Radiation Therapy Professional Curriculum

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Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3917.

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Introduction

Advances in radiation therapy have brought forth necessary changes in the education of radiation therapists. A national committee representing a variety of program types from across the country developed the curriculum. Input from The American Registry of Radiologic Technologists (ARRT) and the Joint Review Committee on Education in Radiologic Technology (JRCERT) also were included in this revision to maintain continuity among the professional curriculum, accreditation standards and the certification examination.

This curriculum is divided into specific content areas that represent the essential components of an entry-level radiation therapy program. The content and objectives should be organized to meet the mission, goals and needs of each radiation therapy program. Faculty are encouraged to expand and broaden these fundamental objectives as they incorporate them into their curricula. Specific instructional methods were intentionally omitted to allow for programmatic prerogative as well as creativity in instructional delivery.

Advances in radiation therapy and employer expectations demand more independent judgment by radiation therapists. Consequently, critical thinking skills must be fostered, developed and assessed in the educational process. Critical thinking has been incorporated in multiple content areas. These areas include, but are not limited to, clinical practice and the required postsecondary general education. It is expected that the faculty will continue to develop and implement critical thinking throughout the curriculum.

New content and objectives have been added to the radiation therapy curriculum. New areas include adaptive technologies, expanded imaging for radiation oncology and information technology. Clinical and didactic competencies have been correlated. Some content areas have been retitled or reorganized and outdated content eliminated.

In summary, the new radiation therapy curriculum is based on the latest data relevant to the profession and reflects the changing health care environment. The curriculum offers a foundation for individual lifelong learning and transition to baccalaureate level studies. It allows for flexibility in the development of a curriculum designed to meet the needs of the local community yet meet the requirements for the JRCERT Standards and the ARRT examination.

Note: The general education and professional content areas of the curriculum are not courses. To preserve the flexibility for all radiation therapy programs, content within each topic may be integrated in various courses.

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Required General Education

General education is an integral part of the development of the professional radiation therapist. This portion of the curriculum gives students opportunities to explore broad areas of commonly held knowledge and to prepare them to contribute to society through personal, social and professional interactions with others.

General education provides intellectual flexibility and knowledge to support lifelong learning that will prepare graduates for success in a rapidly changing world.

General Education Content

College-level coursework provides foundational knowledge on which to build the radiation therapy content. The framework for general education may be delivered prior to or congruent to the professional curriculum.

- Oral and written communication can be expanded to facilitate technical and scientific inquiry, analysis and dissemination of knowledge.
- Knowledge of human anatomy can be increased to include the correlation of topographic landmarks to internal organs, in-depth examination of the lymphatic system and transference of sagittal and coronal anatomical structure identification to cross-sectional views.
- Knowledge of human physiology can be expanded to explore the processes by which tumors originate, grow, metastasize and affect the normal functioning of each of the body systems.
- Computer skill literacy can be demonstrated for application in radiation therapy simulation, treatment delivery, information processing and treatment planning.
- Mathematical analysis can be expanded to include calculation for radiation treatment and protection, radioactivity and radiobiological functions.
- Basic physics principles will facilitate the application of radiation physics.

Required General Education Content

Note: These are not specific courses, but represent content areas.

- Human Anatomy
  This content will include terminology and organization of the human organism at the cellular, tissue and organ levels. Structures of human systems including integumentary, skeletal, muscular, nervous, endocrine, sensory, circulatory, respiratory, digestive, urinary and reproductive will be covered. To facilitate understanding, a laboratory section is recommended.
- Human Physiology
  A general introduction of the functional integration of all human body systems will include: integumentary, skeletal, muscular, nervous, endocrine, sensory, circulatory, respiratory, digestive, urinary and reproductive systems. To facilitate understanding of the content material, a laboratory section is recommended.

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- Mathematics
  This content will include a study of the real number system, algebra of sets, exponents, equations and inequalities, polynomial functions, graphing, radical expressions, operations, inverses of function, equations of lines and systems of linear equations and elementary statistics, logarithmic and trigonometric functions and their applications, as well as plane analytic geometry.

- Computer Science
  Students will be able to demonstrate computer literacy in general hardware and software applications.

- Written Communication
  This content will include the written expression of thoughts, ideas, perceptions and observations derived from the critical thinking process. Additionally, it may complement the critical thinking process by providing a vehicle for the organization and clarification of thoughts, for the establishment of conceptual relationships, for the analysis of data and for synthesis of conclusions or new ideas.

- Verbal Communication
  This content will include the theory and practice of public speaking, development of thought process necessary to organize speech content for informative and persuasive situations, application of language and delivery skills to specific audiences.

- General Physics
  This content will include the application of physical principles, conservation laws, gravitation, wave motion, heat and thermodynamics as it relates to scientific disciplines.

- Research Methodology
  This content will include specific elements of the research process and protocols, data interpretation and application of results.

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Clinical Practice

Description
Content is designed to provide sequential development, application, analysis, integration, synthesis and evaluation of concepts and theories in radiation therapy. Through structured sequential assignments in clinical facilities, concepts of team practice, patient-centered clinical practice and professional development shall be discussed, examined and evaluated.

Objectives
1. Operate within the radiation therapy scope of practice.
2. Demonstrate values and attitudes congruent with the profession's standards and ethics.
3. Formulate priorities in daily clinical practice.
4. Apply concepts of teamwork.
5. Adapt to changing clinical situations.
6. Establish patient-centered, clinically effective service delivery strategies.
7. Deliver a prescribed course of treatment adhering to acceptable departmental, institutional, governmental and professional standards.
8. Assess the patient's status and condition in order to deliver a prescribed course of radiation therapy.
9. Use critical thinking for accurate treatment delivery.
10. Demonstrate the principles of radiation protection.
11. Monitor tumor lethal dose and normal tissue tolerance dose.
12. Evaluate the clinical significance of the treatment parameters as prescribed to suspend treatment as appropriate.
13. Apply the principles of total quality management.
14. Detect equipment malfunctions and take appropriate action.
15. Construct and prepare immobilization, beam alignment and beam modification devices.
16. Design, compare, contrast and implement treatment plans.
17. Validate manual and computer dosimetric calculations.
18. Perform simulation, localization and therapeutic procedures as they pertain to radiation therapy in accordance with national patient safety standards.
19. Demonstrate appropriate and effective communication.
20. Demonstrate safe, ethical and legal practices.
21. Evaluate the clinical significance of the patient's uniqueness to formulate appropriate actions.
22. Apply appropriate safety, transfer and immobilization principles.
23. Apply concepts of teaching and learning theories in design, implementation and evaluation in the education of patient, family, colleagues and the community.
24. Evaluate programs designed to promote and maintain health and wellness to meet patient needs.
25. Demonstrate appropriate interaction with patients and patients' family and friends.

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26. Assess patient side effects and complications to create an interdisciplinary management strategy that fosters prevention, healing and comfort.
27. Document all aspects of patient care and management in the appropriate record.
28. Document and communicate errors and discrepancies in accordance with institutional and national quality management procedures.
29. Initiate life support procedures as necessary.
30. Document knowledge of the institution's procedures in response to emergencies, disasters and accidents.
31. Apply strategies that ensure professional development at a level of clinical practice consistent with acceptable standards.
32. Demonstrate quality assurance procedures for all treatment delivery equipment and accessories.
33. Evaluate outcomes to continuously improve radiation therapy services.
34. Incorporate Health Insurance Portability and Accountability Act (HIPAA) requirements into clinical practice.

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Content

I. Essentials of Clinical Practice

A. Legal and ethical considerations

B. Code of ethics

C. Scope of practice

D. Practice standards

E. Lifelong learning and professional development

F. Patient bill of rights

G. Clinical policy and procedure
   1. Incident reporting
   2. General safety practice

H. Orientation to clinical practice
   1. Role of health care team members
      a. Professional staff
      b. Support services
   2. Student responsibilities
   3. Scheduling and continuum of clinical procedures
   4. Billing and coding
   5. Scheduling and sequencing procedures

II. Patient Assessment, Care and Education

A. Communication and education
   1. Patient
   2. Family and significant others
   3. Health care community
   4. Communities of interest

B. Assessment
   1. Physical
   2. Psychosocial
   3. Cultural
   4. Nutritional
   5. Daily progress
   6. Combined modality treatment effects

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C. Care
    1. Management of side effects
    2. Effects of multimodality treatment on the patient
        a. Surgery
        b. Chemotherapy
    3. Infection control
    4. Medical emergencies
    5. Preprocedural and postprocedural education
    6. Nutrition
    7. Physical activity considerations
    8. Safety and transfer positioning
    9. End-of-life services

D. Clinical competencies*

III. Simulation

A. Radiation safety and environmental protection practices

B. Equipment operation

C. Patient and machine monitoring

D. Patient positioning and immobilization

    1. Straightening techniques
    2. Leveling techniques
    3. Patient comfort and reproducibility techniques

E. Contrast media administration
    1. History and physical (H and P), patient preparation instructions
    2. Media administration techniques
        a. Oral
        b. Intravenous (IV)
        c. Intracavitary
        d. Other

F. Treatment field delineation, measuring and proper marking of patient

G. Treatment volume localization

H. Imaging procedures

I. Image processing, capture and export

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J. Documentation

K. Patient assessment, care, management and education

L. Clinical competencies*

IV. Treatment Planning

A. Pertinent patient information

B. Collaboration with team members

C. Equipment operation

D. Procedures
   1. Volume definition
   2. Critical structures
   3. Beam arrangement and modification
   4. Implementation and verification

E. Clinical competencies*

V. Treatment Delivery

A. Radiation safety and environmental protection practices

B. Equipment operation

C. Patient identification

D. Patient and machine monitoring

E. Treatment verification and prescription

F. Consideration of dose to critical structures

G. Patient and machine setup

H. Machine malfunctions and troubleshooting

I. Documentation

J. Comparison analysis of images for verification/localization
   1. Patient repositioning

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2. Dynamic targeting

K. Patient assessment, care, management and education

L. Clinical competencies*

VI. Quality Assurance and Quality Management

A. Documentation

B. General area conditions

C. Safety devices
   1. Interlocks
   2. Power supply
   3. Emergency buttons

D. Accessory and immbolization devices

E. Communication devices

F. Computerization

G. Simulation and treatment units

H. Brachytherapy

I. Medical dosimetry and treatment planning

J. Device fabrication equipment

K. Clinical competencies*

*Refer to ARRT minimum core clinical competencies.

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Ethics in Radiation Therapy Practice

Description
Content is designed to provide sequential development, application, analysis, integration and evaluation of ethical concepts and theories as they relate to radiation therapy practice.

Objectives
1. Identify theories and principles that guide ethical decision making for practice situations.
2. Define practice situations that carry high potential for dilemmas that require ethical scrutiny.
3. Discuss basic ethical duties of health care providers.
4. Demonstrate an awareness of and sensitivity to various cultural and ethnic differences among various client groups.
5. Discuss the concept of patient advocacy in support of patients' rights.
6. Explain the principle of autonomy.
7. Discuss veracity as it relates to autonomy.
8. Discuss role fidelity as it relates to heath care ethics.
9. Discuss the radiation therapy scope of practice, code of ethics and practice standards.
10. Examine concepts of personal honesty, integrity, accountability and professional compassion as ethical imperatives in professional practice.
11. Differentiate between nonmaleficence and beneficence.
12. Differentiate between distributive, compensatory and retributive justice.
13. Differentiate between provider and patient relationships.
14. Discuss the duty of the radiation therapist to take responsibility for actions and decisions.
15. Discuss the elements of an informed consent.
16. Discuss standards of disclosure.
17. Analyze issues related to the use and flow of patient information to determine confidentiality.
18. Explain ethical issues related to different age groups.
19. Identify current ethical issues in health care.
20. Demonstrate application of a system of examination, clarification, determination, the doctrine of informed consent and other issues related to patient rights.
21. Explain ethical issues related to the profession.
22. Discuss the relationship between biomedical ethics and health care policy.
23. Examine ethical issues arising daily in a radiation therapy department.

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Content

I. Ethical Theories and Principles

A. Theories
1. Utilitarianism
2. Kantianism
3. Character ethics
4. Liberal individualism
5. Communitarianism
6. Ethics of care
7. Casuistry
8. Principle-based
9. Convergence across theories

B. Basic principles of health care ethics
1. The right to life
2. The right to receive health care
3. The right to know
4. Autonomy
   a. Three basic elements
   b. Informed consent
   c. Therapeutic privilege
   d. Benevolent deception
   e. Paternalism
   f. Fiduciary relationship
5. Nonmaleficence
   a. Double effect
6. Beneficence
   a. Hippocratic oath
   b. Cost/benefit ratio
7. Veracity
   a. Truth telling
   b. Nondisclosure and deception
8. Role fidelity
   a. Scope of practice
   b. Code of ethics
9. Confidentiality
   a. Patient's bill of rights
   b. Health care information
   c. HIPAA
   d. Computerized information systems
      1) Protected
      2) Third-party payer information

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10. Justice
    a. Distributive justice
    b. Compensatory justice
    c. Retributive justice

II. Provider/Patient Relationship

A. Models
    1. Engineering
    2. Priest
    3. Collegial
    4. Contractual

B. Cultural competency
    1. Cultural concepts of disease
    2. Impact of cultural beliefs on health care delivery

C. Informed consent
    1. Disclosure
    2. Understanding
    3. Voluntariness
    4. Consent
    5. Coercion
    6. Humans as subjects

D. Standards of disclosure
    1. Professional community standard
    2. Reasonable patient standard
    3. Patient-centered standard

E. Competency determination

III. Ethical Decision-making in Health Care Dilemmas

A. Decision-making models

B. Treating the family

C. Futility

D. Brain death and organ procurement

E. Pain management

F. Survivorship

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G. End-of-life issues
    1. Advanced directives
    2. Proxy decision-making standards
    3. Informed nonconsent
    4. Do-not-resuscitate (DNR) orders
    5. Euthanasia
    6. Hospice

H. Abortion

I. Genetic science and biomedical technology

J. Justice and the allocation of scarce resources

K. Professional gatekeeping and professional obligations
    1. Conflicts of interest
    2. Scope of practice
    3. Impaired colleagues
    4. Whistle blowing

IV. Biomedical Ethics and Health Care Policy

V. Role of the Radiation Therapist in Health Care Issues

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Imaging and Processing in Radiation Oncology

Description
Content is designed to establish a knowledge base in factors that govern and influence the production and recording of radiographic images for patient simulation, treatment planning and treatment verification in radiation oncology. Radiation oncology imaging equipment and related devices will be emphasized.

Objectives
1. Define terminology associated with digital imaging systems.
2. Describe the various types of digital receptors.
3. Discuss the fundamentals of digital imaging, distinguishing between cassette-based systems and cassetteless systems.
4. Compare the image acquisition and extraction of cassette-based vs. cassetteless systems, including detector mechanism, initial image processing, histogram analysis, automatic rescaling and exposure index determination.
5. Describe the evaluative criteria for digital imaging detectors.
6. Describe the response of digital detectors to exposure variations.
7. Compare the advantages and limits of each system.
8. Given the performance criteria for a digital imaging detector, evaluate the spatial resolution and dose effectiveness.
9. Compare dynamic range to latitude of a film-screen receptor system to that of a digital imaging system.
10. Describe the histogram and the process or histogram analysis as it relates to automatic rescaling and determining an exposure indicator.
11. Describe or identify the exposure indices used by each photostimulable phosphor (PSP)-based system.
12. Describe the difference between dose area product (DAP) measured with a flat panel system vs. the exposure index for a PSP-based system.
13. Relate the receptor exposure indicator values to technical factors, system calibration, part/beam/plate alignment and patient exposure.
14. Describe image acquisition precautions necessary for computed radiography (CR) imaging.
15. Describe the response of PSP systems to background and scatter radiation.
16. Use appropriate means of scatter control.
17. Avoid grid use errors associated with grid cutoff and Moiré effect.
18. Identify common limitations and technical problems encountered when using PSP systems.
19. Employ appropriate beam/part/receptor alignment to avoid histogram analysis errors.
20. Describe the various image processing employed for digital images.
21. Associate impact of image processing parameters to the image appearance.
22. Associate effects of inappropriate processing on image clarity or conspicuity.
23. Describe the fundamental physical principles of exposure for digital detectors.
24. Apply the fundamental principles to digital detectors.

