Radiation Therapy Professional Curriculum

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Introduction

The Radiation Therapy Professional Curriculum was developed by a committee representing a variety of program types from across the country. The American Registry of Radiologic Technologists® (ARRT®) and the Joint Review Committee on Education in Radiologic Technology (JRCERT) provided input to this revision to maintain continuity between the professional curriculum, accreditation standards and the certification examination.

The healthcare environment requires radiation therapy professionals to meet evolving clinical, organizational and fiscal demands. In particular, students must develop skills in areas such as information literacy, scientific inquiry, self-reflection and collaboration. Advances in technology and employer expectations require more independent judgment from therapeutic practitioners than ever.

This curriculum is divided into specific content areas that represent the essential components of an entry-level radiation therapy program. This document includes lists of learning objectives associated with each content area to serve as guidelines for programs. Faculty are encouraged to expand these fundamental objectives as they incorporate them into their curricula. Specific instructional techniques were intentionally omitted from this curriculum to encourage programs and educators to exercise greater freedom and creativity in instructional delivery. Programs are encouraged to reorganize the content and modify the objectives to meet their programmatic goals and needs.

The radiation therapy curriculum is based on the latest data and reflects the dynamic health care environment. This curriculum offers an educational foundation suitable for a baccalaureate degree program. The curriculum is designed with the flexibility to meet the needs of many communities, without compromising on the requirements of the JRCERT Standards and the ARRT examination.

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

General Education

General education is the foundation for the future development of a therapeutic practitioner, and provides the background knowledge to support continued professional development. General education content is designed to develop essential skills in communication, human diversity, scientific inquiry, critical thinking and judgment. All these skills are required to perform the responsibilities of an entry-level radiation therapist. Knowledge gained from general education enhances the content of the rest of the radiation therapy curriculum.

Starting in 2015, the ARRT began requiring an associate degree in order to apply for the radiation therapy certification exam, eliminating the need for specific general education requirements in the radiation therapy curriculum. Because individual states, accreditation agencies, and educational systems have unique general education requirements, the content listed below is designed to serve only as a guideline for program development.

Postsecondary general education should be gained through courses that provide college credit and meet the general content areas listed below:

- Mathematics and reasoning
    - Demonstrate skills in analysis, quantification and synthesis.
    - Apply problem-solving or modeling strategies.
- Communication
    - Write and read critically.
    - Speak and listen critically.
    - Collect, organize and present information.
- Humanities
    - Demonstrate respect for diverse populations.
    - Define ethics and the role they play in personal and professional interactions.
    - Critically examine personal attitudes and values.
- Information systems
    - Use computerized systems to acquire, transfer and store digital information.
    - Use technology to retrieve, evaluate and apply information.
- Social sciences
    - Adapt communication to meet the cultural and psychological needs of others.
    - Develop and exhibit leadership skills.
    - Exercise responsible and productive social conscience.
- Natural sciences
    - Apply the scientific method.
    - Make informed judgments about science-related topics.
    - Define and use scientific vocabulary.

Expanded General Education Content

- Mathematical knowledge can be expanded to include calculations for radiation treatment and protection, radioactivity and radiobiological functions.

- Communication skills can be expanded to facilitate technical and scientific inquiry, analysis and dissemination of knowledge. This content will include the written expression of thoughts and observations derived from the critical thinking process. Additionally, this content will include the theory and practice of public speaking, development of informative and persuasive skills and the ability to tailor information and delivery to specific audiences.

- Information systems skills can be expanded to radiation therapy simulation, information processing, treatment planning and treatment delivery.

- Knowledge of human anatomy and physiology can be expanded to include correlation of anatomical landmarks to internal organs, in-depth examination of the lymphatic system and recognition of sagittal and coronal anatomical structures in cross-sectional views. This content can explore the processes by which tumors originate, grow, metastasize and alter the normal function of body systems. Terminology and organization of the human organism at the cellular, tissue and organ levels can be included. Additionally, the structure and function of human body systems can be covered in detail. A laboratory section is recommended for these topics.

