COMPREHENSIVE MOCK EXAM 13

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

Board-Review Questions

1. A sonographer identifies a finding during a routine exam that appears to represent an acute, potentially life-threatening condition. Appropriate practice regarding communication of this finding is:

A. Wait until the next day's scheduled reading session

B. Document only in the written report, no verbal communication

C. Promptly notify the physician directly, per critical-result protocol

D. Inform only the patient, with no physician communication at all

2. Following an ultrasound-guided percutaneous biopsy, appropriate post-procedure practice generally includes:

A. Discharging the patient immediately with no observation period whatsoever

B. Performing a second, unrelated ultrasound exam immediately, with no monitoring of the biopsy site

C. A period of post-procedure observation/monitoring for signs of a complication, such as bleeding, before discharge

D. Removing all documentation of the procedure once it is completed

3. A medical device sold within the European Union, including certain ultrasound equipment, must carry which regulatory conformity marking, distinct from FDA clearance in the United States?

A. An FDA 510(k) marking, applying internationally as well as domestically

B. No regulatory marking is required for devices sold in the EU

C. An ISO 9001 marking alone, with no other requirement

D. CE marking, indicating conformity with EU health and safety standards

4. Proper ergonomic setup of a sonographer's workstation, including monitor and exam table height adjustment relative to the sonographer's seated position, is primarily intended to:

A. Automatically increase the transducer's operating frequency

B. Improve the displayed image's overall dynamic range

C. Automatically shorten total exam time for every study

D. Reduce awkward postures contributing to musculoskeletal injury over a career

5. A sonographer develops a work-related repetitive strain injury from years of scanning. Appropriate practice regarding this injury generally includes:

A. Reporting the injury through the facility's occupational injury reporting process

B. Concealing the injury from the employer to avoid any workplace inquiry

C. Continuing to work through the injury with absolutely no modification of technique or workload

D. Assuming no reporting mechanism exists for this type of work-related injury

6. For certain higher-risk invasive procedures performed under ultrasound guidance, some facility protocols require a formal two-person verification step immediately before the procedure begins. This step is primarily intended to:

A. Determine the transducer's optimal frequency for the procedure

B. Independently confirm patient, site, and procedure between two staff members

C. Replace the need for any other safety check

D. Calculate the patient's estimated blood loss in advance

7. When connecting or disconnecting a transducer from the ultrasound system, care should be taken to avoid which specific equipment-handling risk?

A. Accidentally increasing the system's PRF setting

B. Bending connector pins, causing image dropout or transducer failure

C. Automatically triggering a full system software update

D. Permanently altering the transducer's acoustic lens material

8. Appropriate patient positioning and use of side rails or an attendant, where indicated, on the exam table primarily addresses which safety concern?

A. Reducing the risk of the patient falling from the exam table during the exam

B. Improving the acoustic coupling between the transducer and skin

C. Increasing the system's maximum available scanning depth

D. Automatically adjusting the display's dynamic range setting

9. Performing hand hygiene (handwashing or use of an alcohol-based hand sanitizer) between patients, separate from and in addition to transducer-specific disinfection, primarily addresses:

A. The transducer's own acoustic output power level

B. The system's total image storage capacity

C. The display's grayscale calibration setting

D. Reducing pathogen transmission between patients via the hands

10. Some facility protocols require a supervising physician's co-signature on a preliminary finding initially documented by the sonographer before the report is finalized. This requirement primarily serves to:

A. Automatically increase the transducer's frequency for future exams

B. Eliminate the physician's need to ever review the images

C. Provide physician oversight and accountability for final interpretation

D. Replace the sonographer's role entirely with physician judgment

11. Every saved diagnostic image or clip should include an embedded patient identifier, date/time stamp, and facility identifier primarily to:

A. Automatically improve the image's actual spatial resolution

B. Support medical-legal documentation and unambiguous image identification

C. Increase the transducer's output power for that image

D. Eliminate the need for any other part of the report

12. As an ultrasound pulse of sufficient amplitude propagates deeper into tissue, nonlinear distortion of the waveform (the physical basis of harmonic generation) characteristically:

A. Is present only at the transducer face itself and never develops with further propagation

B. Decreases steadily the farther the pulse travels from the transducer

C. Is identical at every depth, with no relationship to propagation distance at all

D. Accumulates progressively with propagation distance, since the distortion builds cumulatively as the wave travels

13. A transducer has a center frequency of 5 MHz and a bandwidth of 2.5 MHz. Using Q-factor = center frequency / bandwidth, what is this transducer's approximate Q-factor?

A. Approximately 0.5

B. Approximately 12.5

C. Approximately 2

D. Approximately 7.5

14. A pulse has a spatial pulse length (SPL) of 0.8 mm and a wavelength of 0.2 mm. Approximately how many cycles does this pulse contain?

A. Approximately 0.25 cycles

B. Approximately 1 cycle

C. Approximately 2 cycles

D. Approximately 4 cycles

15. Ultrasound is fundamentally different from visible light in that ultrasound is a form of:

A. Electromagnetic radiation, exactly like light

B. Ionizing radiation, exactly like an X-ray

C. Radio-frequency wave, exactly like an MRI signal

D. Mechanical wave, requiring a physical medium to propagate, unlike light

16. At an interface where the beam strikes at exactly normal (perpendicular, 0-degree) incidence, what happens with respect to refraction?

A. The beam refracts at the maximum possible angle

B. No refraction occurs, since there is no oblique angle to bend through

C. The beam refracts to exactly the critical angle by definition

D. Refraction always occurs regardless of the incidence angle

17. Considering an oblique interface where Medium 2 has a slower propagation speed than Medium 1, which general rule describes the resulting refraction?

A. The beam always refracts to exactly 90 degrees regardless of the speed difference

B. The beam bends away from the normal (perpendicular line), toward a larger angle

C. No refraction occurs whenever Medium 2 is slower than Medium 1

D. The beam bends toward the normal (perpendicular line), toward a smaller angle, since it is entering a slower medium

18. A beam strikes an interface at an angle smaller than the calculated critical angle for that specific pair of media. What occurs at this sub-critical angle?

A. Total reflection, with no transmission into the second medium

B. The beam is completely absorbed, with no reflection or transmission

C. Both partial reflection and transmission occur, below the critical angle

D. The critical angle threshold does not apply below itself

19. As the Doppler insonation angle approaches very small values (closer to 0 degrees, near-parallel to flow), what happens to the system's ability to discriminate between two closely spaced true velocities?

A. Discrimination between close velocities becomes impossible at any angle

B. Improves, since a small angle spreads shift values more distinctly

C. Has no relationship to insonation angle at all

D. Best at 90 degrees, the worst angle for detecting any signal

20. Full-width-half-maximum (FWHM) bandwidth, a specific method of characterizing a transducer's frequency bandwidth, is defined as:

A. The single center frequency value, with no range specified

B. The transducer's total physical element count

C. The transducer's Curie point temperature threshold

D. The frequency range width at the point amplitude falls to half of peak

21. The superposition principle, a general wave-physics concept underlying both constructive and destructive interference, states that:

A. Waves can never combine or interact with one another

B. Only identical-frequency waves are capable of any interaction

C. Superposition applies only to electromagnetic waves, never mechanical waves

D. Overlapping waves' displacement is the algebraic sum of each wave's displacement

22. Medium 1 has a propagation speed of 1400 m/s and Medium 2 has a propagation speed of 1600 m/s. A beam strikes the interface between them at a 55-degree angle of incidence. Is this angle above, at, or below the critical angle for this specific pair of media?

A. Above the critical angle, since 55 degrees exceeds it

B. Below it — critical angle ≈ 61 degrees, greater than the given 55

C. Exactly at the critical angle

D. This pair of media has no critical angle at all

23. Air has an extremely low acoustic impedance compared with soft tissue or a transducer face. When a significant air gap exists between the transducer and skin (inadequate coupling gel), the resulting reflection at that air interface is best characterized as:

A. A small, clinically insignificant fraction, similar to a soft-tissue interface

B. No reflection at all, since air does not reflect sound

C. Reflection depending entirely on frequency, not on impedance mismatch

D. Near-total reflection, given the enormous mismatch — why gel excludes air

24. The wavelength of sound within a piezoelectric crystal itself (used, for example, in determining appropriate crystal thickness during manufacturing) is calculated using which propagation speed value?

A. The propagation speed of sound in air, since that is the standard reference value used for all ultrasound calculations

B. The propagation speed of sound within the piezoelectric crystal material itself, which differs from the propagation speed in soft tissue

C. The propagation speed of sound in water exclusively, regardless of the crystal material

D. An arbitrary, fixed placeholder value with no actual physical basis

25. Comparing an attenuation coefficient expressed in dB/cm with one expressed in dB/cm/MHz, why does the frequency-dependent unit (dB/cm/MHz) matter for calculating total attenuation at a specific depth?

A. dB/cm/MHz must include frequency, since attenuation rises with frequency

B. The two units are always numerically identical regardless of frequency

C. Frequency has no actual effect on attenuation in real tissue

D. dB/cm/MHz applies only to Doppler mode, never B-mode

26. At a Doppler insonation angle of exactly 0 degrees (the beam running perfectly parallel to flow, cosine of 0 degrees = 1), the resulting Doppler shift for a given true velocity represents:

A. The smallest possible shift for that velocity, effectively zero

B. A shift depending on element count, not on angle

C. The largest possible shift, since cosine is at its maximum value

D. An undefined, incalculable value at exactly 0 degrees

27. A transducer's total operating bandwidth spans from 3 MHz to 9 MHz. What is this transducer's approximate fractional (percentage) bandwidth, using fractional bandwidth = (bandwidth / center frequency) x 100%, with center frequency approximated as the midpoint?

A. Approximately 10 percent bandwidth

B. Approximately 25 percent bandwidth

C. Approximately 50 percent bandwidth

D. Approximately 100 percent, a very broadband design

28. Synthetic aperture imaging, an advanced beamforming technique, achieves a large effective aperture by:

A. Physically manufacturing one single, very large continuous element

B. Sequentially firing element sub-groups and combining data to synthesize a larger aperture

C. Using no elements at all, relying entirely on mechanical motion

D. Doubling the transducer's operating frequency during acquisition

29. Plane-wave imaging, an ultrafast acquisition technique used in some advanced or research applications, transmits which type of wavefront to achieve very high frame rates?

A. A tightly focused, converging wavefront identical to standard focused imaging

B. A broad, unfocused, essentially flat (planar) wavefront that insonates the entire field of view with a single transmission

C. No wavefront at all, relying purely on receive-side processing with no transmission

D. A wavefront that changes frequency continuously throughout a single transmission

30. Certain dedicated, non-imaging CW Doppler probes (such as those used for fetal heart rate monitoring or transcranial Doppler) are manufactured with a fixed, built-in insonation angle. What is the practical implication of this fixed-angle design?

A. Relying on proper probe positioning against the fixed angle instead of a cursor

B. The fixed angle eliminates any need to consider Doppler angle

C. The probe can only be used at 90 degrees, the worst angle

D. The fixed angle lets the probe operate without an actual crystal

31. In advanced beamforming software, a 'virtual element' or 'virtual source' refers to:

A. A physical element that permanently failed and is excluded from processing

B. An element existing only in the blueprint, never actually installed

C. A synthesized source point computed from combined data of real elements

D. The exact physical center point of the housing, unrelated to any element

32. Transducer housing labeling requirements typically include which information printed or engraved directly on the probe itself?

A. The patient's name from the most recent exam performed with that probe

B. The referring physician's contact information

C. The transducer's model number and operating frequency range

D. The exact number of exams performed with that specific probe to date

33. Comparing electrical damping (using a resistive circuit) with mechanical damping (using backing material), both used to shorten a transducer's pulse, these represent:

A. Two distinct engineering approaches to the same general goal of shortening pulse duration/improving axial resolution, each with its own trade-offs

B. Exactly the same physical mechanism, simply described using two different terms

C. Mutually exclusive approaches, such that a transducer using electrical damping can never also use backing material

D. Approaches that have no actual effect on pulse duration or axial resolution whatsoever

34. Comparing a circular versus a rectangular crystal shape for a dedicated, non-imaging CW Doppler probe, a practical design consideration is:

A. Crystal shape can affect the beam's cross-sectional profile and coverage

B. Crystal shape has absolutely no effect on the transducer's function

C. Only a circular crystal shape can generate any ultrasound signal

D. Only a rectangular crystal shape can be used for Doppler

35. Compound plane-wave imaging, combining several angled unfocused plane-wave transmissions into one image, is used primarily to:

A. Eliminate the need for any receive-side beamforming

B. Guarantee an image with absolutely zero possible artifacts

C. Improve quality over a single transmission, retaining much of the frame-rate advantage

D. Convert the acquisition into a fully mechanical, motor-driven technique

36. Within a transducer's internal construction, the active piezoelectric element itself is distinguished from the passive support/frame structure primarily in that the active element:

A. Converts electrical energy to acoustic energy and back, unlike the support structure

B. Is identical in function to the passive support structure

C. Never requires any electrical connection of any kind

D. Is located outside the transducer housing, in a separate unit

37. Early mechanical, single-element ultrasound scanners, largely superseded by modern multi-element array transducers, formed a 2D image by:

A. Using dozens of simultaneously active elements, exactly as a modern array

B. Physically sweeping a single element to build the image scan line by line

C. Requiring no moving parts, using purely electronic beam steering

D. Displaying only a static, unchanging image, with no real-time capability

38. A dedicated thermal monitoring sensor or circuit built into a transducer, distinct from the general MI/TI patient-safety output limits, primarily functions to:

A. Automatically increase frequency whenever a temperature rise is detected

B. Monitor the transducer's own temperature, supporting an equipment-level safety response

C. Replace the need for any patient-focused Thermal Index calculation

D. Function only when the transducer is completely powered off

39. Comparing a 'general-purpose' abdominal transducer with a more specialized, narrow-application transducer, the general-purpose design typically involves which trade-off?

A. Always achieves better resolution than any specialized transducer

B. Are functionally and technically identical in every respect

C. A broader, less-optimized range, balancing performance across many applications

D. Cannot be used for any Doppler application whatsoever

40. Element pitch, a specific array-design term distinct from kerf, refers to:

A. The exact same measurement as kerf, under a different name

B. The transducer's total operating frequency range

C. Center-to-center element spacing, including the element's width plus the kerf gap

D. The transducer's total physical housing length

41. A sparse array design, using fewer active elements than a fully populated array of the same physical aperture size, primarily trades off which factors against each other?