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25. Describe the selection of technical factors and technical factor systems to ensure appropriate receptor exposure levels for digital detectors.
26. Evaluate the effect of a given exposure change on histogram shape, data width and image appearance.
27. Describe the conditions that cause quantum mottle in a digital image.
28. Formulate a procedure or process to minimize histogram analysis and rescaling errors.
29. Describe the exposure precautions and limitations associated with PSP-based systems.
30. Avoid poor quality images by observing acquisition precautions.
31. Examine the potential impact of digital imaging systems on patient exposure and methods of practicing the as low as reasonably achievable (ALARA) concept with digital systems.
32. Describe picture archiving and communications system (PACS) and its function.
33. Identify components of a PACS system.
34. Describe patient benefits gained throughthe use of telemedicine.
35. Identify modality types that may be incorporated into a PACS.
36. Define accession number.
37. Describe worklist and correct usage.
38. Define digital imaging and communications in medicine (DICOM).
39. Describe data flow for a DICOM image from an imaging modality to a PACS.
40. Describe HIPAA concerns with electronic information.
41. Identify common problems associated with retrieving/viewing images.
42. Identify the primary uses of the simulation display workstation, treatment planning display and treatment unit workstation.
43. Describe the components and the operation of a conventional simulator.
44. Analyze relationships of factors affecting image contrast, density and resolution to determine optimal image quality for a conventional simulator.
45. Apply techniques to enhance image details and reduce image distortion in conventional simulation.
46. Discuss the effects of processing and storage on image quality of hardcopy films.
47. Determine artifact types, cause and preventive measures needed for hardcopy films.
48. Explain the basic principles of image formation for each of the following modalities: MR, ultrasound and nuclear medicine.

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Content

I. Basic Principles of Digital Imaging

A. Digital image characteristics
   1. Picture elements – pixels
   2. Pixel size
   3. Matrix size
   4. Spatial resolution
   5. Bit depth
   6. Information content – megabytes/image

B. Digital receptors
   1. Cassetteless systems
      a. Thin film transistor (TFT) arrays
      b. Charged coupled device (CCD) and complementary metal oxide semiconductor (CMOS) systems
         1) Linear scanning arrays
            a) Fixed photostimulable phosphor (PSP) plates
         2) Optically coupled cameras
            a) Phosphor structure
            b) Detector characteristics
   2. Cassette-based systems
      a. PSP plates
         1) Turbid phosphors
         2) Structured phosphors

C. Comparison of detector properties and evaluative criteria
   1. Detective quantum efficiency (DQE) predicts dose efficiency
   2. System speed vs. "speed class" operation
   3. Spatial resolution
      a. Cassette-based systems
         1) Sampling frequency – pixel pitch
         2) Receptor size vs. sampling frequency
         3) Light spread – phosphor layer thickness
      b. Cassette-less systems – detector element size
   4. Advantages over film-screen
      a. Increased dynamic range
      b. More contrast resolution
   5. Limitation relative to film-screen
      a. Lower spatial resolution
      b. Strong dependence of image quality on:
         1) Image processing
         2) Display characteristics

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D. Dynamic range vs. latitude
    1. Dynamic range of the detector
        a. Acquisition data width
        b. Greater than film-screen
    2. Latitude – allowable error for optimal image acquisition
        a. Actual exposure latitude is approximately double that of film-screen
            1) 50% below ideal causes mottle
            2) Greater than 200% above ideal results in loss of contrast
        b. Beam-part-receptor alignment latitude less than film-screen

II. Image Acquisition (simulation, portal imaging, onboard image guidance)

A. Raw data acquisition – "latent image"
    1. Positioning
    2. Exposure field alignment and collimation
        a. Cassetteless system
        b. Cassette-based system
            1) Film
            2) PSP

B. Comparison and analysis of images for verification/localization
    1. Cine
    2. Single/double exposure
    3. Cone beam (CT)
    4. Fan beam (tomotherapy)
    5. kV/kV matching
    6. MV/MV matching
    7. Ultrasound guided
    8. Fluoroscopic

C. Patient repositioning and dynamic targeting
    1. Interfraction motion
    2. Intrafracation motion
    3. Respiratory gating
        a. Optical guidance
    4. Fiducial markers
    5. Volumetric imaging

D. Image extraction – cassetteless system
    1. Rows and columns read line by line
    2. Data transferred to external electronics
    3. Digitized by analog-to-digital converter (ADC)
    4. Histogram created and analyzed by software

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5. Initial image processing
    a. Exposure field recognition
    b. Histogram analysis
    c. Automatic rescaling – risk of failure

E. Image extraction – cassette-based system
    1. Film
        a. Automatic processing
    2. PSP
        a. Plate scanned by laser
        b. Signal data digitized by ADC
        c. Exposure field(s) identified
        d. Histogram created and analyzed by software
        e. Initial image processing
            1) Exposure field recognition
            2) Histogram analysis
                a) Exposure index determination – risk of inappropriate value
                b) Automatic rescaling – risk of failure

F. Exposure indicators
    1. Cassetteless systems
        a. Dose area product (DAP)
            1) Actual patient dose calibrated by DAP
            2) No established DAP standard
            3) Receptor exposure not indicated
        b. Relationship to patient exposure
            1) Exposure indicator – "speed class"
            2) Reached exposure index (REX)
    2. Cassette-based systems
        a. Vendor specific values
            1) Sensitivity ("S")
            2) Exposure index (EI)
            3) Log mean exposure (LgM)
        b. Relationship to patient exposure
        c. Reader calibration
        d. Centering and beam collimation
        e. Optimal value ranges

III. Image Acquisition Errors

A. Exposure field recognition
    1. Single field patterns – collimation margins and alignment
    2. Multiple exposure fields – optimal patterns

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B. Histogram analysis error
    1. Incorrect anatomic menu selection
    2. Exposure field not detected
        a. Collimation border recognition
        b. Exposure field distribution – multiple fields/plate
    3. Unexpected material in data set, i.e., metal
    4. Large exposure error – plate saturation
    5. Inappropriate rescaling – dark or light image

C. Low intensity radiation response
    1. Background
        a. Cassetteless system constantly refreshed
        b. Cassette-based system plate is storage phosphor
            1) Stores background exposure
            2) Plate responds to an exposure as low as 60 μR
            3) Background is 40 μR/day to 80 μR/day
            4) Plates unused for more than 48 hours should be erased
    2. Scatter
        a. More intense than background
        b. Scatter control becomes critical

D. Scatter control
    1. Beam limiting
    2. Optimal exposure – overexposure produces more scatter
    3. Grid use
        a. Kilovoltage (kVp) conversion preferred
        b. Grid cutoff produces low contrast
        c. Compare short dimension (SD) grid and long dimension (LD) grid
        d. Moiré effect
            1) Grid frequency approximately equal to Nyquist
            2) Reduce risk – unmatched frequencies
                a) Grid frequency less than Nyquist (178 lpi)
                b) Grid frequency greater than Nyquist (103 lpi)

IV. Software (Default) Image Processing

A. Automatic rescaling

B. Final image processing
    1. Gradient processing
        a. Brightness
        b. Contrast
    2. Frequency processing
        a. Smoothing

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b. Edge enhancement
3. Equalization

C. Effects of excessive processing

D. Recognition of image processing errors that affect image clarity

V. Fundamental Principles of Exposure

A. Optimal receptor exposure
1. Receptor exposure variables
2. Receptor exposure control

B. Receptor response - DQE

C. Selection of exposure factors
1. Same principles as film-screen
a. Maintain consistent specific receptor exposure
b. Control scatter
c. Adjust for differences in:
1) Structure composition
2) Source-to-image receptor distance (SID)
3) Grid utilization

D. Exposure myths associated with digital systems
1. Milliampere-seconds (mAs)
2. kVp
3. Collimation
4. Grid
5. SID
6. Speed class
7. Fog

E. Control patient exposure
1. Higher kVp levels
2. Additional filtration
3. Interfacing with automatic exposure control (AEC) systems
4. ALARA principles

F. Monitor patient exposure
1. Part of quality assurance (QA) program
2. Vendor supplied software
3. Logbook

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VI. Image Evaluation

A. Evidence of appropriate exposure level
   1. Exposure indicator
      a. Low contrast due to overexposure
      b. Noise due to underexposure
   2. Evidence of exposure recognition failure or histogram analysis error
      a. Image brightness
      b. Low contrast
      c. Off focus/scatter outside exposure field

B. Contrast
   1. Appropriate for exam
   2. Evidence of processing error

C. Recorded detail
   1. Image blur
   2. Spatial resolution
   3. Distortion
   4. Mottle

D. Artifacts
   1. Motion
   2. Metal "star" artifacts
   3. Beam hardening
   4. Partial volume

VII. Quality Assurance and Maintenance Issues

A. Initial acceptance testing

B. Cassette-based system reader preventive maintenance (PM)

C. Plate maintenance
   1. Cleaning and inspecting plates
   2. Erasing plates

D. Uniformity of default processing codes

E. Reject analysis

VIII. Display

A. Monitor
   1. Liquid crystal display (LCD)
   2. Cathode ray tube (CRT)

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B. Contouring
   1. Reformating in 3-D/4-D

C. Film
   1. Digital reconstructed radiograph (DRR)

D. PACS
   1. Terminology
   2. System components and function
   3. Record and verify/PACS
      a. Image manipulation
      b. Access to report information
      c. Access from multiple locations
      d. Image retrieval
      e. PACS issues – contingency plans
   4. DICOM

E. Telemedicine

F. Radiation therapist responsibilities
   1. Order verification (worklist)
   2. Image acquisition
   3. Postprocessing – image manipulation
   4. Annotation issues
   5. Transmitting image(s)
      a. HIPAA and patient confidentiality

IX. Imaging Equipment

A. Conventional simulator
   1. Components
      a. X-ray tube
      b. Collimators
      c. Field defining wires
      d. Table (relative to treatment unit)
      e. Grid
      f. Film tray or digital receptor
      g. Fluoroscopic unit
      h. Video system
      i. Control console
      j. Other

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X. Principles of Operation

A. Image characteristics
   1. Radiographic density
      a. Definition
      b. Acceptable range
      c. Technical factors
         1) mAs
         2) kVp
         3) Distance
         4) Beam limitation
         5) Patient considerations
         6) Contrast media
         7) Other
   2. Radiographic contrast
      a. Definition
      b. Types
         1) Long scale
         2) Short scale
      c. Components
         1) Subject
         2) Image receptor
      d. Technical factors
         1) kVp
         2) Scattered radiation
         3) Filtration
         4) Patient considerations
         5) Distance
         6) Contrast media
   3. Recorded detail
      a. Definition
      b. Factors
         1) Geometric unsharpness
            a) Focal film distance
            b) Object film distance
            c) Focal spot
         2) Motion unsharpness
            a) Voluntary
            b) Involuntary
   4. Distortion
      a. Definition
      b. Types
         1) Shape
            a) Foreshortening

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b) Elongation
c. Size (magnification)
d. Factors
1) Distance
2) Tube/part (image receptor) relationships
5. Exposure latitude
a. Definition
b. Factors
1) kVp
6. Image receptor scattered/secondary radiation
a. Definition
b. Interactions
c. Factors
1) kVp
2) Patient considerations
3) Distance
4) Contrast media
d. Effects
1) Patient dosage
2) Image quality
3) Occupational exposure
7. Technique formation
a. Purpose
1) Standardization of exposure
2) Image consistency
b. Considerations
1) Choice of technique system
2) Patient measurement
c. Types
1) Optimum kVp/variable mAs
2) Variable kVp/fixed mAs
3) Automated exposure
d. Applications

XI. Portal Imaging/On-board Imaging (OBI)/Image Guidance

A. Electronic portal imaging
1. Image acquisition
a. Cine
b. Double exposure
2. Image manipulation and display
3. Image management/storage
a. PACS

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B. Film for portal imaging and simulation

XII. Artifacts

A. Definition

B. Types

C. Causes

D. Effects

E. Preventive measures

XIII. Other Imaging Modalities

A. Description, basic principles and advantages/disadvantages of each imaging modality
   1. Radiography
   2. CT
   3. MR
   4. Mammography
   5. Ultrasound
   6. Nuclear medicine
   7. Hybrid imaging
      a. PET-CT
      b. SPECT-CT
      c. SPECT-MR

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Introductory Law in Radiation Therapy

Description
Content is designed to develop and use problem solving and critical thinking skills in discussion of the sources of law, causes of action and litigation processes related to the professional practice of radiation therapy. The inter-relatedness of standards of care, law, ethical standards and competence will be examined.

Objectives
1. Apply concepts related to social, political, economic and historical issues to analyze the different sources of law.
2. List the steps in a civil legal procedure and identify the potential role of a radiation therapist.
3. Assess the role of effective communication skills in reducing legal action.
4. Analyze negligence related to clinical practice issues of simulation, treatment delivery, patient assessment, patient education and quality assurance to determine if negligence is present.
5. Examine the role of the radiation therapist in the informed consent process, patient rights and practice standards.
6. Analyze safety programs to reduce patient injury.
7. Examine the importance of documentation and maintenance of clinical practice records.
8. Formulate a risk management program.
9. Analyze the role of code of ethics, radiation therapy scope of practice and radiation therapy practice standards as guides to assess the appropriateness of professional actions.
10. Discuss the practice of lifelong learning in maintaining professional competence.

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Content

I. Sources of Law

A. Criminal

B. Civil

C. Constitutional

D. Administrative

II. Intentional Torts

A. Assault and battery

B. False imprisonment

C. Intentional infliction of emotional distress

D. Defamation

E. Vicarious liability

F. Communication as a deterrent to legal action

III. Negligence

A. Elements of a negligent act

B. Comparative negligence

C. Contributory negligence

D. Medical negligence

E. Doctrine of *res ipsa loquitur*

F. Negligence related to clinical practice issues

G. Elements to reduce charges of negligence

H. Defenses against charges of negligence

IV. The Lawsuit

A. Complaint

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B. Discovery

C. Health professional as a party

D. Health professional as a witness

E. Deposition

F. Trial

V. Components of Informed Consent, Patient Rights and Standard of Care

A. Design of consent form

B. Role of the radiation therapist in the consent process

C. Patient's Bill of Rights

D. Standard of care

E. HIPAA

VI. Safety Issues

A. Developing a safety program

B. Equipment safety

VII. Documentation and Record Maintenance

A. Record requirements of The Joint Commission accreditation or equivalent

B. Critical documentation

C. Correction of documentation

D. Ownership of records

VIII. Risk Management

A. Professional medical liability

B. Risk analysis

C. Role of the radiation therapist in risk management

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IX. Role of the Code of Ethics, Scope of Practice and Practice Standards

A. Guides to professional practice

B. Participation in professional development activities

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Medical Terminology

Description
Content is designed to establish a foundation in the standardized language of medical practice, including its abbreviations and symbols. A word building system will be presented preparatory to reading, understanding, interpreting and applying physician prescriptions to radiation therapy and related services.

Objectives
1. Identify primary and secondary language sources from which medical terms are derived.
2. Define medical terms according to basic elements.
3. Interpret language, abbreviations and symbols in the medical record.

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Content

I. Introduction to the Origin of Medical Terminology

A. Primary language sources
   1. Greek
   2. Latin

B. Secondary language sources
   1. English
   2. French
   3. German

II. The Word-building Process

A. Basic elements
   1. Root words
   2. Prefixes
   3. Suffixes

B. Combining forms

C. Parts of speech
   1. Nouns
   2. Verbs
   3. Adjectives
   4. Adverbs

D. Translation of terms into common language

E. Correct pronunciation of medical terms

III. Medical Abbreviations and Symbols

A. Role in communications

B. Abbreviations
   1. Examples
   2. Interpretations
   3. Do not use (DNU)

C. Symbols
   1. Greek alphabet – upper and lower case
   2. Pharmaceutical symbols and terms
   3. Mathematics/science symbols and constants
   4. Examples
   5. Interpretations

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Operational Issues in Radiation Therapy

Description
Content is designed to focus on various radiation therapy operational issues. Continuous quality improvement (CQI) project development and evaluation and assessment techniques will be emphasized. Human resource concepts and regulations impacting the radiation therapist will be examined. Accreditation agencies and the radiation therapist's role in the accreditation process will be emphasized. Billing and reimbursement issues pertinent to the radiation therapy department will be presented.

Objectives
1. Demonstrate effective and accurate written and oral communication skills using appropriate terminology for radiation therapy.
2. Identify CQI opportunities.
3. Explain the differences between CQI and QA.
4. Select appropriate CQI tools for specific situations.
5. Apply CQI principles to specific situations.
6. Discuss human resources' role in the work environment.
7. Discuss the need for organizational and departmental accreditation.
8. Recognize accreditation effects on radiation therapy operations.
9. Use appropriate current procedural terminology (CPT) codes for clinical applications.
10. Discuss the impact of decisions by various organizations on reimbursement for radiation therapy procedures.
11. Summarize the various types of insurance and the mechanisms necessary for approval of care.
12. Discuss the managed care concept for cost containment.
13. Compare the components and methods of developing and managing a departmental budget.
14. Identify the professional society participation opportunities of the radiation therapist.
15. Recognize the importance of professional commitment and involvement.