- General Physics content can be expanded to include the application of physical principles and laws, such as gravitation, electricity, magnetism, wave motion and thermodynamics as they relate to scientific disciplines and apply to radiation physics.

Curriculum Revision Workgroup

We would like to extend special recognition to the outstanding professionals who volunteered their time as members of the curriculum revision project:

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We also wish to express our sincere appreciation for the many contributions and suggestions from the professional community over the course of this project.

Contents

Clinical Practice

Description

The clinical practice content is designed to provide sequential development of patient care and procedural information specific to radiation therapy. Through structured sequential assignments in clinical facilities, radiation therapy students are introduced to team practice, patient-centered clinical practice and professional development. These concepts can be further discussed, examined and evaluated in the classroom.

Objectives

1. Recognize the scope of practice, professional standards of ethics and legal limitations of radiation therapists.
2. Adhere to accreditation, governmental, institutional and departmental guidelines.
3. Document and communicate errors and discrepancies in patient care and medical records.
4. Apply concepts of teamwork.
5. Perform simulation, localization and therapeutic radiation therapy procedures in accordance with national patient safety standards.
6. Deliver patient-centered care.
7. Use safe patient-transfer techniques.
8. Construct and prepare immobilization and beam modification devices.
9. Apply the principles of radiation protection and safety.
10. Evaluate and verify treatment plan prior to treatment delivery.
11. Execute approved treatment plan in accordance with prescription.
12. Assess the patient's condition prior to, during and after delivery of a prescribed course of radiation therapy.
13. Initiate medical interventions and/or life support procedures as necessary.
14. Explain programs to promote and maintain patient health and wellness as needed.
15. Anticipate potential complications and foster preventive care.
16. Demonstrate effective written, oral and nonverbal communication with patients and other members of the health care team.
17. Document all aspects of patient care and management in the health record.
18. Perform quality assurance procedures for all treatment delivery equipment, accessories and treatment room doors.
19. Identify equipment malfunctions and the necessary steps to resolve them.
20. Employ MRI safety and practice concepts in simulation and treatment delivery.

Content

I. Essentials of Clinical Practice

A. Legal considerations

B. Documentation protocols

C. Regulatory and accreditation agencies

D. Professional behavior
   1. Understanding the patient's expectations, rights and responsibilities
   2. Understanding the therapist's professional responsibilities

E. ASRT Practice Standards

F. Patient Care Partnership (Patient's Bill of Rights)
   1. Privacy and access to health care information
   2. Goal of care
   3. Research participation

G. Clinical policy and procedure
   1. Incident reporting
   2. General safety practice
      a. Emergencies
      b. Disasters
      c. Accidents and reportable events
   3. Departmental guidelines

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

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
   5. Communication style
      a. Age-specific

b. Cultural sensitivity
c. Socioeconomic sensitivity
d. Patient-focused care
e. Health literacy

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

C. Care
1. Management of side effects
2. Effects of multidisciplinary treatment on the patient
a. Surgery
b. Chemotherapy
c. Hormone therapy
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
10. Cancer survivorship

III. Simulation – CT, MRI, PET

A. Safety
1. Radiation safety
2. MRI safety
3. Environmental protection practices

B. Preparation for simulation
1. Physician orders
2. Medical and diagnostic information
3. Procedure and room preparation

C. Equipment operation

D. Patient and machine monitoring
1. Patient considerations

a. Verify screening
    1) Pregnancy
    2) Implantable devices (e.g., pacemaker, ICD)
    3) Previous radiation exposure
    4) Dentures
    5) Hearing aids
b. Claustrophobia

E. Patient positioning and immobilization
1. Construction of immobilization devices
2. Straightening techniques
3. Leveling techniques
4. Patient comfort and reproducibility techniques
5. Gating and deep-inspiration breath-hold radiation therapy (DIBH-RT)

F. Contrast media administration
1. History and physical examination
2. Patient preparation instructions
3. Media administration techniques
    a. Oral
    b. Intravenous (IV)
        1) Hand injection
        2) Mechanical pressure injector
    c. Intracavitary