A. Always produce identical image quality to a fully populated array

B. Cannot be manufactured using any known transducer technology

C. Eliminate the need for any beamforming processing

D. Reduce channel count/cost, at some image-quality cost versus a full array

42. In a duplex combination probe containing both an imaging array and a dedicated CW Doppler crystal pair, the CW crystals are typically positioned:

A. At a fixed offset from the array, angled to intersect a set depth

B. Randomly, with no consistent geometric relationship between probes

C. Exactly overlapping the imaging array's elements in the same location

D. On an entirely separate probe housing connected by a cable

43. Apodization, the technique of tapering drive amplitude across an aperture's elements, can use different specific 'window' shapes (such as a Hamming window versus a simple uniform window). Comparing a tapered window shape with a uniform (no tapering) window, the tapered approach primarily aims to:

A. Increase side lobe level as much as possible, which is always a desirable outcome

B. Reduce side lobe level, generally at some cost to main lobe width/resolution, compared with a uniform, non-tapered aperture

C. Have no effect on the beam profile whatsoever, regardless of which window shape is chosen

D. Function only during receive processing, never applicable during transmit

44. A transducer's very near field can be affected by a hardware-related 'dead zone,' caused specifically by which transducer characteristic?

A. The element's ring-down time before it can reliably receive echoes

B. The system's currently selected color box size setting

C. The patient's own body mass index value

D. The display's currently selected dynamic range setting

45. Comparing a fully populated 2D matrix array with a sparse 2D matrix array for real-time 3D/4D acquisition, a manufacturer might choose the sparse design specifically to manage which practical engineering challenge?

A. A complete inability to manufacture any 2D matrix array at all

B. The need to eliminate any electronic focusing capability

C. The very large channel count a full matrix array would require

D. An FDA requirement that all matrix arrays use a sparse design

46. A Doppler 'power threshold' or 'noise floor' control, distinct from gain, sets:

A. The transducer's own operating frequency setting

B. The system's maximum available scanning depth

C. An amplitude cutoff treating weak signal as noise, separate from gain

D. The color box's physical size on the display

47. An automatic image-freeze feature triggered by a specific point in the cardiac cycle (such as end-diastole, detected via a simultaneous ECG trace) is primarily useful for:

A. Randomly freezing at an unpredictable point in the cycle each time

B. Automatically diagnosing any abnormality, with no physician review needed

C. Increasing output power specifically at the triggered moment

D. Consistently capturing a still image at the same reproducible cycle point

48. A Doppler waveform auto-classification feature that also displays a numeric confidence score alongside its suggested classification is primarily useful because:

A. Eliminates any need for the sonographer to review the actual waveform

B. Conveys how certain the algorithm is, informing clinical judgment on its weight

C. Directly measures the patient's actual blood pressure

D. Is a fixed value that never varies between different waveforms

49. A cine-loop review interface's scroll-bar or timeline element, distinct from simple play/pause controls, allows the sonographer to:

A. Automatically diagnose any abnormality found within the loop

B. Change the transducer's frequency retroactively for an acquired loop

C. Directly navigate to a specific frame via the timeline, not only sequentially

D. Permanently delete all frames except the one displayed

50. A vertical image-flip control, distinct from a left-right (horizontal) flip control, adjusts the displayed image by:

A. Changing the transducer's operating frequency

B. Inverting the image top-to-bottom, leaving left-right orientation unchanged

C. Automatically adjusting the system's color Doppler scale

D. Permanently and irreversibly altering the actual acquired raw data

51. A spectral Doppler temporal-smoothing (averaging) filter, applied to the displayed velocity trace over several consecutive samples, is primarily used to:

A. Increase the transducer's acoustic output power

B. Automatically eliminate the Nyquist limit entirely

C. Reduce sample-to-sample jitter, smoothing the trace at some cost to fine detail

D. Convert the spectral display into a color display automatically

52. A spectral Doppler baseline auto-centering feature, distinct from manual baseline shift, functions by:

A. Permanently disabling any further manual baseline adjustment

B. Automatically increasing the system's PRF to its maximum value

C. Requiring manual calculation and keypad entry of the baseline position

D. Automatically repositioning the baseline to avoid clipping the waveform

53. An on-screen indicator simultaneously displaying the position of all currently active focal zones (when multiple zones are selected) is primarily useful for:

A. Helping the sonographer see which depths have focused beam coverage

B. Automatically increasing focal zone count with no sonographer input

C. Replacing the need for any TGC adjustment

D. Displaying the patient's current heart rate numerically

54. Automated risk-stratification software for a thyroid nodule, applying a structured scoring system based on grayscale features (such as composition, echogenicity, margin, and calcification pattern), primarily functions to:

A. Automatically perform a biopsy without any physician order

B. Replace the need for grayscale image acquisition

C. Apply structured risk criteria to help stratify a nodule's relative risk

D. Directly measure the nodule's internal temperature

55. An elastography display's accompanying quality-indicator overlay, showing whether a given measurement met acceptable technical criteria, primarily helps the operator to:

A. Automatically increase the transducer's acoustic output power

B. Flag when a measurement may be technically unreliable and should be repeated

C. Replace the need for grayscale correlation of findings

D. Determine the patient's exact age from the image alone

56. Automated ovarian volume calculation software, using the standard ellipsoid formula applied to measured ovarian dimensions, functions by:

A. Requiring the sonographer to perform the calculation entirely by hand

B. Measuring only blood flow, with no volume component at all

C. Providing no numeric output, only a vague qualitative impression

D. Applying the ellipsoid formula to measured dimensions to estimate volume

57. A spectral Doppler trace-thickness display adjustment, distinct from sweep speed or baseline position, primarily affects:

A. The transducer's actual operating frequency

B. The visual thickness of the displayed trace, a cosmetic preference only

C. The system's maximum available scanning depth

D. The color Doppler box's physical size on the display

58. A digital measurement standard such as DICOM Structured Reporting (SR), used to encode sonographic measurements in a standardized, structured digital format, primarily supports:

A. Physically performing the scan on behalf of the sonographer

B. Eliminating the physician's need to ever interpret the measurements

C. Structured, machine-readable transfer of values between systems, unlike free text

D. Automatically changing frequency for each specific measurement type

59. Adjusting multiplanar reformatting (MPR) slice thickness, increasing it from a very thin single-voxel slice to a thicker slab, primarily affects the resulting reformatted image by:

A. Automatically increasing frequency for the original acquisition

B. Having no visible effect on the reformatted image's appearance

C. Eliminating the need for the original 3D volume acquisition

D. Averaging data across the slab, at some cost to fine detail

60. Automated common bile duct (CBD) diameter measurement software, applied to a grayscale image of the duct in cross-section or longitudinal view, functions by:

A. Automatically detecting the duct's near and far wall borders and calculating the diameter between the detected borders

B. Measuring only the gallbladder, never the common bile duct itself despite the name

C. Requiring administration of a contrast agent for every single measurement

D. Providing no numeric measurement output of any kind, only a categorical normal/abnormal flag

61. By long-standing display convention in a standard transverse abdominal scan plane, the patient's right side is displayed on which side of the screen?

A. The left side of the screen, following the same convention used for axial CT and MRI cross-sectional images

B. The right side of the screen, opposite the CT/MRI convention

C. Display side is entirely arbitrary and follows no consistent convention at all

D. Display side depends exclusively on the specific transducer frequency being used

62. Automated fetal heart rate calculation, derived from either an M-mode trace or a Doppler waveform of the fetal heart, functions by:

A. Requiring manual stopwatch counting, with no software assistance

B. Measuring the interval between cycle events and converting it to bpm

C. Measuring only the maternal heart rate, despite the name

D. Providing no numeric value, only a vague fast/slow categorization

63. Selecting a different color Doppler palette (the specific color scheme used to encode velocity/direction, beyond the basic BART red/blue convention) primarily allows the operator to:

A. Automatically increase the transducer's transmitted power

B. Eliminate the underlying Doppler shift calculation

C. Change the actual measured velocity values on the spectral trace

D. Choose a gradient some find shows subtle variation more clearly

64. A grayscale image-invert display toggle, distinct from color Doppler directional inversion, primarily changes:

A. The transducer's actual acoustic output power

B. The system's maximum available imaging depth

C. The color Doppler directional convention specifically

D. Which end of the grayscale spectrum corresponds to strongest echo amplitude

65. An adaptive PRF auto-scaling feature, which automatically adjusts Doppler PRF/scale based on the detected range of velocities present in the sample volume, is primarily intended to:

A. Reduce manual adjustment need by selecting a scale for the detected range

B. Permanently disable any further manual scale adjustment

C. Automatically convert the acquisition into continuous-wave Doppler

D. Have no actual effect on the displayed spectral waveform

66. A whole-image automatic gain compensation feature, distinct from depth-specific TGC, is intended to:

A. Apply a single uniform gain across the image, unlike depth-specific TGC

B. Function identically to TGC, with no meaningful distinction

C. Automatically change frequency based on detected brightness

D. Eliminate the underlying physical need for depth compensation

67. A structured, checklist-style Doppler protocol worksheet, distinct from a general exam-type measurement package, is primarily useful for:

A. Physically performing the acquisition on behalf of the sonographer

B. Automatically diagnosing any abnormal finding without physician review

C. Ensuring all protocol-required vessels are systematically obtained and documented

D. Eliminating the need for any spectral Doppler acquisition

68. An adaptive wall filter algorithm, which automatically adjusts wall filter cutoff based on detected clutter characteristics rather than a single fixed manual setting, is primarily intended to:

A. Permanently eliminate the wall filter control from the system

B. Automatically increase the transducer's transmitted power

C. Have no actual effect on the displayed Doppler signal

D. Dynamically balance clutter removal against preserving genuine slow flow

69. Automated liver span measurement software, applied to a longitudinal grayscale image of the liver, functions by:

A. Requiring the sonographer to manually calculate the span using a formula with no border-detection assistance

B. Automatically detecting the superior and inferior liver margins in the selected view and calculating the craniocaudal span between them

C. Measuring only the spleen, never the liver itself despite the name

D. Providing no numeric measurement output, only a categorical normal/enlarged flag

70. A spectral Doppler sweep-speed auto-adjustment feature, which automatically selects sweep speed based on the patient's detected heart rate, is primarily intended to:

A. Automatically increase transmitted power based on heart rate

B. Show a consistent number of cardiac cycles regardless of heart rate

C. Eliminate the underlying need for spectral Doppler acquisition

D. Convert the spectral display into a color display automatically

71. A B-mode image rotation control, distinct from a flip control, adjusts the displayed image by:

A. Mirroring left-to-right only, with top-to-bottom fixed

B. Mirroring top-to-bottom only, with left-right fixed

C. Automatically adjusting the color Doppler scale to match orientation

D. Rotating the whole image around a central point, without mirroring

72. When positioning and sizing the region-of-interest box for an elastography measurement, general guidance typically recommends:

A. Always using the absolute smallest possible box regardless of target size

B. Always using the absolute largest possible box regardless of target size

C. Box size and position have no bearing on measurement reliability

D. Positioning the box in a representative area, avoiding confounding structures

73. Automated endometrial thickness measurement software, applied to a sagittal grayscale image of the uterus, functions by:

A. Requiring the entire measurement to be performed manually

B. Measuring only the ovaries, despite the name

C. Automatically detecting the interfaces and calculating thickness between them

D. Providing no numeric output, only a categorical thin/thick flag

74. A dual-image display allowing each panel to be independently frozen (one panel live, the other frozen on a prior frame) is primarily useful for:

A. Automatically diagnosing any asymmetry between the two panels

B. Comparing a live image against a frozen reference frame simultaneously

C. Eliminating the need to ever unfreeze either panel again

D. Increasing output power in the live panel only

75. Automated ejection fraction calculation methods that rely on tracing the endocardial border in two orthogonal apical views (biplane method) generally provide which advantage over a single-plane calculation?

A. A more accurate estimate by accounting for geometry in two planes

B. An automatic elimination of the need for endocardial tracing

C. A measurement requiring no image acquisition at all

D. A result always numerically identical to a single-plane calculation

76. A sonographer notices that a needle-guide overlay's projected path line appears to increasingly diverge from the needle's actual visualized path as a long procedure progresses. The most appropriate immediate action is:

A. Ignore the discrepancy and continue relying on the overlay line

B. Recognize possible calibration drift and rely on direct needle visualization instead

C. Immediately increase the system's overall gain to maximum

D. Assume the anatomy physically changed and proceed without caution

77. A vessel has a true flow velocity of 60 cm/s, insonated at a 50-degree angle (cos 50 degrees ≈ 0.643) by a 7.5 MHz transducer, propagation speed 1540 m/s. Approximately what Doppler shift frequency results?

A. Approximately 2900 Hz

B. Approximately 3760 Hz

C. Approximately 7520 Hz

D. Approximately 1880 Hz

78. A system has a PRF of 7000 Hz, insonating at a 40-degree angle (cos 40 degrees ≈ 0.766) with a 4 MHz transducer, propagation speed 1540 m/s. Approximately what is the maximum velocity measurable before aliasing?