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Content

I. Continuous Quality Improvement

A. Purpose

B. Project assessment
   1. Team charter
      a. Define success measures
   2. Baseline
      a. Data collection
      b. Quantify performance
   3. Causes
      a. Brainstorming
   4. Pilot
   5. Solutions
   6. Future

C. CQI tools
   1. Venn diagram
   2. Flow chart
   3. Pareto chart
   4. Cause-and-effect (fishbone) diagram
   5. Run chart
   6. Histograms
   7. Scatter diagram
   8. Control charts
   9. Process capability
   10. Stratification

II. Human Resources

A. Strategic recruitment
   1. Position description and analysis
   2. Staffing
      a. Scope of practice
      b. ASRT standards
      c. Human resources surveys
      d. Performance evaluations
      e. Merit increases
      f. Flexible staffing
      g. Consolidation of resources
   3. Selection of candidate
   4. Salary and benefits
   5. Full-time equivalent (FTE) status

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6. Interview process
    a. Resume writing
    b. Resume vs. curriculum vitae
    c. Interview skills

B. Education
    1. Orientation
    2. Annual inservice training
    3. Continuing education

C. Employee relations
    1. Job satisifaction surveys
    2. Benefits

D. Labor relations
    1. Due process
    2. Grievances
    3. Arbitration
    4. Disciplinary actions
    5. Sexual harassment

E. Laws and regulations
    1. Federal legislation
        a. Labor laws
        b. Safety and health laws
        c. Employee benefit laws
        d. Wage and hour laws
    2. Civil rights laws
        a. Bona fide occupational qualifications
        b. Equal Employment Opportunity Commission (EEOC)
        c. Affirmative action
    3. Disability laws
    4. Layoffs and terminations
    5. State worker's guidelines

III. Accreditation

A. The Joint Commission

B. American College of Radiology (ACR)

C. State agencies

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IV. Insurance and Billing

A. Primary insurance
   1. Healthcare Maintenance Organizations (HMOs)
   2. Preferred Provider Organizations (PPOs)
   3. Other

B. Supplemental insurance

C. Medicare

D. Charity care

E. CPT Billing
   1. American Medical Association (AMA)
   2. Centers for Medicare and Medicaid Services (CMS). Formerly Health Care Financing Administration (HCFA)
   3. Coding perspective
      a. Proper coding
      b. Documentation
      c. Audit procedures

V. Departmental Budget

A. Operational budget
   1. Fixed costs
   2. Variable costs
   3. Flexible budget

B. Capital budget
   1. Capital purchases
   2. Business plans
   3. Request for proposal (RFP)
   4. Depreciation
   5. Market analysis

VI. Professional Societies and Participation Opportunities

A. Organizations
   1. American Society of Radiologic Technologists (ASRT)
      a. Function
      b. Structure
      c. Involvement opportunities
   2. Other organizations

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Orientation to Radiation Therapy

Description

Content is designed to provide student with an overview of the foundations in radiation therapy and the practitioner's role in the health care delivery system. Principles, practices and policies of the educational program, health care organizations, principles of radiation and health safety and professional responsibilities of the radiation therapist will be discussed and examined.

Objectives

1. Discuss the policies and procedures of the educational program.
2. Discuss the policies and procedures of clinical education settings.
3. Identify the responsibilities of a radiation therapy student.
4. Use library/Internet resources pertinent to radiation oncology.
5. Discuss the responsibility of patient, staff and facility confidentiality.
6. Analyze the importance of interdisciplinary care of cancer patients.
7. Discuss the philosophy and mission of health care delivery systems and educational programs.
8. Incorporate key terms used in the principles and practice of radiation therapy.
9. Identify the contents/sections of the patient's records.
10. Explain radiation safety procedures for radiation therapy.
11. Explain health safety procedures for personnel and patients.
12. Differentiate between accreditation, credentialing, certification, registration, licensure and regulations.
13. Explain the purposes, functions and activities of international, national, state and local professional organizations.
14. Discuss the importance of professional and community commitment.
15. Discuss the radiation therapist scope of practice, practice standards and the professional code of ethics.
16. Discuss the benefits of continuing education as related to improved patient care, professional development and personal enhancement.
17. Discuss career advancement and opportunities for the radiation therapist.

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Content

I. Policies and Procedures of the Educational Program

A. Program officials
1. Director
2. Didactic faculty
3. Clinical coordinators
4. Clinical supervisors
5. Clinical faculty
6. Medical director/advisor
7. Students
8. Others

B. Educational program information
1. Mission, goals and outcomes
2. Family education rights and privacy act (FERPA)
3. Curriculum/master plan
4. Course registration
5. Tuition and fee policies
6. Academic standards and related policies
7. Student insurance
8. Textbooks
9. Graduation requirements/terminal objectives
10. Educational schedule
    a. Didactic
    b. Clinical
11. Attendance
12. Dress code
13. Grading policy
14. Vacation/sick leave policy
15. Progressive discipline policy
16. Appeals procedure
17. Library/computer/Internet resources

C. Clinical education setting(s)
1. Operations schedule
2. Conference schedule
3. Clinical hours
4. Equipment
5. Record keeping
6. Dress code
7. Security measures
8. Parking regulations
9. Emergencies/incident reporting

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10. Supervision
11. Clinical evaluation
12. Confidentiality

D. Responsibilities of students
   1. Didactic
      a. Attendance
      b. Class participation
      c. Assignments
      d. Examinations
   2. Laboratories
      a. Attendance
      b. Assignments
      c. Evaluations
   3. Clinical
      a. Attendance
      b. Assignments
      c. General patient care
      d. Radiation treatment delivery
      e. Simulation procedures
      f. Medical dosimetry
      g. Evaluation

II. The Health Science Professions

A. Radiologic sciences
   1. Radiography
   2. Radiation therapy
   3. Medical dosimetry
   4. Quality management
   5. Nuclear medicine
   6. Diagnostic medical sonography
   7. Magnetic resonance
   8. Computerized tomography
   9. Mammography
   10. Vascular-interventional
   11. Other

B. Other patient care professionals
   1. Dietetics
   2. Health information
   3. Medical laboratory sciences
   4. Occupational therapy
   5. Pharmacy

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6. Physical therapy
7. Respiratory therapy
8. Social services
9. Dentistry
10. Pastoral care
11. Nursing
12. Other

III. Hospital and Health Care Organizations

A. Philosophy and mission

B. Administrative services
   1. Governing board
   2. Hospital education setting administration
   3. Admissions
   4. Information technology systems
   5. Finance
   6. Human resources
   7. Other

C. Medical services
   1. Medical director
   2. Medical staff
   3. Resident staff
   4. Intern staff
   5. Medical students
   6. Other

D. Ancillary services
   1. Environmental services
   2. Security
   3. Other

E. Radiation therapy services organization
   1. Professional personnel
      a. Director/chairman
      b. Radiation oncologists
         1) Attending
         2) Resident
         3) Intern
      c. Radiation physicist
         1) Staff physicist
         2) Research assistant

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d. Radiobiologist
e. Radiation therapist
    1) Administrative director
    2) Department manager
    3) Clinical supervisor/lead radiation therapist
    4) Chief/senior radiation therapist
    5) Staff radiation therapist
f. Medical dosimetrist
g. Researcher
h. Nurses
i. Social worker
j. Nutritionist
k. Others

2. Support personnel
    a. Clerical staff
        1) Administrative assistant
        2) Receptionist
        3) Medical secretary
    b. Accounting
        1) Billing
        2) Purchasing
    c. Cancer registry
    d. Transportation services
    e. Medical records
    f. Others

IV. Introduction to Radiation Therapy Practice

A. The radiation therapist
    1. Scope of practice
    2. Practice standards
    3. Code of ethics

B. Cancer management
    1. Cancer incidence
    2. Epidemiology and etiological studies
    3. Detection and diagnosis
    4. Prevention
    5. Treatment
        a. Radiation oncology
        b. Surgical oncology
        c. Medical oncology
        d. Immunotherapy
        e. Complementary and alternative medicine

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6. Research
    a. Clinical trials
    b. Protocols

C. Key terms
1. Radiation therapy equipment
    a. External beam delivery systems
    b. Simulators
    c. Oncology information system
        1) Record and verify
        2) Electronic medical record
        3) Other
    d. Brachytherapy
    e. Other emerging technologies
2. Terms related to the equipment
    a. Collimators
    b. Gantry/gantry angle
    c. Pendant
    d. Wedge/compensators
    e. Portal imaging devices
    f. Isocenter
    g. Optical distance indicator (ODI)
    h. Source skin distance (SSD)/target skin distance (TSD)
    i. Source axis distance (SAD)/target axis distance (TAD)
    j. Other
3. Terms related to the dose to be delivered
    a. Treatment plan
    b. Maximum dose (D_{max})
    c. Monitor unit/time
    d. Tumor dose
    e. Fraction
    f. Other
4. Positioning terms
    a. Beam positioning
        1) POP
        2) AP/PA
        3) Lateral
        4) Oblique
        5) Tangential
        6) Vertex
        7) Rotational
        8) Other
    b. Patient positioning

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1) Supine
2) Prone
3) Other

D. Radiation therapy treatment techniques
1. External beam radiation
2. Brachytherapy
3. Systemic
4. Intraoperative
5. Stereotactic
6. Hyperthermia
7. Other

E. Patient rights and responsibilities
1. HIPAA
2. Record/chart contents
3. Confidentiality
4. Bill of Rights
5. Patient responsibilities

F. Radiation safety
1. Monitoring
2. Protection
   a. Personnel
   b. Patient
   c. Public

G. Health safety
1. Prevention of disease spread
   a. Hand washing
   b. Equipment cleaning
   c. Standard precautions
2. National patient safety goals (NPSG) of The Joint Commission
   a. Patient identification
   b. Time out (verification)
   c. Other
3. Workplace safety
   a. Fire
   b. Electrical
   c. Hazardous materials
   d. Radioactive materials
   e. Personal belongings
   f. Occupational Safety and Health Administration (OSHA)

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V. Professional Organizations

A. Credentialing
   1. Purpose
   2. Functions and activities
   3. Agencies

B. Accreditation
   1. Purpose
   2. Functions and activities
   3. Agencies

C. Associations
   1. Purpose
   2. Functions and activities
   3. Agencies

D. Federal and state agencies
   1. Licensure
   2. Regulations

VI. Professional and Community Commitment

A. Organizations

B. Role of radiation therapist

VII. Professional Development

A. Individual
   1. Continuing education/competency requirements
      a. Definition
      b. Rationale
      c. Requirements
      d. Opportunities
   2. Pursuit of higher education
      a. Scholarly activity
      b. Personal empowerment

B. Career advancement
   1. Administration/education
   2. Medical dosimetry/treatment planning
   3. Physics
   4. Research
   5. Other

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C. Governmental

D. Commercial

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Pathophysiology

Description
Content is designed to introduce concepts related to the disease process. An emphasis on etiological considerations, neoplasia, and associated diseases in the radiation therapy patient should be presented.

Objectives
1. Describe the physiological response in inflammation and cell injury due to pathological insult.
2. Assess the predictive factors, including genetics, lifestyles, age and environment as they influence the development of cancer and associated diseases.
3. Compare the body's response to hereditary, lifestyle, age and environmental factors.
4. Given a specific oncologic-related disease, determine probable diagnostic, prognostic, staging, grading and the rationale for the appropriate therapeutic pathway.
5. Given the histology of a neoplasm, determine the tumor characteristics.
6. Given a common disease, anticipate the effects of the disease on the oncologic patient.

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Content

Part I: General Pathology

I. Introduction to Human Disease

A. Pathologic terminology

B. Most frequent and significant diseases

II. Theories of Disease Causation

A. Current issues/ongoing research

B. Theories

C. Etiology

D. Epidemiology

E. Prevention/screening

III. Basic Principles and Mechanisms of Disease

A. Cell injury
   1. Types
   2. Clinicopathologic correlations

B. Inflammatory response

C. Tissue healing and repair

D. Cellular adaptation
   1. Atrophy
   2. Hypertrophy
   3. Hyperplasia
   4. Metaplasia
   5. Dysplasia

E. Neoplasms
   1. Benign
   2. Malignant

F. Fluid and hemodynamic derangements
   1. Edema
   2. Hyperemia
   3. Hemorrhage
   4. Thrombosis

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5. Embolism
6. Infarction
7. Shock

IV. Common Diagnostic Tests and Procedures

A. Medical history

B. Physical examination

C. Screening tests and procedures

D. Laboratory tests and procedures

E. Radiologic tests and procedures

V. Disorders of Nutrition

A. Starvation and obesity

B. Vitamins and mineral

VI. Body Systems and Disorders including:

Auditory	**Genetic**	**Musculoskeletal**
Cardiovascular	**Hematopoietic**	**Ocular**
Central Nervous	**Immune**	**Reproductive**
Digestive	**Integumentary**	**Respiratory**
Endocrine	**Mental Health**	**Urinary**

A. Overview

B. Common diseases and disorders
1. Etiology and epidemiology
2. Pathophysiology
3. Natural history
4. Clinical manifestations
5. Evaluation of treatment

C. Effects of aging

Part Two: Neoplasia

I. Introduction

A. Overview

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B. Terminology

II. Nomenclature

A. Benign neoplasms
   1. Characteristics
   2. Histologic classification
   3. Clinical behavior and effects

B. Malignant neoplasms
   1. Characteristics
   2. Histologic classification
   3. Clinical behavior and effects

III. Carcinogenesis

A. Theories
   1. Genetic
   2. Epigenetic

B. Prevention

IV. Diagnosis

A. Medical history

B. Physical examination

C. Biopsy

D. Microscopy

E. Laboratory (other)
   1. Molecular probes
   2. Tumor markers
   3. Flow cytometry
   4. Cytogenetic analysis

F. Diagnostic imaging studies

V. Grading and Staging

A. Definitions

B. Purpose

C. Methods

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D. Effect on treatment

VI. Prognostic Factors

A. Tumor related

B. Host related

VII. Malignancies Including:

Breast	**Head and neck**	**Musculoskeletal**
Cardiovascular	**Hematopoietic**	**Reproductive**
Central Nervous	**Integumentary**	**Respiratory**
Digestive	**Lymphatic**	**Urinary**
Endocrine		

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread
   1. Direct invasion
   2. Lymphatic
   3. Blood
   4. Seeding

F. Treatment rationale

G. Prognosis

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Principles and Practice of Radiation Therapy I

Description
Content is designed to provide an overview of cancer and the specialty of radiation therapy. The historic and current aspects of cancer treatment will be covered. The roles and responsibilities of the radiation therapist will be discussed. In addition, treatment prescription, techniques and delivery will be covered.

Objectives
1. Given diagnostic information about a particular cancer, determine the appropriateness of using radiation therapy as a primary treatment modality.
2. Determine the medical and patient information necessary to develop a radiation therapy treatment plan.
3. Determine the appropriate treatment energy for any given tumor type or location.
4. Differentiate between beam modifiers and their uses with a variety of treatment energies.
5. Determine the appropriate treatment setup aid, immobilization technique and beam modifier for a given treatment technique.
6. Identify inconsistencies between treatment prescription and treatment plan.
7. Develop a conventional simulation plan for a particular tumor to include steps needed prior to, during and after the procedure.
8. Develop a CT simulation plan for a particular tumor to include steps needed prior to, during and after the procedure.
9. Critique treatment images in relation to simulation images.
10. Discuss the radiation therapist scope of practice and practice standards.

