Chapter 1

Questions

1. The speed of sound in tissues is:
   A. Roughly 1540 m/s
   B. Roughly 1540 km/s
   C. Roughly 1540 cm/s
   D. Roughly 1540 m/min

2. The mitral flow measurements in a 62-year-old man are: left ventricular (LV) isovolumic relaxation time (IVRT) 50 ms, E/A ratio 1.5 and E-wave deceleration time 140 ms. This is suggestive of:
   A. Normal left atrial (LA) pressure
   B. Abnormal LV relaxation
   C. High LA pressure
   D. None of the above

3. The frame rate increases with:
   A. Increasing the depth
   B. Reducing sector angle
   C. Increasing line density
   D. Adding color Doppler to B-mode imaging

4. The mitral flow measurements in a 1-year-old child are: LV IVRT 50 ms, E/A ratio 2.5 and E-wave deceleration time 120 ms. This is:
   A. Normal
   B. Suggestive of abnormal LV relaxation
   C. Suggestive of high LA pressure
   D. Is pseudonormal

5. Determination of regurgitant orifice area by the proximal isovelocity surface area (PISA) method is based on:
   A. Law of conservation of mass
   B. Law of conservation of energy
   C. Law of conservation of momentum
   D. Jet momentum analysis

6. In which situation can you not use the simplified Bernoulli equation to derive the pressure gradient?
   A. Peak instantaneous gradient across a nonobstructed mitral valve
   B. Peak gradient across a severely stenotic aortic valve

C. Mean gradient across a severely stenotic aortic valve
D. Mean gradient across a stenotic tricuspid valve

7. Which of the following resolutions changes with increasing field depth?
   A. Axial resolution
   B. Lateral resolution

8. With a fixed-focus transducer with crystal diameter 20 mm and wavelength 2.5 mm, what is the depth of the focus?
   A. 40 m
   B. 30 mm
   C. 40 mm
   D. 4 m

9. A sonographer adjusts the ultrasound machine to double the depth of view from 5 cm to 10 cm. If sector angle is reduced to keep the frame rate constant, which of the following has changed?
   A. Axial resolution
   B. Temporal resolution
   C. Lateral resolution
   D. The wavelength

10. Which of the following properties of a reflected wave is most important in the genesis of a two-dimensional image?
    A. Amplitude
    B. Period
    C. Pulse repetition period
    D. Pulse duration

11. Increasing depth will change all of the following except:
    A. Pulse duration
    B. Pulse repetition period
    C. Pulse repetition frequency
    D. Duty factor

12. The two-dimensional images are produced because of this phenomenon when the ultrasound reaches the tissue:
    A. Refraction
    B. Backscatter
    C. Specular reflection
    D. Transmission

13. Attenuation of ultrasound as it travels to the tissue is increased by:
    A. Greater depth
    B. Lower transducer frequency
    C. Blood rather than soft tissue like muscle
    D. Bone more than air

14. The half-intensity depth is a measure of:
    A. Ultrasound attenuation in tissue
    B. Half the wall thickness in mm
    C. Coating on the surface of the transducer
    D. Half the ultrasound beam width

15. What is the highest pulse repetition frequency (PRF) of a 3 MHz pulsed wave transducer imaging at a depth of 7 cm?
    A. 21 000 Hz
    B. 2 333 Hz
    C. 11 000 Hz
    D. 2.1 million Hz

16. Examples of continuous wave imaging include:
    A. Two-dimensional image
    B. Volumetric scanner-acquired LV image
    C. Color flow imaging
    D. Nonimaging Doppler probe (Pedoff)

17. Which of the following manipulations will increase the frame rate?
    A. Increase depth
    B. Increase transmit frequency
    C. Decrease sector angle
    D. Increase transmit power

18. The lateral resolution increases with:
    A. Decreasing transducer diameter
    B. Reducing power
    C. Beam focusing
    D. Reducing transmit frequency

19. Axial resolution can be improved by which of the following manipulations?
    A. Reduce beam diameter
    B. Beam focusing
    C. Reduce gain
    D. Increase transmit frequency

20. Type of sound used in medical imaging is:
    A. Ultrasound
    B. Infrasound
    C. Audible sound

Answers for chapter 1

1. **Answer: A.**
   Hence travel time at a depth of 15 cm is roughly 0.1 ms one way (154 000 cm/s or 154 cm/ms or 15 cm per 0.1 ms) or 0.2 ms to and fro. This is independent of transducer frequency and depends only on the medium of transmission.

2. **Answer: C.**
   High LA pressure. Normal IVRT in adults is 70–100 ms, E/A ratio is about 1 and E-wave deceleration time is 160–250 ms. High LA pressure shortens IVRT and E-wave deceleration time and increases early LV filling. Abnormal LV relaxation has exactly the opposite effect on the mitral flow profile. Very young children may have a pattern mimicking high LA pressure because of superefficient LV relaxation, which promotes early LV filling.