G. Isocenter localization
1. Imaging procedures
2. Patient marking (temporary and permanent)
3. Programmable lasers
4. Surgical clips or fiducial markers

H. Treatment volume localization

I. Treatment field delineation

J. Image processing, capture and export

K. Documentation

IV. Treatment Planning

A. Collaboration with team members

B. Software operation

C. Procedures
    1. Volume definition
    2. Image fusion/contouring
    3. Critical structures
    4. Beam energy, arrangement and modification
        a. Dose and fractionation schedule
        b. Parameters of treatment field design and arrangement
    5. Implementation and verification

V. Treatment Delivery

A. Radiation safety and environmental protection practices

B. Equipment operation

C. Patient identification

D. Patient and machine monitoring

E. Treatment verification

F. Prescription and plan verification

G. Monitoring critical structures dose

H. Performing and documenting procedural timeout

I. Patient positioning and immobilization

J. Machine setup, malfunctions and troubleshooting

K. Radiation oncology charting/medical records
    1. Purpose, authorization and responsibilities
    2. Details of delivered treatment
    3. Dose monitoring to prescription and critical structures
    4. Observations, alerts and status notations

L. Comparison of images for verification/localization
    1. Patient repositioning
    2. Dynamic targeting

M. MRI safety

VI. Quality Assurance and Quality Management

A. Documentation

B. General area conditions
   1. Electrical and mechanical safety interlocks
      a. Treatment room door
      b. Treatment unit and console
      c. Table
      d. Gantry
   2. Power supply disconnection
   3. Emergency switches
   4. Critical machine parameters (e.g., pressure, temperature)

C. Accessory devices (e.g., beam modifiers)

D. Immobilization devices
   1. Standard
   2. Custom

E. Communication devices
   1. Audio
   2. Visual

F. Computerization

G. Simulation and treatment units

H. Brachytherapy

I. Treatment planning

J. Device fabrication equipment

VII. Clinical Competency

ARRT Competency Requirements
(refer to the handbook and documents located at www.arrt.org)

Ethics in Radiation Therapy Practice

Description

The ethics content describes ethical theories and principles and how they relate to radiation therapy practice.

Objectives

1. Identify theories and principles that guide ethical decision making in practice.
2. Differentiate distributive, compensatory and retributive justice.
3. Recognize the ethical imperatives of personal honesty, integrity, accountability and compassion in professional practice.
4. Discuss basic ethical duties of health care providers.
5. Identify current ethical issues in health care.
6. Demonstrate provider and patient relationships.
7. Defend the concept of patient advocacy and support of patients' rights.
8. Discuss the elements of informed consent.
9. Describe standards of disclosure.
10. Analyze the use of patient information to ensure confidentiality.
11. Demonstrate sensitivity to patients of various cultures, ethnicities and gender identities.
12. Explain ethical issues related to treatment of patients from various age groups.
13. Discuss the radiation therapy scope of practice, code of ethics and practice standards.
14. Recognize the duty of radiation therapists to take responsibility for actions and decisions.
15. Describe likely situations that will require ethical scrutiny.
16. Examine ethical issues that arise daily in a radiation therapy department.

Content

I. Ethical Theories and Principles

A. Theories (e.g. Utilitarianism, Kantianism)

B. Basic principles of health care ethics
   1. Autonomy
      a. Three basic elements of autonomy
      b. Therapeutic privilege
      c. Benevolence
      d. Paternalism
      e. Fiduciary relationship
   2. Nonmaleficence
   3. Beneficence
      a. Hippocratic oath
      b. Cost/benefit ratio
   4. Veracity
      a. Honesty
      b. Nondisclosure and deception
   5. Role fidelity
      a. ARRT Standards of Ethics
         1) ARRT Code of Ethics
         2) ARRT Rules of Ethics
   6. Confidentiality
      a. Health Insurance Portability and Accountability Act (HIPAA)
      b. Digital information systems
         1) Protected
         2) Third-party payer information
         3) Electronic medical record (EMR)
         4) Verify and record
   7. Justice
      a. Distributive justice
      b. Compensatory justice
      c. Retributive justice