A. Approximately 88 cm/s

B. Approximately 176 cm/s

C. Approximately 440 cm/s

D. Approximately 22 cm/s

79. Tricuspid regurgitation jet peak velocity, measured with Doppler, is used in a simplified Bernoulli-based calculation to estimate:

A. The patient's left ventricular ejection fraction

B. The patient's exact cardiac output in liters per minute

C. RV systolic pressure via 4x(TR jet velocity)^2 plus estimated RA pressure

D. The patient's heart rate directly from the jet velocity alone

80. A normal ureteral jet, visualized on color or grayscale Doppler as a periodic burst of urine entering the bladder from the ureteral orifice, is used clinically to help assess for:

A. The patient's own systemic blood pressure

B. The gallbladder's own wall thickness value

C. The patient's own blood type category

D. Functional patency, since an absent jet supports obstruction

81. Axillary-subclavian vein thrombosis occurring in an otherwise healthy, often young and athletic patient after strenuous, repetitive upper-extremity activity (sometimes called Paget-Schroetter syndrome or effort thrombosis) is characteristically evaluated with Doppler to identify:

A. A finding restricted exclusively to elderly, sedentary patients, never occurring in young athletic individuals

B. A finding limited to the lower extremity, never involving the upper extremity despite the name

C. Isolated arterial, not venous, thrombosis, despite the clinical description given

D. Thrombosis of the axillary-subclavian vein, often with associated findings of thoracic outlet compression contributing to the venous injury

82. A carotid web, an uncommon but recognized cause of embolic stroke particularly in younger patients, refers to:

A. A thin fibrous shelf in the carotid bulb, a nidus for thrombus

B. A normal structure present in every patient's carotid artery

C. A finding restricted to the vertebral artery, not the carotid

D. A vein, not an artery, despite the name

83. Comparing the grayscale and Doppler appearance of an acute deep vein thrombosis with that of a chronic, longstanding one, a recognized distinguishing pattern is:

A. Acute and chronic thrombus always appear entirely identical

B. Chronic thrombus is always non-compressible and echo-free, like acute

C. Acute is hypoechoic/dilated; chronic is echogenic/recanalized with collaterals

D. Only acute thrombus is assessable with Doppler; chronic shows nothing

84. A single umbilical artery (SUA), an anatomic variant identified on grayscale and color Doppler evaluation of the umbilical cord, refers to:

A. Complete absence of the umbilical vein, with only one artery present

B. A normal finding present in every single pregnancy

C. Only one umbilical artery present, a variant with increased anomaly risk

D. A finding identifiable only after delivery, never prenatally

85. Twin-to-twin transfusion syndrome, a complication of monochorionic twin pregnancies involving unbalanced blood flow through shared placental vascular connections, is evaluated in part with Doppler assessment of:

A. Umbilical artery, ductus venosus, and MCA waveforms in each twin

B. Only the maternal uterine artery, with no assessment of either twin

C. A finding restricted to dichorionic, non-shared-placenta twin pregnancies

D. A condition producing no detectable Doppler abnormality in either twin

86. A splenic artery aneurysm, distinct from splenic artery stenosis, is characterized on Doppler by which finding?

A. A focal narrowing with locally elevated velocity, identical in every respect to stenosis

B. Complete absence of any detectable flow signal anywhere within the splenic artery

C. A focal, saccular dilation of the artery, sometimes containing turbulent or swirling flow, with an intact but abnormally widened lumen

D. A finding that occurs only in the splenic vein, never in the splenic artery despite the name

87. A hepatic artery aneurysm, an uncommon but recognized vascular finding sometimes identified incidentally or in the setting of trauma or prior intervention, is characterized on Doppler by which finding, distinct from hepatic artery stenosis?

A. A focal narrowing with elevated velocity, identical to stenosis

B. Complete absence of any detectable flow in the hepatic artery

C. A focal dilation, sometimes turbulent, distinguishing it from a narrowed segment

D. A finding occurring only in the hepatic vein, not the artery

88. A lymphatic malformation, a congenital vascular-adjacent anomaly composed of abnormal lymphatic channels, is characteristically distinguished from a venous malformation on Doppler by which finding?

A. Always shows the same robust flow signal as a venous malformation

B. Shows little to no detectable flow, given its fluid-filled composition

C. Can only ever be assessed using MRI, never Doppler ultrasound

D. Is restricted exclusively to adult patients, never occurring in a child

89. Placenta accreta spectrum, a condition of abnormal placental attachment/invasion into the uterine wall, is evaluated in part with color Doppler to identify:

A. A completely normal-appearing, uniform placental-myometrial interface in every affected case, ruling out the diagnosis definitively

B. A finding restricted exclusively to the placenta's fetal surface, never involving the maternal myometrial interface

C. A finding that can only ever be assessed using MRI, with Doppler ultrasound contributing no useful information at all

D. Abnormal, often turbulent or 'lacunar' vascularity at the placental-myometrial interface, sometimes with bridging vessels crossing into the myometrium or bladder wall, supporting the diagnosis

90. Chronic venous insufficiency, evaluated in part with Doppler reflux testing, is often clinically staged (such as with the CEAP classification system) based on:

A. Clinical findings alongside the Doppler-confirmed distribution/severity of reflux

B. The patient's blood type exclusively, with no relationship to findings

C. A single, isolated Doppler velocity number with no other information

D. A finding assessable only using venography, never Doppler ultrasound

91. Phlegmasia cerulea dolens, a severe and limb-threatening complication of extensive deep venous thrombosis, is characterized on Doppler by which finding?

A. A completely normal venous and arterial Doppler exam

B. Isolated superficial thrombosis only, with the deep system entirely spared

C. A finding restricted to the upper extremity, never the lower

D. Extensive deep occlusion, sometimes with secondary arterial compromise from congestion

92. Characterizing the internal flow pattern within an arteriovenous malformation's central nidus, distinct from simply describing the overall feeding artery and draining vein waveforms, primarily helps to:

A. Determine the patient's blood type from the nidus pattern alone

B. Automatically eliminate the need for further imaging or planning

C. Replace the need to assess the feeding artery or draining vein

D. Characterize the malformation's complexity, relevant to treatment planning

93. Comparing Doppler vascularity patterns in an adrenal adenoma with those in a pheochromocytoma, a general (though not absolute) pattern sometimes described is:

A. Adenoma sparse, pheochromocytoma more vascular, though imaging alone is unreliable

B. The two entities always show completely identical Doppler patterns

C. Only a pheochromocytoma can be assessed with Doppler at all

D. An adenoma always shows more vascularity than any pheochromocytoma

94. Following pancreas transplantation, Doppler surveillance for venous thrombosis of the graft's venous outflow is important because:

A. A recognized, graft-threatening complication detectable by abnormal venous flow

B. Venous thrombosis of a pancreas graft has never been described

C. Only arterial inflow is ever clinically relevant to graft viability

D. Doppler provides no useful information on pancreas transplant venous patency

95. A hepatic hemangioma, the most common benign liver lesion, typically demonstrates which Doppler characteristic, distinct from a more aggressively vascular malignant liver lesion?

A. Extremely high-velocity, chaotic flow throughout the entire lesion

B. Minimal to absent flow on Doppler, despite its vascular composition

C. Complete, uniform replacement of normal surrounding hepatic flow

D. A finding assessable only using nuclear medicine, never Doppler ultrasound

96. Right ventricular outflow tract (RVOT)-based Doppler cardiac output calculation, an alternative to the standard LVOT-based method, uses which measurement site?

A. The mitral valve inflow, identical to the LVOT method

B. The aortic valve, identical to the standard LVOT method

C. The pulmonary valve/RVOT, using its own area and velocity-time integral

D. The inferior vena cava exclusively, unrelated to either outflow tract

97. Following placement of an inferior vena cava (IVC) filter, Doppler surveillance for filter-related complications may assess for:

A. Filter-associated IVC thrombosis or reduced flow, a possible device complication

B. Only the filter's physical position by X-ray, Doppler adds nothing

C. The patient's blood type, directly determined by the filter's presence

D. A finding never described in association with any IVC filter

98. A vessel has a measured diameter of 0.8 cm and a time-averaged mean velocity of 25 cm/s. Using volume flow rate = cross-sectional area x mean velocity, approximately what is the volume flow rate?

A. Approximately 6.3 mL/s

B. Approximately 12.6 mL/s

C. Approximately 25 mL/s

D. Approximately 50 mL/s

99. A stenotic segment shows a peak systolic velocity of 320 cm/s, while the proximal, non-stenotic segment of the same vessel shows a peak systolic velocity of 80 cm/s. What is the velocity ratio between these two segments?

A. 2:1

B. 4:1

C. 8:1

D. 1:4

100. A renal artery Doppler waveform shows a peak systolic velocity of 60 cm/s and an end-diastolic velocity of 20 cm/s. Using resistive index (RI) = (PSV - EDV) / PSV, what is the calculated RI?

A. Approximately 0.67

B. Approximately 0.33

C. Approximately 3.0

D. Approximately 1.33

101. Pulsatility index (PI), a Doppler-derived resistance index distinct from resistive index (RI), is calculated using which formula?

A. PI uses mean velocity in its denominator, unlike RI's peak-systolic value

B. PSV divided by EDV directly, with no subtraction step

C. PI is calculated using exactly the same formula as RI

D. PI has no established formula, purely a subjective impression

102. A vessel shows a peak systolic velocity of 90 cm/s and an end-diastolic velocity of 30 cm/s. What is the systolic/diastolic (S/D) ratio for this waveform?

A. 1:3

B. 0.33:1

C. 9:1

D. 3:1

103. Serial umbilical artery pulsatility index (PI) trending above the expected normal range for gestational age, in the context of suspected fetal growth restriction, is used clinically to:

A. Help monitor placental resistance over time, supporting closer surveillance

B. Provide no useful clinical information regarding placental status

C. Directly diagnose a fetal chromosomal abnormality from the PI value

D. Replace the need for any other growth-restriction surveillance component

104. A post-traumatic arteriovenous fistula, resulting from penetrating or blunt vascular trauma creating an abnormal direct connection between an adjacent artery and vein, characteristically shows which Doppler finding at the fistula site?

A. High-velocity turbulent flow with arterialized flow in the adjacent vein

B. A normal-appearing arterial and venous waveform at the injury site

C. Complete absence of any detectable flow at the trauma site

D. A finding restricted exclusively to iatrogenic post-biopsy fistulas

105. Comparing the NASCET and ECST methodologies for measuring and grading carotid artery stenosis severity on angiography, a key methodological difference is:

A. The two methods always produce numerically identical stenosis values

B. Only NASCET has ever been used clinically, never ECST

C. Neither method relates to Doppler-based stenosis criteria in ultrasound

D. NASCET uses distal ICA diameter; ECST uses estimated bulb diameter

106. In the supine position during later pregnancy, compression of the inferior vena cava by the gravid uterus can reduce venous return, sometimes correlating with a detectable change in fetal or uteroplacental Doppler parameters. This physiologic effect is one reason for:

A. Never performing any obstetric ultrasound exam under any circumstance

B. Automatically diagnosing fetal distress from positional changes alone

C. Positioning the patient laterally to reduce caval compression during the exam

D. Eliminating the need for any Doppler component of the exam

107. A congenital arteriovenous fistula, present from birth rather than resulting from trauma or a medical procedure, characteristically differs from an acquired (traumatic or iatrogenic) AV fistula primarily in:

A. Flow characteristics entirely different in every respect from an acquired fistula

B. Occurring exclusively in patients over 80, never in a child

C. Its developmental origin from birth, though findings can look similar to an acquired one

D. A complete absence of any detectable Doppler abnormality

108. Contrast-enhanced Doppler signal augmentation, applied to a very deep or technically difficult vessel, can be further supported by combining it with tissue harmonic Doppler processing. What is the rationale for combining these two techniques together?

A. Combining any two Doppler techniques together is never permitted

B. Harmonic processing suppresses artifact while contrast boosts signal, improving SNR together

C. The two techniques are functionally identical, providing no added benefit

D. Harmonic processing eliminates the need for any contrast agent

109. A complex multi-vessel evaluation requires distinguishing a very slow, near-occlusive residual arterial flow signal from complete occlusion, characterizing a co-existing high-velocity stenotic jet in an adjacent segment, and precisely localizing signal between two closely adjacent vessels. Which combined approach addresses all of these needs together?

A. Grayscale imaging alone is sufficient for all three needs

B. Power Doppler alone is sufficient for all three needs

C. Color Doppler alone is sufficient for all three needs

D. Low-filter PW for slow flow; CW for the jet; PW-gating for localization

110. A comprehensive trauma-focused vascular ultrasound protocol must integrate grayscale, color Doppler, power Doppler, and spectral (PW/CW) Doppler as needed for a given injury pattern. What principle should guide selecting which combination of these techniques to use for a specific patient?

A. Always use every technique simultaneously for every patient regardless of injury

B. Select based solely on scan time, regardless of diagnostic adequacy

C. Match the technique combination to the specific clinical question and injury pattern

D. Select based solely on which technique was most recently added

Answers

1. C. C. When a finding appears acute and potentially life-threatening, appropriate practice is prompt, direct notification of the interpreting physician or ordering provider, following the facility's defined critical-result communication protocol, rather than allowing the finding to sit in a routine report queue — timely communication of urgent findings is a recognized patient-safety practice distinct from routine result reporting. Waiting until the next scheduled reading session (A) risks a dangerous delay in a time-sensitive situation. Documenting only in the written report with no direct verbal communication (B) does not meet the urgency the situation calls for. Informing only the patient directly, without physician communication, is not appropriate, since interpretation and clinical decision-making responsibility rests with the physician, not the sonographer (contradicting D).

2. C. C. Appropriate post-procedure practice after an invasive biopsy includes a defined period of observation and monitoring for early signs of a potential complication, such as bleeding, hematoma formation, or a vasovagal response, before the patient is discharged, allowing timely recognition and management if a complication develops. Discharging the patient immediately with no observation period at all (A) would not allow adequate time to identify an early complication. Proceeding immediately to an unrelated exam with no monitoring of the biopsy site specifically (B) does not fulfill the post-procedure safety monitoring role. Procedure documentation should be retained as part of the medical record, not removed once the procedure is completed, contradicting D.

3. D. D. Medical devices, including certain ultrasound equipment, sold within the European Union must carry CE marking, indicating the manufacturer's declaration that the device conforms to applicable EU health, safety, and environmental protection requirements — a distinct regulatory framework from the FDA clearance process used in the United States. FDA 510(k) clearance (A) is specifically a US regulatory pathway and does not itself satisfy EU marketing requirements. A regulatory marking requirement does, in fact, apply to medical devices sold in the EU, contradicting the claim of no requirement at all in B. ISO 9001 (C) is a general quality-management-system certification standard, not itself the specific product conformity marking required for EU medical device sales.

4. D. D. Proper ergonomic workstation setup, including appropriately adjusting monitor height, exam table height, and seating position relative to the sonographer's own body, is intended to reduce awkward, sustained, or repetitive postures that contribute to musculoskeletal injury (such as shoulder, neck, or back strain) accumulated over a sonographer's scanning career — a distinct occupational-health consideration from broader general ergonomics awareness alone. This adjustment has no effect on the transducer's operating frequency, a separate hardware parameter (contradicting A); it does not change the displayed image's dynamic range, a separate processing setting (contradicting B); and while a comfortable setup may support efficient work, it does not mechanically or automatically shorten total exam time for every study, contradicting C.

5. A. A. A work-related repetitive strain injury should be reported through the facility's occupational/workplace injury reporting process, which supports appropriate medical evaluation, potential workers' compensation coverage, and workplace accommodations or ergonomic modifications that may help prevent further injury — a recognized occupational-health practice for sonographers, a profession with a well-documented cumulative trauma disorder risk. Concealing the injury from the employer (B) forgoes access to appropriate support and documentation. Continuing to work with absolutely no modification of technique or workload (C) risks worsening the injury rather than supporting recovery. A reporting mechanism for work-related injury does, in fact, generally exist in a healthcare workplace, contradicting the assumption of no mechanism at all in D.

