BIO-2200: RADIOBIOLOGY

Cuyahoga Community College

Viewing: BIO-2200 : Radiobiology

Board of Trustees:
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Academic Term:
Fall 2023

Subject Code
BIO - Biology

Course Number:
2200

Title:
Radiobiology

Catalog Description:
Theories of the biological effects of ionizing radiation, quantities and units of measurement, proper protective measures for patient and personnel, effective dose equivalents radiation absorption processes and shielding, exposure monitoring devices.

Credit Hour(s):
2

Lecture Hour(s):
2

Lab Hour(s):
0

Other Hour(s):
0

Requisites

Prerequisite and Corequisite
BIO-1221 Anatomy and Physiology for Diagnostic Medical Imaging, and departmental approval: admission to Radiography Program.

Outcomes

Course Outcome(s):
Apply knowledge of the units, detection and measurement of all forms of ionizing radiation.

Objective(s):
a. Comprehend the need for radiation protection.
b. Relate radiation exposure to quantities and units.
c. Identify methods of detection and detection devices.

Course Outcome(s):
Apply knowledge of the interaction of radiation with living systems from molecules, cells, tissues and the body as a whole.

Objective(s):
a. Compare the different types of photon interactions.
b. Compare the different types of radiation.
c. Evaluate the biophysical events and relate them to the causes of biologic damage.
d. Analyze radiosensitivity and radioresistency.

e. Describe the somatic and genetic effects.
f. Explain the effects of irradiation on human tissues.

Course Outcome(s):

Understand the operation and principles of equipment used with radiation.

Objective(s):

a. Identify and display the appropriate use of image receptors.
b. Apply grid methodology.
c. Differentiate between digital, conventional and fluoroscopic radiation events or effects, and relate them to the cause of biologic damage.

Course Outcome(s):

Apply knowledge of the principles of radiation protection, including the responsibilities of the radiographer, radiation safety officer and radiation health agencies.

Essential Learning Outcome Mapping:

Civic Responsibility: Analyze the results of actions and inactions with the likely effects on the larger local and/or global communities.

Objective(s):

a. Describe the operation and principles of personnel monitoring and personnel monitoring devices.
b. Describe the regulatory/advisory agencies and their recommendations and regulations regarding radiation exposures.
c. Apply the as low as reasonably achievable (ALARA) concept for radiation workers and the general public.

Methods of Evaluation:

a. Examinations
b. Quizzes
c. Essay papers
d. Oral presentations
e. Workbook assignments
f. Weekly discussion presentations

Course Content Outline:

a. Introduction
    i. Molecules
        1. Ionic bonds
        2. Covalent bonds

b. Cell biology
    i. Cellular structure
        1. Cell membrane
        2. Cytoplasm
        3. Protoplasm
        4. Organelles
        5. Nuclei

    ii. Cellular function
        1. Cell chemistry
        2. Metabolism
        3. Organic and inorganic compounds
    iii. Cell proliferation
        1. Cell cycle
        2. Mitosis

3. Meiosis
4. Differentiation

c. Radiation production and characteristics
   i. Types of ionizing radiation
      1. Electromagnetic radiation
         a. X-rays
         b. Gamma rays
      2. Particulate radiation
         a. Alpha
         b. Beta
            i. Negatron
            ii. Positron
         c. Neutrons
         d. Protons
      3. Radioactivity
         a. Radioactive decay
            i. Alpha emission
            ii. Beta emission
            iii. Gamma emission
         b. Half-life ($T_{1/2}$)
      4. Sources of medical radiation exposure
         a. Diagnostic radiology
         b. Cardiovascular-interventional radiology
         c. Nuclear medicine
         d. Radiation oncology
      5. Transmission of photons
         a. Attenuated radiation
         b. Exit/remnant radiation
      6. Unmodified scattering (coherent, classical, Rayleigh, Thompson)
      7. Photoelectric effect
         a. Description of interaction
         b. Relation to atomic number
         c. Energy of incident photon and resulting product
         d. Probability of occurrence
            i. Atomic number
            ii. Photon energy
            iii. Part density
         e. Application
      8. Modified scattering (Compton's)
         a. Description of interaction
         b. Relation of electron density
         c. Energy
         d. Probability of occurrence
      9. Pair production
      10. Photodisintegration
d. Attenuation by various tissues
   i. Thickness by body part (density)
   ii. Type of tissue (atomic number)
e. Radiation energy transfer
   i. Radiosensitivity and response
      1. Molecular effects of radiation
         a. Direct effect
            i. Target theory
               1. Target molecules
               2. Cell death
         b. Indirect effect
            i. Radiolysis of water
      2. Factors affecting energy transfer
         a. Linear Energy Transfer (LET)
         b. Relative Biological Effect (RBE)

