The Royal Australian and New Zealand
College of Radiologists®

AIT
(Applied Image Technology)
Paper 1

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Case 1

Section 1 (Radiation Biology and Safety)

Question 1

Dose indicators are used when comparing the results of a dose audit (typically involving >20 patients) for a particular examination to an appropriate diagnostic reference level (DRL).

(a) Name two commonly used dose indicators for a CT examination and define each quantity. **(4 marks)**

(b) Name two commonly used dosimetric quantities for interventional angiography and define each quantity. **(3 marks)**

(c) State what statistic from the dose indicator data collected for a dose audit is used to compare to the DRL and explain why this particular statistic is employed. **(2 marks)**

(d) A dose audit for an AP abdominal x-ray examination was conducted at a radiology practice and the audit results indicated an entrance surface dose below the published DRL of 4 mGy for this procedure. However, it was found that one patient had a recorded entrance surface dose of 7.3 mGy. Discuss a possible reason for this higher dose given the audit result was judged to be below the DRL. **(1 mark)**

Question 2

(a) An average sized pregnant female patient who is 7 weeks pregnant requires a clinically justified AP abdominal X-ray. What advice should be given to the referring doctor who wants to know what he can tell his patient about any possible radiation concerns for the fetus given that:

(i) an entrance skin dose of 4 mGy is posted as the diagnostic reference level for an abdominal X-ray for your hospital;

(ii) automatic exposure control is routinely used.

Outline your response to this situation beginning with an approximate estimate of the fetal dose. **(6 marks)**

(b) At the time of the abdominal X-ray examination, a colleague suggests that before exposing the patient, a lead apron be placed on the patient's abdomen claiming that this will significantly reduce the dose to the fetus while still generating a diagnostically useful image. Discuss the appropriateness of such a dose reduction strategy. **(4 marks)**

Question 3

(a) CT fluoroscopy is a convenient imaging modality for needle biopsy including drainage procedures. It is accompanied by increased radiation risks to the radiologist or registrar performing the procedure. What are these risks and what precautions might you take to minimise them? **(5 marks)**

(b) A female nurse who works part-time 2 days per week in the interventional suite has just found out she is pregnant and is concerned about her radiation exposure and what dose limits might apply. How would you advise her and detail what steps, if any, you would take to demonstrate compliance with regulatory or hospital requirements. **(3 marks)**

(c) She is also concerned about the eye dose she receives and would like an indication of her exposure. How could this be achieved and what is the dose limit for such an exposure. **(2 marks)**

Case 2

Section 2 (Basic Physics & Technology including Mammography, Fluoroscopy & DSA)

Question 1

(a) Briefly explain the expected changes to the shape of the X-ray spectrum (see diagram) when:

(i) the mAs in increased; **(1 mark)**

(ii) the kVp applied to the X-ray tube is increased. **(2 marks)**

(b) Explain the intent behind the operation of an Automatic Exposure Control (AEC) system used with a Digital Radiography system. A description of the technology is not required. **(3 marks)**

(c) Discuss, with reasons, the impact of increasing the kVp on image quality and patient dose when a Digital Radiography unit is used in conjunction with an AEC system. **(4 marks)**

Question 2

(a) Explain why 'noise' is a stochastic process that is a persistent component of every x-ray beam as well as its potential effect on image quality. **(2 marks)**

(b)

(i) With regard to image noise, what is 'quantum mottle'? **(1 mark)**

(ii) What determines the amount present in an image? **(1 mark)**

(c)

(i) Will quantum mottle increase or decrease if the dose that reaches the imaging plate doubles? **(1 mark)**

(ii) By how much will the quantum mottle change if the dose is doubled? **(2 marks)**

(d) A referrer mentions that the x-ray images from your facility are diagnostically adequate but noisier than those from other service providers. In responding to the referrer, list three factors that you believe justify the quality of images from your facility. **(3 marks)**

Question 3

(a) K-edge filtration is frequently used in mammography. Explain what is meant by this concept and why it is particularly useful in mammography. **(3 marks)**

(b) When undertaking assessment of women with suspected breast disease, magnification mammography views are undertaken as an adjunct to the usual contact mammography views. Briefly describe three differences between the magnification technique and the contact technique. **(3 marks)**

(c) Discuss the advantages and disadvantages of magnification mammography when compared with contact mammography. **(4 marks)**

Case 3

Section 3 (CT, MRI, US & Nuclear Medicine)

Question 1

For images taken with a multislice CT scanner, describe the effects of increasing the following parameters (Pitch, kV and mAs per rotation) on each of the following features of the image:

- Signal to noise in the image
- Patient effective dose

You should assume that the parameters modified are the only ones changed. That is, ignore machine adjustments that might be made with a modern scanner.

You should also give brief reasons to justify your answers since half the marks for the questions will be given for correct reasons.

(a) Pitch **(3 marks)**

(b) kV **(4 marks)**

(c) mAs per rotation **(3 marks)**

Question 2

The attached diagram is a simplified version of an MRI pulse sequence. With respect to this pulse sequence answer the following questions:

(a) What type of sequence does this represent? **(1 mark)**

(b) The slices will be perpendicular to which axis? (give reasons for your answer) **(1 mark)**

(c) Which is the frequency encoding axis? (give reasons for your answer) **(1 mark)**

(d) What changes would you make to the RF pulses to convert this to a gradient recalled echo sequence? **(1 mark)**

(e) In terms of the times t1, t2, t3, and t4 define the echo time TE and the repetition time TR. **(2 marks)**

(f) What would be required to make T1 relaxation time dominate contrast in the image? **(2 marks)**

(g) What would be required to make T2 relaxation time dominate contrast in the image? **(2 marks)**

Question 3

(a) In gamma camera imaging, a collimator is fitted to the face of the camera.

(i) Briefly describe the physical structure of a gamma camera collimator. **(1 mark)**

(ii) Explain why it is necessary for image formation. **(2 marks)**

(b) For gamma camera imaging, an "energy window" is utilised.

(i) Define "energy window". **(1 mark)**

(ii) Using an energy window results in rejection of many unwanted photons. Given that Tc99m emits a single photon energy, what are the main type of unwanted photons that are rejected. **(1 mark)**

(iii) Describe the processes that cause these photons to be outside the "energy window". **(1 mark)**

(c) For PET imaging, briefly describe:

(i) The processes that occur between radioactive decay and photon detection. **(2 marks)**

(ii) How the signals from detected photons are used to spatially localise activity distribution. **(2 marks)**

Question 4

(a) For the following transducer types, describe how the individual crystal elements are fired in order to sweep the beam through the tissue being imaged:

(i) phased array **(2 marks)**

(ii) linear array **(2 marks)**

(b) One of the criteria for identifying a structure as being filled with fluid (such as a cyst) is the presence of an artefact in the image.

(i) Describe this artefact. **(1 mark)**

(ii) Explain what causes it. **(3 marks)**

(c) Most ultrasound real-time imaging devices display an MI value. This represents the likelihood of a particular phenomenon occurring.

(i) State what "MI" stands for. **(1 mark)**

(ii) State the phenomenon it refers to. **(1 mark)**