RADIATION PROTECTION & BIOLOGY
STUDY GUIDE

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Summary:

1. The radiations of the electromagnetic spectrum all travel at the same velocity, 186,000 mps, but differ in wavelength.
2. Wavelength is the distance between two consecutive wave crests.
3. The number of cycles and crests per second is frequency; its unit of measure is the Hz.
4. Wavelength and frequency are inversely related.
5. Natural background and artificial (man-made) are the two kinds of radiation sources; natural sources account for the largest human exposure to radiation.
6. Medical radiation exposure is the largest source of artificial radiation exposure for humans.
7. Ionization is caused by high-energy, short-wavelength electromagnetic radiations that break apart electrically neutral atoms.
   A. Two types of radiation are produced at the anode through energy conversion processes: brems and characteristic radiation, brems radiation predominates.
8. Characteristics of photoelectric effect:
   A. Low-energy x-ray photon gives up all its energy ejecting an inner shell electron.
   B. Produces a characteristic ray.
   C. Major contributor to patient dose.
   D. Produces short-scale contrast.
9. Characteristics of compton scatter:
   A. High-energy x-ray photon uses a portion of its energy to eject an outer shell e.
B. Responsible for scattered-radiation film fog.
C. Radiation hazard to personnel.

10. Exposure dose depends on the type of interaction between x-ray photons and tissue and attenuation, therefore, is affected by radiation quality and the subject being irradiated (ie, thickness and nature of part).

11. Ionization of living tissue can cause chemical and biologic damage to somatic and/or genetic cells.

12. A nonthreshold dose-response curve indicates that there is no safe dose of radiation below which there will be no effects.

13. The linear, nonthreshold dose-response curve illustrates stochastic responses (cancer, genetic effects) and is the curve of choice for occupational exposure.

14. Occupationaly exposed workers are concerned with late effects of radiation such as carcinogenesis, cataractogenesis, and life-span shortening.

15. The Law of Bergeonie and Tribondeau states that the most radiosensitive cells are young, stem, and highly mitotic cells.

16. LET is another means of expressing quality and determining QF.

17. Identical absorbed doses of different kinds of radiation will cause different biologic effects, hence the need for a QF.

18. Diagnostic x-radiation is low-energy, low LET radiation.

19. Radiation effect on cells is named according to the interaction site, namely: direct effect, indirect effect, radiolysis of water.

20. The most radiosensitive cell is the lymphocyte.

21. As radiation professionals, we are obliged to keep radiation exposure to our patients and ourselves ALARA.

22. Delivery of ionizing radiation during early pregnancy is particularly hazardous.

23. There are five responses of concern to irradiation in utero: spontaneous abortion, congenital anomalies, mental retardation, microcephaly, and childhood malignancies.

24. Female patients of childbearing age should be questioned regarding LMP and possible pregnancy.

25. The 10-day rule may be employed to schedule elective radiography for female patients.

26. Gonadal shielding is easier in the male patient because the reproductive organs are located externally.

27. Genetic effects refer to damage to reproductive cells, affecting the reproductive capacity of the individual, or creating mutations that will be passed on to future generations.

28. The genetic dose of radiation borne by each member of the reproductive population is called the genetically significant dose (GSD).

29. Somatic effects include those manifesting themselves in the exposed individual and can be described as early or late effects.

   A. Early somatic effects can occur only after a very large single exposure of Radiation to the whole body.

   B. Late somatic effects include carcinogenesis, cataractogenesis, embryologic effects, and life-span shortening.

30. Occupationally exposed personnel are concerned with the late effects of radiation exposure.
PATIENT PROTECTION

Key Terms:

Added Filtration  
AEC  
Air Gap  
Aperture Diaphragm  
Backup Timer  
Beam Restrictor  
Breast Shields  
Collimator  
Cone  
Contact Shield  
Contour Contact Shield  
Inherent Filtration  
Ionization Chamber  
Linearity  
Minimum Response Time  
PBL  
Phototimer  
Polyenergetic  
Reproducibility  
Scattered Radiation  
Shadow Shields  
SSD

Summary:

1. Beam restriction is the most important way to reduce patient dose.
   A. Beam restrictors reduce the production of scattered radiation.
   B. Types of beam restrictors include aperture diaphragms, cones, and cylinders, and collimators (most efficient).

2. Devices used in most equipment today are PBL.
   A. A properly calibrated PBL will provide an unexposed border on all sides of the finished radiograph.

3. For the light and x-ray field to correspond accurately, the focal spot and light bulb must be exactly the same distance from the mirror.