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Content

I. Cancer Perspectives

A. Cancer incidence

B. Cancer management
   1. Surgery
   2. Radiation therapy
   3. Chemotherapy
   4. Immunotherapy
   5. Multimodality treatment
   6. Cancer diagnosis
   7. Cancer prognosis

C. Cancer prevention

D. Cancer diagnosis

E. Cancer prognosis

II. Treatment Determination for Overall Cancer Management

A. Medical considerations

B. Tumor histology and grade

C. Tumor location

D. Tumor natural history

E. Medical resources

F. Patient considerations

G. Quality of life

H. Protocols

III. Radiation Therapy Treatment

A. Goals of treatment

B. Treatment considerations
   1. Primary vs. multimodality treatment
   2. Tumor histology and grade
   3. Tumor location

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4. Radiosensitivity of tumor
5. Radiosensitivity of surrounding normal structures
6. Medical status of patient
7. Quality of life
8. Survivorship

IV. Radiation Therapy Treatment Equipment

A. External beam
   1. Megavoltage
      a. Linear accelerators
         1) Componenets
         2) Methods of radiation production
            a) Photons
            b) Electrons
         3) Energy
         4) Depth of maximum dose
         5) Target-to-skin distance (TSD)/target-to-axis distance (TAD)
         6) Auxiliary devices
         7) Radiation protection
         8) Patient observation and communication
         9) Emergency procedures
      b. Specialized units
         1) Stereotactic radiosurgery
         2) Intraoperative
            a) Orthovoltage
            b) Megavoltage
         3) Gamma knife
         4) Heave particle accelerators
         5) Tomotherapy
         6) Emerging units

B. Radioisotope units
   1. Teletherapy
      a. Purpose
      b. Methods of radiation production
      c. Half-life
      d. Energy
      e. Components
      f. Radiation protection
      g. Auxiliary devices
      h. Patient observation and communication
      i. Emergency procedures

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j. Proton cyclotrons/synchrotrons
1) Components
2) Methods of radiation production
3) Energy deposition/Bragg peak
4) Compensation
5) Radiation Production

2. Brachytherapy
a. Types
1) High-dose rate (HDR)
2) Medium-dose rate (MDR)
3) Low-dose rate (LDR)
4) Pulsed-dose rate (PDR)
b. Isotopes
c. Purpose
d. Methods of radiation production
e. Half-life
f. Energy
g. Components
h. Radiation protection
i. Auxiliary devices
j. Patient observation and communication
k. Emergency procedures

C. Emerging technologies

V. Simulation and Localization

A. Purpose

B. Equipment
1. Conventional
2. CT
3. Fusion imaging

C. Procedures
1. Preparation for simulation
a. Medical and diagnostic information
b. Check of supplies
c. Physician plan
2. Simulation
a. Patient education
b. Patient safety
c. Construction of immobilization devices
d. Patient positioning

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e. Tumor localization
f. Determination of isocenter
g. Treatment field delineation
h. Measurements
i. Imaging techniques/tumor localization
1) Orthogonal films
2) Slice thickness
a) CT
b) MR
3) Exposure techniques
4) Fluoroscopy
5) Ultrasound
6) Other
j. Contrast

3. General procedure for conventional simulation
4. General procedure for CT simulation

D. Image processing/acquisition

E. Treatment field delineation and measurements

F. Documentation of simulation information

G. Patient observation and communication

H. Emergency medical procedures

VI. Treatment Delivery Accessories

A. Beam directional devices
1. Types
a. Optical laser
b. Front and back pointer
c. Field light and cross-hairs
d. Applicators and cones
e. Other
2. Purpose
3. Applications

B. Beam modification devices
1. Types
a. Bolus
b. Filters
1) Wedges

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2) Hardening
3) Compensating
4) Transmission

2. Beam shaping
   a. Blocks
   b. Collimators
   c. Multileaf collimators (MLC)
   d. Apertures
   e. Snout
   f. Other
3. Purpose
4. Construction
5. Applications
6. Other

C. Patient positioning and immbolization devices
1. Positioning
2. Immobilization
3. Purpose
4. Construction
5. Applications
6. Emerging devices

VII. Treatment Delivery

A. Patient assessment, education and care
1. Communication
2. Physical and psychological response to treatment
3. Report and document reponse to treatment
4. Withhold treatment when conditions warrant
5. Weekly weight recording
6. Checking laboratory values
7. Patient observation
8. Follow-up care

B. Patient safety
1. Radiation protection
2. Standard precautions
3. Biohazards
4. Daily quality assurance of machine and treatment chart
5. Safe transfers
6. Interpretation of treatment prescription
7. Evaluation and interpretation of treatment plan
8. Patient positioning and accessories

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9. Identify, respond to and document equipment malfunctions

C. Treatment parameters
   1. Patient positioning
   2. Field size
   3. Beam modifiers
   4. Treatment beam alignment
   5. Daily dose

D. Treatment imaging

E. Documentation of treatment

F. Reporting and documentation of treatment errors

G. Steps for basic treatment setup and double checks

H. Medical emergency procedures

VIII. Quality Assurance

A. Basic machine checks

B. Treatment plan evaluation

C. Treatment chart evaluation

D. Reporting errors

E. Procedures for preventing errors

IX. Technical Aspect

A. Radiation therapy equipment

B. Simulators
   1. Purpose
   2. Components
   3. Method of radiation production
   4. Fluoroscopy
   5. Auxiliary devices
   6. Radiation protection
   7. Patient observation and communication
   8. Emergency procedures

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C. Superficial and orthovoltage units
    1. Purpose
    2. Components
    3. Method of radiation production
    4. Energy
    5. Auxiliary devices
    6. Patient observation and communication
    7. Emergency procedures

D. Megavoltage units
    1. Linear accelerator
        a. Purpose
        b. Components
        c. Method of radiation production
            1) Photons
            2) Electrons
        d. Energy
        e. Auxiliary devices
        f. Radiation protection
        g. Patient observation and communication
        h. Emergency procedures
    2. Specialized units
        a. Stereotactic radiosurgery
        b. Intraoperative
            1) Orthovoltage
            2) Megavoltage
        c. Heavy particle accelerators

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Principles and Practice of Radiation Therapy II

Description
Content is designed to examine and evaluate the management of neoplastic disease using knowledge in arts and sciences, while promoting critical thinking and the basis of ethical clinical decision making. The epidemiology, etiology, detection, diagnosis, patient condition, treatment and prognosis of neoplastic disease will be presented, discussed and evaluated in relation to histology, anatomical site and patterns of spread. The radiation therapist's responsibility in the management of neoplastic disease will be examined and linked to the skills required to analyze complex issues and make informed decisions while appreciating the scope of the profession.

Objectives
1. Distinguishes tumor histology to determine pathways associated with cancer and neoplastic disease.
2. Examine the role of surgical, radiation and medical oncology to include immunotherapy (biological therapy) in the management of neoplastic disease.
3. Discuss multidisciplinary emerging approaches to neoplastic disease management.
4. Discuss epidemiologic and etiologic information pertinent to each neoplastic site.
5. Identify dose limiting structures and their tolerances.
6. Discuss the clinical presentation for each anatomic neoplastic site.
7. Discuss preventive methods/screening tools associated with each neoplastic site.
8. Explain detection, diagnosis, grading and staging systems for each neoplastic site.
9. Implement the principles and practice of simulation to prepare a patient for treatment.
10. Apply the parameters of treatment field design and arrangement used to treat neoplastic diseases.
11. Examine the role of radiation therapy in palliative disease management.
12. Identify the treatment regimens and fractionalization schemes used in palliative disease management.
13. Describe the role of radiation therapy in the management of oncology emergencies.
14. Discuss the role of radiation therapy in the management of pediatric, acquired immunodeficiency (AIDS)-related and benign neoplasms.

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Content

I. Introduction to Multidisciplinary Approaches to Neoplastic Disease Management

A. Biology of cancer

B. The pathophysiology of cancer

C. Principles of surgical oncology
   1. Surgical detection and biopsy for tissue diagnosis
   2. Principles of curative surgery
   3. Complications associated with surgery as the treatment modality

D. Role and scope of medical oncology
   1. Rationale for the use of chemotherapy
   2. Chemotherapeutic agents
   3. Medical oncology management approaches
   4. Chemotherapy toxicities

E. Roles and scope of immunotherapy
   1. Immunotherapy agents
   2. Immunotherapy management approaches
   3. Complications associated with immunotherapy agents

F. Role and scope of radiation oncology
   1. Biologic basis of radiation oncology
      a. Radiosensitivity
      b. Tissue tolerance and radiation pathology
      c. Time, dose and volume relationships
   2. Principles of radiation oncology practice

G. Emerging approaches to neoplastic disease management

H. Multidisciplinary treatment decisions in the management of neoplastic disease

II. Radiation Therapy Treatment of Neoplastic Disease Originating in the following sites:

Breast	**Genitourinary**	**Lymphoreticular**
Central Nervous	**Head and Neck**	**Musculoskeletal**
Endocrine	**Hematopoietic**	**Reproductive**
Gastrointestinal	**Integumentary**	**Respiratory**

A. Epidemiology

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B. Etiology

C. Prevention methods and screening tools

D. Pertinent anatomy and lymphatics
   1. Dose limiting structures

E. Natural history of disease

F. Clinical presentation

G. Detection and diagnosis
   1. History and physical examination
   2. Imaging studies
   3. Tumor markers
   4. Laboratory studies
   5. Surgical and pathology reports

H. Histopathology
   1. Disease classification
      a. Staging
      b. Grading

I. Multimodality treatment approach
   1. Treatment modality combinations
   2. Treatment morbidity/toxicity
      a. Acute
      b. Chronic
      c. Survivorship

J. Simulation and treatment principles and practice
   1. Treatment volume localization
   2. Interpretation and implementation of treatment plan
   3. Treatment delivery
      a. Patient positioning
      b. Immobilization devices
      c. Parameters of treatment field design and arrangement
      d. Beam energy
      e. Dose schedule

III. Radiation Therapy in the Management of Neoplasms with Speacial Considerations

A. Pediatric neoplasms
   1. Leukemia

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2. Lymphomas
3. Solid tumors

B. AIDS-related neoplasms
   1. Kaposi sarcoma
   2. Non-Hodgkin lymphoma (NHL)

C. Benign neoplasms

IV. Metastatic and Palliative Treatment Applications

A. Common sites of metastases

B. Detection and diagnosis

C. Therapeutic management of metastases

V. Emergency Treatment Applications

A. Types of oncologic emergencies

B. Diagnosis

C. Treatment

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Principles of Computed Tomography in Radiation Oncology

Description
Content is designed to provide students with an exposure to principles related to computed tomography (CT) imaging.

Objectives
1. Describe the components of the CT imaging system.
2. Differentiate between conventional and spiral/helical CT scanning.
3. Explain the functions of collimators in CT.
4. List the CT computer data processing steps.
5. Name the functions of the array processor used for image reconstruction.
6. Define the term "algorithm" and explain its impact on image scan factors and reconstruction.
7. Define the terms "raw data" and "image data."
8. Explain the difference between reconstructing and reformatting an image.
9. Describe the application of the following terms to CT:
    - Pixel.
    - Matrix.
    - Voxel.
    - Linear attenuation coefficient.
    - CT/Hounsfield number.
    - Partial volume averaging.
    - Window width (ww) and window level (wl).
    - Spatial resolution.
    - Contrast resolution.
    - Noise.
    - Annotation.
    - Region of interest (ROI).
    - Standard vs. volumetric data acquisition.
10. Name the common controls found on CT operator consoles and describe how and why each is used.
11. Identify the types and appearance of artifacts most commonly affecting CT images.
12. Explain how artifacts can be reduced or eliminated.
13. List and describe current data storage techniques used in CT.
14. Name the radiation protection devices that can be used to reduce patient dose in CT and describe the correct application of each.

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Content

I. Current Computed Tomography Equipment

A. Capabilities and limitations

II. Components, Operations and Processes

A. Data acquisition

1. Methods
   a. Slice-by-slice
   b. Volumetric
2. Elements
   a. Beam geometry
      1) Parallel
      2) Fan
      3) Spiral

3. Data acquisition system (DAS)
   a. Components
      1) Tube
      2) Detectors
      3) Filters
      4) Collimators
      5) Analog-to-digital converter (ADC)
      6) Gantry/table
      7) Optical lasers
   b. Functions
      1) Measurement of transmitted beam
      2) Encoding measurements into binary data
      3) Logarithmic conversion of data
      4) Data transmission to computer
4. Data acquisition process
   a. Scanning/raw data/image data
      1) Rays
      2) Views
         a) Beams eye view (BEV)
         b) Volumes of interest
      3) Profiles
         a) Pixels
         b) Matrices
         c) Voxels
   b. Attenuation
      1) Linear attenuation coefficients
      2) CT/Hounsfield numbers
         a) Baseline reference numbers

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i) Water equal to 0
ii) Bone (white) equal to 400 – 1000
iii) Air (black) equal to – 1000

c. Selectable scan factors
1) Scan field of view
2) Display field of view
3) Matrix size
4) Slice thickness
5) Algorithm
6) Scan time and rotational arc
7) Radiographic tube output
8) Region of interest (ROI)
9) Magnification
10) Focal spot size and tube geometry

d. Power injectors

B. Factors controlling image appearance

C. Anatomical structures
1. Artifacts
2. Contrast resolution
a. Window width
3. Grayscale manipulation
a. Window level
4. Distortion
5. Noise
6. Spatial resolution

D. Postprocessing
1. Image reformation
2. Image smoothing
3. Edge enhancement
4. Grayscale manipulation

III. Radiation Protection

A. Methods for reducing radiation dose to the patient
1. Technical factor selection
2. Technical adjustments for children
3. Scatter radiation reduction

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Quality Management

Description
Content is designed to focus on the components of quality improvement (QI) programs in radiation oncology. Topics will include quality control and assurance checks for the clinical aspects of patient care, medical records, treatment delivery and localization equipment and treatment planning equipment. The role of the various radiation therapy team members in continuous quality improvement will be discussed as well as the legal and regulatory implications for maintaining appropriate quality care.

Objectives
1. Discuss components of a quality management (QM) program.
2. Discuss the purpose, function and member's role on a quality management team.
3. Explain federal, state and institutional accreditation standards and reporting regulations for quality management.
4. Examine outcomes of quality management in radiation oncology.
5. Explain the purpose, procedures and frequency for manual and electronic treatment documentation.
6. Identify errors in treatment documentation.
7. Describe the procedure for assuring accuracy of manual and electronic records.
8. Examine the purpose and function of record and verify systems.
9. Examine the patient chart in terms of medical and legal issues.
10. Discuss the significance of treatment outcomes for patient care, education and research in radiation oncology.
11. Discuss the quality indicators to evaluate patient care areas.
12. Explain the purpose, procedure and frequency for all QA and QM procedures in a radiation therapy department.
13. Evaluate how the outcomes of QA and QM procedures impact patient care, education and research.
14. Examine statistical reporting available through quality assurance computerization.
15. Perform quality measures for computerized operation, data collection and reporting.
16. Determine sources of malfunction on the treatment and simulation/localization units.
17. Distinguish between safe and hazardous equipment operation.
18. Comply with acceptable quality limits for treatment operation.
19. Identify the source of error and determine the effect on treatment delivery, education and research.
20. Differentiate between quality management programs.
21. Discuss the importance of patient education in the quality management process.
22. Discuss the importance of proper patient identification and treatment field documentation.
23. Discuss aspects of clinical evaluation, therapeutic decision-making and informed consent.
24. Identify the key aspects of delivering a precise prescribed treatment dose.

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25. Discuss quality control procedures and recommended tolerances for simulation equipment, megavoltage treatment units and treatment planning systems.
26. Discuss quality control procedures and recommended tolerances for the safe handling of brachytherapy sources and remote afterloading equipment.

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Content

I. Introduction

A. QM or QI
   1. Definition
   2. Rationale

B. Types of QI/QM programs
   1. Model
   2. Mandatory

C. Goals
   1. Comprehensive assessment
   2. Team approach

II. General Principles

A. Regulating agencies
   1. Federal
   2. State
   3. Institutional
   4. Professional

B. Definitions
   1. Quality assurance
   2. Quality control
   3. Quality assessment
   4. Quality audit
   5. Quality improvement
   6. Continuous quality improvement
   7. Total quality improvement

C. Standards
   1. Staffing levels, qualifications, responsibilities
   2. Equipment availability
   3. Dosimetric accuracy

D. Components
   1. Team/committee members and responsibilities
   2. QI plan
   3. Policies and procedures
   4. Quality indicators
   5. Outcomes
   6. QI process

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III. Clinical Aspects QI Checks

A. General conditions of patient care area
   1. Purpose, procedure and frequency
   2. Corrective measures
   3. Material safety data sheet (MSDS)
   4. Documentation

B. Communication
   1. Purpose, procedure and frequency
   2. Corrective measures
   3. Documentation

C. Mold/block fabrication area
   1. Purpose, procedure and frequency
   2. Protective measures
   3. Corrective measures
   4. Documentation

D. Accessory devices
   1. Purpose, procedure and frequency
   2. Corrective measures
   3. Documentation

E. Treatment chart
   1. Required contents
   2. Treatment documentation
   3. Record and verify
   4. Electronic and paper
   5. Medical/legel aspects of documentation
   6. Corrective measures and documentation
   7. Chart review purpose, procedure and frequency

F. Portal imaging
   1. Purpose, procedure and frequency
   2. Corrective measures
   3. Documentation

G. Computerization
   1. Purpose, procedure and frequency
   2. Corrective measures
   3. Documentation

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IV. QA or QC for Treatment and Simulation/Localization to include:

- Control panel and indicator lights
- Light field, radiation field and collimator
- Field symmetry and flatness
- Stability of isocenter under collimator and gantry rotation
- Mechanical and electrical safety devices
- Machine dose rate
- Mechanical and optical patient alignment devices
- Collimator rotation
- Treatment couch isocenter
- Distance indicators
- Beam penetration quality
- Linear scales on treatment tables
- Gantry rotation
- Target verification systems
- Treatment devices

A. Purpose, procedure and frequency (AAPM, Task Group 40)

B. Sources of malfunction

C. Materials and methodology

D. Evaluation and interpretation of results

E. Corrective measures

F. Documentation

G. Safety and hazards

H. Guidelines to tolerance values

I. Preventative maintenance

V. Particle Accelerators

A. Purpose, procedure and frequency of checks

B. Sources of malfunction/error

C. Materials and methodology

D. Safety and hazards

E. Corrective measures

F. Guidelines to tolerance values

G. Documentation

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VI. Brachytherapy

A. Purpose, procedure and frequency of checks

B. Sources of malfunction/error

C. Materials and methodology

D. Safety and hazards

E. Corrective measures

F. Guidelines to tolerance values

G. Documentation

VII. Medical Dosimetry and Treatment Planning

A. Purpose, procedure and frequency of checks

B. Sources of malfunction/error

C. Data acquisition

D. Materials and methodology

E. Safety and hazards

F. Corrective measures

G. Documentation

H. Outcomes
   1. Patient care
   2. Educational
   3. Research

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Radiation Biology

Description
Content is designed to present basic concepts and principles of radiation biology. The interactions of radiation with cells, tissues and the body as a whole and resultant biophysical events will be presented. Discussion of the theories and principles of tolerance dose, time-dose relationships, fractionation schemes and the relationship to the clinical practice of radiation therapy will be discussed, examined and evaluated.