6. B. B. A formal two-person verification step (sometimes part of a broader procedural time-out) has two staff members independently confirm critical details — correct patient identity, correct procedure site, and correct planned procedure — immediately before an invasive procedure begins, adding a redundant safety check beyond a single individual's confirmation alone, reducing the risk of a wrong-site or wrong-patient error. This verification step has no role in determining transducer frequency, an unrelated technical imaging parameter (contradicting A); it does not replace the need for other patient safety checks entirely, functioning instead as one component within a broader safety protocol (contradicting C); and it does not calculate estimated blood loss, an unrelated clinical parameter not determined by this specific verification step (contradicting D).

7. B. B. The connector interface between a transducer and the ultrasound system contains numerous delicate pins that carry the individual element signals; careless or forceful connection/disconnection can bend or damage these pins, which can cause partial image dropout (affecting only certain elements) or complete transducer failure, making careful, deliberate handling during connection and disconnection an important equipment-care practice. This handling action does not affect the system's PRF setting, an unrelated software/timing parameter (contradicting A); it does not trigger a system software update, an unrelated software-management process (contradicting C); and it does not alter the acoustic lens material at the transducer face, a separate structure from the connector interface (contradicting D).

8. A. A. Appropriate patient positioning, along with side rails or an attendant when clinically indicated (such as for a sedated, very young, elderly, or otherwise at-risk patient), primarily addresses the risk of the patient falling from the exam table during the exam — a basic physical patient-safety consideration distinct from the acoustic/technical aspects of the exam itself. This has no direct relationship to acoustic coupling between transducer and skin, which is instead addressed by coupling gel (contradicting B); it does not affect the system's maximum scanning depth, an unrelated technical imaging parameter (contradicting C); and it has no relationship to the display's dynamic range setting, a separate image-processing parameter (contradicting D).

9. D. D. Hand hygiene performed between patients — separate from, and in addition to, transducer-specific cleaning and disinfection — specifically addresses the risk that a sonographer's own hands could transmit pathogens from one patient to the next through direct contact, a basic and foundational infection-control practice distinct from equipment-focused disinfection protocols. This practice has no effect on the transducer's acoustic output power, a separate hardware/output parameter (contradicting A); it does not affect the system's image storage capacity, an unrelated data-management parameter (contradicting B); and it has no relationship to the display's grayscale calibration, a separate display-quality parameter (contradicting C).

10. C. C. A required physician co-signature on a sonographer's preliminary finding provides a layer of physician oversight and accountability for the final clinical interpretation, reflecting the fact that final diagnostic interpretation is a physician responsibility even though the sonographer performs the technical exam and may note preliminary observations. This requirement has no effect on transducer operating frequency, an unrelated technical imaging parameter (contradicting A); it does not eliminate the physician's need to independently review the actual images before co-signing, since a meaningful co-signature implies genuine review, not a rubber stamp (contradicting B); and it does not replace the sonographer's essential technical role in performing the exam, which remains a distinct and necessary function alongside physician interpretation (contradicting D).

11. B. B. Embedding a patient identifier, date/time stamp, and facility identifier directly on every saved image or clip supports accurate medical-legal documentation, ensuring the image can be unambiguously matched to the correct patient, exam date and time, and originating facility — an important safeguard against image mix-up or misattribution, particularly when images may later be reviewed separately from the full report or transferred between systems. This embedded information has no effect on the image's actual spatial resolution, a separate acquisition-quality parameter (contradicting A); it does not affect acoustic output power for that image, an unrelated acquisition setting (contradicting C); and embedded image labeling supplements, rather than replaces, the need for other components of a complete exam report, such as measurements and interpretive findings (contradicting D).

12. D. D. Nonlinear distortion of the waveform accumulates progressively as the pulse propagates through tissue, since the physical mechanism (faster-moving compression peaks gradually catching up to slower-moving rarefaction troughs) builds cumulatively with propagation distance, meaning harmonic content is generally weak near the transducer face and becomes more pronounced at depth before eventually being reduced again by attenuation. This contradicts a claim that distortion exists only at the transducer face and never develops further (A); it does not decrease with propagation distance, the opposite of the actual cumulative buildup (contradicting B); and it is not identical at every depth with no relationship to distance, since the entire physical basis of harmonic generation depends specifically on propagation distance (contradicting C).

13. C. C. Q-factor = center frequency ÷ bandwidth = 5 MHz ÷ 2.5 MHz = 2, a relatively low Q-factor consistent with a broadband transducer design (a lower Q-factor indicates wider relative bandwidth, while a higher Q-factor indicates a narrower, more resonant, narrowband design). Option A (0.5) inverts the correct division (bandwidth ÷ frequency rather than frequency ÷ bandwidth). Option B (12.5) results from multiplying rather than dividing the two values. Option D (7.5) results from adding rather than dividing the two given values, none of which reflect the correct Q-factor formula application.

14. D. D. Number of cycles = SPL ÷ wavelength = 0.8 mm ÷ 0.2 mm = 4 cycles, using the standard relationship SPL = (number of cycles) × wavelength rearranged to solve for cycle count. Option A (0.25) inverts the correct division (wavelength ÷ SPL rather than SPL ÷ wavelength). Option B (1 cycle) and Option C (2 cycles) are both smaller than the correctly calculated value and are not consistent with the given SPL-to-wavelength ratio.

15. D. D. Ultrasound is fundamentally a mechanical (acoustic) wave, requiring a physical medium (such as tissue) through which particles oscillate and transmit energy from one location to the next — a form of wave propagation entirely different from electromagnetic radiation such as visible light, which can travel through a vacuum with no medium required at all. This directly contradicts a claim that ultrasound is electromagnetic radiation exactly like light (A); ultrasound at diagnostic output levels is specifically classified as non-ionizing, unlike an X-ray, which is a form of ionizing electromagnetic radiation (contradicting B); and ultrasound is a mechanical wave, not a radio-frequency electromagnetic wave like an MRI system's RF signal, despite both being used in medical imaging (contradicting C).

16. B. B. At normal (perpendicular, 0-degree) incidence, there is no oblique angle for the beam's path to bend through, so no refraction occurs even if the two media have different propagation speeds — the beam continues straight through the interface, with only reflection (if any impedance mismatch exists) and transmission occurring, both along the same straight-line path. This directly contradicts a claim of maximum refraction at normal incidence (A), which instead would occur at some oblique angle approaching the critical angle in an appropriate speed-mismatch scenario; the critical angle is a specific angle related to total reflection, not something that automatically applies to normal incidence by definition (contradicting C); and refraction specifically requires an oblique, not perpendicular, angle of incidence with a speed mismatch, so it does not occur regardless of angle, contradicting D.

17. D. D. As a general rule, when a beam travels obliquely into a medium with a slower propagation speed, it bends toward the normal (the perpendicular reference line), resulting in a smaller refraction angle than the original angle of incidence — conceptually similar to the general optical principle that a wave bends toward the normal when entering a 'denser' (here, slower) medium. This is the opposite of bending away from the normal toward a larger angle, which instead describes the case of entering a faster, not slower, medium (contradicting B); refraction very much still occurs (given an oblique angle and a genuine speed difference) when entering a slower medium, not an absence of refraction altogether (contradicting C); and the beam does not automatically refract to exactly 90 degrees regardless of the specific speed difference, which would only apply at the specific critical-angle condition for the reverse (faster-to-slower... actually faster-medium) scenario, not this one (contradicting A).

18. C. C. At any angle of incidence smaller than the calculated critical angle for a given pair of media, both partial reflection and partial transmission (with refraction, assuming a speed mismatch and oblique angle) occur together, since total internal reflection specifically requires reaching or exceeding the critical angle threshold — below that threshold, some portion of the beam is still transmitted into the second medium. This contradicts a claim of total reflection with no transmission at all, which specifically describes behavior at or beyond the critical angle, not below it (contradicting A); the beam is not simply absorbed with no reflection or transmission at all, an inaccurate characterization of normal interface behavior (contradicting B); and the critical angle threshold is precisely what defines the boundary between this partial-reflection/partial-transmission regime and the total-reflection regime, so it very much remains relevant to describing behavior below it (contradicting D).

19. B. B. Because the Doppler shift for a given true velocity is largest when the cosine of the angle is closest to 1 (angle near 0 degrees, near-parallel to flow), a small insonation angle produces the greatest spread of Doppler shift values across a given range of true velocities, which improves the system's ability to discriminate between two closely spaced true velocities compared with a larger angle, where the same velocity range would compress into a smaller range of shift values. This contradicts a claim that discrimination is impossible at any angle, an overstated claim given that near-parallel angles specifically favor good discrimination (contradicting A); insonation angle very much affects velocity discrimination through this cosine relationship, not having no relationship at all (contradicting C); and 90 degrees is specifically the WORST angle for detecting any Doppler signal at all, since the shift approaches zero, not the best angle for discrimination, contradicting D.

20. D. D. FWHM bandwidth is defined as the width of the frequency range measured between the two points on either side of the peak frequency where the amplitude has fallen to half of its peak value (equivalent to -6dB down from peak) — a specific, standardized method of quantifying bandwidth distinct from simply stating a general frequency range or calculating Q-factor. It is not simply the single center frequency value with no range at all, since bandwidth by definition describes a range, not a single point (contradicting A); it has no relationship to the transducer's physical element count, an unrelated hardware property (contradicting B); and it has no relationship to the Curie point, a piezoelectric material's thermal depolarization threshold, an entirely separate material property (contradicting C).

21. D. D. The superposition principle states that when two or more waves overlap at a given point in space and time, the resulting net displacement at that point is simply the algebraic sum of the individual waves' displacements — this general principle is the underlying basis for both constructive interference (when the sum increases amplitude) and destructive interference (when the sum decreases or cancels amplitude), depending on the relative phase of the overlapping waves. This directly contradicts a claim that waves can never combine or interact at all (A), since superposition is fundamentally about how waves DO combine; interacting waves are not restricted to exactly identical frequencies, since superposition applies generally to any overlapping waves (contradicting B); and superposition is a general wave-physics principle applying to mechanical waves like sound just as much as to electromagnetic waves, not exclusively to the latter (contradicting C).

22. B. B. The critical angle is calculated as arcsin(c1/c2) = arcsin(1400/1600) = arcsin(0.875) ≈ 61 degrees; since the given angle of incidence (55 degrees) is smaller than this calculated critical angle (approximately 61 degrees), the beam is striking the interface below the critical angle, meaning both partial reflection and partial transmission (with refraction) would occur rather than total reflection. This contradicts a claim that 55 degrees exceeds the critical angle (A), since the calculation shows the critical angle is actually larger, at approximately 61 degrees; the given 55-degree angle is not exactly at the calculated ~61-degree critical angle (contradicting C); and a critical angle does exist for this pair of media, since c2 (1600 m/s) is greater than c1 (1400 m/s), satisfying the condition required for a critical angle to exist, contradicting D.

23. D. D. Because air's acoustic impedance is extremely low compared with soft tissue, the transducer face, or typical coupling gel, the impedance mismatch at an air interface is enormous, producing near-total reflection of the incident beam back away from the interface rather than meaningful transmission into the patient — this is precisely the physical reason coupling gel (which is impedance-matched much more closely to tissue) is required to exclude any air gap from the beam's path and allow adequate acoustic transmission. This is not a small, clinically insignificant reflected fraction similar to typical tissue-to-tissue interfaces, which have a far smaller impedance mismatch than an air gap (contradicting A); air very much reflects sound strongly given this severe impedance mismatch, not failing to reflect at all under any circumstance (contradicting B); and the magnitude of reflection at an interface is fundamentally governed by the impedance mismatch between the two media, not primarily by the transducer's operating frequency (contradicting C).

24. B. B. Because wavelength depends on propagation speed (wavelength = propagation speed ÷ frequency), and the piezoelectric crystal material itself has its own characteristic propagation speed — generally quite different from the standard 1540 m/s soft-tissue average used for most diagnostic wavelength calculations — the wavelength used to determine appropriate crystal thickness during manufacturing (approximately half this internal wavelength) must be calculated using the crystal material's own actual propagation speed, not the soft-tissue value. This is not calculated using the propagation speed of air, which is not the relevant reference value for crystal thickness design (contradicting A); it is not based on water's propagation speed regardless of the actual crystal material, since the crystal's own specific material property is what matters here (contradicting C); and this internal wavelength calculation has a real, specific physical basis tied to the actual crystal material's properties, not an arbitrary placeholder value with no physical grounding (contradicting D).

25. A. A. Because attenuation in real tissue increases with increasing frequency (higher-frequency beams attenuate more per centimeter than lower-frequency beams in the same tissue), an attenuation coefficient expressed in dB/cm/MHz must be multiplied by both distance AND the operating frequency (in MHz) to correctly calculate total attenuation in dB — a fixed dB/cm value alone, with no frequency term, would not correctly account for this well-established frequency dependence, potentially under- or over-estimating actual attenuation depending on the frequency actually used. This directly contradicts a claim that the two units are always numerically identical regardless of frequency (B); frequency does have a real, well-established effect on attenuation, contradicting a claim of no effect at all in C; and this frequency-dependence concept applies generally to attenuation calculations, not being restricted only to Doppler mode and excluded from B-mode imaging (contradicting D).

26. C. C. Because the Doppler shift is directly proportional to the cosine of the insonation angle, and cosine reaches its maximum possible value of 1 at exactly 0 degrees (beam running perfectly parallel to the direction of flow), this angle produces the largest possible Doppler shift achievable for a given true velocity — though in practice, achieving a genuine 0-degree angle is rarely feasible given real anatomic constraints, making angles up to about 60 degrees the practical clinical target instead. This is the opposite of producing the smallest possible shift, effectively zero, which instead describes the situation near 90 degrees, not 0 degrees (contradicting A); the shift's magnitude depends on the cosine of the angle among other variables, not on the transducer's element count, an unrelated hardware property (contradicting B); and the value is well-defined and calculable at exactly 0 degrees, not undefined or incalculable, contradicting D.

27. D. D. Bandwidth = 9 MHz - 3 MHz = 6 MHz; center frequency (midpoint) = (3+9)/2 = 6 MHz; fractional bandwidth = (6 MHz / 6 MHz) x 100% = 100%, indicating a very broadband transducer design, since the bandwidth spans the full width of the center frequency itself. Option A (10%) and Option B (25%) are both far smaller than the correctly calculated value and would instead be more consistent with a much narrower operating range relative to the center frequency. Option C (50%) is exactly half the correct value, consistent with a calculation error such as failing to correctly compute the bandwidth or center frequency from the given range.

28. B. B. Synthetic aperture imaging sequentially fires smaller sub-groups of elements (rather than the full aperture at once) and mathematically combines the received data from these sequential firings during processing, synthesizing the beamforming effect of a much larger physical aperture than any single firing actually used — a technique that can improve focusing/resolution without requiring a correspondingly larger number of simultaneously active channels. This is not achieved by physically manufacturing one large continuous element, which would be a fundamentally different, simpler transducer design (contradicting A); it does rely on discrete elements and their sequential firing, not an absence of elements relying purely on mechanical motion (contradicting C); and it has no relationship to doubling the operating frequency, an unrelated acquisition parameter (contradicting D).

