because therapeutic HIFU intentionally delivers much higher acoustic output than diagnostic imaging, a live power-output readout lets the operator titrate and monitor delivered energy within the intended therapeutic window. It has no automatic-mode-conversion function. Ultrasound involves no ionizing radiation, so a radiation-dose calculation is inapplicable. The readout monitors power, not elapsed time, and does not impose an automatic time-based stop.

68. D. Parathyroid glands are small and can be easily missed on routine imaging, so a flag prompting closer evaluation supports pre-operative localization for parathyroidectomy planning, without independently establishing a diagnosis. It does not replace complementary nuclear medicine localization

techniques commonly used alongside ultrasound. It does not confirm the diagnosis, which requires biochemical correlation. It is not restricted to thyroid-specific exams alone.

69. A. Automatically organizing images/clips into the same consistent layout speeds up and standardizes physician review, reducing search time and layout variability between exams. It does not generate the diagnostic interpretation, which remains the physician's judgment. It works within, rather than replacing, the facility's PACS infrastructure. It has no relationship to the transducer's acoustic output.

70. D. This comparison functions as a visual reference aid, helping the sonographer orient real-time findings against expected normal anatomy, supporting scanning technique and landmark recognition. It does not automatically measure deviation; it's a visual reference only. It supports, rather than replaces, the sonographer's own anatomic knowledge. It is not restricted to obstetric exams.

71. C. B-lines are vertical reverberation artifacts from thickened interlobular septa/fluid at the pleural surface, and their number/density is a recognized semi-quantitative indicator of pulmonary interstitial fluid, making automated counting clinically useful for monitoring. Bone density is unrelated and not assessed via lung B-lines. Gallbladder wall thickness and renal cortical thickness are unrelated organ-specific measurements, clearly mismatched distractors.

72. C. Because a panoramic image is stitched from many individual frames potentially acquired under slightly different depth/gain conditions, real-time gain normalization prevents visible brightness inconsistencies or seams at stitch junctions. Aliasing is a Doppler/sampling-related artifact, unrelated. Range ambiguity relates to PRF/depth limitations, not gain normalization. Grating lobe artifact arises from element spacing exceeding a wavelength, unrelated to this stitching issue.

73. B. Splenic vein diameter can enlarge as portal venous pressure rises, so tracking this measurement serially provides a useful, non-invasive indicator of portal hypertension progression or treatment response. Appendicitis is an acute right-lower-quadrant process unrelated to splenic venous measurements. Thyroid nodule surveillance and testicular torsion follow-up are anatomically unrelated, clearly mismatched distractors.

74. B. An audible alert provides a redundant, different sensory channel so a critical measurement is less likely to be missed if the sonographer's eyes are elsewhere -- a human-factors safety redundancy. It supplements, rather than replaces, the visual system, as stated in the question itself. It does not itself page the physician; that requires a separate notification system. It has no effect on acoustic output settings.

75. C. Quantitative fat fraction measurement provides a numeric, reproducible value that can be tracked over time to monitor treatment response, addressing the subjectivity and operator-dependence inherent in qualitative echogenicity-based grading, while both approaches share the same underlying diagnostic purpose. It does not eliminate the role of biopsy in all cases, particularly for grading fibrosis or excluding other pathology. It does not require contrast agent administration; it is typically a non-contrast quantitative technique.

76. D. This type of flag serves as a prompt directing attention to specifically evaluate and document a possible nuchal cord finding, with clinical significance ultimately determined by the interpreting physician. It does not, by itself, confirm fetal distress or dictate delivery timing. It supplements rather than replaces grayscale confirmation. It is not restricted to the third trimester.

77. D. Delta-f = 2 x f0 x v x cos(theta)/c = (2 x 5,000,000 x 0.6 x 0.5)/1,540, approximately 1,948 Hz. Option A results from omitting the factor of 2. Option B results from using cos(theta)=1 instead of 0.5. Option C results from mistakenly substituting cos 45 degrees (about 0.707) for cos 60 degrees.

78. A. The Nyquist limit is exactly half the PRF, so a PRF of 6,000 Hz gives a Nyquist limit of 3,000 Hz; any true shift exceeding this will alias. Option B incorrectly equates Nyquist to the full PRF. Option C doubles the PRF instead of halving it. Option D is one-quarter of the PRF, an over-halving error.

