Specific question requests…

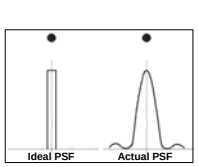
- Increasing kVp → increases penetrating power of x-rays
  - contrast decreases
  - dose increase proportional to kVp^2
- Increasing mAs → provides more x-rays therefore better statistics
  - contrast improves because ↓ noise
  - dose increase is linear with mAs
- The exposure for a given kVp and filtration is directly proportional to the mAs, HOWEVER, adjustments in the kVp affect the attenuation characteristics of the x-rays as they traverse the patient, so the mAs varies with the fifth power of the kVp

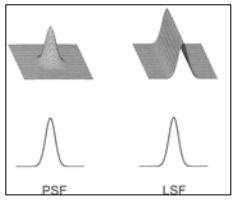
$$kVp_1^5 \cdot mAs_1 = kVp_2^5 \cdot mAs_2$$

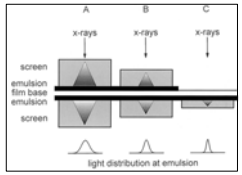
- ***To improve spatial resolution*** –
  - increase matrix
  - decrease FOV
  - decrease slice thickness (tomographic imaging),
  - decrease motion artifact (including sample rate for temporal imaging),
  - decrease air gap (obj-to-detector distance),
  - use smaller focal spot
- ***To improve contrast*** –
  - decrease kVp,
  - increase mAs (which decreases quantum noise)

Specific question requests…

- Point spread functions and line spread function describe the systems response to a stimulus (e.g. in nuclear medicine, a source of Tc-99m or in general radiography, an incident x-ray on a detector)







- PSF or LSF is a physical measure of the system resolution
  - In clinical practice, you can measure the PSF and LSF – it is related to the system MTF (which is much harder to make a physics measurement for)
  - Related to the detector system blur (not the blur due to motion)
    - Example: in screen film, the result PSF or LSF from a stimulus (incident xray) depends on the screen thickness → thicker screens will have a wider "spread" of the stimulus on the film

Review Questions

The ratio of heat to x-rays (heat : x-rays) produced in a typical diagnostic target is:

A. 1 : 99
B. 10 : 90
C. 50 : 50
D. 90 : 10
E. 99 : 1

Two filaments are found in some x-ray tubes. The purpose is to:

A. Function as a spare in case one filament burns out.
B. Produce higher tube currents by using both filaments simultaneously.
C. Double the number of heat units that the target can accept.
D. Enable the smallest focal spot to be used, consistent with the kVp/mA setting.

Review Questions

In an x-ray machine with a tungsten target, increasing the kVp from 100 to 125 will increase all of the following ***except***:

A. The total number of x-rays emitted.
B. The maximum energy of the x-rays.
C. The average energy of the spectrum.
D. The energy of the characteristic x-rays.
E. The heat units generated (for the same mAs).

A series of measurements has a mean of 100 counts. A range of ± σ is _____.

A. 95 – 105
B. 90 – 110
C. 68 – 132
D. 50 – 150
E. 33 – 167

$$\sigma = \sqrt{N} = \sqrt{100} = 10$$
$$N \pm 10 = [90,110]$$

To achieve a standard deviation of 2%, _____ counts must be collected.

A. 400
B. 1,414
C. 2,500
D. 10,000
E. 40,000

$$\%\sigma = \frac{\sigma}{N} * 100 = \frac{\sqrt{N}}{N} * 100 = \frac{100}{\sqrt{N}}$$

$$2 = \frac{100}{\sqrt{N}}$$
$$N = \left(\frac{100}{2}\right)^2 = 2500$$

Review Questions

A radioactive sample is counted many times and the mean is 2500 counts. 99.7% of the readings will lie between _____ and _____ counts.

A. 2300, 2700
B. 2400, 2600
C. 2350, 2650
D. 2450, 2550
E. 2500, 2700

- If a large # of measurements are made
  - Approx 67% will fall b/w +/- 1σ
  - Approx 95% b/w +/- 2σ
  - Approx 99.7% b/w +/- 3σ
- The σ = sqrt(N), or 50 in this case. Therefore 2500 +/- 150 = [2350, 2650]

Review Questions

How many counts must be collected in an instrument with zero background to obtain an error limit of 1% with a confidence interval of 95%?