C. Informed consent

D. Proper documentation protocols

II. Provider/Patient Relationship

A. Models (e.g. Collegial, 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. Determination of competency

III. Ethical Decision-making in Health Care Dilemmas

A. Ethical decision-making models

B. Treating the family

C. Futility

D. Brain death and organ procurement

E. Pain management

F. Survivorship

G. End-of-life issues
   1. Advanced directives (e.g., living will)
   2. Proxy decision-making
      a. Durable power of attorney
      b. Medical power of attorney
   3. Informed nonconsent
   4. Do-not-resuscitate (DNR) orders
   5. Euthanasia
   6. Hospice

H. Other ethical issues in health care
   1. Genetic science and biomedical technology
   2. Justice and the allocation of scarce resources

3. Professional gatekeeping and professional obligations
    a. Conflicts of interest
    b. Scope of practice
    c. Impaired colleagues
    d. Whistle blowing

Imaging and Processing in Radiation Oncology

Description

Imaging and processing content for radiation oncology describes the factors that affect production and recording of radiographic images for patient simulation, treatment planning and treatment verification, with an emphasis on radiation oncology imaging equipment and related devices.

Objectives

1. Define terminology associated with digital imaging systems.
2. Discuss the fundamentals of digital imaging.
3. Describe digital imaging applications in radiation therapy practice.
4. Recognize how digital imaging systems respond to background and scatter radiation.
5. Apply techniques to control scatter radiation.
6. Describe image processing techniques for digital images.
7. Explain methods to prevent poor quality images.
8. Describe picture archiving and communications systems (PACS) and their function.
9. Evaluate the benefits of telemedicine.
10. Explain the digital imaging and communications in medicine (DICOM) standards.
11. Describe the data flow of a DICOM image to a PACS.
12. Discuss HIPAA concerns with electronic information.
13. Identify common problems associated with retrieving and viewing images from a PACS.
14. List various informatics applications in health care.
15. Describe the functions and components of a computed tomography (CT) imaging system.
16. Differentiate between axial/sequential and spiral/helical CT scanning.
17. List the steps of CT data processing.
18. Name the functions of the array processor used for image reconstruction.
19. Explain the difference between reconstructing and reformatting an image.
20. Identify the types and appearance of common artifacts affecting CT images.
21. Explain how CT artifacts can be reduced or eliminated.
22. Describe current data storage techniques used in CT.
23. Demonstrate the use of radiation protection devices that can reduce patient dose in CT.
24. Explain image formation for magnetic resonance (MR), ultrasound imaging, nuclear medicine, positron emission tomography (PET), hybrid imaging and fusion imaging.

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. Region of interest (ROI)
   6. Analog to digital conversion

B. Digital receptors
   1. Amorphous selenium/thin-film transistor (TFT) arrays
   2. Cesium iodide/amorphous silicon TFT arrays
   3. Charge-coupled device (CCD) and complementary metal oxide semiconductor (CMOS) systems
   4. Photostimulable phosphor (PSP) plates
      a. Cassette-based systems
      b. Cassetteless systems

C. Comparison of detector properties and evaluative criteria
   1. Detective quantum efficiency (DQE) predicts dose efficiency
   2. Spatial resolution
      a. Sampling frequency – pixel pitch
      b. Receptor size
      c. Light spread – phosphor layer thickness
      d. TFT detector element size (DEL)

D. Dynamic range and latitude
   1. Dynamic range of the detector
      a. Acquisition data width
   2. Latitude – allowable error for optimal image acquisition

E. Exposure indicators and deviation index
   1. Air kerma (e.g., K indicator)
   2. Deviation index (DI)
   3. Exposure indicators
      a. Centering and beam collimation
      b. Optimal value ranges

II. Image Characteristics

A. Image brightness
   1. Definition
   2. Acceptable range

3. Technical factors
    a. mAs
    b. kVp
    c. Distance
    d. Beam limitation
    e. Patient considerations
    f. Contrast media