79. D. RI = (PSV-EDV)/PSV = (80-20)/80 = 60/80 = 0.75. Option A mistakenly calculates EDV/PSV instead of the RI formula. Option B reflects an arithmetic slip. Option C similarly reflects a miscalculation.

80. A. PI = (PSV-EDV)/mean velocity = (90-10)/40 = 80/40 = 2.0. Option B would result from mistakenly dividing by 80 instead of 40. Option C reflects using EDV/mean instead of the correct PI numerator. Option D reflects an arithmetic error.

81. B. Volume flow = Area x TAV = 0.5 x 20 = 10 cm cubed/s (mL/s); converting to per minute: 10 x 60 = 600 mL/min. Option A is off by roughly two orders of magnitude. Option C reflects forgetting the per-second-to-per-minute conversion by a factor of 10. Option D doubles the correct answer.

82. D. The velocity ratio is stenotic PSV divided by pre-stenotic PSV: 320/40 = 8, an 8:1 ratio consistent with a high-grade stenosis by most velocity-ratio criteria. Options A, B, and C all reflect arithmetic under-calculation of the true ratio.

83. B. S/D ratio = systolic/diastolic = 45/15 = 3.0. Option A reflects an arithmetic underestimate. Option C reflects mistakenly using the systolic value divided by 10 rather than by the actual diastolic value. Option D is the inverse (D/S) rather than the requested S/D ratio, a common reversal error.

84. A. In laminar flow, red blood cells move at a narrow, similar range of velocities at any instant, producing a narrow spectral trace with a clear window beneath the peak; turbulence involves a wide range of simultaneous velocities that fills in this window. Option B describes the opposite of what a clear window indicates. Excessive wall filter would remove low-velocity signal near baseline, not create a systolic-peak window. Baseline aliasing is a distinct wraparound phenomenon.

85. C. The standard technique increases gain until noise just appears, then backs it off slightly, just enough for noise to disappear, optimizing true signal without under- or over-gaining. Continuing to increase gain would worsen noise contamination. Switching modes doesn't address the gain-optimization technique. Reducing to the lowest possible setting risks losing real, weak signal along with the noise.

86. C. Power Doppler displays the total amplitude of the Doppler signal rather than frequency shift, giving excellent sensitivity to weak/slow flow but no direction or velocity information. Spatial resolution is not the specific trade-off described. Frame rate is typically reduced, not increased, with power Doppler. Power Doppler is actually LESS susceptible to aliasing than conventional color Doppler, since it isn't encoding a frequency value that can wrap around.

87. B. The wall filter removes low-frequency, high-amplitude signals from moving vessel walls; if set too low, this clutter isn't adequately filtered and appears as baseline noise. Setting the wall filter too HIGH would instead risk removing true low-velocity flow signal, the opposite problem. PRF affects the velocity scale/aliasing threshold, not wall-motion clutter filtering. Color gain affects the color-flow image, not this spectral trace clutter.

88. B. Because the flow is purely unidirectional, shifting the baseline down reallocates the display's full vertical range to that one direction, increasing usable velocity range without needing reverse-flow display space. Wall filter addresses low-velocity clutter, not display cutoff. Power Doppler removes directional/velocity display entirely, not helpful for viewing a spectral peak. Sample volume size affects spatial/velocity specificity, not display scale allocation.

89. D. Regular waveform patterns are expected across normal cardiac cycles; irregular beat-to-beat variability reflects irregular cardiac cycle timing and filling, most consistent with an underlying arrhythmia. An inadequate Doppler angle would cause a consistent, systematic velocity underestimation across all beats, not beat-to-beat irregularity. Aliasing produces a specific wraparound artifact, not irregular waveform shape. Excessive wall filter would remove low-velocity signal uniformly, not create beat-to-beat variability.

90. A. Similar to the grayscale mirror-image artifact, a strong reflector can cause an indirect reflected path, duplicating the true flow signal as a mirrored spectral trace even though flow is actually unidirectional. True bidirectional flow would represent a real physiologic finding, not an artifact. Aliasing produces a specific wraparound pattern, a different mechanism. Spectral broadening from turbulence fills in the spectral window but does not create a symmetric mirrored duplicate.

91. C. Acceleration time as a percentage = (time to peak / cycle length) x 100 = (120/800) x 100 = 15%, and a prolonged percentage can suggest proximal arterial obstruction (tardus parvus). Option A underestimates by roughly a factor of 3. Option B underestimates by roughly 1.5. Option D overestimates, potentially from a division error using the wrong denominator.