A. 1000
B. 3162
C. 10,000
D. 40,000
E. 100,000

$$1\% = 0.01 = \frac{2\sigma}{N} = \frac{2}{\sqrt{N}}$$

$$N = \left(\frac{2}{0.01}\right)^2 = 40{,}000$$

- 95% CI means the counts fall within 2σ of the mean.

Review Questions

The modulation transfer function (MTF) is a tool for describing the _____ of an imaging system.

A. Properties of the characteristic (H&D) curve
B. Sharpness
C. Noise content
D. Latitude

Review Questions

All of the following affect the shape of the x-ray spectrum ***except***:

A. The added filtration.
B. The type of rectification used in the x-ray circuit.
C. The speed of rotation of the anode.
D. The energy of the electrons hitting the target.
E. The composition of the x-ray target.

Tungsten has the following binding energies: K = 69 keV, L = 12 keV, M = 2 keV. A 68 keV electron striking a tungsten target could cause emission of which of the following photons?

1. 66 keV characteristic x-ray.
2. 57 keV bremsstrahlung.
3. 57 keV characteristic x-ray.
4. 10 keV characteristic x-ray.

A. 1, 2, 3 and 4
B. 1, 3
C. 2, 4
D. 4 only

Review Questions

The original technique is 60 kVp, 40 mAs. If the kVp is changed from 60 kVp to 80 kVp, what adjustment should be made to the mAs to maintain the same exposure (i.e. dose)?

A. 95 mAs
B. 50 mAs
C. 20 mAs
D. 9.5 mAs
E. 5 mAs

$$kVp_1^5 \cdot mAs_1 = kVp_2^5 \cdot mAs_2$$

$$\left(\frac{kVp_2}{kVp_1}\right)^2 = \left(\frac{80}{60}\right)^2 \cong 1.78$$

Change in kVp from 60 to 80 increases the dose 78%.

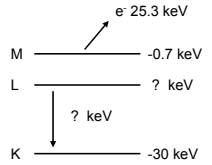
$$\left(\frac{kVp_2}{kVp_1}\right)^5 \cdot mAs_1 = \left(\frac{80\,kVp}{60\,kVp}\right)^2 \cdot 40\,mAs \cong 9.5\,mAs$$

- Exposure is proportional to kVp^2; the exposure for a given kVp and filtration is directly proportional to the mAs
- HOWEVER, adjustments in the kVp affect the attenuation characteristics of the x-rays as they traverse the patient, so the mAs varies with the fifth power of the kVp!

Review Questions

Consider an atom with the following binding energies: K-shell, 30 keV; M-shell, 0.7 keV. An electron with a kinetic energy of 25.3 keV is ejected from the M-shell as an Auger electron following L to K transition. The binding energy of the L-shell electron is _____ keV.

A. 1.4
B. 4.0
C. 4.7
D. 15.0
E. 29.3



- E = 25.3 + 0.7 = 26 keV where E is equal to the difference between the binding energies of the K- and L-shells.
- 26 keV = BE_K - BE_L = 30 keV - BE_L; BE_L = 4 keV.

Review Questions

A CT scanner is operated at 120 kVp and 200 mA. Scans are 1 second in duration. If the anode heat storage capacity of the x-ray tube is 2.4 MJ, how many consecutive CT slices can be taken safely without overheating the tube?

A. 40
B. 60
C. 80
D. 100
E. 120

$$\text{For 1 slice:}$$
$$120kVp \cdot 200mA \cdot 1\text{sec} = 24{,}000J = 24kJ$$

$$2.4MJ = 2400kJ$$
$$\frac{2400kJ}{24kJ} = 100slices$$

Review Questions

Referring to Figure 1, which demonstrates three different line spread functions (LSF), which LSF will yield the best spatial resolution?