B. Image contrast
    1. Definition
    2. Types
        a. Long scale
        b. Short scale
    3. Components
        a. Subject
        b. Image receptor
    4. Technical factors
        a. kVp
        b. Scattered radiation
        c. Filtration
        d. Patient considerations
        e. Distance
        f. Contrast media

C. Spatial resolution
    1. Definition
    2. Geometric
        a. Focal spot size
        b. Source-to-image receptor distance (SID)
        c. Object-to-image receptor distance (OID)

D. Magnification

E. Image receptor scattered/secondary radiation
    1. Definition
    2. Interactions
    3. Factors
        a. kVp
        b. Patient considerations
        c. Distance
        d. Contrast media
    4. Effects
        a. Patient dosage

1) Adult
2) Pediatric
3) Body habitus

b. Image quality
c. Occupational exposure

III. Fundamental Principles of Exposure

A. Selection of exposure factors
1. Consistent specific receptor exposure
2. Control scatter
3. Adjusting for variation
a. Structure composition
b. SID
c. Pathology

B. Controlling patient exposure
1. Technical factor selection (e.g., mA, kVp, collimation)
2. Filtration
3. ALARA principles
4. Patient exposure monitoring
5. Dose reduction software
6. Exposure indicators

IV. Computed Tomography Equipment in Radiation Oncology

A. Capabilities and limitations

B. Components, operations and processes of CT
1. Data acquisition
a. Methods
1) Slice-by-slice
2) Volumetric
3) Beam geometry

b. Data acquisition system (DAS)
1) Components
2) Functions
a) Measurement of transmitted beam
b) Encoding measurements into binary data
c) Logarithmic conversion of data
d) Transmission of data to computer

c. Data acquisition process
1) Scanning/raw data/image data
a) Rays
b) Views

i) Beam's eye view (BEV)
ii) Volumes of interest

c) Profiles
i) Pixels
ii) Matrices
iii) Voxels

1) Attenuation
a) Linear attenuation coefficients
b) CT/Hounsfield numbers (e.g., baseline reference number)

2) Selectable scan factors
a) Scan field of view
b) Display field of view
c) Matrix size
d) Slice thickness
e) Window width
f) Window level
g) mAs and kVp
h) Algorithm
i) Scan time and rotational arc
j) Radiographic tube output
k) Region of interest (ROI)
l) Magnification
m) Focal spot size and tube geometry
n) Pitch

3) Contrast media
a) Methods of administration
b) Types of contrast

C. Factors controlling image appearance

D. Image evaluation/anatomical structures
1. Artifacts
b. Motion
c. Metal "star" artifacts and metal artifact reduction (MAR)
d. Beam hardening
e. Preventative measures
2. Window width/window level for display
3. Distortion
4. Noise
5. Spatial resolution

E. Processing evaluation and correction of image quality
1. Image reconstruction

2. Image reformation
3. Image smoothing
4. Edge enhancement
5. Grayscale manipulation

F. Image backup and storage

G. Radiation protection
   1. Methods for reducing radiation dose to the patient
      a. Technical factor selection
      b. Pediatric patient considerations (i.e., Image Gently)
      c. Scatter radiation reduction
      d. MITA Smart Dose

V. Radiation Oncology Digital Imaging Applications

A. Image-guided radiation therapy (IGRT) for verification and localization
   1. Cine (e.g., motion management)
   2. Single and double exposure
   3. Cone beam CT in 3D and 4D
   4. Fan beam (tomotherapy)
   5. Stereoscopic matching, 2D2D and 2D3D
   6. kV/kV matching
   7. MV/MV matching
   8. Ultrasound
   9. Fluoroscopy
   10. Digitally reconstructed radiograph (DRR)
   11. Electronic portal imaging device (EPID)
   12. Surface-guided radiation therapy (SGRT) (e.g., OSMS, Vision RT)

B. Patient positioning and dynamic targeting
   1. Interfraction motion
   2. Intrafraction motion
   3. Respiratory gating
   4. Fiducial markers
   5. Volumetric imaging

C. Radiation therapist responsibilities
   1. Order verification
   2. Image acquisition
   3. Processing – image manipulation
   4. Annotation issues
   5. Transmitting image
      a. HIPAA and patient confidentiality