29. B. B. Plane-wave imaging transmits a broad, unfocused, essentially flat (planar) wavefront that insonates the entire field of view in a single transmission, rather than the many sequentially focused, scanned transmit beams standard focused imaging requires — because only one (or a few) transmissions are needed to acquire data for an entire frame, this technique can achieve dramatically higher frame rates than conventional focused-beam scanning, at some cost to transmit-side focusing quality that is often at least partly recovered through more sophisticated receive-side processing. This is the opposite of a tightly focused, converging wavefront, which describes standard focused imaging rather than this ultrafast technique (contradicting A); a real transmitted wavefront is still required, not an absence of transmission relying purely on receive processing (contradicting C); and it does not involve continuously changing frequency within a single transmission, an unrelated and inaccurate characterization (contradicting D).

30. A. A. Because these dedicated probes have a fixed, built-in insonation angle rather than a steerable beam or an on-screen adjustable angle-correction cursor as used in general-purpose imaging/duplex systems, the operator must instead rely on proper physical positioning of the probe itself against the body to achieve an appropriate angle relative to the target vessel or fetal heart — angle still fundamentally matters to signal quality, but is managed through probe placement technique rather than software correction. This directly contradicts a claim that angle no longer matters at all with this fixed design (B), since the underlying Doppler angle physics is unchanged, only the correction MECHANISM differs; these probes are not restricted to use at exactly 90 degrees, the worst possible angle, which would defeat their functional purpose entirely (contradicting C); and the probe still requires an actual functioning piezoelectric crystal to generate and receive the Doppler signal, not an ability to function with no crystal at all (contradicting D).

31. C. C. A virtual element or virtual source is a mathematically synthesized source point, computed from the combined received data of multiple actual physical elements (as used, for example, in synthetic aperture imaging), functioning in processing algorithms as if it were a real, physically located source, even though no single physical element actually occupies that exact position. This is not describing a permanently failed physical element excluded from processing, an unrelated equipment-malfunction concept (contradicting A); it is not an element that was designed but never actually installed, which would simply be a manufacturing discrepancy rather than a deliberate processing concept (contradicting B); and it is not merely the physical center point of the housing with no relationship to element data at all, since a virtual element is specifically derived from combined real element data (contradicting D).

32. C. C. Transducer housing labeling typically includes the model number and operating frequency range printed or engraved directly on the probe, allowing staff to quickly identify which specific transducer they are handling and its intended frequency range without needing to consult a separate reference document. This is not patient-specific information from a prior exam, which would be inappropriate to permanently label on reusable equipment and would also violate patient privacy principles (contradicting A); it is not referring physician contact information, an unrelated administrative detail not typically included on equipment labeling (contradicting B); and transducer housings do not typically track and display a running count of total exams performed, a usage-tracking function not part of standard physical labeling (contradicting D).

33. A. A. Electrical damping, using a resistive circuit to absorb electrical ringing energy, and mechanical damping, using an absorptive backing material to absorb the crystal's physical vibrational ringing, represent two distinct engineering approaches to the shared general goal of shortening pulse duration (and thereby improving axial resolution), each involving its own design trade-offs (such as electrical versus acoustic energy loss and their respective effects on sensitivity). This contradicts a claim that they are exactly the same physical mechanism merely described differently (B), since one acts electrically and the other acoustically/mechanically; the two approaches are not mutually exclusive, and many real transducer designs can incorporate elements of both mechanical backing and electrical circuit damping together (contradicting C); and both approaches do have a real, intended effect on pulse duration and axial resolution, not no effect at all (contradicting D).

34. A. A. The geometric shape of a dedicated CW Doppler crystal (circular versus rectangular, among other possible shapes) can affect the resulting beam's cross-sectional profile and spatial coverage pattern, a practical design consideration manufacturers weigh based on the specific intended clinical application (such as a probe optimized for a particular vessel geometry or fetal heart monitoring use case). This contradicts a claim that crystal shape has absolutely no effect on function at all (B); a rectangular (or any other) crystal shape is equally capable of generating an ultrasound signal, not exclusively a circular shape (contradicting C); and CW Doppler applications are not restricted to only a rectangular crystal shape, since circular and other shapes are also used in various dedicated Doppler probe designs (contradicting D).

35. C. C. Compound plane-wave imaging combines several plane-wave transmissions sent at different angles into a single combined image, improving image quality (such as reducing artifacts and improving apparent resolution) compared with using just a single plane-wave transmission alone, while still retaining much of plane-wave imaging's substantial frame-rate advantage over fully focused, line-by-line conventional scanning, since only a modest number of angled transmissions (rather than many fully focused scan lines) are needed per frame. This does not eliminate the need for receive-side beamforming, which remains essential to forming a usable image from the received data regardless of the transmit strategy used (contradicting A); no real imaging technique can guarantee absolutely zero possible artifacts of any kind, an overstated and inaccurate claim (contradicting B); and it remains an electronically steered, array-based technique, not a conversion to fully mechanical, motor-driven scanning (contradicting D).

36. A. A. The active piezoelectric element is specifically the component that performs the actual electromechanical energy conversion — converting an applied electrical voltage into mechanical (acoustic) vibration during transmission, and converting received mechanical vibration back into an electrical signal during reception — while the passive support/frame structure provides mechanical housing, alignment, and support for the active element without itself performing this piezoelectric conversion function. This contradicts a claim that the two components are functionally identical with no meaningful distinction (B); the active element specifically requires electrical connections to receive the driving voltage and carry the received signal, not an absence of any electrical connection (contradicting C); and the active piezoelectric element is located within the transducer housing itself, not in an entirely separate external unit (contradicting D).

37. B. B. Early mechanical, single-element scanners physically moved (oscillated or rotated) a single crystal element to mechanically sweep the beam across the desired field of view, building up a full 2D image one scan line at a time as the element's position changed — a fundamentally different, now largely obsolete approach compared with a modern multi-element array's electronic beam steering and focusing, which requires no bulk mechanical motion of the imaging elements themselves for standard 2D imaging. This contradicts a claim of using dozens of simultaneously active elements exactly as a modern array does, which instead describes the very array technology that superseded this older single-element approach (contradicting A); mechanical motion was, in fact, required, not an absence of moving parts (contradicting C); and these early mechanical scanners could still produce a real-time (if lower quality by modern standards), continuously updating image as the element continued to sweep, not merely a single static frame with no real-time capability at all (contradicting D).

38. B. B. A dedicated thermal monitoring sensor or circuit built into the transducer directly measures the probe's own internal or face temperature during active use, supporting an equipment-level safety response (such as an alert or automatic output reduction) if an abnormal temperature rise is detected — a hardware-level monitoring function distinct from, though related in purpose to, the patient-focused Thermal Index (TI) calculation and display that estimates potential tissue heating based on output settings. This monitoring function does not automatically increase operating frequency upon detecting a temperature rise, which would be counterproductive to a thermal safety response (contradicting A); it supplements, rather than replaces, the separate patient-focused TI calculation, since the two serve related but distinct monitoring purposes (contradicting C); and this monitoring circuit is specifically active and functional during actual transducer use, not only when the transducer is completely powered off, which would defeat its real-time monitoring purpose (contradicting D).

39. C. C. A general-purpose transducer is typically designed with a somewhat broader, less narrowly optimized bandwidth and frequency range, balancing reasonably adequate performance across a wider variety of clinical applications, whereas a more specialized, narrow-application transducer can be more tightly optimized (potentially achieving superior performance) for that one specific narrow use case, at the cost of being less well suited to other applications outside its narrow design target. This contradicts a claim that the general-purpose transducer always achieves better resolution than any specialized transducer with no trade-off at all (A), which reverses the typical relationship for the specialized transducer's specific target application; the two transducer categories are not functionally and technically identical, given this real design trade-off between broad versus narrow optimization (contradicting B); and general-purpose transducers are fully capable of Doppler applications, not excluded from Doppler use entirely (contradicting D).

40. C. C. Element pitch refers to the center-to-center spacing between adjacent elements in an array, a measurement that includes both the physical width of each individual element and the kerf (the gap/cut) separating it from its neighboring element — pitch and kerf are related but distinct measurements often confused with one another, since kerf describes only the gap itself, while pitch describes the full repeating spacing interval that includes both the element and its adjacent gap. This directly contradicts a claim that pitch and kerf are exactly the same measurement under different names (A); pitch is a spatial/geometric measurement, not a description of the transducer's operating frequency range, an unrelated electronic parameter (contradicting B); and pitch refers to the repeating element-to-element spacing pattern, not the transducer's overall total housing length, a different overall dimension (contradicting D).

41. D. D. A sparse array design deliberately uses fewer active elements than a fully populated array covering the same physical aperture, reducing the number of required processing channels and the associated system cost and complexity, but this typically comes at some cost to image quality — commonly increased side lobe or grating lobe artifact — compared with a fully populated array of the same size, a genuine engineering trade-off manufacturers weigh for certain applications such as 3D matrix arrays where a fully populated design would require an impractically large number of channels. This contradicts a claim of literally no trade-off in image quality at all (A); sparse arrays are, in fact, a real, manufacturable transducer technology used in various clinical systems, not something impossible to manufacture (contradicting B); and sparse arrays still fundamentally require beamforming processing to combine their fewer elements' signals into a usable image, not an elimination of beamforming altogether (contradicting C).

42. A. A. In a duplex combination probe, the dedicated CW Doppler crystal pair is typically positioned at a fixed geometric offset from the imaging array's active elements, angled so that the CW beam intersects the imaging plane at a predetermined depth and location, allowing the sonographer to use the 2D image to help position the probe for an appropriate CW Doppler sample location even though the CW crystals themselves are not electronically steerable like the imaging array. This is not a random arrangement with no consistent geometric relationship from probe to probe, since this offset and angle is a deliberate, engineered design feature (contradicting B); the CW crystals do not physically overlap the imaging array's elements in the identical location, since both need their own distinct physical space within the probe housing (contradicting C); and this is a single combined probe housing, not two entirely separate, physically detached probes connected by a cable (contradicting D).

43. B. B. A tapered apodization window (such as a Hamming window), which gradually reduces drive amplitude toward the edges of the active aperture rather than driving all elements equally, generally reduces side lobe level compared with a uniform (non-tapered) aperture, though this benefit typically comes at some cost to main lobe width (a slightly wider main lobe, meaning somewhat reduced lateral resolution) — a real trade-off between side lobe suppression and main lobe sharpness that different window shapes balance differently. This is the opposite of increasing side lobe level, which is generally an undesirable outcome apodization aims to reduce, not maximize (contradicting A); the specific window shape chosen does have a real, measurable effect on the resulting beam profile, not no effect at all (contradicting C); and apodization can be applied during both transmit and receive processing, not exclusively during receive (contradicting D).

44. A. A. A hardware-related near-field dead zone can result from the element's own ring-down time — brief residual mechanical vibration continuing after the transmit pulse, during which the element cannot yet reliably distinguish genuine returning echoes from its own still-decaying vibration — meaning very superficial structures within this extremely shallow zone may not be reliably imaged, a transducer-hardware-related limitation distinct from software/display-related near-field imaging challenges. This has no relationship to the color box size, a separate Doppler display parameter unrelated to this specific hardware ring-down limitation (contradicting B); it is not caused by the patient's body mass index, a patient-related factor rather than a transducer hardware characteristic (contradicting C); and it is not caused by the display's dynamic range setting, a separate image-processing parameter (contradicting D).

45. C. C. Because a fully populated 2D matrix array with enough elements for good image quality would require an extremely large total channel count (and correspondingly complex, costly, and bulky cabling/electronics) to individually address every single element, manufacturers may choose a sparse 2D matrix design specifically to manage this practical engineering and cost challenge, accepting some image-quality trade-off (such as increased grating lobe artifact) in exchange for a more manageable, commercially practical channel count and system complexity. This is not because 2D matrix arrays cannot be manufactured at all using current technology, since fully populated designs do exist commercially, just at higher cost/complexity (contradicting A); a sparse design still very much retains genuine electronic focusing capability across both azimuthal and elevational dimensions, not an elimination of electronic focusing altogether (contradicting B); and there is no FDA regulatory requirement mandating that all matrix arrays specifically use a sparse design, which is instead a manufacturer engineering choice (contradicting D).

46. C. C. A power threshold or noise-floor control sets a specific amplitude level below which signal is treated as background noise and excluded from the Doppler display, functioning as a distinct baseline cutoff setting separate from overall gain, which instead uniformly amplifies the entire received signal above whatever the noise floor happens to be. This control does not set the transducer's operating frequency, an unrelated hardware parameter (contradicting A); it does not determine the system's maximum scanning depth, a separate imaging parameter (contradicting B); and it does not directly set the color box's physical size, a separate display region-of-interest parameter (contradicting D).

47. D. D. An ECG-triggered automatic freeze feature consistently captures a still image at the same specific, reproducible point in the cardiac cycle (such as end-diastole) each time it is used, supporting standardized measurement (such as chamber dimensions at a defined cardiac phase) and more reliable comparison across serial exams performed at different times, rather than relying on the sonographer's own timing judgment for each individual freeze. This is the opposite of randomly freezing at an unpredictable point, since the entire purpose is achieving a consistent, reproducible timing (contradicting A); it does not automatically diagnose any abnormality present, remaining an image-capture timing feature rather than an interpretive tool (contradicting B); and it has no effect on acoustic output power at the triggered moment, an unrelated separate output parameter (contradicting C).

48. B. B. Displaying a numeric confidence score alongside an automated waveform classification helps convey how certain the underlying algorithm is in its own suggested classification for that specific waveform, supporting more informed clinical judgment about how much weight to place on the automated suggestion — a lower confidence score appropriately signals that closer independent scrutiny by the sonographer or physician may be warranted, rather than treating every automated suggestion with equal certainty. This does not eliminate the need for actual waveform review, since the score itself is meant to inform, not replace, that review (contradicting A); the confidence score reflects the algorithm's certainty in its classification, not a direct measurement of the patient's blood pressure, an unrelated physiologic parameter (contradicting C); and the score is expected to vary meaningfully between different waveforms based on how clearly each one matches a recognized pattern, not remaining a fixed, unchanging value (contradicting D).

