Radiation Oncology

Initial Certification Qualifying (Computer-based) Examination: Study Guide for Radiation and Cancer Biology

This exam tests your knowledge of the principles of cancer and radiation biology underlying the practice of radiation oncology. Included are questions on the following topics:

- Basic cancer biology and the molecular biology of cancer
- Response to radiation at the subcellular and cellular levels
- Radiation responses of normal and malignant tissues
- Radiation carcinogenesis
- Hereditary effects as they relate to radiation protection

Categories for Radiation and Cancer Biology

- **Interaction of radiation with matter**
  - Definition of ionizing radiation and types
  - Generation of free radicals
  - Direct and indirect action of radiation
- **Molecular and cellular damage and repair**
  - Molecular mechanisms of DNA damage
    - Assays for DNA damage
    - Types of DNA lesions and numbers per cell per Gy
    - Multiply damaged sites
    - Single lethal hits and accumulated damage (inter- and intratrack)
  - Molecular mechanisms of DNA repair
    - Types of repair
    - Repair of base damage, single-strand and double-strand breaks
    - Homologous recombination
    - Nonhomologous end joining
  - Chromosome and chromatin damage
    - Assays
    - Dose-response relationships
    - Use of peripheral blood lymphocytes in vivo dosimetry

        - Stable and unstable chromatid and chromosome aberrations
        - Human genetic diseases that affect DNA repair, fragility, and radiosensitivity
        - Genomics
    - Repair at the cellular level
        - Sublethal damage repair
        - Dose-rate effects and repair
        - Dose-fractionation effects
- **Cellular responses to radiation**
    - Mechanisms of cell death
        - Apoptotic death
        - Necrotic death
        - Mitotic-linked cell death
        - Cell division postradiation and time to clonogen death
        - Radiation-induced senescence
        - Autophagy
    - Cell and tissue survival assays
        - In vitro clonogenic assays - effects of dose, dose rate, and cell type
        - In vivo clonogenic assays - bone marrow stem cell assays, jejunal crypt stem cell assay, skin clones, and kidney tubules
    - Models of cell survival
        - Random nature of cell killing and poison statistics
        - Single hit, multitarget models of cell survival
        - Two-component models
        - Linear-quadratic models
        - Calculations of cell survival with dose
- **Linear energy transfer (LET) and oxygen effect**
    - Linear energy transfer
        - Definition of LET and quality of radiation
        - RBE defined
        - RBE as a function of LET
        - Tissue type
    - Oxygen Effect
        - Definition of OER
        - Dose or dose per fraction effects
        - OER vs LET
        - Impact of O_2 concentration
        - Mechanisms of oxygen effect
- **Tumor biology and microenvironment**
    - Solid tumor assay systems
        - TCD_{50} tumor control assay
    - Tumor microenvironment
        - Tumor vasculature
        - Angiogenesis

        - Hypoxia in tumors
        - Reoxygenation after irradiation
        - Relevance of hypoxia in radiation therapy
        - Hypoxia as a factor in tumor progression
        - Hypoxia-induced signal transduction
        - Cellular composition of tumors
    - Immune microenvironment
- **Cancer biology**
    - Cell
        - Cell cycle
        - Effect of cell cycle phase on radiosensitivity
        - Cell cycle arrest and redistribution after irradiation
        - Cell cycle checkpoints, cyclins, cyclin-dependent kinase inhibitors
    - Molecular signaling
        - Receptor/ligand interactions
        - Phosphorylation/dephosphorylation reactions
        - Transcriptional activation
        - Radiation-induced signals
        - Cell survival and death pathways
    - Mechanisms of cancer development
        - Cancer as a genetic disease
        - Oncogenes
        - Tumor suppressor genes
        - Telomeric changes in cancer
        - Multistep nature of carcinogenesis
        - Signaling abnormalities in carcinogenesis
        - Effects of signaling abnormalities on radiation responses
        - Prognostic and therapeutic significance of tumor characteristics
    - Cancer genetics/genomics
        - Epigenetic changes in cancer
        - Molecular profiling of cancer
- **Radiobiology of normal tissues**
    - Clinically relevant normal tissue responses to radiation
        - Responses in skin, oral mucosa, oropharyngeal and esophageal mucous membranes, salivary glands, bone marrow, lymphoid tissues, bone and cartilage, lung, kidney, testis, eye, and central and peripheral nervous tissues
        - Reirradiation
    - Mechanisms of normal tissue radiation responses
        - Molecular and cellular responses in slowly and rapidly proliferating tissues
        - Mechanisms underlying clinical symptoms
        - Tissue kinetics
    - Total body irradiation

        - Prodromal radiation syndrome
        - Cerebrovascular syndrome
        - Gastrointestinal syndrome
        - Hematopoietic syndrome
        - Mean lethal dose and dose/time responses
        - Immunological effects
        - Assessment and treatment of radiation accidents
        - Bone marrow transplantation
- **Dose delivery**
    - Therapeutic ratio
        - Tumor control probability (TCP) curves
        - Normal tissue complication probability (NTCP) curves
        - Causes of treatment failure
    - Time, dose, and fractionation
        - The four R's of fractionation
        - Radiobiological rationale behind dose fractionation
        - Effect of tissue type on the response to dose fractionation
        - Effect of tissue/tumor types on A/B ratios
        - Quantitation of multifraction survival curves
        - BED and isoeffect dose calculations
        - Hypofractionation
    - Brachytherapy
        - Dose-rate effects (HDR and LDR)
        - Choice of isotopes
        - Radiolabeled antibodies
    - Radiobiological aspects of different radiation modalities
        - Protons, high LET sources
        - Stereotactic radiosurgery/radiotherapy, IMRT, IORT
        - Dose distributions and dose heterogeneity
- **Combined modality therapy**
    - Chemotherapeutic agents and radiation therapy
        - Classes of agents
        - Mechanisms of action
        - Oxygen effect for chemotherapy
        - Multiple drug resistance
        - Interactions of chemotherapeutic agents with radiation therapy
        - Molecular-based therapy
    - Radiosensitizers, bioreductive drugs, and radioprotectors
        - Tumor radiosensitization
        - Normal tissue radioprotection
        - Biological response modifiers
        - DNA repair inhibitors
        - Hyperthermia
    - Immune therapeutics

- **Late effects and radiation protection**
    - Radiation carcinogenesis
        - Dose response for radiation-induced cancers
        - Importance of age at exposure and time since exposure
        - Malignancies in prenatally exposed children
        - Second tumors in radiation therapy patients
        - Risk estimates in humans
        - Calculations based on risk estimates
    - Heritable effects of radiation
        - Single gene mutation
        - Relative vs absolute mutation risk
        - Doubling dose
        - Heritable effects in humans
        - Risk estimates for hereditable effects
    - Radiation effects in the developing embryo
        - Intrauterine death
        - Congenital abnormalities and neonatal death
        - Microcephaly, intellectual disabilities
        - Dose, dose rate, and stage in gestation
        - Human experience of pregnant women exposed to therapeutic doses
    - Radiation protection
        - General philosophy
        - Stochastic and deterministic effects
        - Relative weighting factors
        - Equivalent dose - tissue weighting factor
        - Effective dose, committed dose
        - Collective exposure dose
        - Dose limits for occupational and public exposure
        - ICRP and NCRP