A. LSF A
B. LSF B
C. LSF C

Figure 1:

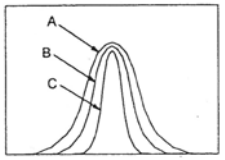
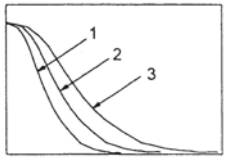


Figure 2:



Referring to Figure 1 which shows LSFs, and Figure 2 which shows the corresponding modulation transfer functions (MTFs), which MTF corresponds to LSF C?

A. MTF number 1
B. MTF number 2
C. MTF number 3

Review Questions

Low contrast detectability refers to the ability of a system to distinguish:

A. A calcified lung nodule.
B. A non-calcified lung nodule.
C. Between overlying and underlying tissues.
D. The size of a small fracture.
E. Vessels during the arterial phase of a normal angiogram.

Image contrast-to-noise ratio could not be increased by using:

A. Lower tube voltages
B. Higher-ratio grids
C. Larger x-ray beam areas
D. Screens with lower conversion efficiency
E. Slower films

Review Questions

The induction of cancer from exposure to radiation is:

A. Stochastic
B. Deterministic
C. Both
D. Neither

Skin burns from prolonged fluoroscopic exams are:

(Same choices as above)
Deterministic

Review Questions

Match the exposure or dose with the appropriate item:

A. 15 mR
B. 40 mR
C. 5 R
D. 10 R
E. 50 mrem

1. CT head scan ESE
2. Lateral chest ESE
3. 10 min fluoro (thin patient)
4. Monthly limit for a pregnant technologist

1. Ans: C. Typically 4-6 R.

2. Ans: B. P/A chest is @ 10-15 mR and Lateral chest images are 2-3x the ESE of the P/A chest.

3. Ans: D. Typically 1-2 R per min.

4. Ans: E. 0.5 mSv or 50 mrem per month.

Review Questions

Which has a higher estimated effective dose?

A. Cervical spine x-ray
B. Thoracic spine x-ray

A. Pelvic x-ray
B. Upper GI series

A. Mammogram
B. Extremity x-ray

X-Ray Interactions – Q&A

Which is characteristic of photon interaction with soft tissue?

A. Some Compton, some photoelectric, no pair production.
B. Some Compton, some pair production, no photoelectric.
C. Brehmstralung only.
D. Pair production only.
E. Compton only.

X-Ray Interactions – Q&A

In comparison to 20 keV photons, the probability of photoelectric interaction in bone at 60 keV is approximately:

A. 27 times as great.
B. 3 times as great.
C. The same.
D. 3 times less.
E. 27 times less.

- remember: PE $\propto Z^3/E^3$
- $\approx (Z/60)^3/(Z/20)^3 = (20/60)^3 = (1/3)^3 = 1/27$

X-Ray Interactions – Q&A

The ratio of Compton interactions in one gram of hydrogen to one gram of water is approximately:

A. 0.5:1
B. 1:1
C. 2:1
D. dependent on the photon energy
E. the ratio of the density of hydrogen to water

- Answer C: the number of Compton interactions depends on the number of electrons present. Most materials have the same number of electrons per gram, but hydrogen is an exception. It has one electron per nucleon (proton), whereas all other atoms have approximately one electron to every 2 nucleons (proton + neutron). Thus, hydrogen has approximately twice as many electrons per gram as water.

X-Ray Interactions – Q&A

The intensity of a beam is reduced by 50% after passing through x cm of an absorber. Its attenuation coefficient, μ, is:

A. $(0.693)\cdot$
B. $x/0.693$
C. $0.693/x$
D. $2x$
E. $(0.693)\cdot x^2$

- HVL = 0.693/μ, so μ = 0.693/HVL = 0.693/x

Screen-Film Radiography – Q&A

The penumbra associated with the image of the edge of an object placed 50 cm above the film plane, for an SID of 100 cm, and a focal spot size of 1.0 mm is _____ mm.

A. 0.01
B. 0.1
C. 1.0
D. 10
E. 100

- Answer C: From similar triangles, f/F = OID/SOD
- f = F (OID/SOD) = 1 (50/50) = 1.0

Screen-Film Radiography – Q&A

Two x-ray films, each with optical density of 1.5, are placed on top of one another. The fraction of incident light transmitted through the "sandwich" is _____.

