Multi choice quiz with motivation on X-ray Imaging

This quiz is intended to test your knowledge on topics that could be part of the exam. It is possible that the exam will include 1-2 multi-choice quiz explaining your choice.

1) **In x-ray imaging, quantum noise is determined by**

a. Energy of x-rays hitting the detector
b. Number of x-rays hitting the detector
c. Tissue contrast
d. Amount of scatter hitting the detector

Quantum noise is principally determined by the number of photons (according to a Poisson distribution) received by the detector: more photons, less noise. To be complete, another form of noise is scatter noise that can be considered a type of structured or background noise, and it is determined by Rayleigh and mostly Compton effect or secondary radiation.

2) **Tissue contrast is generated by what type of interaction**

a. Coherent (Rayleigh) scatter
b. Incoherent (Compton) scatter
c. Photoelectric effect
d. Overall attenuation
e. Beam hardening effect

Photoelectric absorption, or the photoelectric effect, is essential to the formation of the radiographic image. The photoelectric effect takes place when the energy of the incident x-ray is just slightly greater than the binding energy holding the electron it collides with in place. Photoelectric absorption ionizes the atom and the x-ray is completely absorbed. This results *in representation of the anatomy on the image receptor because energy is not being deposited.*

3) **Larger patients require higher tube currents (more radiation, increased air kerma) in order to improve image**

a. Contrast
b. Noise
c. Resolution
d. Dose

Since *larger patients attenuate X-ray beams more, fewer photons would be available to form the image. Since noise is related to the number of photons available (SNR is proportional to 1/sqrt(N)), we need to increase the number of X-rays to create a less noisy image. Tissue contrast is typically worse in large patients because of increased scatter, and that can be mitigate with anti-scatter grids.*

4) **Iodine is an effective contrast agent because**

    a. **It has a high likelihood of photoelectric interaction at diagnostic x-ray energies**
    b. It has a high likelihood of Compton interaction at diagnostic x-ray energies
    c. It has a high electron density
    d. It has a high mass density

The k-edge of iodine around 30 keV strongly increases its likelihood of photoelectric interaction, thereby increasing the attenuation.

5) **In order to distinguish cancer from glandular tissue, mammography relies on**

    a. Intravenous contrast agents
    b. High tube currents (mA)
    c. High x-ray energies to increase photoelectric effect
    d. Low x-ray energies to increase Compton scattering
    e. **Low x-ray energies to increase photoelectric effect**

The photoelectric effect predominates at low X-ray energies and is the best way to distinguish different soft tissues of breast.

6) **Molybdenum is traditionally used as an x-ray anode in mammography because of its**
    a. Good heat capacity
    b. **Characteristic x-rays**
    c. Efficient Bremsstrahlung radiation
    d. Intrinsic filtration

Molybdenum is an ideal anode for producing low-energy x-rays because it has characteristic X-rays at lower keV energy than Tungsten. The lower energy range very good photoelectric interactions in glandular tissue.

7) **In x-ray imaging, scatter:**

    a. Contributes to better tissue contrast
    b. **Degrades tissue contrast**
    c. Has no effect on tissue contrast

Scatter degrades tissue contrast by adding a large amount of 'background' noise. So, CNR decreases.

8) **The major disadvantage of using anti-scatter grids is**

    a. Worse resolution
    b. **Increased dose**
    c. Worse contrast

d. Longer imaging time

Because grids attenuate primary beam x-rays, they decrease signal; for the same reason, the quantum noise increases. The combination of these effects requires an increased dose to obtain the same image noise.

9) Collimation results in

a. Increased radiation exposure to the patient
b. Increased scatter within the patient
c. Improved tissue contrast

By reducing the FOV by collimation we also reduce the scatter from elsewhere in the body so collimation improves contrast. There is decreased radiation to the patient because a smaller area is irradiated (and there is less scatter).

10) Changing filters (aka kernels) in filtered backprojection results in

a. Trade-off between image sharpness and noise
b. Different window levels in CT images
c. Different patient dose
d. Different reconstructed field of view (FOV)

Changing the filter in filtered backprojection allows more or less high-frequency features through. High frequencies are responsible for image sharpness - but also noise. Thus, sharper kernels to better visualize bone result in noisier images. Soft tissue kernels blur out the noise for a smoother image.

11) The main advantage of iterative reconstruction techniques versus filtered backprojection is

a. Better depiction of bone detail
b. **Better handling of noisy images**
c. Faster reconstruction
d. Lower pitch

Iterative reconstruction techniques use cycles of simulation to converge on the 'best' solution for what the CT image should be. These are less sensitive to noise than filtered backprojection and thus allow better-looking reconstructions from low-dose (thus noisy) CT scans.

12) In helical CT, a single coronal slice represents

a. A plane through the body perpendicular to the scan axis
b. A plane through the body oblique to the scan axis
c. A reconstruction made from projections at neighboring scan axis positions

In CT, the scanner never takes slices in the coronal plane; instead, slices are acquired in the transverse plane. Moreover, the slice is reconstructed by interpolating CT projections taken 180 degrees apart - which are separated along the scan axis based on the value of the pitch. So, the coronal slice is a reconstruction of neighboring z-position.

13) High-pitch techniques are useful for

a. Very small findings
b. Gated cardiac CT
c. Accurate multiplanar reconstructions
d. Fast scans

The advantage of a high pitch is that it reduces scan time and dose. However, it will blur small findings such as tiny liver lesions or nondisplaced fractures because it increase the partial volume artifact.

14) In helical CT, a low-pitch technique might be most helpful for

a. Scanning a tachypneic patient
b. Detecting a non-displaced fracture
c. Detecting a subtle liver lesion
d. Scanning a child

Low-pitch is most helpful for detecting small lesions, and gives less partial volume effects, so it would be ideal for detecting a non-displaced fracture.

15) The major technical challenge in 4DCT is

a. Spatial resolution
b. Acquiring a regular physiological signal for image rebinning
c. Contrast resolution
d. Three-dimensional reconstruction

In 4D CT, some kind of physiological movement (mostly breathing and heart beating) is compensated. To do that, the physiological signal has to be recorded over time and the images are rebinned on the basis of the amplitude and/or phase of the signal. However, if the movement is irregular the rebinning will fail, and more artifacts will be present.

16) The major determinant of temporal resolution in CT is

a. Gantry rotation speed
b. Reconstruction algorithm
c. Fan-beam angle
d. Detector collimation
e. Computer processing power

Temporal resolution represents the amount of time needed to reconstruct a single slice - which is the time needed to obtain 180 degrees (+ fan angle) of data. This is directly

determined by the gantry rotation speed, which represents a major engineering challenge in scanner design. While fan-beam angle is relevant, it plays only a minor role in temporal resolution. Pitch is also a relevant factor.