Physics Radiology
In-Training Test Questions
for Diagnostic Radiology Residents

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Commission on Education
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1. The limiting spatial resolution of ultrasound is similar to which other imaging modality?

A. Mammography
B. SPECT
C. MRI
D. **CT**

Rationale:

A. Incorrect. US resolution is about 0.3 mm for a 5 mHz probe, mammography is 0.03 mm for film-screen, 0.05 to 0.1 mm for FFDM.
B. Incorrect. US resolution is about 0.3 mm for a 5 mHz probe, SPECT is about 7 mm
C. Incorrect. US resolution is about 0.3 mm for a 5 mHz probe, MRI is about 1 mm
D. Correct. US resolution is about 0.3 mm for a 5 mHz probe, CT is about 0.4 mm

Reference:

Bushberg JT, Seibert JA, Leidholdt EM, Boone JM **The Essential Physics of Medical Imaging, 2nd Edition** p. 15 2002

2. Sensitivity is equal to which of the following?

A. **the true-positive fraction**
B. the true-negative fraction
C. the false-positive fraction
D. the false-negative fraction

Rationale:

A. Correct. Sensitivity is the ability to detect the abnormal. It is defined as the TP / (TP + FN).
B. Incorrect. Also known as specificity
C. Incorrect. X-axis on an ROC graph, 1-specificity
D. Incorrect. This is equal to 1-sensitivity

Reference:

Bushberg JT, Seibert JA, Leidholdt EM, Boone JM **The Essential Physics of Medical Imaging, 2nd Edition** p. 289 2002

3. An MRI fast-spin-echo (FSE) pulse sequence decreases the overall acquisition time compared to a standard-spin-echo (SE) pulse sequence by using which one of the following?

A. Very short TR
B. Very short TE
C. Multiple frequency encode gradient variations per TE
D. **Multiple phase encode gradient variations per TR**

Rationale:

A. Incorrect. The TR for FSE determines the image contrast weighting as it does in standard spin echo.
B. Incorrect. The TE for FSE determines the image contrast weighting as it does in standard spin echo.
C. Incorrect. Only one frequency encode gradient is applied for each TE period (although there are multiple TE's per TR interval in an FSE sequence).
D. Correct. Phase encode gradients determine the location of k-space data; for FSE imaging, this is performed by changing the gradients and creating subsequent echoes to fill k-space faster per TR interval.

Reference:

Essential Physics of Medical Imaging. Second Edition. Bushberg, Seibert, Leidholdt, Boone, Lippincott Williams and Wilkens, 2002. MRI, The Basics. Hashemi, Bradley, Lisanti. Second Edition. Lippincott, Williams & Wilkens, 2004.

4. Concerning abdominal multidetector CT (MDCT), the z-axis resolution MOST LIKELY increases with decreasing:

A. **Slice thickness**
B. Radiation dose
C. MAs (product of tube current and scan time)
D. Image noise

Rationale:

A. Correct. Spatial resolution in CT is dependent on the image matrix (FOV) in transaxial plane and slice thickness in z- direction. One of the driving force in MDCT is to obtain high spatial resolution and this is achieved by scanning very thin slice thickness.

B. Incorrect. The radiation dose per slice in CT increases with decreasing slice thickness. This is done in order to maintain lower image noise.

C. Incorrect. Decreasing mAs yeilds higher image noise and could degrade spatial resolution.

D. Incorrect. See correct answer.

Reference:

Essential Physics of Medical Imaging. Second Edition. Bushberg, Seibert, Leidholdt, Boone, Lippincott Williams and Wilkens, 2002.

5. A film cassette spot film is taken of the chest of a supine patient with an under-table tube on a fluoroscopic system. How does the spot film image taken with an under-table fluoroscopy system differ from a typical properly exposed PA chest radiography film performed using an upright Bucky with similar kVp and cassette?

A. The spot film will have significantly lower noise.
B. The longer exposure time will cause increased cardiac motion blurring for the spot film image.
C. **A larger difference in image size is seen between anterior and posterior structures in spot film image.**
D. The spot film yields lower entrance dose to patient.