c. Factors influencing RBE
i. LET
ii. Oxygen enhancement ratio (OER)
3. Law of Bergonie and Tribondeau
a. Differentiation
b. Mitotic rate
c. Metabolic rate
4. Cell survival and recovery
a. Factors affecting survival
i. Linear energy transfer (LET)
ii. Oxygen enhancement ratio (OER)
iii. Relative biologic effect (RBE)
iv. Fractionation
v. Protraction
vi. Age
vii. Chemical agents
b. Lethal dose (100/60, 10/30, 50/30, 50/60)
5. Radiation dose-response curves
a. Linear, non-threshold
b. Nonlinear, non-threshold
c. Linear, threshold
d. Nonlinear, threshold

ii. Individual radiation effects
1. Somatic effects
a. Short-term
b. Long-term
c. Stochastic (probabilistic) effects/tissue reactions
d. Nonstochastic (deterministic) effects
2. Embryo and fetal effects

iii. Systemic response to radiation
1. Hemopoietic
2. Integumentary
3. Digestive
4. Urinary
5. Respiratory
6. Reproductive
7. Muscle
8. Nervous
9. Endocrine

iv. Total body irradiation
1. Acute radiation syndromes
a. Central nervous system
b. Hemopoietic
c. Gastrointestinal
2. Stages of response and dose levels
3. Factors that influence response
4. Medical interventions of response

v. Embryonic and fetal effects

vi. Late effects of radiation
1. Somatic response
a. Mutagenesis
b. Carcinogenesis
2. Genetic effects
3. Occupational risks for radiation workers

vii. Risk estimates

1. Relative
2. Excess
3. Absolute

f. Patient protection
   i. Principles (ALARA)
   ii. Radiation safety practices
      1. Beam restriction
      2. Shielding
      3. Exposure factors
      4. Patient considerations
         a. Positioning (e.g. AP versus PA)
         b. Communication
         c. Pediatric
         d. Morbid obesity
         e. Pregnancy
      5. Immobilization
   iii. Education
      1. Image Gently
      2. Image Wisely
      3. CARES (Communicating Advances in Radiation Education for Shielding) Committee
   iv. Equipment and accessories
      1. Filtration
      2. Image receptor
      3. Grid
      4. Automatic exposure control (AEC)
   v. Fluoroscopic procedures
      1. Last image hold
      2. Kerma display
      3. Magnification mode
      4. Image intensifier positioning
      5. Automatic brightness control (ABC)
      6. Fluoroscopy time
      7. Positioning
      8. Pulsed
   vi. Mobile radiography
      1. Exposure reduction
         a. As low as reasonably achievable (ALARA)

g. Personnel protection
   i. Sources of radiation
      1. Natural
      2. Man-made (artificial)
   ii. Exposure sources
      1. Primary x-ray beam
      2. Secondary radiation
         a. Scatter
         b. Leakage
      3. Patient as source
   iii. Cardinal principles of radiation protection
      1. Time
      2. Distance
      3. Shielding
   iv. Radiation detectors
      1. Area monitors
      2. Personal detection devices
   v. Requirements for personnel monitoring
      1. Deep dose equivalents (DDE)
      2. Shallow dose equivalents (SDE)

3. Eye dose equivalents (EDE)
4. Total effective dose equivalents (TEDE)

vi. Protective devices
1. Types
2. Attenuation properties
3. Minimum lead equivalent (NCRP #102)

vii. Regulatory agencies
1. Nuclear Regulatory Commission (NRC)
2. Food and Drug Administration (FDA)
3. Environmental Protection Agency (EPA)
4. Occupational Safety and Health Administration (OSHA)
5. State agencies

viii. Advisory agencies
1. International Council on Radiation Protection and Measurement (ICRP)
2. National Council on Radiation Protection and Measurement (NCRP)
3. Biologic Effects on Ionizing Radiation (BEIR)