Objectives
1. Integrate laws and principles of radiation biology to the clinical practice of radiation therapy.
2. Identify radiosensitive components of the cell.
3. Distinguish between units of radiation quantities and radiobiologic measures.
4. Differentiate between direct and indirect effects of ionizing radiation.
5. Explain factors affecting relative biological effectiveness (RBE).
6. Discuss the effects of electromagnetic and particulate radiations on cellular interactions.
7. Evaluate factors influencing radiobiologic/biophysical events at the cellular and subcellular level.
8. Determine biologic damage due to radiation-induced chemical reactions.
9. Discuss radiation effects on the cell cycle.
10. Compare somatic and genetic effects of radiation.
11. Describe factors influencing radiation response of cells and tissues.
12. Discuss the laws of Bergonié and Tribondeau.
13. Interpret cell survival curves to determine radiosensitivity under numerous conditions.
14. Discuss the relationship of radiation quality and dose to systemic responses.
15. Describe radiation syndromes and factors influencing response.
16. Differentiate between linear, nonlinear, and threshold and nonthreshold dose response curves.
17. Describe the 5 Rs of radiobiology.
18. Describe the clinical significance of $TD_{5/5}$ and $TD_{50/5}$.
19. Discuss the concept of $LD_{50/30}$.
20. Compare the relationship of time, dose, fractionation, volume, distance and site to radiation effects.
21. Discuss the use of radiation response modifiers.
22. Describe the influence of chemotherapy and hyperthermia alone and in combination with radiation therapy.

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Content

I. Introduction

A. Review of cell biology
   1. Basic unit of life
   2. Cell constituents
   3. Cell structure
   4. Cell growth
      a. Mitosis
      b. Meiosis
      c. Cell cycle
      d. Differentiation

B. Types of ionizing radiations
   1. Electromagnetic radiations
   2. Particulate radiations

C. Sources of medical radiation exposure

II. Biophysical Events

A. Specification of radiation quantities
   1. Physical units
   2. Biologic units
      a. Gray (Gy)
      b. Sievert (Sv)

B. Molecular effects of radiation
   1. Radiolysis of water
   2. Target theory
      a. Target molecules
      b. Cell death

C. The deposition of radiant energy
   1. Linear energy transfer (LET)
   2. Relative biological effectiveness (RBE)
   3. Factors influencing RBE
      a. LET
      b. Oxygen

III. Radiation Effects

A. Subcellular radiation effects
   1. Radiation effects on deoxyribonucleic acid (DNA)
      a. Types of damage
      b. Implications in humans

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2. Radiation effects of chromosomes
    a. Types of damage
    b. Implications in humans

B. Cellular radiation effects
1. Types of cell death
    a. Interphase death
    b. Mitotic (genetic) death
2. Other effects
    a. Mitotic delay
    b. Reproductive failure
    c. Interference of function

C. Individual radiation effects
1. Somatic effects
    a. Short term
    b. Long term
    c. Stochastic effects
    d. Nonstochastic effects
2. Genetic effects
    a. Mutagenesis

D. Factors influencing radiation response
1. Determining response
2. Lethal and sublethal response

IV. Radiosensitivity and Response

A. Law of Bergonié and Tribondeau
1. Differentiation
2. Mitotic rate
3. Metabolic rate

B. Cell survival curves
1. Typical survival parameters
    a. Slope
    b. Shoulder
    c. Quasi-threshold
2. Factors influencing survival curves
    a. LET
    b. Oxygen
    c. Fractionation

C. Systemic response to radiation

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1. Hemopoietic system
2. Skin
3. Digestive
4. Urinary
5. Respiratory
6. Reproductive
7. Nervous
8. Other

D. Tolerance dose
   1. Minimal
   2. Maximal
   3. Mean

E. Total body irradiation (TBI)
   1. Radiation syndromes
      a. Acute
      b. Hemopoietic
      c. Gastrointestinal
      d. Central nervous system

F. Radiation dose response curves
   1. Threshold
   2. Nonthreshold
   3. Linear
   4. Nonlinear
   5. Linear quadratic

V. Biologic Principles of Radiation Therapy

A. Tumor cell kinetic clinical radiation therapy concepts
   1. Therapeutic ratio
   2. Cell cycle age response
   3. Radiation type
      a. High LET
      b. Low LET
   4. Five Rs of radiobiology
      a. Repair
      b. Repopulation
      c. Reoxygenation
      d. Redistribution
      e. Radiosensitivity
   5. Fractionation
      a. Definition

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b. Rationale
c. Types

6. Time-dose relationships
   a. Nominal standard dose (NSD)
   b. Isoeffect curves
   c. Rad equivalent therapy (RETS)
   d. Dose rate
   e. Alpha-beta ratios (α-β ratios)
7. Volume
   a. Tumor volume
   b. Treatment volume
   c. Volume vs. complications
   d. Time-dose-volume relationship

B. Chemotherapeutic considerations
   1. Chemotherapy and radiation therapy
      a. Concurrent
      b. Neoadjuvant
   2. Radioprotectors and sensitizers
      a. Strategy
      b. Action

C. Hyperthermia
   1. Cellular response to heat
   2. Methods of heating
   3. Interactions of heat and radiation

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Radiation Physics

Description
Content is designed to establish a basic knowledge of physics pertinent to developing an understanding of radiations used in the clinical setting. Fundamental physical units, measurements, principles, atomic structure and types of radiation are emphasized. Also presented are the fundamentals of x-ray generating equipment, x-ray production and its interaction with matter.

Objectives
1. Define the fundamental units of the English, metric and Système International d'Unites (SI) systems.
2. Calculate various unit conversions.
3. Demonstrate applications of the general principles that relate to inertia, work, energy and momentum.
4. Describe Bohr's theory of atomic structure.
5. Compare the characteristics and functions of a proton, neutron and electron.
6. Discuss the energy levels of the atom.
7. Define the terms relating to atomic nomenclature.
8. Compare covalent bonding and ionic bonding.
9. Describe the process of ionization.
10. Differentiate between the characteristics of a mixture, substance and element.
11. Classify the characteristics of an element using the periodic table.
12. Compare the characteristics of a molecule and compound.
13. Describe the nature of light.
14. Explain the relationship between wavelength, frequency and velocity.
15. Differentiate between the radiations of the electromagnetic (EM) spectrum.
16. Explain the relationship of energy and frequency to Planck's constant.
17. Distinguish between electrical charge and electrical field.
18. Describe the methods of electrification.
19. Explain the laws of electrostatics and their application.
20. Describe the properties and laws of magnetism.
21. Explain the electronic spin of an element to its potential magnetic properties.
22. Describe the principle of magnetic induction.
23. Define potential difference, current, resistance, circuit and electric power.
24. Compare the characteristics of direct and alternating currents.
25. Compare electrical measuring devices.
26. Discuss electrical protective devices.
27. Discuss the interaction between electric and magnetic fields.
28. Describe the characteristics and functions of a cathode and rotating anode.
29. Describe the construction and function of tube housing.
30. Identify the parts of an x-ray tube.

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31. Determine heat units and cooling characteristics of x-ray tube housings.
32. Propose methods to extend tube life.
33. Discuss application and components of automatic exposure devices.
34. State the principles of x-ray production.
35. Compare the production of bremsstrahlung with the production of characteristic radiations.
36. Compare various photon interactions in terms of description of interaction, relation to atomic number and applications.
37. Discuss relationships of wavelength and frequency to beam characteristics.
38. Define units of radiation measurement and provide an example of its application.

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Content

I. Units of Measurement

A. Fundamental units
   1. Length
   2. Mass
   3. Time
   4. Temperature

B. Derived units
   1. Area
   2. Volume
   3. Density
   4. Specific gravity
   5. Velocity

C. Systems of measurement
   1. English
   2. Metric
   3. SI

II. General Principles

A. Mass

B. Force

C. Energy

D. Relationship between matter and energy

E. Forces of nature

III. Structure of the Atom

A. Atom
   1. Size
   2. Atomic mass and energy

B. Nucleus
   1. Components
      a. Proton
      b. Neutron
      c. Other
   2. Structure
      a. Size

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b. Neutron/proton ratio
c. Binding energy

C. Electron Shells
1. Components
2. Arrangements
a. Binding energy
b. Movement
c. Ionization
d. Excitation

D. Nomenclature
1. Atomic number
2. Mass number
3. Isotope
4. Isobar
5. Isomer
6. Isotone
7. Ion

IV. Structure of Matter

A. Elements
1. Definition
2. Periodic table
3. Nuclides

B. Compound
1. Definition
2. Molecule

C. Mixtures
1. Definition
2. Examples

V. Nature of Radiation

A. Radiation
1. Electromagnetic
2. Particulate
3. Nonionizing vs. ionizing
a. Atomic number
b. Energy
c. Probability

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B. Radioactivity
   1. Historical introduction
   2. Half-life ($T_{½}$)
   3. Units
      a. Curie (Ci)
      b. Becquerel (Bq)
   4. Line of stability

VI. Electromagnetic Radiation

A. Nature of electromagnetic radiation
   1. Speed of light
   2. Wavelength
   3. Frequency

B. Electromagnetic spectrum
   1. Types of electromagnetic radiation
   2. X-rays and gamma rays
      a. Energy
      b. Planck's constant

VII. Electrostatics

A. Electrical charge
   1. Definition
   2. Source
   3. Unit of charge (coulomb)

B. Electrical field
   1. Definition
   2. Source

C. Methods of electrification
   1. Friction
   2. Contact
   3. Induction

D. Laws of electrostatics

VIII. Magnetism

A. Fields

B. Interactions with charged particles

C. Magnetic resonance

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IX. Electrodynamics

A. Moving charges
   1. Potential differences
   2. Current
      a. Direct
      b. Alternating
   3. Resistance
   4. Circuit

B. Measuring devices

C. Protective devices
   1. Fuse
   2. Ground
   3. Circuit breaker
   4. Other

X. Electromagnetism

A. Interaction between electric/magnetic fields

B. Induction
   1. Self
   2. Mutual

XI. Diagnostic X-ray Tubes

A. Construction
   1. Anode
   2. Cathode
   3. Tube housing
   4. Thermal capacity
      a. Tube rating
      b. Anode cooling
      c. Housing cooling

XII. Production and Characteristics of Radiation

A. X-ray production
   1. Processes
      a. Bremsstrahlung
      b. Characteristic
   2. Necessary conditions (electron)
      a. Source
      b. Acceleration

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c. Deceleration
3. X-ray energy spectra
4. Factors affecting x-ray exposure rate
   a. Tube potential
   b. Tube current
   c. Filament current
   d. Time
   e. Distance
   f. Filtration

B. Wave model

C. Quantum model

D. Interactions of photons with matter
1. Transmission
2. Unmodified scattering (coherent), photoelectric effect, Compton scattering
   a. Description of interaction
   b. Relation to atomic number
   c. Energy of incident photon and resulting product
   d. Probability
   e. Application
3. Pair production
   a. Description of interaction
   b. Relation to atomic number
   c. Energy
   d. Probability
   e. Application
   f. Annihilation reaction
4. Photodisintegration
   a. Description of interaction
   b. Energy
   c. Products
   d. Application

E. Clinical significance and relative importance of the various types of interactions

F. Beam characteristics
1. Energy
2. Attenuation
   a. Atomic number of attenuating medium
   b. Thickness of attenuating medium
   c. Scatter

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G. Units of measurement
    1. Coulomb/kilogram/roentgen
    2. Gray(Gy)/rad
    3. Sievert(Sv)/(rem)
    4. Electron volt (eV)
    5. Ergs
    6. Joules

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Radiation Protection

Description
Content is designed to present basic principles of radiation protection and safety for the radiation therapist. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated. Specific responsibilities of the radiation therapist are discussed, examined, performed and evaluated.

Objectives
1. Distinguish between somatic and genetic effects of radiation exposure.
2. Differentiate between stochastic and nonstochastic effects of radiation exposure.
3. Defend the concept of as low as reasonably achievable (ALARA).
4. Discuss the concept of negligible individual risk.
5. Describe the legal and ethical radiation protection responsibilities of radiation workers.
6. Use appropriate terminology and units when discussing radiation protection issues.
7. Select the correct units of radiation for exposure, absorbed dose, dose equivalence and radioactivity.
8. Discuss the interrelationship between relative biological effectiveness and quality factors.
9. Explain the theory, operation, applications and limitations of radiation detection devices.
10. State the authority, boundaries and regulations of the state and national regulatory agencies.
11. Discuss the requirements and responsibilities of the radiation safety officer.
12. Compare the various methods used for personnel monitoring.
13. State the exposure limits for occupational and nonoccupational individuals.
14. Explain techniques used to reduce unnecessary dose to the patient.
15. Develop an emergency action plan for equipment failure.
16. Discuss the principles of radiation protection room design factors.
17. Describe the elements of a radiation protection survey for an inpatient undergoing brachytherapy.
18. Calculate exposure doses based on time, distance and type of radioactivity.
19. Describe the procedure for a hot lab room survey.
20. Describe procedures to receive and ship radioactive materials.
21. Evaluate a record keeping system for radioactive sources to ensure inclusion of all required elements.

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Content

I. Introduction

A. Justification for radiation protection

B. Biologic damage potential of ionizing radiation
   1. Somatic effects
   2. Genetic effects
   3. Stochastic and nonstochastic effects

C. Objectives of a radiation protection program
   1. Documentation
   2. Occupational and nonoccupational dose equivalent limits
   3. ALARA concept
   4. Comparable risk
   5. Negligible individual risk level (NIRL)

D. Sources of radiation

E. Legal and ethical responsibilities

II. Units, Detection and Measurement

A. Physical unit of exposure

B. Biologic unit of dose

C. Unit of dose equivalent
   1. Recommendations for effective dose equivalent limits
   2. Quality factors

D. Physical unit of radioactivity

E. Measurement devices: principle/application/types
   1. Ion chambers
   2. Proportional counters
   3. Thermoluminescent dosimeter
   4. Other

III. Surveys, Regulatory Agencies and Regulations

A. General survey procedures
   1. Qualified expert
   2. Records

B. Equipment survey

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1. Treatment
2. Simulation

C. Area survey
   1. Controlled/uncontrolled areas
   2. Conditions
   3. Recommendations
   4. "Radiation Area" sign posting

D. Regulatory and advisory agencies

E. Radiation safety officer roles and responsibilities

IV. Personnel Monitoring

A. Requirements for personnel monitoring

B. Methods and types of personnel monitors
   1. Radiation
   2. Particle

C. Records of accumulated dose
   1. Purpose
   2. Content
   3. Length of record keeping
   4. Retrieval from previous employers

D. Dose limits – Nuclear Regulatory Commission, Title 10, CFR part 20
   1. Occupational
   2. Nonoccupational limits
   3. Critical organ sites
   4. Embryo-fetus
   5. Age proration formula

E. Responsibility for radiation protection
   1. Radiation therapist
   2. Radiation safety officer (RSO)
   3. Facility

V. Practical Radiation Protection

A. Design
   1. Barriers
   2. Factors
      a. Use (U) controlled/uncontrolled

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b. Workload (W)
c. Occupancy (T)
d. Distance (d)

3. Safety ancillary equipment
   a. Interlocks
   b. Visual monitors
   c. Audio monitors
   d. Emergency controls
   e. Quality assurance
4. Equipment safety
   a. Beam defining equipment
   b. Exposure control devices
   c. On and off switches
   d. Performance standards per design specifications
   e. Calibrations
   f. Quality assurance
   g. Emergency switches/brakers

B. Regulation and advisory recommendations
   1. NRC
   2. National Council on Radiation Protection and Measurements (NCRP)
   3. State agency

C. Cardinal principles in protection

D. Emergency procedures

VI. Brachytherapy

A. Storage
   1. Inventory systems
   2. Containers
   3. Room design

B. Source preparation
   1. Applicators and maintenance
   2. Preparation and loading of applicators
   3. Unloading and cleaning applicators

C. Remote afterloaders
   1. Equipment components
   2. Applicators
   3. Maintenance

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D. Surveys
    1. Patient
    2. Leak testing
    3. Area/room surveys
    4. Area radiation monitor
    5. Methods, documentation, frequency

E. Licensing, transport, area posting and documentation
    1. Governmental regulations
    2. State regulations

F. Management of accidents
    1. Procedures for confinement and decontamination
    2. Procedures for source retrieval
    3. Notifications
    4. Documentation

G. Disposal of radioactive waste material

H. Quality assurance for brachytherapy

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Radiation Therapy Patient Care

Description
Content is designed to provide the student with foundation concepts and competencies in assessment and evaluation of the patient for service delivery. Psychological and physical needs and factors affecting treatment outcome will be presented and examined. Routine and emergency care procedures will be presented.