Rationale:

A. Incorrect. Since both films are properly exposed and are using the same cassette, equivalent number of photons will be absorbed to produce the images, and they should have equivalent levels of noise.
B. Incorrect. The exposure time for the spot film should be shorter due to the shorter source-film distance
C. Correct. The shorter source-to-image distance with the fluoroscopic system will result in a wider beam divergence, and a larger difference in image magnification of structures on the posterior side of the patient versus the anterior side.
D. Incorrect. Because of the shorter source-to-image distance, the entrance dose for spot film will be greater than chest radiography.

Reference:

The Essential Physics of Medical Imaging, 2nd edition. J.T. Bushberg, J.A. Seiabert, E.M. Leidholdt, and J.M. Boone, Lippincott Williams & Wilkins (2002), Chap 6, p146.

6. For radiographs using a table Bucky cassette, the MOST LIKELY reason why the grid lines are not visible is due to which one?

A. Use of larger focal spot
B. Focusing of the grid at proper tube-grid distance
C. **Motion blurring of the grid**
D. Use of image post-processing

Rationale:

A. Incorrect. The use of large focal spot can cause some geometric blurring, however the amount of blurring is dependent on the geometric magnification, and the grid is next to the cassette and will have little magnification. Geometric blurring would also degrade the image.

B. Incorrect. Using the grid at the appropriate tube-grid distance is important to prevent cut-off, but it does not obscure the individual grid lines.

C. Correct. A bucky grid system moves or oscillates the grid to blur out the individual grid lines.

D. Incorrect. While there are techniques for reducing periodic artifacts, such as grid lines, image post-processing is not performed in film-screen radiography, and grid lines may be eliminated by use of the Bucky without post-processing.

Reference:

The Essential Physics of Medical Imaging, 2nd edition. J.T. Bushberg, J.A. Seiabert, E.M. Leidholdt, and J.M. Boone, Lippincott Williams & Wilkins (2002), Chap 6, p171.

7. A standard spin echo pulse sequence with TR = 4000 ms and TE = 90 ms will have image contrast chiefly dominated by _____ weighting.

A. T1
B. Proton density
C. **T2 X**
D. T2*

Rationale:

A. Incorrect: Standard spin-echo sequences rely on the fact that tissues with short (long) T1 will typically have a short (long) T2. T1 is the spin-lattice relaxation constant, which describes the time required for re-establishment of 63% of the longitudinal magnetization, and T2 is the spin-spin relaxation constant, which describes the time required for decay of the transverse magnetization to 37% of its original peak amplitude. T1 contrast is manifested by selecting a TR time that maximizes differences in the T1 characteristics of the tissues, and is typically between about 300-700 ms for a standard spin-echo sequence. In order to reduce the effects of T2 decay, a short TE (

B. Incorrect: TR is considered â€œlongâ€☐ in a standard spin-echo pulse sequence above about 800 to 1000 ms, where the longitudinal magnetization differences are manifested chiefly as spin-density (proton-density) variations, with minimal T1 weighting. While a TR of 4000 ms can certainly result in spin-density weighting, the other part of signal generation is the spin-spin decay of transverse magnetization, which requires a very short TE (

C. Correct: TR is considered â€œlongâ€☐ in a standard spin-echo pulse sequence greater than 800 to 1000 ms, where the longitudinal magnetization differences are manifested chiefly as spin-density (proton-density) variations, to reduce any T1 weighting effects. For TR = 4000 ms, there is little or no T1 weighting. Transverse magnetization losses (spin-spin decay) are due to T2 effects; by allowing the decay to occur over a relatively long time prior to producing an echo, more T2 contrast will result. For spin-echo sequences, TE > 50 ms is considered long, and will permit more transverse decay to occur, resulting in the manifestation of T2 contrast.

