The Royal Australian and New Zealand
College of Radiologists®

AIT
(Applied Imaging Technology)
Paper 1

Tuesday, 20 October 2020

Head Office: Level 9, 51 Druitt Street, Sydney NSW 2000, Australia Ph: +61 2 9268 9777 Fax: +61 2 9268 9799 Email: ranzcr@ranzcr.edu.au
New Zealand Office: Floor 6, 142 Lambton Quay, Wellington 6011, New Zealand Ph: +64 4 472 6470 Fax: +64 4 472 6474 Email: nzbranch@ranzcr.org.nz Web: www.ranzcr.edu.au ABN 37 000 029 863

Case 1

Section 1 (Radiation Biology and Safety)

Question 1

a) Regarding ICRP recommended dose limits:

   i. What is the occupational dose limit for effective dose? (1)
   ii. What is the occupational dose limit for the lens of the eye and why is the dose to the lens of the eye a concern in radiology practice? (2)
   iii. Explain why it is inappropriate to set dose limits for medical exposures. (1)

b) Identify and outline the two key principles of radiation protection for medical exposure. (2)

c) You would like to compare the doses for CT chest examinations at your hospital with the national Diagnostic Reference Levels (DRL).

   i. State two quantities, with units, indicative of patient dose to include in your dose audit. (2)
   ii. If either of your survey dose quantities are higher than the DRL, describe two actions that should be taken. (2)

Question 2

a) Ionising radiation exposure may be expressed as absorbed dose, equivalent dose or effective dose. Define each of these quantities and give their units. (3)

b) Ionising radiation can cause harmful effects to persons irradiated.

   i. Briefly describe stochastic effects and tissue reactions (deterministic effects). (2)
   ii. Describe two possible effects for medical irradiation at low doses (<100 mGy). (1)
   iii. Describe two possible effects of high doses (>2 Gy) in interventional radiology. (1)

c) A patient has received a considerable dose of ionising radiation over the course of many years as a result of multiple CT scans. Their GP believes that they should have another CT scan, but is concerned about the previous dose received. What would your advice be concerning the advisability of further CT scans? How would this advice differ if the patient had no previous ionising radiation exposure? (3)

Question 3

a) Identify the major study which has contributed most to our knowledge of the carcinogenic effects of radiation. (1)
b) Name four organs or tissues most sensitive to radiation. (2)
c) The total air kerma incident on an area of a patient's skin during a lengthy vascular procedure is estimated to be 5Gy. State two possible tissue reactions the patient may experience, and their approximate timeframes. What should be the response of the clinical centre to such an event? (3)
d) It is a general observation that reducing peak skin dose (PSD) to the patient is associated with reduced occupational dose to the operator. List four practical measures, each of which would ensure minimized patient PSD, and therefore operator dose. (4)

Case 2

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

Question 1

In the context of digital projection radiographic imaging:

a) Define the term 'contrast resolution' and provide one example of a medical imaging examination where contrast resolution is critical. (2)

b) Define the term 'spatial resolution' and provide one example of a medical imaging examination where spatial resolution is critical. (2)

c) Identify, and briefly describe the impact of, three factors having a substantial effect on:
   i. contrast resolution (3)
   ii. spatial resolution (3)

Question 2

a) Describe, with reasons, the effects on:

   - beam quantity,
   - beam quality, and
   - the expected changes to the shape of the X-ray spectrum (see diagram)

   when the following parameters are changed:
   i. the added filtration is increased. (3)
   ii. the kVp is reduced to 60 kVp. (4)

b) Explain the role of the Automatic Exposure Control (AEC) system used in Digital Radiography. A detailed description of the technology is not required. (3)

Question 3

a) Name one filter material that is used in conjunction with a:

   i. Molybdenum (Mo) target (1)
   ii. Tungsten (W) target (1)

b) Briefly describe four differences between the magnification technique and the contact technique used in mammography. (4)

c) Describe, with reasons, four advantages associated with breast compression during mammography. (4)

Case 3

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

Question 1

a) The image shows a CT slice containing beam hardening and an additional artefact. Name this additional artefact and briefly explain why it has occurred. (2)

b) A CT exam is performed where the exposure factors are 120 kV, 150 mAs and a pitch of 1:1. Automatic current modulation is not employed.
The reconstruction is performed using filtered back projection with a bone filter. The reconstructed slice width is 1 mm.
The signal to noise ratio (SNR) of the resultant images is too low.
   i. If the patient is to be rescanned, discuss how you would change the mAs to increase the SNR, explaining how the change you suggest leads to the desired improvement. (2)
   ii. State the effect of this mAs change on the effective dose received by the patient and explain why it occurs. (2)
   iii. List two ways that the initial data set could have been reconstructed to improve SNR without having to rescan the patient. For each, briefly explain why the SNR is improved. (4)

Question 2

a) For a basic MRI spin echo pulse sequence, voxels within a particular slice are encoded with unique spatial information. Describe the key steps of this encoding process (NB. you do NOT need to address slice selection). (4)

b) Fast pulse sequences sometimes employ a reduced flip angle for the initial RF pulse. Explain why this allows for faster image acquisition compared to a conventional spin echo pulse sequence. (3)

c) For each patient device listed below, list one reason why it may contraindicate an MRI:
   i. Cardiac pacemaker (1)
   ii. Aneurysm clip (1)
   iii. Intracardiac pacing leads (1)

Question 3

c) Diagnostic ultrasound images can be created using a pulse echo mode. Describe the key principles of how pulse echo mode is employed to form a single line of the ultrasound image. Your answer should include how depth and brightness are determined. (3)

d) A fluid filled cyst is surrounded by normal liver tissue. Describe the appearance of the tissue immediately deep to the cyst, and explain why this occurs. (2)

e) Explain how the beam is swept through the field of view by a linear array transducer. (2)

f) Modern diagnostic ultrasound machines provide a thermal index value to the operator.
   i. Define this term. (1)
   ii. Suppose you are overseeing a fetal scan and the displayed TIS (thermal index of soft tissue) reaches 2.4. The sonographer asks if it is safe to continue scanning. What would you advise? (2)

Question 4

a) Gamma cameras are the basic imaging device for much of nuclear medicine imaging. The diagram (FIG. 1) depicts a schematic of the major components of a gamma camera detector head. For the components labelled A and B in the diagram, name each component and briefly describe its function in the detector head's operation. (3)

b) The image (FIG. 2) 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)

   ii. Discuss one method by which the image quality may be improved and detail any potential drawbacks associated with your suggestion (NB. assume that the gamma camera's collimator was positioned as close to the patient as possible). (3)

c) ^{99m}Tc is the most widely used radioisotope in Nuclear Medicine (NM) imaging. List two physical or chemical properties of ^{99m}Tc that make it ideally suited for NM imaging and explain why each property is desirable. (3)