49. C. C. A scroll-bar or timeline element in a cine-loop review interface allows the sonographer to directly navigate to and select a specific individual frame by visually referencing and dragging to its position along the overall loop's timeline, offering faster, more flexible navigation than only stepping sequentially forward or backward one frame at a time using basic play/pause/step controls. This interface element does not itself diagnose any abnormality found within the loop, remaining a navigation tool rather than an interpretive one (contradicting A); it has no effect on the transducer's operating frequency for an already-acquired loop, since that acquisition parameter is fixed once the data has been captured (contradicting B); and using the scroll-bar for navigation does not permanently delete any other frames in the loop, which remain available for continued review (contradicting D).

50. B. B. A vertical flip control inverts the displayed image top-to-bottom, so that structures previously shown near the top of the screen (typically the more superficial, near-field structures) now appear near the bottom and vice versa, while leaving the image's left-right orientation entirely unchanged — a distinct display adjustment from a horizontal (left-right) flip, which instead mirrors the image side-to-side while leaving the top-to-bottom orientation unchanged. This control has no effect on the transducer's operating frequency, an unrelated acquisition parameter (contradicting A); it does not adjust the color Doppler scale, a separate Doppler-specific parameter (contradicting C); and it is a reversible display-orientation adjustment, not a permanent, irreversible alteration of the actual underlying acquired data (contradicting D).

51. C. C. A temporal-smoothing filter averages the displayed velocity value over several consecutive samples, reducing sample-to-sample noise or jitter that would otherwise make the trace appear rough or erratic, producing a visually smoother waveform for easier interpretation — though, as with any smoothing/averaging technique, this comes at some potential cost to capturing very fine, rapid temporal detail in the true underlying signal. This filter has no effect on acoustic output power, an unrelated separate output parameter (contradicting A); it does not eliminate the Nyquist limit, which remains governed by PRF regardless of any smoothing applied to the displayed trace afterward (contradicting B); and it remains a spectral Doppler display processing feature, not a conversion into an entirely different display mode such as color Doppler (contradicting D).

52. D. D. A baseline auto-centering feature analyzes the acquired spectral waveform and automatically repositions the baseline to a position that keeps the full waveform visible without clipping off the top or bottom of the trace, sparing the sonographer from manual trial-and-error baseline adjustment while still achieving an appropriately centered display. This automated feature does not permanently disable the sonographer's ability to make further manual adjustments afterward if desired, remaining a convenience feature rather than a lockout (contradicting A); it has no effect on the system's PRF setting, a separate scale-related parameter rather than baseline position specifically (contradicting B); and it performs this positioning automatically through image analysis, not by requiring the sonographer to manually calculate and enter a numeric value via a keypad (contradicting C).

53. A. A. A multi-focal-zone position indicator helps the sonographer visually understand exactly which depths are currently receiving focused beam coverage from each active zone, informing decisions about whether to add an additional zone, remove an unnecessary one, or reposition an existing zone's depth for the specific structure being evaluated, all while being mindful of the frame-rate cost that comes with additional focal zones. This on-screen indicator does not itself automatically add focal zones without sonographer input, remaining an informational display rather than an automated adjustment feature (contradicting B); it does not replace the separate, ongoing need for appropriate TGC adjustment, a different depth-compensation parameter (contradicting C); and it displays focal zone depth information, not the patient's heart rate, an unrelated physiologic parameter (contradicting D).

54. C. C. Automated thyroid nodule risk-stratification software systematically applies a structured set of established sonographic risk criteria (composition, echogenicity, margin characteristics, and calcification pattern, among others) to a given nodule, helping stratify its relative risk category and supporting a more standardized, reproducible recommendation regarding further workup (such as biopsy versus routine follow-up) compared with a purely unstructured, individual visual impression alone. This software does not itself perform an actual biopsy, which remains a separate, physician-ordered invasive procedure requiring its own distinct consent and technique (contradicting A); the software relies on, rather than replaces, grayscale image acquisition, since it specifically analyzes grayscale features to generate its scoring (contradicting B); and it assesses sonographic risk features, not the nodule's internal temperature, an unrelated and not typically clinically relevant parameter for this application (contradicting D).

55. B. B. An elastography quality-indicator overlay flags whether a specific stiffness measurement met acceptable technical criteria (such as adequate signal quality, consistent repeated measurements, or absence of excessive motion artifact), helping the operator recognize when a given measurement may be technically unreliable and should be repeated rather than accepted and reported at face value, supporting more consistent and trustworthy elastography results overall. This quality indicator has no effect on the transducer's acoustic output power, an unrelated separate output parameter (contradicting A); it does not replace the ongoing need to correlate elastography findings with grayscale (and other) imaging findings for full clinical context (contradicting C); and it provides technical quality information about the measurement itself, not the patient's age, an unrelated demographic detail not derivable from this specific indicator (contradicting D).

56. D. D. Automated ovarian volume software applies the standard ellipsoid volume formula (length × width × height × 0.523) to the ovarian dimensions measured by the sonographer, automatically calculating an estimated ovarian volume without requiring the sonographer to perform this multiplication by hand for every single exam, a routine but genuinely useful automated calculation given how frequently ovarian volume is assessed. This is the opposite of requiring the entire calculation to be performed manually with no software assistance at all (contradicting A); it is specifically a dimensional/volume-based calculation, not a blood-flow measurement with no volume component (contradicting B); and it does provide a specific numeric volume estimate, not merely a vague qualitative size impression with no numeric output at all (contradicting C).

57. B. B. A trace-thickness display adjustment changes only the visual line thickness or boldness with which the spectral waveform trace is rendered on screen, a cosmetic display preference some operators find easier to view or that displays more clearly at a given screen resolution, without changing any of the underlying acquired velocity data itself, which remains identical regardless of how thick or thin the trace is drawn. This display setting has no effect on the transducer's actual operating frequency, a separate acquisition parameter (contradicting A); it does not affect the system's maximum scanning depth, an unrelated imaging parameter (contradicting C); and it has no relationship to the color Doppler box's physical size, a distinct display region-of-interest parameter (contradicting D).

58. C. C. DICOM Structured Reporting (SR) encodes specific sonographic measurement values, along with their labels and units, in a standardized, structured, machine-readable digital format, supporting consistent transfer of that specific data between systems (such as automatically populating an EMR field or feeding a growth-chart/percentile calculation tool), rather than relying only on unstructured free-text report language or a static image screenshot that a receiving system cannot automatically parse into discrete data values. This standard does not itself physically perform the scan, remaining a data-encoding and transfer standard rather than an acquisition tool (contradicting A); it does not eliminate the physician's role in interpreting the clinical significance of the measurements, remaining a data-structuring standard rather than an interpretive one (contradicting B); and it has no relationship to the transducer's actual operating frequency, an unrelated acquisition-side hardware parameter (contradicting D).

59. D. D. Increasing MPR slice thickness from a very thin, single-voxel slice to a thicker slab causes the reformatted image to average or combine data across that thicker slab (a technique sometimes called slab or thick-MPR), which can reduce noise and improve visualization of larger, more continuous structures, but at some potential cost to depicting very fine detail that a single thin slice would show more precisely — a genuine trade-off in reformatting slice thickness selection. This adjustment does not affect the transducer's operating frequency during the original 3D acquisition, which has already been completed by the time reformatting occurs (contradicting A); it does have a real, visible effect on the reformatted image's appearance, not no effect at all (contradicting B); and this reformatting technique is applied to an already-acquired 3D volume, not something that eliminates the need for that original 3D acquisition in the first place (contradicting C).

60. A. A. Automated CBD diameter software analyzes the grayscale image of the duct, automatically detecting its near and far wall borders in the selected view and calculating the diameter as the distance between those detected borders, reducing manual caliper-placement variability compared with an entirely manual measurement for this routinely assessed structure. This is not a tool that measures the gallbladder instead of the duct despite its name, which would misdescribe the software's actual target structure (contradicting B); it does not require contrast agent administration, an invasive and unnecessary requirement for this standard grayscale measurement (contradicting C); and it provides a specific numeric diameter measurement, not merely a vague categorical normal/abnormal flag with no actual numeric value (contradicting D).

61. A. A. By long-standing display convention, a standard transverse abdominal scan plane is displayed with the patient's right side appearing on the left side of the screen, matching the same convention used for viewing axial CT and MRI cross-sectional images (as if looking up at the patient from their feet), supporting consistent cross-modality orientation expectations for the interpreting physician. This directly contradicts a claim that the patient's right appears on the right side of the screen, opposite the CT/MRI convention, which would create an inconsistent, potentially confusing cross-modality mismatch (contradicting B); display side does, in fact, follow this well-established convention rather than being entirely arbitrary with no consistency at all (contradicting C); and this display convention has no relationship to which specific transducer frequency happens to be in use for a given exam (contradicting D).

62. B. B. Automated fetal heart rate calculation software analyzes the M-mode trace or Doppler waveform, automatically measuring the time interval between repeating cardiac cycle events (such as consecutive systolic peaks), and converts that measured interval into a calculated beats-per-minute value, sparing the sonographer from manually timing and counting heartbeats for this frequently performed measurement. This is the opposite of requiring entirely manual stopwatch-based counting with no software assistance at all (contradicting A); it specifically analyzes the fetal cardiac trace, not the maternal heart rate despite superficially similar terminology (contradicting C); and it provides a specific numeric beats-per-minute value, not merely a vague qualitative categorization with no actual number (contradicting D).

63. D. D. Different color Doppler palettes offer alternative color gradient schemes for encoding velocity and direction information beyond the basic BART (blue-away, red-toward) convention, and selecting a different palette allows the operator to choose a scheme some may find provides better visual differentiation of subtle velocity variations for a given clinical situation, without changing any of the actual underlying Doppler shift data being encoded — only how that same data is visually color-coded for display. This palette selection has no effect on the transducer's transmitted power, an unrelated separate output parameter (contradicting A); it does not eliminate the underlying Doppler shift calculation, which remains the basis for whatever color is ultimately displayed regardless of palette (contradicting B); and it does not change the actual numeric velocity values shown on a separate spectral trace, remaining purely a color-display preference for the color Doppler overlay (contradicting C).

64. D. D. A grayscale invert toggle reverses which end of the black-to-white display spectrum corresponds to the strongest versus weakest echo amplitude (for example, switching from the standard convention where the strongest echoes appear white and weakest appear black, to the reverse), changing only how the same underlying acquired amplitude data is visually displayed, without altering the actual acquired data itself. This grayscale-specific toggle has no effect on the transducer's actual acoustic output power, an unrelated separate parameter (contradicting A); it does not change the system's maximum imaging depth, a separate acquisition parameter (contradicting B); and it is specifically a grayscale (B-mode) display adjustment, distinct from and unrelated to the separate color Doppler directional (red/blue) convention (contradicting C).

65. A. A. An adaptive PRF auto-scaling feature analyzes the detected range of velocities present in the current sample volume and automatically adjusts the PRF/scale setting to a value appropriate to that detected range, reducing the need for the sonographer to manually fine-tune the scale through trial and error, while helping avoid both unnecessary aliasing (scale set too low for the true velocities present) and excessive, wasted vertical display range (scale set far higher than the actual velocities require). This automated convenience feature does not permanently disable the sonographer's own ability to make further manual scale adjustments afterward if desired (contradicting B); it does not convert the acquisition into continuous-wave Doppler, remaining a pulsed-wave scale-optimization feature (contradicting C); and it does have a real, intended effect on the displayed spectral waveform's scale, not no effect at all (contradicting D).

66. A. A. A whole-image automatic gain compensation feature analyzes the overall image brightness and applies a single, uniform gain adjustment across the entire image to reach a target overall brightness level, distinct from TGC, which instead applies depth-specific compensation that can vary independently at different depths to address depth-dependent attenuation differences within the same image. This directly contradicts a claim that the two features function identically with no meaningful distinction (B), since whole-image auto-gain and depth-specific TGC address different aspects of image brightness; this feature does not change the transducer's operating frequency based on detected brightness, an unrelated acquisition parameter (contradicting C); and it does not eliminate the underlying physical need for depth-based compensation (TGC), which remains a separate, still-necessary adjustment addressing attenuation's depth-dependent nature (contradicting D).

67. C. C. A structured, checklist-style Doppler protocol worksheet for a specialized, multi-vessel exam (such as a comprehensive renal or mesenteric duplex, which requires numerous specific vessel measurements) helps ensure all protocol-required measurements are systematically obtained and documented in sequence, reducing the risk of an inadvertently incomplete study missing a required vessel or measurement that would otherwise necessitate recalling the patient for a repeat exam. This checklist tool does not physically perform the acquisition itself, which remains the sonographer's hands-on task (contradicting A); it does not automatically diagnose any abnormal finding, remaining a workflow/completeness tool rather than an interpretive one (contradicting B); and it specifically supports, rather than eliminates, thorough spectral Doppler waveform acquisition across the required vessels (contradicting D).

68. D. D. An adaptive wall filter algorithm analyzes the detected clutter characteristics in real time and dynamically adjusts the wall filter cutoff to balance effectively removing wall-motion clutter against preserving genuine slow-flow signal, rather than relying entirely on the sonographer correctly guessing and manually setting a single fixed cutoff value appropriate to every specific clinical situation encountered. This adaptive feature does not permanently eliminate the wall filter control from the system, since manual override or adjustment typically remains available (contradicting A); it has no effect on the transducer's transmitted acoustic power, an unrelated separate output parameter (contradicting B); and it does have a real, intended effect on the displayed Doppler signal by actively managing the clutter/slow-flow trade-off, not no effect at all (contradicting C).

69. B. B. Automated liver span software analyzes the longitudinal grayscale image, automatically detecting the superior (dome) and inferior liver margins in the selected view, and calculates the craniocaudal span (distance) between those detected margins, reducing manual caliper-placement variability for this frequently performed, routine measurement. This is not a technique requiring the entire calculation to be performed manually with no border-detection assistance at all, which would defeat the purpose of the automated feature (contradicting A); it specifically targets the liver, not the spleen, an entirely different organ despite the general similarity of the measurement concept (contradicting C); and it provides a specific numeric span measurement, not merely a vague categorical flag with no actual numeric value (contradicting D).

70. B. B. Because sweep speed determines how much time (and therefore how many cardiac cycles, for a heart-rate-dependent trace) is represented across a given screen width, an automatic sweep-speed adjustment based on detected heart rate helps display a consistent, appropriate number of visible cardiac cycles regardless of whether the patient's heart rate happens to be relatively fast or slow, rather than requiring the sonographer to manually readjust sweep speed for each individual patient's heart rate. This feature has no effect on the transducer's transmitted power, an unrelated separate output parameter (contradicting A); it does not eliminate the underlying need for spectral Doppler acquisition itself, remaining a display-timing optimization for an acquisition still being performed (contradicting C); and it remains a spectral Doppler display feature, not a conversion into an entirely different display mode such as color Doppler (contradicting D).