Objectives
1. Analyze the radiation therapist scope of practice and code of ethics for clinical application.
2. Explain Bill of Rights for Patients.
3. Differentiate between the roles and responsibilities of health care team members treating cancer patients.
4. Demonstrate applications of professional self-care.
5. Examine different psychological aspects of dying.
6. Explain the dynamics of communicating with the cancer patient and family.
7. Recognize radiation side effects and complications and select the appropriate medical intervention.
8. Identify factors that influence a patient's emotional responses.
9. Formulate content for answers to questions frequently asked by patients.
10. Assess the physical condition of the patient before, during and after treatment delivery.
11. Demonstrate application of the principles of health safety.
12. Discuss the principles of medication administration.
13. Recognize common medications and explain their actions and side effects.
14. Evaluate a patient for an adverse reaction to medication.
15. Describe emergency response procedures.
16. Describe the proper care of patients with tubes.
16. Provide patient education for medical procedures.
18. Assess the patient before, during and after brachytherapy procedures.
19. Demonstrate the application of the principles of radiation protection during brachytherapy procedures.
20. Assess the nutritional status of the cancer patient to provide nutritional education or intervention.
21. Demonstrate proper use of the principles of patient safety and transfer.
22. Provide appropriate patient education following patient assessment.
23. Select patient education materials appropriate for patient needs.
24. Compare conventional and alternative medicine.

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Content

I. Introduction

A. The multidisciplinary health care team

B. The radiation oncology team

II. Communication in Patient Care

A. Health-illness continuum

B. Developing professional attitudes
   1. Serve as health role models
      a. Avoiding burnout
         1) Definition
         2) Factors that increase burnout
         3) Signs and symptoms
         4) Principles of self care
   2. Empathy
   3. Assertiveness

C. Communication
   1. Verbal
   2. Nonverbal
   3. Challenges in patient communication
      a. Hearing, vision and speech problems
      b. Impaired mental function
      c. Literacy
      d. Altered states of consciousness
      e. Pediatric and adolescent patients
      f. Geriatric patients
      g. Communicating in stressful circumstances
      h. Cultural diversity
      i. Artificial speech
         1) Transesophageal puncture (TEP)
         2) Esophageal speech
         3) Electrolarynx devices
      j. Language barriers
         1) Foreign
         2) Colloquialism/slang
         3) Medical jargon
   4. Feedback
   5. Patient interactions
      a. Establishing therapeutic relationships
         1) Reducing distance

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2) Listening
3) Using therapeutic silence
4) Responding to the feeling and the meaning of the patient's statement
5) Restating the main idea
6) Reflecting the main idea

b. Body language

6. Communicating with families
7. Communicating with other health care professionals

D. Psychological considerations
1. End-of-life issues
a. Understand the process
b. Aspects of death
1) Emotional
2) Psychological
a) Depression
b) Coping
c) Quality of life
3) Physical
a) Pain
b) Suffering
c) Disability
d) Deterioration
c. Stages of dying
1) Disbelief
2) Denial
3) Anger
4) Bargaining
5) Acceptance
d. Patient support services
1) Family/friends
2) Pastoral care
3) Patient-to-patient support groups
4) Cancer-specific support groups
5) Hospice
6) Health professionals
7) Community agencies
8) Referrals
a) Appropriate time
b) Process
2. Patient's emotional responses
a. General behavior

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b. Influencing factors
   1) Age
   2) Sex
   3) Marital/family status
   4) Socioeconomic factors
   5) Cultural/religious variations
   6) Physical condition
   7) Self-image
   8) Life experiences
   9) Health care environment
   10) Beliefs/values
   11) Attitudes
   12) Prejudices
   13) Self-awareness

III. Patient-family Interactions

A. Patient identification

B. Treatment procedure questions and explanations
   1. Positioning
   2. Length of procedure/treatment
   3. Audio and visual intercommunication system
   4. Room noises
   5. Immobilization devices
   6. Machine movement
   7. Machine-patient contact
   8. Machine type
   9. Application of auxiliary equipment
   10. General expectations

C. Other common patient concerns
   1. Misconceptions related to radiation
   2. Scheduling
   3. Transportation
   4. Financial

D. Holistic approaches to family members and friends
   1. Informing
   2. Supporting
   3. Family systems concepts
   4. Conflict resolution

IV. Assessment of Acute Side Effects

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A. Influencing factors
    1. Dose
    2. Fractionation
    3. Combination treatments

B. Specific side affects
    1. Skin reactions
        a. Erythema
        b. Dry and moist desquamation
    2. Fatigue
    3. Sleep
    4. Mouth changes
    5. Diarrhea
    6. Cystitis
    7. Nausea and vomiting
    8. Pharyngitis/esophagitis
    9. Mucositis
    10. Xerostomia
    11. Alopecia
    12. Pain
    13. Skin pallor
    14. Weight loss
    15. Taste changes

V. Assessment of Other Physical Needs

A. Physical needs of the patient

B. Assessing patient status

C. Physical signs

D. Vital signs
    1. Temperature
    2. Pulse
    3. Respiration
    4. Blood pressure
    5. Pain

E. Weight

F. Laboratory values
    1. Complete blood count (CBC) with differential
    2. Blood urea nitrogen (BUN)

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3. Creatinine

VI. Patient Examination

A. Initial assessment

B. Records
   1. Diagnostic
   2. Medical record

C. General physical examination
   1. Purpose
   2. Preparation
   3. Procedure

D. Selected examinations/purpose and procedure
   1. Oral
   2. Rectal
   3. Pelvic
   4. Neurological
   5. Other

E. Selected procedures
   1. Papanicolaou (Pap) smear
   2. Lesion biopsy
   3. Cultures
   4. Laboratory studies/normal values
      a. Complete blood count
      b. Urinalysis
      c. Electrolytes
      d. Other
   5. Aspiration/centesis

F. Equipment/instruments
   1. Identification
   2. Care

VII. Health Safety

A. Terminology
   1. Nosocomial
   2. Communicable
   3. Infectious pathogens

B. Centers for Disease Control (CDC)

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C. Cycle of infection
    1. Infectious pathogens
        a. Endopathogens
        b. Ectopathogens
    2. Reservoir of infection
    3. Susceptible host
    4. Transmission of disease
        a. Direct
        b. Indirect
            1) Vehicle
            2) Vector
            3) Airborne

D. Asepsis
    1. Medical
        a. Definition
        b. Methods
            1) Heat
            2) Chemical
        c. Hand washing
            1) Soap
            2) Water
            3) Friction
            4) Time
            5) Chemical disinfectants
    2. Surgical
        a. Definition
        b. Growth requirements for microorganisms
        c. Methods used to control microorganisms
            1) Moist heat
                a) Steam under pressure
            2) Dry heat
                a) Incineration
                b) Dry heat oven
                    (1) Gas
                    (2) Chemicals
                    (3) Ionizing radiation
        d. Procedures
            1) Opening packs
            2) Gowning/gloving
            3) Skin preparation
            4) Draping

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5) Dressing changes
e. Packing
f. Storage
g. Rules for surgical asepsis

E. Practical asepsis
1. Handling linens
2. Wound care
a. Cleansing
b. Dressing
3. Personal protective equipment (PPE)

F. Isolation techniques and communicable diseases
1. Category-specific
2. Disease-specific
3. Standard precautions
4. Examples
a. Human immunodeficiency virus (HIV)/AIDS
b. Hepatitis
1) Type A
2) Type B
3) Type C
c. Tuberculosis (TB)
d. Methicillin-resistant staphylococcus aureus (MRSA)
e. Other

G. Isolation patient in the department
1. Procedure
a. Gowning
b. Gloving
c. Masking
2. Patient transfer
3. Clean-up

H. Precautions for the compromised patient (reverse isolation)
1. Purpose
2. Procedure

I. Psychological considerations

VIII. Medications and Their Administration

A. Role of the radiation therapist

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B. Medication information
    1. Generic name
    2. Trade name
    3. Drug information
        a. *Physician's Desk Reference* (PDR)
        b. Product information sheets
    4. Abbreviations/equivalents
    5. Pharmacology and administration
        a. Adrenergic blocking agents
        b. Analgesics
        c. Anesthetics
        d. Antibacterials
        e. Anticonvulsants
        f. Antidepressants
        g. Antiemetics
        h. Antineoplastics
            1) Alkylating agents
            2) Antimetabolites
            3) Antineoplastic antibiotics
            4) Vinca alkaloids
            5) Hormones
            6) Miscellaneous agents
        i. Antifungals
        j. Antihistamines
        k. Contrast media
        l. Hypoglycemics
        m. Narcotics
            1) Narcotic antagonists
        n. Radioactive materials
        o. Sedatives
        p. Skeletal muscle relaxants
        q. Stimulants
        r. Vasodilators
    6. Biological response modifiers
        a. Monoclonal antibodies
        b. Immunotherapy
        c. Other
    7. Nutrients, fluids and electrolytes
    8. Clinical research
        a. Phase I trials
        b. Phase II trials
        c. Phase III trials

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C. Medication administration
    1. Time out
    2. Six right system
        a. Right dose
        b. Right medication
        c. Right patient
        d. Right time
        e. Right route
        f. Right documentation
    3. Routes of administration
        a. Topical
        b. Systemic
            1) Oral
            2) Sublingual
            3) Rectal
            4) Parenteral
    4. Equipment
    5. Special precautions
    6. Monitoring IV infusions
    7. documentation
    8. Adverse reactions
    9. Disposal of equipment and drugs

IX. Medical Emergencies

A. Emergency equipment

B. Latex reactions

C. Shock
    1. Signs and symptoms
    2. Types
    3. Medical intervention

D. Signs, symptoms and medical intervention
    1. Diabetic
        a. Hypoglycemia
        b. Ketoacidosis
        c. Hyperosmolar coma
    2. Respiratory and cardiac failure
    3. Airway obstruction
    4. Cerebral vascular accident (CVA)/stroke
    5. Fainting (syncope)
    6. Seizures

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7. Radiation oncology emergencies
    a. Superior vena cava (SVC) syndrome
    b. Spinal cord compression
    c. Severe tumor bleed
    d. Increased intracranial pressure
8. Other medical conditions

X. Care of Patients With Tubes

A. Purpose, types and special precautions
1. Nasogastric/nasointestinal
2. Tracheostomy
3. Chest tube
4. Tissue drains
5. Ileostomy
6. Ureteroileostomy
7. Colostomy

B. Procedures and special precautions
1. Suction
    a. Purpose
    b. Emergency
    c. Equipment
2. Oxygen administration
    a. Purpose
    b. Values
    c. Delivery systems
    d. Documentation
3. Urological devices
    a. Purpose
    b. Equipment
    c. Procedures
    d. Removal
    e. Documentation

XI. Brachytherapy Procedures

A. Patient care
1. Physical and psychological response to treatment
2. Adverse effects, reactions and therapeutic responses
3. Interruption of treatment when conditions warrant
4. Detection, documentation and reporting significant changes in patient condition
5. Respiratory care
6. Nutritional care
7. Urinary care

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8. Medications
9. Contraindications

B. Creating a safe environment
   1. Radiation protection
   2. Biohazards

C. Follow-up patient care

D. Patients/family caregiving

XII. Assessment of Nutritional Status

A. Advising and referral
   1. Pharyngitis
   2. Mucositis
   3. Anorexia
   4. Cachexia
   5. Xerostomia
   6. Dysphagia
   7. Early satiety
   8. Nausea
   9. Vomiting
   10. Constipation

B. Types of malnutrition
   1. Primary
   2. Secondary (malignancy-related)

C. Dietary recommendations
   1. General
      a. Benefits
      b. Effect on outcome
   2. Irradiated site specific
   3. Types of diet
      a. Sodium regulation
      b. Residue regulation
      c. Caloric regulation
      d. Protein regulation
      e. Pre-existing diabetes
      f. Renal failure
      g. Other
   4. Dietary supplements
   5. Monitor progress

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6. Documentation

D. Total parenteral alimentation
   1. Nutritional dysfunctions
      a. Anorexia
      b. Cachexia

XIII. Physical Activity Considerations

A. Karnofsky scale/performance status

B. Activity as appropriate

C. Recognizing limitations

XIV. Patient Transfer

A. Body mechanics

B. Movement techniques
   1. Assessing the patient's mobility
   2. Rules for safe patient transfer
   3. Wheelchair transfer
   4. Stretcher transfer
   5. Patients with tubes and catheters

C. Patient safety and immobilization methods
   1. Purpose
   2. Types and applications
   3. Legal considerations

D. Adverse event and incident reports

XV. Patient Education

A. Assessment of educational needs
   1. Patient
   2. Family
   3. Caregiver

B. Methods
   1. Written
   2. Oral
   3. Visual

C. Treatment procedures and compliance

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D. Medical imaging procedures

E. Documentation

XVI. Alternative and Complementary Treatments

A. Types
   1. Conventional
   2. Unconventional

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Radiation Therapy Physics

Description
Content is designed to review and expand concepts and theories in the radiation physics course. Detailed analysis of the structure of matter, properties of radiation, nuclear transformations, x-ray production and interactions of ionizing radiation are emphasized. Also presented are treatment units used in external radiation therapy, measurement and quality of ionizing radiation produced, absorbed dose measurement, dose distribution and scatter analysis.

Objectives
1. Compare and contrast atomic structure and composition among the elements, including but not limited to particles (their location, energy level and charge), atomic number and mass number.
2. Compare isotope, isotone, isobar and isomer.
3. Discuss nuclear stability and types of radioactive decay.
4. Categorize the four fundamental forces of nature.
5. Differentiate between electromagnetic (EM) radiation and their characteristics.
6. Describe the processes of ionization and excitation.
7. Calculate radioactivity, decay constant, activity and half-life, average life and attenuation requirements for commonly used isotopes in radiation therapy.
8. Differentiate between artificially produced and naturally occurring therapeutic nuclides.
9. Identify the radioactive series and the decay schemes for commonly used radiation therapy nuclides.
10. Explain the various forms of radioactive equilibrium.
11. Identify nuclear reactions by recognizing the projectile and radiation emitted.
12. Define fission and fusion.
13. Discuss the activation of nuclides in terms of yield, probability, activity growth and saturation activity.
14. Describe methods of artificial production of radionuclides.
15. Describe x-ray production for linear accelerators.
16. Compare and contrast the factors that influence x-ray production and output.
17. Compare and contrast the energy ranges and characteristics of the various radiation therapy modalities (Grenz-ray through megavoltage).
18. Discuss all components and function in a linear accelerator.
19. Discuss methods of x-ray production in alternate therapy units (e.g., tomotherapy, stereotactic radiosurgery, etc.)
20. Compare the characteristics of other radiation therapy beams (cyclotron and other accelerated particles).
21. State the gamma energies and average gamma energy of cobalt 60 (^{60}Co).
22. Describe the basic components of a ^{60}Co unit.
23. Compare the characteristics of an isotope beam and an x-ray beam.
24. Explain linear energy transfer (LET).

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25. Compare photon interactions with matter and classify radiations produced by direct and indirect ionization.
26. Explain major influencing factors of photon beam attenuation.
27. Describe the parameters of narrow beam geometry used in the measurement of attenuation.
28. Plot heteroenergetic and monoenergetic beam attenuation data.
29. Calculate half-value layer (HVL).
30. Calculate the *homogeneity coefficient*.
31. Calculate attenuation requirements for beam modification devices.
32. Discuss activation of clinical accessories and alternate shielding materials due to photodisentigration.
33. Explain charged particle interactions with matter, describing dose deposition, energy loss and shielding requirements.
34. Define mass stopping power.
35. Describe a Bragg curve.
36. Discuss the purpose and importance of the National Institute of Standards and Technology (NIST).
37. Discuss the purpose and importance of the Accredited Dosimetry Calibration Labs (ADCL).
38. Demonstrate use of the appropriate type of radiation detector for given clinical applications.
39. Calcualte correction factors for chamber calibration, temperature, pressure and other factors used to correct a chamber reading.
40. Discuss protocols used for external beam calibration.
41. Analyze spot check data to make appropriate judgement decisions regarding machine treatment parameters. Describe the quality of a gamma-ray (γ) beam in terms of HVL, γ energy or mean γ energy/nuclide of origin.
42. Describe beam filtration for the various external beam modalities, including but not limited to purpose, types of filters and their construction, energy considerations, inherent vs. added filtration and effect on HVL.
43. Calculate the approximate mean energy of a megavoltage beam.
44. Compare absorbed dose vs. exposure.
45. Discuss the relationship between kinetic energy released in the medium (KERMA), exposure and absorbed dose.
46. Calculate air dose to absorbed dose conversions in tissue, including but not limited to, energy considerations, applicable conversion factors, necessary instrumentation and methods.
47. Discuss the clinical importance of phantom material and size when applying the Bragg-Gray Cavity Theory.
48. Critique how dose distribution measured in a phantom is used to predict dose distribution in a patient.
49. Compare the characteristics and composition of various phantoms.
50. Compare source-skin distance (SSD) and isocentric methods of calibration.