A. 0.03
B. 0.015
C. 0.001
D. 0.0225
E. None of the above

- Answer C: $T = 10^{-OD}$ so $T = 1/10^{-3}$ or 1/1000 or 0.001 (remember the OD is additive for two films superimposed on top of each other)

Digital Radiography– Q&A

In digital radiography, image post-processing software can do all of the following except:

A. Reduce the appearance of noise
B. Enhance the appearance of edges
C. Produce artifacts
D. Reduce motion blur
E. Extend dynamic range

- Answer E: dynamic range is determined by the acquisition system

Digital Radiography – Q&A

Concerning computed radiography (CR), which of the following is true?

A. Numerous small solid-state detectors are used to capture the x-ray exposure patterns
B. It has better resolution than film
C. It is ideal for portable x-ray examinations, when phototiming cannot be used
D. It is associated with high reject/repeat rates
E. The image capture, storage and display are performed by the received

Digital Radiography – Q&A

Which of the following digital detectors directly converts x-ray energy into an electric current?

A. Photostimulable storage phosphor (PSP)
B. Structured cesium-iodide (CsI) scintillator
C. Amorphous selenium (a-Se) semiconductor
D. Charge-coupled device (CCD) photodiode
E. Thin-flat transistor device (TFT) photodiode

Radiation Biology – Q&A

The current "best" estimate (BEIR VII value) for the risk of fatal cancer from a high dose of 1 Sv received over a short period of time among 1 million exposed people is approximately:

A. 1
B. 10
C. 1000
D. 10,000
E. 100,000

Answer: E - On average, the BEIR VII lifetime risk model predicts that approximately **1 person in 100 would be expected to develop cancer from a dose of 0.1 Sv above background**

Radiation Biology – Q&A

At what time during human gestation is the fetus at greatest risk for the development of mental retardation resulting from irradiation?

A. 0-1 weeks
B. 1-3 weeks
C. 3-8 weeks
D. 8-15 weeks
E. 15-40 weeks

Radiation Biology – Q&A

Radiation-induced deterministic effects:

A. Include cancer induction
B. Are commonly produced by the procedures used in diagnostic radiology
C. Are rarely manifested earlier than 6 months following irradiation
D. May be produced at any dose
E. Vary in severity in a dose-dependent manner

Radiation Biology – Q&A

Which of the following chemical species is responsible for causing approximately two-thirds of the damage through the indirect action of x-rays?

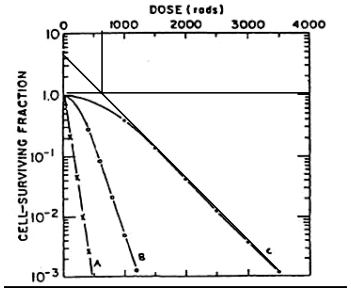
A. $OH\cdot$
B. H^3O^+
C. OH^-
D. H-
E. H^+

Answer: $OH\cdot$ (hydroxyl radicals) are responsible for the damage

Radiation Biology – Q&A

The quasi-threshold dose (D_q) for cell line C is:

A. 500
B. 700
C. 1,000
D. 1,500
E. impossible to determine from this data



Radiation Biology – Q&A

According to NCRP there is a negligible increase in the risk of adverse effects to the fetus, compared with other risks of pregnancy, up to a total dose of _____ mGy.

A. 5
B. 20
C. 100
D. 500
E. 1000

Radiation Biology – Q&A

A barium enema was performed on a 25 year-old female who was determined to be three weeks pregnant at the time of examination. As the consulting radiologist, you should:

A. Recommend a therapeutic abortion.
B. Counsel the patient that the embryo is at a significantly high risk for gross malformations as a result of the radiation exposure; however, an abortion is not necessarily warranted.
C. Discuss the implications of the radiation exposure with the hospital's legal department.
D. Do not discuss any potential effects of the radiation exposure on the embryo because very little is known about in utero radiation exposure and your comment would be totally speculative and unsubstantiated.
E. Explain to the referring physician and patient that the radiation received by the embryo by this diagnostic procedure is relatively small and that the increase in risk is negligible compared to the spontaneous incidence of congenital abnormalities.