71. D. D. A rotation control rotates the entire displayed image by a selected angle around a central point (such as 90, 180, or 270 degrees, or sometimes a continuously adjustable angle), changing the image's overall orientation on the screen without mirroring or flipping it — a genuinely distinct display adjustment from a flip control, which instead mirrors the image along one axis rather than rotating it around a central point. This is not simply a left-right mirror with top-to-bottom orientation fixed, which instead describes a horizontal flip control, a different function from rotation (contradicting A); it is not simply a top-to-bottom mirror with left-right orientation fixed, which instead describes a vertical flip control (contradicting B); and rotating the image display has no automatic effect on the separate color Doppler scale setting, an unrelated Doppler-specific parameter (contradicting C).

72. D. D. General elastography guidance recommends positioning the region-of-interest box within a representative, artifact-free area of the target tissue, sized appropriately relative to the structure being assessed, and specifically avoiding inclusion of vessels, calcifications, or other confounding structures within the sampled region, since these can introduce inaccurate or unreliable stiffness readings unrelated to the tissue characteristic actually being assessed. This is not simply always using the smallest possible box regardless of the target's actual size (A) or always the largest possible box regardless of target size (B), since appropriate sizing depends on the specific structure and clinical context rather than a fixed always-smallest or always-largest rule; and box position/size does have a real, meaningful bearing on measurement reliability, contradicting the claim of no bearing at all in C.

73. C. C. Automated endometrial thickness software analyzes the sagittal grayscale image of the uterus, automatically detecting the anterior and posterior endometrial-myometrial interfaces and calculating the double-layer endometrial thickness as the distance between those detected borders, reducing manual caliper-placement variability for this frequently performed measurement relevant to numerous gynecologic clinical scenarios. This is the opposite of requiring an entirely manual measurement with no border-detection assistance at all (contradicting A); it specifically targets the endometrium, not the ovaries, an entirely different structure despite the general topic area (contradicting B); and it provides a specific numeric thickness measurement, not merely a vague categorical flag with no actual numeric value (contradicting D).

74. B. B. Independent per-panel freeze capability in a dual-image display allows one panel to remain live and actively updating while the other stays frozen on a specific prior reference frame, useful for tasks such as directly comparing a real-time image against a previously identified target or landmark, or guiding a needle relative to a frozen reference image while still viewing live real-time anatomy in the other panel simultaneously. This feature does not itself automatically diagnose any asymmetry between the two panels, remaining a display/workflow tool rather than an interpretive one (contradicting A); it does not permanently prevent either panel from ever being unfrozen again, remaining a flexible, reversible display state (contradicting C); and it has no effect on acoustic output power specifically in the live panel, an unrelated separate output parameter (contradicting D).

75. A. A. Using two orthogonal apical views (the biplane method) for ejection fraction calculation generally provides a more accurate chamber volume estimate than a single-plane calculation, since it accounts for the ventricle's actual three-dimensional geometry across two planes rather than relying on a simplified geometric model derived from just one single plane, which can be less accurate if the true chamber shape deviates from that plane's assumed geometry. This does not eliminate the need for endocardial border tracing, which remains required in each of the two views used, not none at all (contradicting B); a real image acquisition in each of the two views is still required, not a measurement requiring no image acquisition whatsoever (contradicting C); and the biplane result is not always numerically identical to a single-plane calculation, since the entire point of using two planes is to potentially capture geometric differences a single plane alone would miss (contradicting D).

76. B. B. A projected needle-guide path increasingly diverging from the needle's actual directly visualized path over the course of a procedure is a recognized sign of possible calibration drift in the needle-guide overlay system, and the appropriate immediate response is to stop relying on the overlay projection alone, instead prioritizing direct grayscale visualization of the actual needle position for continued safe guidance, while arranging for recalibration of the guide system before it is relied upon again. Continuing to rely solely on the increasingly inaccurate projected overlay line despite the observed discrepancy (A) risks a dangerous mismatch between the displayed guidance and the needle's true position. Simply increasing overall gain to maximum (C) does not address a geometric calibration problem and is not an appropriate response to this specific issue. Assuming the patient's anatomy itself has physically shifted, rather than considering equipment calibration drift, and proceeding without further caution is not the appropriately cautious first response to this specific observed pattern (contradicting D).

77. B. B. Doppler shift = (2 x transmit frequency x velocity x cos angle) / propagation speed = (2 x 7,500,000 Hz x 0.6 m/s x 0.643) / 1540 m/s ≈ 3757 Hz, closest to 3760 Hz. Option A is roughly three-quarters of the correct value, consistent with a rounding or arithmetic slip. Option C is roughly double the correct value, consistent with an extra unintended doubling. Option D is roughly half the correct value, consistent with omitting the factor of 2 for round-trip shift.

78. C. C. Nyquist limit = PRF/2 = 3500 Hz; max velocity = (Nyquist limit x propagation speed) / (2 x transmit frequency x cos angle) = (3500 x 1540 m/s) / (2 x 4,000,000 Hz x 0.766) ≈ 4.40 m/s ≈ 440 cm/s. Option A is roughly one-fifth of the correct value, consistent with an arithmetic error. Option B is roughly two-fifths of the correct value. Option D is roughly one-twentieth of the correct value, none of which reflect the correct rearranged Doppler equation calculation.

79. C. C. The peak velocity of a tricuspid regurgitation jet is used in the simplified Bernoulli equation (pressure gradient = 4 x velocity^2) to estimate the pressure gradient between the right ventricle and right atrium during systole; adding an estimated right atrial pressure to this calculated gradient yields an estimate of right ventricular systolic pressure, which, in the absence of pulmonic stenosis, approximates pulmonary artery systolic pressure — a widely used noninvasive screening estimate for pulmonary hypertension. This calculation does not estimate left ventricular ejection fraction, an entirely different measurement derived from left ventricular volumes, not a right-sided regurgitant jet velocity (contradicting A); it does not directly yield cardiac output in liters per minute, which requires a different calculation method entirely (contradicting B); and heart rate is determined from cycle timing, not derived from this specific jet's peak velocity value (contradicting D).

80. D. D. A ureteral jet — a periodic burst of urine (with slightly different acoustic properties than surrounding bladder urine) entering the bladder from the ureteral orifice, visualized on grayscale or color Doppler — is used clinically to help assess functional ureteral patency, since an absent or significantly diminished jet on the affected side, particularly when compared with a normal jet on the contralateral side, can support a diagnosis of ureteral obstruction (such as from a stone) even before hydronephrosis is clearly visible. This finding does not directly measure the patient's systemic blood pressure, an unrelated hemodynamic parameter (contradicting A); it has no relationship to gallbladder wall thickness, an entirely different organ and finding (contradicting B); and it provides no information about the patient's blood type, an unrelated laboratory parameter (contradicting C).

81. D. D. Paget-Schroetter syndrome (effort thrombosis) involves thrombosis of the axillary-subclavian vein, classically in an otherwise healthy, often young and physically active patient following strenuous, repetitive upper-extremity activity, with Doppler evaluation identifying the venous thrombus and often associated findings of thoracic outlet compression that contributed to the underlying venous injury and subsequent clot formation. This is not a finding restricted to elderly, sedentary patients, which contradicts the classic young, athletic demographic actually described (contradicting A); it is specifically an upper-extremity, not lower-extremity, venous condition despite superficially similar DVT terminology (contradicting B); and it is fundamentally a venous, not arterial, thrombosis, as reflected in its very name and clinical description (contradicting C).

82. A. A. A carotid web is a thin, shelf-like fibrous intimal irregularity projecting into the posterior aspect of the carotid bulb lumen, an uncommon but increasingly recognized variant that can serve as a nidus for thrombus formation, with subsequent embolization contributing to stroke, particularly in younger patients without other typical atherosclerotic risk factors. This is not a normal, universally present anatomic structure found in every patient, since it is specifically an uncommon variant, not typical carotid anatomy (contradicting B); despite being a less commonly recognized entity, it specifically involves the carotid artery, not the vertebral artery, an entirely different vessel (contradicting C); and it is, as its clinical description indicates, an arterial (intimal) finding, not a venous structure (contradicting D).

83. C. C. Acute DVT characteristically appears relatively hypoechoic (sometimes nearly anechoic), is non-compressible, and is often associated with vein dilation compared with the normal contralateral vein, while chronic, longstanding thrombus tends to become more echogenic over time, may partially recanalize with some restored compressibility and flow, and is often associated with a smaller, non-dilated (sometimes even contracted) vein along with visible collateral venous channels that developed to bypass the chronically obstructed segment — a genuinely useful distinguishing pattern for staging DVT chronicity. This directly contradicts a claim that acute and chronic thrombus always appear entirely identical (A); it also contradicts a claim that chronic thrombus is always non-compressible and echo-free identical to acute thrombus, since chronic thrombus characteristically differs in exactly these respects (contradicting B); and both acute and chronic thrombus are well assessable with Doppler and grayscale ultrasound, not exclusively the acute form (contradicting D).

84. C. C. A single umbilical artery refers to the presence of only one umbilical artery, rather than the normal two, running alongside the normal single umbilical vein within the umbilical cord — an anatomic variant identifiable on grayscale (cord cross-section, the classic 'Mickey Mouse' sign, here showing only two vessels instead of three) and color Doppler evaluation, associated with an increased risk of certain other structural or chromosomal anomalies that warrants further detailed anatomic evaluation when identified. This is not a description of the umbilical vein being entirely absent, since the vein remains present in this variant, only one artery is missing (contradicting A); SUA is a variant occurring in a minority of pregnancies, not present in every single pregnancy without exception (contradicting B); and it is specifically identifiable on prenatal ultrasound, not exclusively after delivery (contradicting D).

85. A. A. Twin-to-twin transfusion syndrome, resulting from unbalanced blood flow through shared placental vascular connections in a monochorionic twin pregnancy, is evaluated in part through Doppler assessment of each twin's umbilical artery, ductus venosus, and middle cerebral artery waveforms, since characteristic abnormal patterns differ between the volume-depleted donor twin and volume-overloaded recipient twin, supporting condition staging and ongoing monitoring. This is not assessed using only the maternal uterine artery with no assessment of either twin's own vessels, since twin-specific vessel assessment is central to evaluating and staging this specific condition (contradicting B); it is specifically a complication of monochorionic (shared placenta), not dichorionic, twin pregnancies, given the shared vascular connections required for the condition to occur (contradicting C); and it does produce real, clinically important, detectable Doppler abnormalities in the affected twins, not an absence of any detectable finding at all (contradicting D).

86. C. C. A splenic artery aneurysm appears on Doppler and grayscale imaging as a focal, saccular dilation of the artery (an abnormally widened segment, distinct from a narrowed one), sometimes containing turbulent or swirling flow within the dilated segment — the most common visceral artery aneurysm, with Doppler used to characterize the dilated segment's flow and help assess for any associated complication. This is not the same finding as stenosis, since aneurysm and stenosis represent opposite geometric abnormalities — widening versus narrowing (contradicting A); an aneurysm, unlike a fully thrombosed vessel, generally still shows detectable flow within its patent, if abnormally dilated, lumen, not a complete absence of flow signal (contradicting B); and a splenic artery aneurysm is, as its name indicates, a splenic ARTERY finding, not a splenic vein entity (contradicting D).

87. C. C. A hepatic artery aneurysm appears on Doppler and grayscale imaging as a focal, saccular or fusiform dilation of the vessel, sometimes containing turbulent internal flow, distinguishing it geometrically from hepatic artery stenosis, which instead produces a narrowed segment with locally elevated velocity — an uncommon but clinically important finding sometimes identified incidentally, after trauma, or following a prior hepatic intervention such as transplantation or biopsy. This is not the same finding as stenosis, since aneurysm and stenosis represent opposite geometric abnormalities (contradicting A); an aneurysm generally still shows detectable flow within its patent, dilated lumen, not a complete absence of flow signal, unless a separate complication such as thrombosis has also occurred (contradicting B); and a hepatic artery aneurysm is, as its name indicates, a hepatic ARTERY finding, not a hepatic vein entity (contradicting D).

88. B. B. A lymphatic malformation, composed of abnormal channels or cystic spaces containing lymphatic fluid rather than blood, characteristically shows little to no detectable internal flow signal on Doppler, distinguishing it from a venous malformation, which does contain blood and can show slow, sometimes compressible, venous flow within its channels — this Doppler flow distinction is a genuinely useful feature in differentiating these two vascular-anomaly categories, alongside other grayscale characteristics. This contradicts a claim that a lymphatic malformation shows the same robust flow as a venous malformation with no distinguishing feature (A), since the characteristic absence of significant flow is precisely the distinguishing point; lymphatic malformations are well assessable with Doppler ultrasound, not requiring MRI exclusively (contradicting C); and lymphatic malformations are congenital and can present at any age, including commonly in children, not restricted exclusively to adult patients (contradicting D).

89. D. D. Color Doppler evaluation of suspected placenta accreta spectrum looks for abnormal, often turbulent, high-velocity, or irregular 'lacunar' vascularity at the placental-myometrial interface, sometimes with bridging vessels that appear to cross the normal interface plane into the myometrium or even the bladder wall in more invasive cases, supporting the diagnosis alongside characteristic grayscale findings (such as loss of the normal retroplacental clear zone and myometrial thinning). This is not a claim of a completely normal, uniform interface ruling out the diagnosis, since abnormal vascularity is precisely the finding supporting the diagnosis (contradicting A); the relevant abnormal interface is specifically at the maternal myometrial surface, not restricted to the fetal surface of the placenta (contradicting B); and Doppler ultrasound does contribute meaningfully useful diagnostic information to this evaluation, not being limited to MRI alone (contradicting C).

90. A. A. Clinical staging systems for chronic venous insufficiency, such as CEAP, incorporate both clinical findings (ranging from telangiectasias and varicosities to skin changes and active or healed ulceration) alongside the Doppler-confirmed anatomic distribution and severity of venous reflux, combining clinical presentation with objective Doppler data to arrive at a more complete staging assessment than either alone would provide. This is not based on the patient's blood type, an entirely unrelated laboratory parameter (contradicting B); staging incorporates broader clinical and anatomic information, not a single isolated Doppler velocity number in isolation (contradicting C); and Doppler ultrasound is, in fact, a standard, widely used tool for this evaluation, not requiring venography exclusively (contradicting D).

