The Royal Australian and New Zealand College of Radiologists®

AIT
(Applied Image Technology)
Paper 1

Tuesday, 5 September 2017

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Case 1

Section 1 (Radiation Biology and Safety)

Question 1

During an abdominal angiographic procedure the total air kerma incident on a section of the patient's skin is estimated to be 3.5 Gy.

(a) What form of detriment to the patient might take place in the short and long term and what advice or notification might you give the patient's referring doctor? **(3 marks)**

(b) There are a number of procedural precautions that can minimize exposure to patient and staff. Name:

(i) two precautions that result in substantial reduction in exposure to both patients and staff;

(ii) one precaution that minimizes specifically staff dose; and

(iii) one precaution that specifically minimizes patient dose **(4 marks)**

(c) Name 3 organs and their radiation weighting factors that have been exposed in the above procedure and that would contribute substantially to the effective dose of the patient.

Note: organ radiation weighting factors have a value of either 0.12, 0.08, 0.04 or 0.01. **(3 marks)**

Question 2

(a) A woman, 26 weeks pregnant, undergoes a CTPA examination on day 1, which is then followed on day 2 with a non-contrast abdominal CT scan with full involvement of the foetus and a CT angiogram of the heart. The report from the medical physicist estimated the total foetal dose at 18 mSv.

(i) Discuss how you would brief the referring doctor in relation to the possible effects this series of examinations might have on the patient. **(3 marks)**

(ii) On review of the procedures undertaken, what areas might be investigated in order to optimise the procedure protocols for the future? (**4 marks)**

(b) For a pregnant staff member what is the regulatory radiation limit for the foetus? **(1 mark)**

(c) For a CT scan done on manual settings (no AEC) what is the effect on paediatric dose, if adult protocols are accidentally used to scan a child? **(2 marks)**

Question 3

(a) Dose limits apply to occupational and public exposures, but not to medical exposures of patients.

(i) What is the occupational dose limit for effective dose? **(1 mark)**

(ii) Define equivalent dose and briefly explain why dose limits for the lens of the eye and skin are expressed using this quantity. **(2 marks)**

(iii) Why is it inappropriate to set dose limits for medical exposures? **(1 mark)**

(b) The concept of Diagnostic Reference Levels (DRLs) is used in conjunction with which ICRP principle? **(1 mark)**

(c) Outline TWO key elements involved in the clinical use of DRLs. **(2 marks)**

(d) You would like to compare the doses at your hospital to national DRL values for the CT Chest examination. State TWO quantities indicative of patient dose to include in your dose audit. Briefly define these quantities. **(3 marks)**

Case 2

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

Question 1

(a) Briefly explain the heel effect and its impact on the radiographic image. **(2 marks)**

(b) What is the line focus principle? **(2 marks)**

(c) Describe how the heel effect and the line focus principle may be applied in chest radiography to optimise image quality. **(4 marks)**

(d) For a given X-ray tube how would you produce a harder or softer beam? **(2 marks)**

Question 2

(a) Define and explain how the terms contrast and spatial resolution are applied in digital radiography. **(4 marks)**

(b) Explain why contrast to noise ratio is a more useful metric than contrast alone when optimising the presentation of digital images. **(2 marks)**

(c) Identify and briefly describe the impact of 3 factors having a substantial effect on spatial resolution in projection radiographic imaging. **(4 marks)**

Question 3

(a) You are performing a fluoroscopically guided intervention in the abdomen of a large patient and the catheter movement appears stepped or jerky.

(i) What simple action, taken by you or the radiographer, involving changes in the X-ray imaging technique may be undertaken to remedy this situation? **(3 marks)**

(ii) Explain any possible negative consequences of the above action. **(2 marks)**

(b) As the above procedure continues you drive the gantry to a steep angle to provide an optimized view of a tortuous blood vessel. The image now appears unacceptably "grainy" or "noisy".

(i) What is the likely underlying reason for this image degradation? **(2.5 marks)**

(ii) Assuming that the procedure is unlikely to involve an excessive fluoroscopy time what remedial actions may be recommended? **(2.5 marks)**

Case 3

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

Question 1

(a) In CT, explain how iterative reconstruction might be utilised in conjunction with suitably altered operator controlled exposure factors to reduce patient dose while keeping image noise constant. (Note: Assume tube current modulation cannot be utilised) (6 marks)

(b) In helical multislice CT, the patient's effective dose can be significantly affected by overranging.

(i) Define overranging. **(2 marks)**

(ii) Explain the impact overranging will have on a patient's effective dose as the beam width is increased. **(2 marks)**

(Note: Assume that no technology to reduce the effects of overranging is employed)

Question 2

(a) In an MRI spin-echo pulse sequence, the slice selection gradient is used to select the position of the slice of tissue that is acted upon by an RF pulse. Describe how this is achieved. **(4 marks)**

(b) Safety in MRI is an important consideration in clinical practice.

(i) List three (3) safety issues associated with MRI and briefly describe why each is a concern. **(3 marks)**

(ii) For each one, list one step that could be taken to reduce or eliminate the potential hazard. **(3 marks)**

Question 3

(a) Time Gain Compensation (TGC) is used in all real time ultrasound imaging. Explain:

(i) What TGC is designed to achieve and why is it required. **(3 marks)**

(ii) How it is implemented**. (2 marks)**

(b) Explain why axial spatial resolution in ultrasound imaging is improved by increasing the ultrasound frequency. **(2 marks)**

(c) Given that improved axial spatial resolution is desirable, explain why high frequency ultrasound is not used for all real time ultrasound imaging. **(1 mark)**

(d) Real time ultrasound machines all display a TI or TIs value on the image display, for example "TIs 0.6 or TI 0.6". Discuss how TI/TIs is defined and used. **(2 marks)**

Question 4

(a) Gamma cameras are the basic imaging device for much of nuclear medicine imaging. The diagram below depicts a schematic of the major components of a gamma camera detector head. For each of the components labelled A to D in the diagram, name the component and briefly describe its function in the detector head's operation. **(6 marks)**

(b) The image below is a static nuclear medicine bone scan image that is of poor quality.

(i) Give the most likely reason for the poor image quality. **(1 mark)**

(ii) Discuss one method by which the image quality may be improved and detail any potential drawbacks associated with your suggestion**. (3 marks)**

(Note: assume that the gamma collimator was positioned as close to the patient as possible)