92. B. The modified Bernoulli equation estimates pressure gradient as 4V squared: 4 x 4 squared = 4 x 16 = 64 mmHg. Option A reflects omitting the multiplying factor of 4. Option C reflects a halving error somewhere in the calculation. Option D reflects using 4V instead of 4V squared, a common formula-substitution error.

93. A. Radial artery occlusion is a recognized, relatively common complication of transradial catheterization access; because the hand has dual arterial supply via the palmar arches, adequate ulnar

collateral flow typically keeps the hand well-perfused despite radial occlusion, making it usually asymptomatic though still a documented complication. Acute hand ischemia would require radial occlusion WITHOUT adequate collateral flow. It should still be documented as an access-site complication, not dismissed as requiring no documentation. A pseudoaneurysm would show a focal outpouching with turbulent flow, not simply absent flow in the artery itself.

94. D. An interstitial ectopic implants within the interstitial portion of the tube, appearing eccentrically in the fundal myometrium with a thin surrounding mantle, a high-risk location given proximity to uterine vasculature. A normal eccentric intrauterine pregnancy would show a thicker, more symmetric myometrial mantle. A cervical ectopic implants low in the cervix, an anatomically distinct location. A cesarean scar ectopic implants specifically at a prior lower-segment scar, also anatomically distinct from the fundal interstitial location described.

95. C. A chorioangioma is a benign vascular tumor of placental origin, characteristically solid and hypervascular with a feeding vessel from the fetal circulation, distinguishing it from avascular findings. A placental infarct is typically avascular on Doppler, the opposite of the vascularity described. A subchorionic hematoma is a fluid collection, not a solid vascular mass. A simple placental cyst would be anechoic and avascular, not a vascular solid mass.

96. B. A Meckel's diverticulum is a congenital true diverticulum of the ileum that can become inflamed and classically present with painless rectal bleeding; increased Doppler vascularity supports active inflammation. Appendicitis is anatomically distinct and classically presents with pain, not painless bleeding. Crohn's terminal ileitis typically presents with pain/diarrhea and a different, contiguous bowel involvement pattern. Intussusception presents as a target/donut sign, a distinctly different appearance from a blind-ending diverticular structure.

97. D. Uterine artery notching normally resolves by the end of the second trimester as placental vascular resistance falls; persistence into the third trimester reflects ongoing high resistance and is associated with increased risk of pre-eclampsia and fetal growth restriction, not a normal or reassuring finding at this stage. It is not a technical artifact; it is a real physiologic waveform feature when present.

98. B. Diffuse, tiny, non-shadowing echogenic foci without an associated mass or abnormal vascularity is the classic appearance of testicular microlithiasis, an incidental finding generally considered to carry low independent malignancy risk when isolated, though surveillance recommendations vary. A malignancy would typically present as a discrete mass with abnormal vascularity, not diffuse tiny foci without a mass. Segmental infarction would show a wedge-shaped area of altered echogenicity with absent flow. The foci are described as within the testicular parenchyma itself, not the scrotal wall.

99. D. A vascular structure on the left connecting to the left renal vein, with the expected right-sided IVC absent, in the setting of normal patent Doppler flow, is most consistent with a congenital left-sided or duplicated IVC anatomic variant rather than a pathologic process, since normal flow is confirmed and no thrombus or collateral pattern is described. IVC thrombosis would show absent or abnormal flow with an echogenic thrombus. A retroaortic left renal vein describes the renal vein's course posterior to

the aorta, a related but distinct variant not matching an absent right-sided IVC. Portal hypertension collaterals would show a different pattern (e.g., a recanalized paraumbilical vein) rather than a variant IVC course.

100. C. A postoperative fluid collection large or positioned enough to extrinsically compress the adjacent renal vein can cause focal venous stenosis, producing elevated velocity and turbulence specifically at the point of compression. This scenario describes a NEW hemodynamic finding correlating with the collection's location, inconsistent with a designation of no hemodynamic significance. Acute rejection typically presents with elevated intrarenal ARTERIAL resistive indices, not focal venous compression. Transplant renal ARTERY stenosis would affect the artery, not specifically the vein at the point where it courses near the collection.