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Content

I. Structure of Matter and Properties of Radiation

A. Review of atomic structure
   1. The atom
      a. Periodic table
         1) Rows
         2) Columns
      b. Size
   2. The nucleus
      a. Atomic number
      b. Unit charge
      c. Mass number
      d. Categories
         1) Isotopes
         2) Isotones
         3) Isobars
         4) Isomers
      e. Odd/even rules
      f. Line of stability
   3. Distribution of orbital electrons
   4. Atomic mass and energy units
   5. Avogadro's number
   6. Fundamental forces
      a. Strong force
      b. Electromagnetic force
      c. Weak force
      d. Gravitational force
   7. Atomic energy levels
   8. Nuclear forces
   9. Nuclear energy levels
   10. Other elementary particles

B. Particle radiation
   1. Types
   2. Characteristics

C. Electromagnetic radiation
   1. Spectrum
   2. Characteristics
   3. Wave model
   4. Quantum model
   5. Ionization and excitation
   6. Nonionizing vs. ionizing EM radiation

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D. Relevant Equations
   1. $E=1/2mv^2$
   2. $E=mc2$
   3. $m=\frac{m_o}{\sqrt{1 - v2/c2}}$
   4. $c=\lambda v$
   5. $E=h v$

II. Nuclear Transformations

A. Radioactivity

B. Decay constant

C. Activity
   1. Definition
   2. Environment influence
   3. Units

D. Half-life
   1. Definition
   2. Relationship to decay constant
   3. Specific values of commonly used nuclides in radiation therapy

E. Mean life
   1. Definition
   2. Relationship to half-life

F. Radioactive series

G. Radioactive equilibrium
   1. Transient
   2. Secular

H. Modes of decay
   1. Line of stability
   2. Decay schemes
   3. Primary modes
      a. Alpha (α) particle decay
      b. Beta (β) particle decay
         1) Negatron emission (β-)
         2) Positron emission (β+)
      c. Electron capture decay

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4. Secondary modes
    a. Gamma (γ)
    b. Internal conversion
    c. Isomeric transition
5. Multimode decays

I. Decay equations and problems

J. Nuclear reactions
1. Alpha (α) bombardment
2. Proton bombardment
3. Deuteron bombardment
4. Neutron bombardment
5. Photodisintegration
6. Fission
7. Fusion

K. Activation of nuclides
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2. Probability
3. Activity growth
4. Saturation activity
5. Methods of production by nuclear reactors and by acceleration
6. Relevant artificial therapeutic nuclides

L. Nuclear reactors

M. Charged particle accelerators

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A. The x-ray tube

B. Basic x-ray circuit

C. Voltage rectification

D. Physics of x-ray production
1. Bremsstrahlung x-rays
2. Characteristic x-rays
3. Percentage relationship with energy

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E. X-ray energy spectra
    1. Unfiltered
    2. Filtered
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        b. Added filtration
F. Spatial distribution

G. Operating characteristics

IV. Radiation Therapy Treatment Units (External Teletherapy)

A. Historical Equipment
B. Equipment in current use
    1. Contact, superficial, orthovoltage or deep therapy
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        b. Tube current
        c. Reflection target
        d. Typical treatment distance
        e. Typical filtration
        f. Typical HVL
        g. Beam characteristics
            1) D_{max} Depth
            2) Depth dose
        h. Megavoltage therapy
        i. Linear accelerator
            1) Accelerator structure design
            2) Basic components
            3) Cyclotron
                a) Basic design
                b) Energy range of accelerated particles
                c) Clinical treatment beams
                d) Radionuclide production
            4) Microtron
                a) Basic design
                b) Energy range of photons and electrons
                c) Clinical treatment beams
                d) Radionuclide production
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                a) Basic design
                b) Energy range of photons and particles
                c) Advantages
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        a. Neutrons
            1) D-T generators

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2) Cyclotrons
3) Linear accelerators

b. Heavy ions
1) Cyclotrons
2) Linear accelerators

C. Isotope beams
1. ^{60}Co
a. Gamma energies and average energy
b. Review of decay scheme
c. Specific activity
d. Typical treatment distances
e. Basic components

V. Interaction of Ionizing Radiation

A. Ionization and excitation
1. Definition
2. Linear energy transfer
3. Indirect ionizing radiation
4. Direct ionizing radiation

B. Interaction of photons
1. Photon beam attenuation
a. Influencing factors
1) Absorber atomic number dependence
2) Energy dependence
3) Absorber thickness dependence
b. Measurement of attenuation
1) Narrow beam geometry
2) Plotting of data
3) HVL
4) Attenuation coefficient (μ)
a) Linear attenuation coefficient
b) Mass attenuation coefficient
c) Electronic attenuation coefficient
d) Atomic attenuation coefficient
5) Relationship between HVL and μ
6) Homogeneity coefficient
7) Attenuation differential equation
2. Interactions of photons with matter
a. Transmission
b. Coherent scattering\

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c. Photoelectric effect
    1) Associated energy range
    2) Absorption edges
    3) Probability
        a) Energy dependence
        b) Z dependence
    4) Angular distribution of photoelectrons
    5) Clinical association and significance
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    2) Probability
        a) Energy dependence
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    3) Electrons per gram
    4) Special cases of Compton
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    5) Clinical association and significance
e. Pair production
    1) Associated energy range and energy threshold
    2) Probability
        a) Energy dependence
        b) Z dependence
    3) $E=mc^2$
    4) Annihilation radiation
    5) Clinical association and significance
f. Photodisintegration
g. Relative importance of photon interactions

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1. Mediation of coulomb force
    a. Collisions with atomic electrons
        1) Ionization
        2) Excitation
    b. Collisions with atomic nucleus
        1) Bremsstrahlung
    c. Particle scattering and energy loss
2. Nuclear reactions
3. Mass stopping power
4. Heavy charged particles
    a. Rate of energy loss
    b. Bragg peak

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5. Electrons
    a. Lack of Bragg peak
    b. Delta rays (δ)
    c. Bremsstrahlung

D. Interaction of neutrons
    1. Recoil nuclei
    2. Nuclear disintegration
    3. Absorption material efficiency

E. Overview of comparative beam characteristics

VI. Measurement of Ionizing Radiation

A. Introduction

B. Unit of exposure
    1. Roentgen–special unit
    2. Coulomb per kilogram (C/kg)
    3. Photon fluence and fluence rate

C. Collection of charge instruments
    1. Free-air (standard) ionization chamber
        a. Primary standard
            1) National Institute of Standards and Technology (NIST)
            2) Accredited Dosimetry Calibration Labs (ADCL)
        b. Schematic of free-air chamber
            1) Electric field
            2) Ion collection plates
            3) Current
            4) Specified air volume
            5) Ionization beyond specified volume
            6) Electronic equilibrium
            7) Saturation
        c. Energy limitations
    2. Thimble chambers
        a. Function
        b. Principle of operation
            1) Air equivalence
            2) Chamber wall
                a) Effective atomic number (Z_{eff})
                b) Electronic equilibrium and build-up caps
            3) Central electrode
            4) Air cavity, sensitive volume and sensitivity

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c. Chamber calibration
d. Desirable chamber characteristics

3. Practical thimble chambers
   a. Condenser chambers
      1) Schematic
      2) Chamber sensitivity
      3) Stem effect
      4) Phantom limitations
   b. Farmer chamber
      1) Schematic
      2) Collecting volume
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D. Electrometers
1. Charge measurement
2. String electrometer
   a. Schematic
   b. Use with condenser chamber
      1) Charging
      2) Measuring loss of charge
3. Baldwin-Farmer type electrometer
4. Others

E. Special chambers
1. Purpose
   a. Measurement of surface dose
   b. Measurement of build-up region
2. Extrapolation chamber
3. Parallel-plate chamber

F. Environmental conditions
1. Standard temperature and pressure (STP)
2. Standard calibration temperature and pressure

G. Measurement of exposure
1. NIST traceable chamber factor
2. Temperature and pressure factor
3. Other correction factors
4. Scatter radiation avoidance
5. Narrow beam geometry

VII. Quality of X-Ray Beams

A. Energy fluence (spectral distribution)

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B. Clinically practical expression of beam quality
    1. Gamma ray energy or stating nuclide of origin
    2. X-ray beams
        a. Low energy beams
            1) HVL
            2) Peak kVp
        b. Megavoltage beams
            1) HVL
            2) Peak energy
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C. Filters
    1. Inherent filtration
    2. Added filtration
    3. Combination filters (Thoraeus)
    4. Clinical use with low energy x-ray beams
        a. Proper placement
        b. Typical material for low energy ranges
    5. Megavoltage x-ray beams
        a. Transmission target
        b. Beam-flattening filter

D. Measurement of beam quality parameters
    1. HVL
    2. Peak voltage
        a. Direct measurement
        b. Indirect measurement
    3. Effective energy
    4. Mean energy

E. Measurement of megavoltage beam energy
    1. Clinically relevant method
        a. Percentage depth dose (PDD)
        b. Tissue-air ratios (TAR)
        c. Tissue-maximum ratios (TMR)
    2. Photoactivation ratio (PAR) method

F. Measurement of energy spectrum

VIII. Measurement of Absorbed Dose

A. Radiation absorbed dose
    1. Definition

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2. Advantages over exposure units
3. Units

B. Relationship between KERMA, exposure and absorbed dose

C. Calculation of absorbed dose from exposure
1. Absorbed dose to air
2. Absorbed dose to any medium
a. Roentgen-to-rad conversion factor (*f* factor)
1) Photon energy
2) Atomic number of medium
b. Clinical impact
3. Dose calibration with ion chamber
4. Dose measurement of exposure with ion chamber in a medium

D. Bragg-Gray cavity theory
1. Advantages
2. Components overview

E. Calibration of megavoltage beams overview
1. American Association of Physicists in Medicine (AAPM) RTC Task Group 51 protocol
2. Application of Bragg-Gray cavity theory

F. Other methods of measurement of absorbed dose
1. Calorimetry
2. Chemical dosimetry
3. Solid state
a. Thermoluminescence dosimetry
b. Film dosimetry

G. Monte Carlo Methods

IX. Dose Distribution and Scatter Analysis Overview

A. Phantoms
1. Purpose
2. Properties
a. Z_{eff}
b. Number of electrons per gram
c. Mass density
3. Physical properties of various phantom materials
4. Anthropomorphic phantoms

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B. Depth dose distribution
    1. Percentage depth dose
        a. Dependence on beam quality and depth
            1) Dose buildup and skin sparing
            2) KERMA vs. absorbed dose
        b. Effect of field size and shape
            1) Geometric field size
            2) PDD function of field size and beam quality
            3) Square fields vs. rectangular, irregular and circular fields
                a) Equivalent square tables
                b) Sterling's "Rule of Thumb" equation
                c) Precautions in use of approximation equations
            4) Dependence on source-surface distance
                a) Dose rate vs. PDD
                b) Standard distance PDD tables
                c) Nonstandard distance
                    (1) Mayneord F factor
                    (2) Formula and limitations
            5) Dependence on beam collimation system
    2. Tissue-air ratio (TAR)
        a. Effect of distance
        b. Variation with energy, depth and field size
    3. Backscatter factor (BSF)
        a. Effect of distance
        b. Effect of beam energy and field size
    4. Scatter-air ratio (SAR)

ASRT

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Sectional Anatomy

Description
Content will introduce students to medical imaging methods currently used in the field of radiation therapy. Students will identify normal anatomical structures via a variety of imaging formats. Basic anatomical relationships will be compared using topographical and cross-sectional images.

Objectives
1. Relate the importance of imaging with computed tomography, magnetic resonance and PET-CT in radiation therapy.
2. Differentiate between sagittal, coronal and axial planes of the body.
3. Review the principles of imaging for imaging modalities using relevant terminology.
4. Compare the imaging modalities for application to radiation therapy.
5. Identify normal anatomical structures on sectional images.
6. Identify topographic anatomy used to locate underlying internal structures.

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Content

I. Anatomic Planes of the Body

A. Sagittal (median)

B. Coronal (frontal)

C. Axial (transverse)

II. Image Formation, Image Orientation and Pros and Cons

A. Computed tomography

B. Magnetic resonance

C. Positron emission tomography-computed tomography fusion images

D. Ultrasound

III. Other Sectional Imaging Modalities

IV. Topographic and Sectional Anatomy to include:

Abdomen	**Extremities**	**Pelvis**
Chest	**Head and Neck**	**Spine**

A. CT

B. MR

C. PET-CT

D. Ultrasound

E. Other modalities

ASRT

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Treatment Planning

Description
Content is designed to establish factors that influence and govern clinical planning of patient treatment. This encompasses isodose descriptions, patient contouring, radiobiologic considerations, dosimetric calculations, compensation and clinical application of treatment beams. Optimal treatment planning is emphasized along with particle beams. Stereotactic and emerging technologies are presented.

Objectives
1. Compare photon isodose curves for clinically relevant photon beams.
2. Describe the general influencing factors that distinguish various isodose curves.
3. Determine internal and external patient factors that influence a beam's distribution and apply isodose correction methods.
4. Describe methods of determining a patient's external contour, definition of internal structures and volumes of interest used in treatment planning.
5. Identify organs and tissues at risk and their dose limitations using published tolerance dose tables.
6. Describe how biologic effective dose is influenced by prescription and treatment variables.
7. Compare fractionation schemes.
8. Discuss the integral dose concept.
9. Use appropriate factors for manual treatment calculations.
10. Describe the interrelationships of the various factors used in treatment calculations.
11. Perform dose calculations for external photon and electron beam treatments for all clinical variations.
12. Calculate the absorbed dose to off-axis points of interest.
13. Compare absorbed doses within a treatment volume with beam variations.
14. Explain algorithms incorporated into treatment planning computers.
15. Describe the clinical applications for moving beam techniques.
16. Describe the past pointing technique.
17. Calculate equivalent squares using various methods that consider the limitations of each.
18. Describe the effect of asymmetric beam collimation on dose distribution.
19. Describe methods for determining dose distribution at points outside the treatment field.
20. Calculate dose under a block using manual and computerized methods.
21. Evaluate a variety of treatment plans for clinical use.
22. Identify all possible techniques that may be employed to clinically match adjacent fields.
23. Describe the multiple junction shift methods.
24. Examine hot and cold regions that occur with the various matching methods.
25. Describe possible procedures used to provide a permanent record and legal documentation of matching fields.
26. Analyze dose distributions to determine the need for beam modifiers.
27. Compare various methods of tissue compensation and the dosimetric impact.

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28. Examine the fabrication of 2-D and 3-D compensators.
29. Construct manual and computerized isodose curves.
30. Differentiate between isodose distributions for all clinical variations.
31. Evaluate possible corrections for treatment errors to correct misadministration of prescribed dose.
32. Differentiate between the treatment planning terms: maximum, minimum, mean, modal and median dose.
33. Describe International Commission on Radiological Units (ICRU) recommendations on dose variance within a target volume and the effect that variances may have on cure rates, local control and tolerance.
34. Analyze dose volume histograms relative to treatment planning.
35. Evaluate patient changes to determine the integrity of a treatment plan.
36. Compare electron beam depth dose characteristics for various energies.
37. Identify clinical factors that would influence beam type and energy selection.
38. Differentiate between standard treatment distance and virtual distance.
39. Discuss why equivalent squares used with photon beams are inappropriate with electron beams.
40. Describe how inhomogeneities influence electron beam path.
41. Discuss the considerations of matching an electron field to other adjacent photon or electron fields.
42. Analyze what shielding materials and what thickness would be needed to attenuate electron beams to appropriate levels in given situations.
43. Describe how electron shielding materials should be arranged for external vs. internal shielding.
44. Discuss changes in dose rate and dose distribution with changes in blocking extent, shielding thickness and electron energy.
45. Compare "rule of thumb" calculations of shielding thicknesses to measured data for electron beams.
46. Determine why specific isodose lines are prescribed for various clinical situations involving critical and noncritical structures.
47. Calculate "rule of thumb" percentage depth dose for 10%, 50%, 80% and 90% lines for various electron energies.
48. Describe the considerations in the clinical application of special electron treatments, including total skin irradiation and arc therapy.
49. Compare the general isodose pattern of other particle beams.
50. Determine clinical usefulness of various beam types and the clinical implications involved.
51. Describe the various imaging modalities in tumor localization and planning.
52. Discuss planning techniques used to accommodate the treatment volume shape.
53. Discuss isocenter localization for radiosurgery.
54. Identify vital structures that must be considered during treatment planning.
55. Compare single dose delivery to fractionated dose delivery schedules.
56. Discuss the need for specific equipment used to deliver radiation for conformal therapy.
57. Discuss the purpose and contents of the ICRU Report 62 and supplements.

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58. Discuss the computer system features necessary for conformal therapy treatment planning.
59. Identify common sites amenable to conformal therapy and the typical doses employed for those sites.
60. Compare configurations of multileaf collimation systems.
61. Discuss considerations to be taken when using multileaf collimators.
62. Review the differences between static and dynamic multileaf collimation systems.
63. Identify appropriate clinical applications for brachytherapy.
64. Compare and contrast brachytherapy delivery systems.
65. Describe the techniques and applicators used for intracavitary, interstitial and endovascular brachytherapy procedures.
66. Explain how simulation and CT data is used for source localization.
67. Discuss the objective of treatment planning for brachytherapy procedures.
68. Summarize dose specification and prescription techniques for different types of implants.
69. Describe optimization techniques used in computer aided dose calculations.
70. Discuss procedural processes and record keeping requirements for radioactive material.
71. State radiation safety requirements for brachytherapy procedures.
72. Identify appropriate clinical applications for using intensity modulated radiation therapy (IMRT).
73. Describe the general flow of the IMRT process from patient immobilization through treatment delivery.