3. **Answer: B.**
   Reducing the sector angle will reduce the time required to complete a frame by reducing the number of scan lines. This increases the temporal resolution. Decreasing depth will increase the frame rate as well. Adding color Doppler will reduce the frame rate.

4. **Answer: A.**
   This is normal and results from a very efficient relaxation process, which facilitates early diastolic LV filling. Rapid E-wave deceleration results in physiological S3. And also, as most of the filling occurs in early diastole, children are able to tolerate rapid heart rates and loss of atrial kick without much of a problem. In other words, efficient relaxation mimics high LA pressure in terms of mitral inflow pattern.

5. **Answer: A.**
   The law of conservation of mass is the basis of the continuity equation. As the flow rate at the PISA surface and the regurgitant orifice are the same, dividing this by the velocity at the regurgitant orifice obtained by continuous wave Doppler gives the effective regurgitant area (regurgitant flow rate in cm^3/s divided by flow velocity in cm/s equals effective regurgitant area in cm^2).

6. **Answer: A.**
   In a nonobstructed mitral valve, significant energy is expended in accelerating the flow (flow acceleration). As viscous losses in this situation are minimal, the other two components (flow acceleration and convective acceleration) of the Bernoulli equation have to be taken into account. In the simplified Bernoulli equation, the flow acceleration component is ignored. Put simply, when you deal with low-velocity signals from pulsatile flows, the simplified Bernoulli equation does not describe the pressure flow relationship accurately.

7. **Answer: B.**
   Lateral resolution depends on beam width, which increases at increasing depths. Axial resolution depends on spatial pulse length, which is a function of transducer frequency, pulse duration and propagation velocity in the medium.

8. **Answer: C.**
Depth of focus equals crystal diameter squared divided by wavelength multiplied by 4. In this situation, 400/10 = 40 mm.

9. **Answer: C.**
Lateral resolution diminishes at depths due to beam divergence. Frame rate determines the temporal resolution. Wavelength is a function of the transducer and is independent of depth and frame rate adjustments.

10. **Answer: A.**
Amplitude or strength of the reflected beam and its temporal registration, which determines depth registration.

11. **Answer: A.**
Pulse duration is the characteristic of the pulse and does not change with depth. Increasing depth will reduce pulse repetition period, frequency and hence the duty factor.

12. **Answer: B.**
Backscatter or diffuse reflection produces most of the clinical images. Specular reflection reaches the transducer only when the incident angle is 90° to the surface, which is not the case in most of the images produced. Refracted and transmitted ultrasounds do not come back to the transducer.

13. **Answer: A.**
Attenuation is the loss of ultrasound energy as it travels through the tissue and is caused by absorption and random scatter. It is greater with longer travel path length as it has to go through more tissue. Attenuation is greater at higher frequencies due to smaller wavelength. Attenuation is greatest for air followed by bone, soft tissue and water.

14. **Answer: A.**
It is a measure of attenuation and reflects the depth at which the ultrasound energy is reduced by half. It is given by the formula: 6 cm/frequency in MHz. For example, for an ultrasound frequency of 3 MHz the half-intensity depth is 2 cm, and for 6 MHz it is 1 cm.

15. **Answer: C.**
The PRF is independent of transducer frequency and only determined by time of flight, which is the total time taken by ultrasound in the body in both directions. Ultrasound can travel 154 000 cm in a second at a travel speed of 1540 m/s. In other words, at 1 cm depth (2 cm travel distance) the technical limit to the number of pulses that can be sent is 77 000 per second (Hz). Hence the PRF equals 77 000/depth in cm.

16. **Answer: D.**
Pedoff is a continuous wave Doppler modality for velocity recording. All other modalities utilize the pulsed wave technique where each of the crystals performs both transmit and receive functions.

17. **Answer: C.**
Increase in frame rate occurs with reducing sector angle and depth. It is independent of transmit frequency and power.

18. **Answer: C.**

Focusing increases lateral resolution. Increasing transducer diameter and increasing frequency also increase lateral resolution.

19. **Answer: D.**

Increasing the transmit frequency will reduce the wavelength and hence the spatial pulse length. This will increase the PRF and the axial resolution. Beam diameter and focusing have no effect on axial resolution.

20. **Answer: A.**

Typical frequency is 2–30 MHz: 2–7 MHz for cardiac imaging, 10 MHz for intracardiac echocardiography and 20–30 MHz for intravascular imaging. Ultrasound in the 100–400 MHz range is used for acoustic microscopy. Frequency $> 20\,000$ Hz is ultrasound.