ix. Regulations and recommendations
1. Current NRC recommendations and/or regulations
2. Current NCRP recommendations and/or regulations
3. Applicable state regulations
4. Public Law 97-35 (Patient Consumer Radiation Health and Safety Act of 1981)
5. CARES (Communicating Advances in Radiation Education for Shielding)
6. Public awareness
   a. Background equivalent radiation time (BERT)
   b. Social marketing (Image Gently, Image Wisely)

x. Radiation safety officer
1. Qualifications
2. Responsibilities

xi. Special considerations
1. Portable (mobile) units
2. Fluoroscopy
   a. Protective curtain
   b. Protective bucky slot cover
   c. Cumulative timer
   d. Remote control
3. Design of a radiologic facility
   a. Materials
   b. Primary barrier
   c. Secondary barrier
   d. Half-value layer (HVL) and tenth-value layer (TVL)
   e. Factors
      i. Use (U) controlled and uncontrolled
      ii. Workload (W)
      iii. Occupancy (T)
      iv. Distance (D)
   f. X-ray and ancillary equipment
      i. Beam-limiting devices
      ii. Exposure control devices
      iii. On and off switches
      iv. Interlocks
      v. Visual/audio monitors
      vi. Emergency controls
      vii. Quality control
         1. Calibration
         2. Standards
4. Guidelines for fluoroscopy and portable units (NCRP #102-21 CFR)
   a. Fluoroscopy exposure rates
   b. Exposure switch guidelines
5. Emergency procedures

h. Radiation exposure and monitoring
    i. Objectives of a radiation protection program
        1. Documentation
        2. Occupational and non-occupational dose limits
        3. ALARA concept (optimization)
        4. Comparable risk
        5. Negligible individual dose (NID)
    ii. Legal and ethical responsibilities
    iii. Units of measurement
        1. Absorbed Dose
            a. Gray (Gy)
        2. Air kerma
        3. Dose Equivalent
            a. Sievert (Sv) (Rem)
        4. Effective dose
        5. Exposure
            a. Coulomb/kilogram (C/kg) Roentgen (R)
        6. Kerma
            a. Kinetic energy release in matter
            b. Measurement unit in the gray
            c. Dose Area Product (DAP) meter
        7. Measurement units in CT
            a. CT dose index (CTDI)
            b. Multiple scan average dose (MSAD)
            c. Dose length product (DLP)
        8. Radioactivity
            a. Becquerel (Bq)
    iv. Personnel monitors
        1. Thermoluminescent dosimeter (TLD)
            a. Body badge
            b. Ring badge
        2. Optically stimulated luminescent dosimeter (OSLD)
        3. Digital ionization chamber
    v. NCRP recommendations for personnel monitoring (NRP #116)
        1. Occupational exposure
        2. Public exposure
        3. Embryo/fetus exposure
        4. ALARA and dose equivalent limits
        5. Evaluation and maintenance of personnel dosimetry records
    vi. Dose reporting
        1. NRC Regulations (10 Code of Federal Regulations [CFR]) Part 20 Standards for Radiation Protection
        2. NCRP guidelines
            a. Dose quantities
                i. Effective dose (E)
                ii. Collective effective dose (S)
                iii. Average effective dose to an individual in a group exposed to a specific source (EExp)
                iv. Effective dose per individual in the U.S. population whether exposed to the specific source or not (EUS)
    vii. Medical exposure of patients (NCRP #160)
        1. Typical effective dose per exam
        2. Comparison of typical doses by modality

.

Resources

Forshier S. *Essentials of Radiation: Biology and Protection.* 2nd ed. Albany: Delmar Publishers, 2009.

Statkiewiez-Sherer MA, Visconti PJ, Ritenour ER. *Radiation Protection in Medical Radiography*. 9th ed. St. Louis: Mosby, 2021.

Mosby. *Mosby's Radiography Online: Radiobiology and Radiation Protection*. 4th ed. St. Louis: Mosby, 2022.

Martin, A., Harbison, S., Neach, K., Cole, P. *An Introduction to Radiation Protection*. 7th ed. London: Hodder Arnold, 2018.

Resources Other

a. National Council on Radiation Protection and Measurements Reports https://ncrponline.org
b. American Registry of Radiologic Technologists Radiographic Certification Handbook containing examination content specifications www.arrt.org (http://www.arrt.org)
c. American Society of Radiologic Technologists Radiography Curriculum www.asrt.org (http://www.asrt.org)

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