101. A. Marginal cord insertion describes the cord attaching at the placental edge while the vessels remain protected within Wharton's jelly, distinguishing it from the higher-risk velamentous insertion. Vasa previa specifically involves unprotected fetal vessels crossing near the cervical os, a distinct finding not described here. Placenta previa refers to the placenta covering or being near the cervical os, unrelated to where the cord inserts. Velamentous cord insertion specifically describes vessels traveling unprotected through the membranes, which is explicitly excluded by the stem's description of vessels remaining within Wharton's jelly.

102. D. Absent flow in a major dural venous sinus, combined with signs of raised intracranial pressure and compensatory collateral venous flow, is concerning for venous sinus thrombosis obstructing normal drainage. A normal variant would not explain the absent flow combined with these specific clinical symptoms. Arterial vasospasm affects arterial, not venous, flow. A middle cerebral artery aneurysm is an arterial abnormality, anatomically and physiologically distinct from the venous sinus finding described.

103. B. Rearranging the Doppler equation: v = (shift x c)/(2 x f0 x cos theta) = (1,000 x 1,540)/(2 x 5,000,000 x 0.707), approximately 0.218 m/s, or about 22 cm/s. Option A underestimates, plausible from a denominator error. Option C roughly doubles the correct answer, potentially from omitting the cosine correction entirely. Option D is roughly half the correct value.

104. A. RI = (PSV-EDV)/PSV = (15-6)/15 = 9/15 = 0.60, a value within the normal range for intratesticular arteries. Option B reflects an arithmetic underestimate. Option C overestimates, potentially from a subtraction/division error. Option D reflects a significant miscalculation.

105. C. Radius = diameter/2 = 0.4 cm; Area = pi x 0.4 squared, approximately 0.503 cm squared; Volume flow = Area x TAV = 0.503 x 15, approximately 7.54 mL/s; converting to per minute gives approximately 452 mL/min. Option A results from using the diameter directly as the radius in the area formula. Option B underestimates substantially, consistent with a units or formula-substitution error. Option D is far too low, consistent with a major calculation error such as forgetting to square the radius.

106. B. When the true jet velocity exceeds the Nyquist limit set by the current color scale, aliasing occurs regardless of true flow direction; increasing the color velocity scale raises the Nyquist limit to better accommodate the true high velocity. Color gain affects overall sensitivity/noise, not the velocity range causing aliasing. Wall filter addresses low-velocity clutter removal, unrelated to a high-velocity aliasing problem. Switching to a lower frequency would reduce the shift for a given velocity and could help somewhat, but the scale/PRF adjustment is the direct, standard first-line correction.

107. D. Confirming correct catheter placement within the small and technically challenging adrenal vein is critical to obtaining a valid sample for accurate lateralization of aldosterone secretion, and real-time Doppler flow assessment can support that positional confirmation. It is not used to measure gland volume, an unrelated grayscale task. It does not diagnose malignancy, an unrelated diagnostic question from the sampling procedure's actual purpose. Cortisol-level confirmation from the sample remains the definitive standard, and Doppler assessment supports but does not replace it.

108. B. Free flaps depend entirely on the patency of their microsurgical anastomoses, and early detection of thrombosis via Doppler monitoring allows prompt surgical re-exploration and salvage within a time-limited window. It is not used to assess cosmetic outcome, a separate, later consideration. Doppler monitoring supplements, rather than replaces, standard clinical flap assessment. Both arterial inflow AND venous outflow can and should be assessed with Doppler.

109. D. A niche (isthmocele) is a structural wedge-shaped myometrial defect at a prior cesarean scar site from incomplete healing, which can show mild peripheral vascularity but critically lacks any gestational sac, the key feature distinguishing it from a cesarean scar ectopic. A cesarean scar ectopic specifically requires a gestational sac implanted at the scar, explicitly absent here. Retained products of conception would typically show an echogenic intracavitary mass with more prominent vascularity in a recently pregnant patient. A uterine AVM would show a much more prominent, tangled, high-flow vascular pattern, not mild peripheral vascularity.

110. A. RI = (100-25)/100 = 0.75; PI = (100-25)/50 = 1.50; S/D = 100/25 = 4.0, all three calculated correctly and consistently from the same waveform data. Option B incorrectly calculates RI as EDV/PSV despite getting PI and S/D right. Option C correctly calculates RI and S/D but errs in the PI denominator. Option D correctly calculates RI and PI but inverts the S/D ratio, a common reversal error.