91. D. D. Phlegmasia cerulea dolens represents extensive, often near-total deep venous occlusion (typically involving both the deep and often superficial venous systems of the limb) with severely compromised venous outflow, and the resulting massive venous congestion and limb swelling can, in severe cases, secondarily compromise arterial inflow as well — a rare but genuinely limb- and life-threatening complication requiring urgent recognition and management. This is not a completely normal Doppler examination, since the entire condition is defined by severe venous compromise, not a normal study (contradicting A); it involves extensive DEEP, not isolated superficial, venous thrombosis, contradicting a claim the deep system is entirely spared in B; and while classically described in the lower extremity, the underlying pathophysiologic mechanism is not restricted exclusively to the upper extremity as claimed in C.

92. D. D. Characterizing the internal nidus flow pattern — the tangled, disorganized network of abnormal vessels at the core of an arteriovenous malformation, distinct from the more organized feeding artery and draining vein — helps characterize the malformation's overall complexity and vascularity, information relevant to planning treatment such as embolization, which specifically targets this nidus. This nidus-flow assessment does not determine the patient's blood type, an unrelated laboratory parameter (contradicting A); it does not eliminate the need for further imaging or intervention planning, remaining one component of a fuller evaluation rather than a complete substitute for it (contradicting B); and it supplements, rather than replaces, the separate assessment of the feeding artery and draining vein, which remain clinically relevant components of a complete AVM evaluation (contradicting C).

93. A. A. A general (though not absolute or individually diagnostic) pattern sometimes described is that an adrenal adenoma tends to show relatively sparse internal vascularity on Doppler, while a pheochromocytoma tends to show more prominent internal vascularity, though this Doppler pattern alone is not considered reliable enough to definitively distinguish these entities, and biochemical testing (such as plasma or urine metanephrines) and correlation with other imaging features remain essential for accurate diagnosis, particularly given the clinical importance of not missing a pheochromocytoma before any biopsy or intervention. This contradicts a claim that the two entities always show completely identical patterns with imaging alone always sufficient to distinguish them (B), since neither the identical-appearance claim nor the imaging-alone-sufficiency claim is accurate; both entities are, in fact, assessable with Doppler, not exclusively the pheochromocytoma (contradicting C); and the general pattern described runs the opposite direction from what is claimed in D.

94. A. A. Venous thrombosis of the pancreatic graft's venous outflow is a recognized and potentially graft-threatening complication following pancreas transplantation, and Doppler surveillance can detect this complication by identifying absent or markedly abnormal (such as minimal or reversed) venous flow signal, supporting urgent further evaluation and potential intervention to try to salvage a still-viable graft before complete, irreversible graft loss occurs. This directly contradicts a claim that venous thrombosis has never been described and requires no surveillance at all (B), since it is a well-recognized transplant complication; venous outflow is very much clinically relevant to graft viability, not irrelevant with only arterial inflow mattering (contradicting C); and Doppler ultrasound does provide genuinely useful information regarding pancreas transplant venous patency, not none at all (contradicting D).

95. B. B. Despite being a vascular lesion composed of blood-filled vascular spaces on other imaging techniques (such as contrast-enhanced CT/MRI, which show characteristic peripheral nodular enhancement), a hepatic hemangioma typically demonstrates minimal to absent detectable internal flow on conventional Doppler ultrasound, since the blood flow within its slow-flow vascular spaces is often too slow to generate a detectable Doppler signal with standard settings — a notable, somewhat counterintuitive point given the lesion's fundamentally vascular composition. This is the opposite of extremely high-velocity, chaotic flow throughout, which would be more suggestive of a different, more aggressively vascular process (contradicting A); a hemangioma does not uniformly replace all normal surrounding hepatic flow, remaining a discrete, well-defined focal lesion rather than a diffuse process (contradicting C); and hepatic hemangiomas are well characterized with ultrasound (including Doppler and contrast-enhanced techniques), not requiring nuclear medicine imaging exclusively (contradicting D).

96. C. C. RVOT-based cardiac output calculation applies the same general principle as the standard LVOT-based method (cross-sectional area × velocity-time integral × heart rate) but uses the pulmonary valve/RVOT's own separately measured cross-sectional area and Doppler velocity-time integral instead of the left-sided LVOT/aortic measurements, providing an alternative calculation site sometimes used when LVOT measurement is technically difficult or when right-sided output is specifically of interest. This is not the same measurement site as the standard LVOT method, which uses the left-sided outflow tract, not the mitral inflow (contradicting A) or the aortic valve, which is the LVOT method's actual measurement site, not a separate alternative (contradicting B); and it is not based on the inferior vena cava, an unrelated site not used for this specific stroke-volume-based cardiac output calculation method (contradicting D).

97. A. A. Doppler surveillance following IVC filter placement can assess for filter-associated IVC thrombosis or significantly reduced flow through or around the filter, both recognized potential device-related complications that, if identified, would warrant further evaluation and appropriate management. This is not a claim that only X-ray positional confirmation matters with Doppler contributing nothing useful, since Doppler specifically assesses functional flow status, information X-ray positioning alone cannot provide (contradicting B); IVC filter presence has no relationship to determining the patient's blood type, an unrelated laboratory parameter (contradicting C); and filter-associated thrombosis and flow complications are, in fact, recognized and described complications, not something never described in association with any IVC filter (contradicting D).

98. B. B. Cross-sectional area = $\pi \times (\text{radius})^2 = \pi \times (0.4 \text{ cm})^2 \approx 0.503 \text{ cm}^2$; volume flow rate = area x mean velocity = $0.503 \text{ cm}^2 \times 25 \text{ cm/s} \approx 12.6 \text{ cm}^3\text{/s}$ (mL/s), closest to option B. Option A is roughly half the correct value, consistent with a radius/diameter confusion in the area calculation. Option C approximately equals the mean velocity value alone, without correctly incorporating the calculated cross-sectional area at all. Option D is roughly double the value obtained by using diameter directly as if it were radius in the area formula, an area-calculation error.

99. B. B. Velocity ratio = stenotic segment PSV / proximal segment PSV = 320 cm/s / 80 cm/s = 4, expressed as a 4:1 ratio — a commonly used criterion (alongside the absolute PSV value itself) in grading the severity of an arterial stenosis at various vascular sites. Option A (2:1) and Option C (8:1) are both inconsistent with the correct division of the two given values. Option D (1:4) inverts the correct ratio direction, expressing the proximal-to-stenotic ratio rather than the stenotic-to-proximal ratio actually being asked for.

100. A. A. RI = (PSV - EDV) / PSV = (60 - 20) / 60 = 40/60 ≈ 0.67, a value generally considered within the normal range for a native renal artery (normal RI is typically below approximately 0.7), reflecting relatively low downstream vascular resistance. Option B (0.33) results from an incorrect calculation, roughly the inverse relationship of the correct answer. Option C (3.0) results from dividing PSV by EDV directly rather than applying the correct RI formula. Option D (1.33) is greater than 1, a value that is not possible for a correctly calculated RI, since RI must fall between 0 and 1 by definition.

101. A. A. Pulsatility index is calculated as (peak systolic velocity - end-diastolic velocity) divided by the mean velocity across the full cardiac cycle, distinguishing it from resistive index, which instead divides that same numerator by the peak systolic velocity alone — PI's use of mean velocity in the denominator makes it a somewhat different (and in some contexts more sensitive) index of downstream resistance compared with RI, even though both are conceptually related resistance indices. This contradicts a claim that PI is simply PSV divided directly by EDV with no subtraction step, which instead describes yet another distinct index (the S/D ratio), not PI (contradicting B); PI and RI are not calculated using exactly the same formula despite both being resistance-related indices, since their denominators specifically differ (contradicting C); and PI does have a well-established, specific numeric formula, not being purely a subjective visual impression with no calculation at all (contradicting D).

102. D. D. S/D ratio = peak systolic velocity / end-diastolic velocity = 90 cm/s / 30 cm/s = 3, expressed as a 3:1 ratio, a simpler alternative resistance-related index to RI or PI, calculated as a direct ratio rather than incorporating a subtraction step. Option A (1:3) inverts the correct ratio direction. Option B (0.33:1) is mathematically equivalent to the inverted ratio in A, expressed as a decimal instead of a whole-number ratio, still reflecting the same directional error. Option C (9:1) does not correctly reflect the given values' actual ratio.

103. A. A. Serial trending of umbilical artery pulsatility index above the expected normal range for gestational age helps monitor placental vascular resistance and function over time in the context of suspected fetal growth restriction, with a rising PI trend supporting closer surveillance even before a more severe, later-stage finding such as absent or reversed end-diastolic flow develops — trending the PI over time can add information beyond a single isolated measurement alone. This directly contradicts a claim of providing no useful clinical information whatsoever (B); a PI value does not directly diagnose a fetal chromosomal abnormality, an entirely different type of diagnostic information requiring genetic testing, not a Doppler resistance index (contradicting C); and umbilical artery PI trending is one component within a broader growth-restriction surveillance program, not a replacement for other necessary components such as growth measurements and additional Doppler vessels (contradicting D).

104. A. A. A post-traumatic arteriovenous fistula characteristically shows high-velocity, turbulent flow at the fistula site, with arterialized (higher-velocity, more pulsatile than typical venous flow) flow detected within the adjacent vein, reflecting direct transmission of arterial pressure through the abnormal connection between the injured artery and vein — a Doppler finding pattern conceptually similar to, though resulting from a different mechanism than, an iatrogenic post-biopsy AV fistula. This is not a completely normal-appearing waveform at the site, since the abnormal turbulent, arterialized pattern is precisely the finding that supports the diagnosis (contradicting B); it is not associated with a complete absence of flow signal, since the fistula itself represents an area of abnormally increased, not absent, flow (contradicting C); and this same general Doppler finding pattern can result from various causes of vascular trauma, not being restricted exclusively to iatrogenic post-biopsy fistulas as claimed in D.

105. D. D. NASCET methodology calculates percent stenosis by comparing the narrowed diameter at the stenosis against the diameter of the normal-caliber distal internal carotid artery beyond the stenosis, while ECST methodology instead uses an estimated normal carotid bulb diameter at the level of the stenosis itself as the reference point — because the carotid bulb is normally somewhat wider than the distal ICA, these two different reference points produce different calculated percentage stenosis values for the exact same anatomic degree of narrowing, an important methodological distinction relevant to interpreting stenosis-grading literature and criteria. This directly contradicts a claim that the two methods always produce numerically identical values with no methodological difference (A); ECST has, in fact, been used clinically, not exclusively NASCET as claimed in B; and Doppler-based ultrasound stenosis criteria (such as velocity thresholds) were developed and validated with reference to methodologies like these, not entirely unrelated to them, contradicting C.

106. C. C. Because supine positioning in later pregnancy can lead to inferior vena cava compression by the gravid uterus, reducing maternal venous return and cardiac output in a way that can correlate with detectable changes in fetal or uteroplacental Doppler parameters, positioning the patient in a left lateral decubitus or otherwise tilted position for portions of the exam helps reduce caval compression, supporting a more physiologically representative Doppler assessment less confounded by positional maternal hemodynamic effects. This is not a reason to never perform any obstetric ultrasound at all, an overreaching and impractical conclusion (contradicting A); positional changes alone should not be used to automatically diagnose fetal distress without considering other clinical and Doppler information together (contradicting B); and this consideration supports appropriate positioning to obtain more reliable Doppler information, not eliminating the Doppler component of the exam altogether (contradicting D).

107. C. C. A congenital arteriovenous fistula is present from birth as part of an underlying congenital vascular anomaly, differing fundamentally in developmental origin and timing from an acquired (traumatic or iatrogenic) fistula, which instead results from a discrete later-life traumatic or procedural event — despite this different origin, the resulting Doppler finding of arterialized, turbulent flow at the fistula site can appear broadly similar between congenital and acquired fistulas, since the underlying abnormal direct arterial-to-venous connection produces analogous hemodynamic consequences regardless of how it originated. This contradicts a claim that the Doppler flow characteristics are entirely different with no shared features at all (A), since the resulting flow pattern is often similar despite the different origin; congenital fistulas are, by definition, present from birth and can be identified at any age including in children, not restricted to patients over 80 (contradicting B); and a congenital fistula does produce detectable Doppler abnormalities, not an absence of any detectable finding, contradicting D.

108. B. B. Combining contrast-enhanced signal augmentation (which boosts the genuine flow signal's strength via strongly backscattering microbubbles) with tissue harmonic Doppler processing (which can help further suppress residual tissue or artifactual signal not arising from the contrast microbubbles) can together improve the overall signal-to-noise ratio in a technically difficult vessel beyond what either technique alone might achieve, a combined-technique approach sometimes used for particularly challenging Doppler assessments. This is not a claim that combining any two Doppler techniques is never permitted under any circumstance, an overly absolute and inaccurate claim (contradicting A); the two techniques are not functionally identical, since one boosts signal strength via a contrast agent while the other suppresses non-harmonic artifact signal through processing, distinct mechanisms (contradicting C); and harmonic processing does not eliminate the ongoing need for the contrast agent itself, since the two techniques work together rather than one substituting for the other (contradicting D).

109. D. D. No single technique optimally addresses all three needs at once: an optimized PW Doppler approach with a low wall filter and low scale maximizes sensitivity to detect a genuine, very slow near-occlusive residual flow signal that could otherwise be missed or mistaken for complete occlusion; CW Doppler is best suited to accurately capture a co-existing high-velocity stenotic jet without aliasing, since CW has no Nyquist limit; and PW Doppler's range-gating capability allows precise localization of signal specifically to one of two closely adjacent vessels — using each technique for its particular strength addresses the full complex scenario together. Grayscale alone (A) provides no flow information at all, missing the core of what is being assessed. Power Doppler alone (B) lacks the velocity/directional information and range resolution needed for the jet-characterization and localization components. Color Doppler alone (C) would likely miss the very slow near-occlusive flow (better suited to low-wall-filter PW) and would alias on the high-velocity jet, since color Doppler remains a pulsed technique subject to the Nyquist limit.

110. C. C. The guiding principle for technique selection in a trauma-focused vascular protocol is matching the specific combination of grayscale, color, power, and spectral Doppler techniques to the actual clinical question and injury pattern presented by a given patient — for example, a suspected simple hematoma may be adequately assessed with grayscale and compression technique alone, while a suspected high-flow arteriovenous injury would instead prioritize spectral and color Doppler, with CW added if a very high-velocity jet is suspected — rather than mechanically applying one single fixed technique combination uniformly regardless of the actual presentation. This contradicts an approach of always using every technique simultaneously for every patient regardless of injury pattern, which would be inefficient and is not how thoughtful, question-driven technique selection actually works (contradicting A); selecting based solely on scan-time efficiency without regard to diagnostic adequacy for the specific injury risks missing what the actual clinical question requires (contradicting B); and selecting based solely on which technique was most recently added to the system, rather than its actual clinical suitability, is not a sound guiding principle (contradicting D).