ASRT

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Content

I. Isodose Descriptions and General Influencing Factors

A. Influencing factors
1. Radiation type
2. Beam energy
3. Field size
4. Collimator design
5. Source-to-skin distance (SSD)
6. Source-to-collimator distance (SCD)
7. Source size
8. SSD/source to axis distance (SAD)/normalization methods
9. Beam-flattening filter, blocking and other beam attenuators
10. Bolus
11. Surface dose
12. Penumbra
13. Maximum dose (D_{max}) depth

B. Photon beams and general dose distributions at D_{max}, central axis and off-axis
1. Photon beams
   a. Low energy x-ray
      1) Diagnostic
      2) Superficial
      3) Orthovoltage
   b. Gamma
      1) ^{60}Co
   c. Megavoltage x-ray
      1) Types
         a) Linear accelerator
      2) Without beam-flattening filter
      3) With beam-flattening filter
      4) Flatness and symmetry definitions
      5) Overflattening/underflattening
   d. Field size definition (50% isodose line)
   e. Build up dose region for various energies

C. Influencing external patient factors
1. Oblique incidence of patient/beam defined
2. Isodose correction methods
3. Limitations of various methods

D. Influencing internal patient factors
1. Tissue inhomogeneities
2. Beam type/energy
3. Equivalent path length

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4. Isodose correction methods

E. Treatment planning computer
1. Handling of CT (Hounsfield) numbers
2. Algorithms
3. Measured data
4. Patient individualization
5. Simulation factors
    a. Contrast
    b. Use of anatomic markers

II. Patient Contours

A. External contouring
1. Precautions and comparative accuracy of contouring methods (phantom slice)

B. Internal contouring
1. Defining tumor and target volume
2. Defining organs and tissues at risk

III. Radiobiologic Dosimetric Considerations

A. Alternate fractionation schedules
1. TDF/rad equivalent therapy (rets)
2. Alpha-beta ratios
3. Limitations of concepts

B. Integral dose concepts

C. Edge effect

D. Nominal standard dose calculation

IV. Methods of Dosimetric Calculations

A. SSD techniques (percentage depth dose, or PDD)
1. Definition
2. Concepts and basic formulas/equations
3. Influencing factors
    a. Isodose factors
    b. Distance factor application
    c. Mayneord F factor
4. PDD calculation
    a. Absorbed dose calculation
        1) Entrance dose
        2) Exit dose

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3) Entrance/exit dose summation
4) Area of interest dose
a) Target volume dose
b) Critical organ dose
c) Dose at any point/depth

b. Treatment setting calculation
1) Time
2) Time adjustment
a) Source decay
b) Shutter error
c) Dose rate constancy

5. Monitor unit
a. Weighted fields

B. Isocentric techniques (SAD)
1. Tissue-air ratio (TAR)
a. Definition
b. Concept
c. Field size definition
d. Physical factors in common with PDD techniques
2. Factors affecting TAR value
a. Beam energy
b. Field size
c. Depth
3. Tissue-maximum ratio (TMR)
a. Definition
b. Concept/energy limitation of TAR
c. Tissue-phantom ratio concept
d. Application
1) Tissue output ratios
a) Output factor
b) Collimator scatter factor (S_c)
2) Interchangeability/derivation of factors
3) Phantom scatter correction factor (S_p) (field size factor)
4) Formulas, equations
4. TAR/TMR calculation
a. Absorbed dose calculation
1) Entrance dose
2) Exit dose
3) Entrance and exit dose summation
4) Area of interest dose
a) Target volume dose

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b) Critical organ dose
c) Dose at any point/depth

b. Treatment unit settings calculation
1) Time
2) Monitor units

c. Weighted fields

C. Irregular field technique

1. Calculation techniques

a. Clarkson's method
1) Scatter-air ratio (SAR)
a) Definition
b) Factors affecting SAR value
c) Applicable clinical situations
2) Scatter-maximum ratio (SMR)
a) Definition
b) Application
c) Approximation method—effective field/collimator field

b. SAR, SMR and approximation calculation
1) Mantle and “inverted Y” field
2) Applicable formulas and equations
3) "Construct" a TAR
4) Practical application and fabrication of a SAR ruler
5) Computer algorithms
6) Absorbed dose calculation
a) Entrance dose
b) Exit dose
c) Entrance and exit dose summation
d) Area of interest dose
(1) Target volume dose
(2) Critical organ dose
(3) Dose to multiple patient points/depths
7) Treatment unit settings calculation
a) Time
b) Monitor units
8) Weighted fields

D. Moving beam techniques

1. Definition
2. Concepts, basic formulas and equations
3. Dose rate at isocenter (average TAR/TMR)
4. Correction of first and last TAR/TMR ray values
5. Monitor unit per degree (Gantry rotation speed)

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6. Rotation/arc calculations
    a. Absorbed dose calculation
        1) Dose at isocenter
        2) Target dose specifications
        3) Maximum dose displacement (Arcs, past-pointing)
    b. Treatment unit settings calculation
        1) Time
        2) Monitor units
        3) Monitor unit/degree

E. General dosimetric calculations
    1. Equivalent area
    2. Sterling's formula and its limitations
    3. Dose outside treatment field
    4. Dose under block
    5. Asymmetric fields

V. Prevention of Overdose and Underdose

A. General beam arrangement

B. Hot and cold spot elimination or reduction
    1. Additional treatment ports
        a. Traditional
        b. 3-D conformal therapy/IMRT
    2. Field reduction
    3. Boost ports/field in field
    4. Past pointing
    5. Wedges/tissue compensators/bolus
    6. Shadow blocks
    7. Table angulation

C. Methods of field separation to correct for beam divergence into other fields
    1. Definitions
    2. General guidelines
        a. Assessment of tumor/critical organ/surgical scar at junction
        b. Surface vs. depth considerations
        c. Daily reproducibility guidelines
    3. Methods
        a. Adjacent field junctions
            1) Geometric divergence gap calculation
            2) Matching of isodose curves
            3) Multiple junction shift methods (moving gap)
            4) Asymmetrical jaws

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5) Half-beam/rotating beam block (beam splitter)
6) Gantry angulation (nonopposed central axis abutment)
7) Treatment unit head angulation (nonopposed central axis abutment)
8) Penumbra generators (spoilers, wedges)
9) Other

b. Orthogonal field junctions
1) Asymmetrical jaws
2) Half-beam block (beam splitter)
3) Geometric
4) Table angulation and collimator angulation
5) Penumbra generators
a) Spoilers
b) Wedges
c) Assessment and limitations of methods
(1) Hot/cold regions above and below junction point
(2) Depth of critical organ considerations
(3) Final field size(s) vs. gap size(s)
(4) Measured data vs. predicted data
d) Legal documentation considerations
(1) Permanent records
(2) Gap verification images
(3) Record and verify

VI. Wedge Filters (2-D Compensation)

A. Definition
1. Wedge angle
2. Hinge angle
3. Wedge transmission factor
4. Wedge profile

B. Wedge systems

C. Purpose
1. Tissue compensation
2. Elimination of hot spots in distribution
3. Use of multiple noncoplanar fields

D. Construction/application
1. Materials
2. Design
3. Beam placement

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E. Dose calculation performance exercises
   1. Comparisons — wedged vs. nonwedged
   2. Clinical application

VII. Tissue Compensators (2-D and 3-D Compensation) (XYZ)

A. Definition

B. Purposes

C. Compensator transmission factor

D. Partial field compensation advantage — beam placement

E. Construction/application
   1. Materials (attenuation coefficients)
   2. Loss of scatter at a distance
   3. Density ratio (compensator thickness ratio)

VIII. Clinical Applications of Treatment Beams and Accessories

A. Selection of appropriate isodose curve for clinical application
   1. Influencing parameters of isodose curve selection
      a. Field separation
      b. Radiation type
      c. Beam energy
      d. Field size
      e. Distance
      f. Penumbra
      g. Treatment outcome goal
      h. Treatment technique (SSD/SAD)
   2. Application of isodose curve to patient contour
      a. Special considerations requiring adjustment
         1) Oblique incidence
         2) Tissue inhomogeneity
         3) Weighting
         4) Wedge/compensator placement
         5) Blocking of normal tissue
         6) Partial blocking of low tolerance diseased tissue
         7) Bolus

B. Isodose summation
   1. Single beam delivery
   2. Multiple beam delivery
   3. Rotation and arc delivery

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4. Wedged beam delivery

C. Evaluation of dose distributions
   1. Target volume dose uniformity
   2. Irradiated volume doses
   3. Critical structure doses
   4. Advantages/disadvantages of beam arrangements

D. Planning of combinations
   1. Advantages/disadvantages of combined treatment approaches
      a. Beam arrangements
      b. Beam energies

IX. Optimal Treatment Planning Considerations, Evaluation and Implementation

A. Definitions - ICRU Report 62 or most current report
   1. Gross tumor volume (GTV)
   2. Clinical target volume (CTV)
   3. Planning target volume (PTV)
   4. Treated volume
   5. Irradiated volume
   6. Maximum dose within target volume
   7. Minimum dose within target volume
   8. Mean (average) dose within target volume
   9. Modal dose within target volume
   10. Median dose within target volume

B. Evaluation of dose distribution within target volume

C. Evaluation of dose distribution for critical organs/tissues ($TD_{5/5}$ and $TD_{50/5}$)

D. Evaluation of dose distribution for noncritical organs/tissues

E. International commission on radiological units and measurements (ICRU) recommendations for dose distribution variance within target volume

F. Dose distribution effects on cure rates/local control/tolerance

G. Dose histograms

H. Evaluation and assessment of advantages/disadvantages of a given treatment plan

I. Evaluation, assessment and adaptation of treatment plan due to patient change (weight loss/inflammation/tumor response)

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J. Evaluation and assessment of consequences of dosimetric errors and recording

K. Implementation of error correction post occurrence and evaluation of patient impact

X. 3-D Conformal Therapy

A. Simulation
   1. Immobilization devices
   2. Imaging

B. Treatment planning
   1. Treatment planning system
      a. System capabilities
         1) Image registration and image fusion
         2) Calculation algorithms
      b. Volume definition
      c. Plan optimization
      d. Volume analysis/dose volume histogram (DVH)
      e. Plan output/interpretation
         1) Setup information
         2) Beam parameters
         3) Digitally reconstructed radiographs (DRR)/beams eye view (BEV)/rooms eye view (REV)

C. Treatment execution
   1. Isocenter placement
   2. Port verification
      a. Coplanar vs. noncoplanar
   3. Field shaping
      a. Alloy blocking
      b. Multileaf collimation (MLC)
         1) Configuration/leaf attributes
         2) Limitations
         3) Quality assurance of leaf positions

XI. Intensity Modulated Radiation Therapy (IMRT)

A. Immobilization

B. Treatment planning
   1. Forward planning
   2. Inverse planning

C. Delivery techniques
   1. Physical compensators

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2. Multiple static segments (step and shoot)
3. Dynamic treatment (sliding window)
4. Dynamic conformal arcing (CD-ARC)
5. Intensity modulated arc treatment (IMAT)
6. Tomotherapy

D. Quality assurance
   1. Multileaf collimator
      a. Design
      b. Divergence
      c. Penumbra
      d. Interleaf leakage
      e. Intraleaf leakage
   2. Small segment dosimetry/treatment verification
      a. Dose per segment
      b. Energy stability
      c. Flatness and symmetry stability
      d. Beam interruption effects
      e. Verification of ports

XII. Particle Beams and General Dose Distributions at Dmax, Central Axis and Off-Axis

A. Electron beam
   1. Physical characteristics
      a. Rapid dose build-up (ratio of surface to D_{max} dose)
      b. Dose fall-off (low vs. high energy)
      c. Constriction of isodose curve at depth (field size)
      d. Ballooning of isodose curve at depth
      e. Percentage depth dose data unique to treatment unit, cone and field size
      f. Field size relationship to central axis PDD
         1) Energy ≤ 20 MeV
         2) Energy > 20 MeV
      g. Criticality of choosing beam energy with electrons vs. photons
      h. Distance (standard vs. virtual)
      i. Scatter
         1) Scattering foil(s), scanning magnet, air
         2) Brems photon contamination of electron beam
         3) Collimator opening effect on dose rate
      j. Equivalent area
         1) Equivalent squares
         2) Square root method
         3) Measured data
      k. Equivalent path length
   2. Biological considerations in patient treatment

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3. Energy decelerators for special treatment
4. Build up bolus
5. Adjacent fields
6. Shielding materials, thicknesses, energy and dose relationship
    a. Mass stopping power (low vs. high Z)
        1) Density, Z number and electrons per gram
        2) Material choices and rationales
    b. External shielding
    c. Internal shielding (tissue interfaces)
    d. Changes in dose rate and dose distribution
    e. Thickness rule of thumb (MeV/3 = mm pb)
7. Treatment prescriptions and calculations
    a. Physician prescription to specific isodose line
    b. Critical structure
    c. Noncritical structure
    d. Rules of thumb for determining PDD
8. Applications of electron beam
    a. Single beam
    b. Multiple beams
        1) Mixed (photon and electron)
        2) Abutting
            a) Electron fields
            b) Electron and photon fields
    c. Complex
        1) Electron arc
        2) Total skin irradiation
9. Electron beam calculations

B. Other particle beams
1. Neutrons
    a. General isodose curve pattern
    b. Percentage depth dose energy dependence
    c. Penumbra and adjacent structures
    d. Clinical use
2. Charged particles (protons/helium ions)
    a. Properties
        1) Nonexponential attenuation
        2) Proximal and distal dose gradients
        3) General isodose curve pattern
        4) Bragg peak advantage
        5) Inhomogeneity sensitivity
        6) Percentage depth dose energy dependence
        7) Precision immobilization requirements

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8) Limited penumbra—sparing adjacent structures
b. Clinical applications and treatment delivery
1) Immobilization requirements
2) Simulation
3) Treatment planning
4) Treatment verification

3. High LET charged particles (negative pions)
a. Nonexponential attenuation
b. Proximal and distal dose gradients
c. General isodose curve pattern
d. Bragg peak/star effect advantage
e. Percentage depth dose energy dependence
f. Precision immobilization requirements
g. Penumbra
h. Clinical applications

4. Heavy ions
a. Types
1) Carbon
2) Neon
3) Argon
4) Silicon
5) Other
b. Nonexponential attenuation
c. Proximal and distal dose gradients
d. General isodose curve pattern
e. Bragg peak advantage
f. Percentage depth dose energy dependence
g. Precision immobilization requirements
h. Penumbra
i. Clinical applications

XIII. Stereotactic Radiation Therapy

A. Equipment
1. Gamma knife
2. Linear accelerator based

B. Immobilization
1. Head frame
2. Frameless
3. Image guided techniques

C. Tumor localization and planning
1. Computed tomography

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2. MR and linear distortion effect
3. Digitizing images and tumor outlines
4. Entering isocenters and implications of isocenters with placement
5. Beam shaping
6. Treatment planning system requirements

D. Localizing isocenters
1. Floor stand
2. Couch mount
3. Other

E. Treatment sites and doses
1. Arteriovenous malformation (AVM)
2. Meningiomas
3. Glioblastomas
4. Acoustic neuromas
5. Other

F. Vital structures
1. Optic nerves and chiasm
2. Brain stem
3. Other

G. Advantages and disadvantages
1. Fractionation
2. Stability
3. Comparison to surgery

XIV. Brachytherapy

A. Intracavitary, interstitial, endovascular
1. Procedures and implant techniques
2. Applicators
3. Commonly used sources
a. Review of source characteristics

B. Source/applicator/catheter localization

C. Implant dosimetry systems
1. Objective of treatment planning
a. Dose specification/prescription
1) Point specification
2) Volume specification
b. Critical structures

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2. Calculation methods
    a. Patterson-Parker (Manchester) system
    b. Quimby system
    c. Paris system
3. Computer aided dose calculations
    a. Optimization techniques

D. Radioactive materials
1. Shipping/ receiving
2. Procedures
3. Record keeping

E. Radiation Safety
1. LDR, MDR, HDR and PDR procedures
    a. Quality assurance
    b. Documentation

XV. Emerging Treatment Methods and Planning

ASRT

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American Society of Radiologic Technologists
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Aunt Minnie: Radiology Daily Case Studies
http://www.auntminnie.com

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http://www.air.asn.au

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http://user.shikoku.ne.jp/tobrains/exam/Angio/Angio-e.html

Chorus: Collaborative Hypertext of Radiology
http://chorus.rad.mcw.edu/

Diagnostic Imaging.Com News Service
http://www.dimag.com/

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http://www.ncrel.org/sdrs/areas/issues/educatrs/presrvce/pe300.htm

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http://www.jrcert.org

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http://www.medweb.emory.edu/SPT--Home.php

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http://www.radiologyinfo.org/glossary/glossary1.asp?Term=A

General Information and Radiology Search Sites

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ASRT

Research Center for Excellence in the Radiologic Sciences
https://www.asrt.org/radsci/rs_home.aspx

Altavista
http://www.altavista.com/

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Cognitive Approaches to Instructional Design
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