4. When used properly, AEC's insure consistency of radiographic density.

5. There are two types of AECs: ionization chamber type and phototimer (photomultiplier).

6. The ionization chamber type is located between the patient and cassette.

7. The phototimer/photomultiplier type is located beneath the cassette.

8. Every AEC has a minimum reaction time.

9. AECs require accurate positioning and centering to produce predictable results.

10. The manual timer must be used as backup timer to avoid patient overexposure and tube overload.

11. Low mAs and high kVp factors keep patient dose to a minimum.

12. Proper calibration of equipment is essential for predictable results.

13. Proper selection of technical factors and an effective QA system help reduce exposure.

14. Filtration removes low-energy x-rays from primary beam, thereby
   a. Reducing patient dose
   b. Increasing the average energy of the beam

15. Filtration is usually expressed in mm of Al equivalent.

16. \[ \text{Inherent} + \text{added filtration} = \text{total filtration.} \]

17. Inherent filtration includes the glass envelope and oil coolant.

18. Added filtration includes the collimator, mirror, and thin Al sheets.
19. Equipment operated above 70 kVp must have at least 2.5 mm al equivalent.
20. Inherent filtration increases with tube age, thereby decreasing tube output.
21. Especially radiosensitive organs include the gonads, lenses, and blood forming organs.
22. Gonadal shielding should be used
   a. If the gonads lie in or within 5 cm of collimated beam
   b. If the patient has reproductive potential
   c. If diagnostic objectives permit
23. Three types of gonadal shields are
   a. Flat contact
   b. Shadow
   c. Contour contact
24. Male gonads are more easily and effectively shielded.
25. Breast shields should be used as needed.
26. To reduce exposure to reproductive organs and/or breasts, it is helpful to perform abdominal radiography and scoliosis series in the PA position whenever possible.
27. The fastest screen and film combination consistent with diagnostic requirements should be used.
28. Grids improve the radiographic image by reducing the amount of scattered radiation fog, but necessitate an increase in exposure.
29. An air gap can have the same effect as a low-ratio grid in decreasing, the amount of scattered radiation reaching the film; however, SID (FFD), and therefore exposure, must be increased to preserve recorded detail.
30. There are several important NCRP recommendations governing patient protection with which the radiographer should be familiar.
OCCUPATIONAL EXPOSURE

Key Terms:

Bucky-Slot Cover  Image Intensifier  Primary Beam
Control Booth  Inverse Square Law  Protective Curtain
Dead-Man Switch  Lead Apron  Secondary Barrier
Fetal Monitor  Lead Gloves  Secondary Radiation
Film Badge  Leakage Radiation  TLD
Fluoroscopic  Occupation Exposure
Gestational Dose Limit  Primary Barrier

Summary:
1. Time, distance, and shielding are the principle guideline for reducing radiographic exposure; monitoring evaluates their effectiveness.
2. The principle scattering object is the patient; others include the x-ray table, Bucky-slot closer, and control-booth walls.
3. It is important to be familiar with pertinent guidelines established by the NCRP regulating equipment design, performance, and use (NCRP) Report no. 102; radiation protection for medical and allied health personnel (NCRP Report no. 105); and recommendations on limits for exposure to ionizing radiation (NCRP 91).
4. Mechanical restraining devices should be used to immobilize patients when necessary during radiographic examinations.
5. Persons occupationally exposed to radiation must never assist (hold) patients during radiographic examinations.
6. If someone is required to assist a patient during an examination it is essential that radiation safety guidelines be adhered to.
7. There are several NCRP recommendations regarding protection during fluoroscopic procedures with which the radiographer should be familiar.
8. The cardinal principles of radiation protection are time, distance, and shielding.
9. Primary barriers protect from the useful (primary) beam, eg, the walls and doors of the radiographic room.
10. Secondary barriers protect from sources of leakage and scattered radiation, eg, x-ray tube housing, the patient.
11. Secondary barriers (eg, control-panel wall, lead apron) will not afford protection from the primary beam.
12. There are several NCRP recommendations with which the radiographer should be familiar regarding required thickness and uses of protective shielding.
13. A pregnant radiographer should advise her supervisor of her condition as soon as possible.
14. A pregnant radiographer should wear a second monitor at waist level under her apron.
15. Most occupational exposure is received in fluoroscopy, special procedures, and mobile radiography (especially C-arm).
RADIATION MONITORING

Key Terms:

Dose Equivalent (DE)  Roentgen  Pocket Dosimeter
Radiation Absorbed Dose (RAD)  Particulate Radiation  Unit of Exposure
Radiation Equivalent Man (REM)

Summary:

1. The roentgen, or unit of exposure (R unit) is the unit used to describe quantity of ionization in air.
2. The rad describes absorbed dose.
3. The rem is the unit of dose equivalency (DE), used to quantify occupational exposure.
4. Film badges are convenient, low-cost radiation monitors that are processed monthly.
5. TLDs utilize LiF crystals to store exposure information. They are more precise and more expensive than film badges and may be processed quarterly.
6. Film badges and TLDs measure exposure to beta, x, and gamma radiation.
7. Pocket dosimeters are thimble ionization chambers used to monitor larger quantities of radiation exposure, up to 200 mR.
8. Radiographers must strive to keep their occupational dose ALARA.
9. NCRP Report no. 91 recommends limits for exposure to ionizing radiation with which radiographers should be familiar.