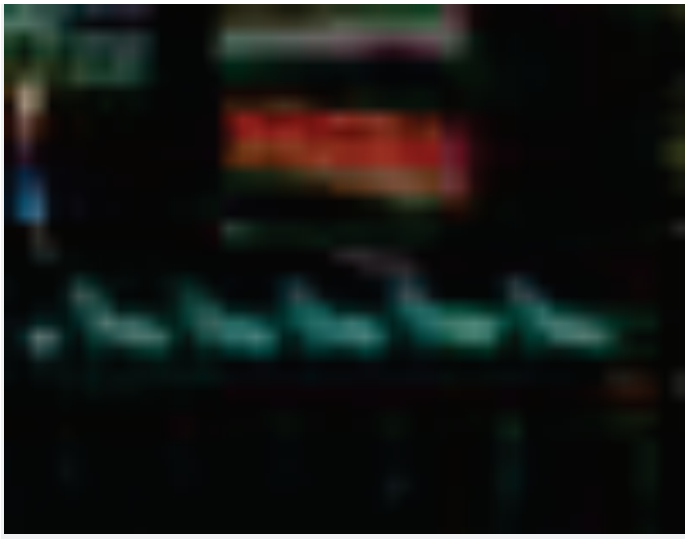
D. Incorrect: T2* weighting is not apparent with a standard spin-echo pulse sequence because of the 180ï,° refocusing pulse, which causes the de-phasing spins to be subject to external magnetic inhomogeneities in the opposite direction, which cancels the de-phasing effect in the reformed echoes.

Reference:

Bushberg JT, Seibert JA, Leidholdt EM, Boone JM. The Essential Physics of Medical Imaging, 2nd Edition, Chapter 14, p. 399.

8. The artifact illustrated in the spectral Doppler tracing is known as:

A. Mirror image artifact
B. **Aliasing**
C. Harmonic instability
D. Over gaining



Rationale:
A. Incorrect.
B. Correct.
C. Incorrect.
D. Incorrect.

Reference:
Allan et al Clinical Doppler Ultrasound 2006 page 19

9. What is the greatest advantage of conventional CR imaging systems over DR imaging systems?

A. Better detective quantum efficiency with lower dose
B. **Positioning flexibility**
C. Instantaneous readout of the latent image
D. Better intrinsic spatial resolution

Rationale:

A. Incorrect. CR typically exhibits lower detection effiency and lower detective quantum efficiency (a measure of the information transfer from the input x-rays to the information content of the output image), chiefly due to thinner screens (compared to CsI structured phosphors) or lower atomic number (compared to Gd2O2S screens : Gd, Z=53 versus BaFBr CR screens : Br, Z=35)

B. Correct. This is the main advantage of CR. A passive, cassette-based imaging detector that emulates the screen-film paradigm, allowing use of conventional imaging equipment and providing excellent positioning flexibility that active, DR detectors in their current technology state cannot provide.

C. Incorrect. This is the advantage of DR over conventional CR (not including the newer line-scan and mechanical CR automatic readers)

D. Incorrect. The intrinsic (prior to sampling) resolution of CR is lower than that of scintillator and photoconductor-based DR units. This is easily discerned by the MTF curves of each modality. The reasons are chiefly due to the use of a structured scintillator (CsI) used for most DR indirect detector systems, which confines the emitted light without spreading, and the use of high voltage placed across the semiconductor materials of DR direct detector, which actively collects the electron/hole pairs from spreading out during acquisition. Of all detector converters, the semiconductor detector has the highest intrinsic spatial resolution.

Reference:

Essential Physics of Medical Imaging. Second Edition. Bushberg, Seibert, Leidholdt, Boone, Lippincott Williams and Wilkens, 2002.

10. Which of the tissue is the least sensitive to damage from ionizing radiation?

A. Breast tissue
B. **Skin**
C. GI tract
D. Gonads

Rationale:

A. Incorrect. Breast tissues are highly sensitive to ionizing radiation.
B. Correct. Among the tissues listed, skin is the least sensitive to damage. The radiation damage to skin is mostly due to deterministic effect. The skin damage occurs only if the skin receives greater than certain threshold dose (2 Gy) which can results from prolonged fluoroscopy exposure.
C. Incorrect. GI tract are highly sensitive to ionizing radiation and is next only to gonadal tissues in terms of sensitivity.
D. Incorrect. Gonads are the most sensitive tissues to damage from ionizing radiation.

Reference:

Radiology Review - Radiologic Physics. Nickoloff EL & Ahmad N, Chapter 15.