6. Image orientation to patient anatomy, position and laterality

VI. Imaging Modalities

A. Description, basic principles and advantages/disadvantages of each imaging modality
   1. Radiography
   2. CT
   3. MRI
   4. Mammography
   5. Ultrasound imaging
   6. Nuclear medicine
   7. PET
   8. Hybrid imaging
   9. Fusion imaging
   10. Molecular imaging

VII. Healthcare Informatics Applications

A. Picture archiving communication system (PACS)

B. Hospital information system (HIS) / radiology information system (RIS)

C. Digital imaging and communications in medicine (DICOM) standards

D. HL-7

Introductory Law in Radiation Therapy

Description

Introductory law content is designed to prepare radiation therapists for discussion of the sources of law, causes of action and litigation processes related to their professional practice. This content describes the inter-relatedness of standards of care, laws, ethical standards and professional competence.

Objectives

1. Evaluate social, political, economic and historical issues to recognize the different sources of laws.
2. List the common categories of legal action and identify the potential role of a radiation therapist.
3. Recognize the role of effective communication in preventing and mitigating legal action.
4. Evaluate clinical practice in simulation, treatment delivery, patient assessment, patient education and quality assurance for negligence.
5. Examine the role of the radiation therapist in the informed consent process, patient rights and practice standards.
6. Recognize the importance of documentation and the maintenance of clinical practice records as legal records.
7. Analyze the role of the code of ethics, radiation therapy scope of practice and radiation therapy practice standards as guides for professional behavior.

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.g., malpractice)

E. Doctrine of *res ipsa loquitur*

F. Doctrine of respondeat superior

G. Negligence related to clinical practice

H. Elements to reduce charges of negligence

I. Defenses against charges of negligence

IV. The Lawsuit

A. Complaint

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 a consent form

B. Role of the radiation therapist in the consent process

C. Patient Care Partnership (Patient's Bill of Rights)

D. Standard of care

E. HIPAA

VI. Quality and Safety

A. Developing a safety program

B. Equipment safety

C. Patient 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

E. HIPAA

F. Security of patient information

VIII. Risk Management

A. Professional medical liability

B. Risk analysis

C. Role of the radiation therapist in risk management

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

A. Guides to professional practice

B. Participation in peer review and professional development activities

Medical Terminology

Description

Medical terminology content establishes a foundation in the standardized language of medical practice, including common abbreviations and symbols. Background in Latin, Greek and the word-building process of medical terminology is necessary for reading, understanding and applying physician prescriptions in radiation therapy and related services.

Objectives

1. Identify primary language sources from which medical terms are derived.
2. Define medical terms by breaking them down into prefixes, roots and suffixes.
3. Interpret language, abbreviations and symbols in the medical record.

Content

I. Introduction to the Origin of Medical Terminology

A. Primary language sources
   1. Greek
   2. Latin

II. The Word-building Process

A. Anatomical body systems

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

C. Combining forms

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

E. Health literacy communication
   1. Translating medical terms into common language

F. Correct pronunciation of medical terms

III. Medical Abbreviations and Symbols

A. Role in communications

B. Abbreviations
   1. Examples
   2. Interpretations
   3. Use of abbreviations

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

Orientation to Radiation Therapy

Description

Orientation content provides students with an overview of the basics of radiation therapy and the practitioner's role in health care delivery. Principles, practices and policies of the educational program and health care organizations will be discussed, as well as safety concerns and the professional responsibilities of the radiation therapist. Operational human resource concepts and billing and reimbursement issues are also presented in this content.

Objectives

1. Discuss the policies and procedures of the educational program and clinical setting.
2. Identify the responsibilities of a radiation therapy student.
3. Recognize print and internet resources pertinent to radiation oncology.
4. Maintain patient and student confidentiality.
5. Describe the importance of multidisciplinary care for cancer patients.
6. Discuss the philosophy and mission of health care facilities and educational programs.
7. Incorporate key terms for the practice of radiation therapy.
8. Identify the contents and sections of patient records.
9. Employ radiation and health safety procedures for radiation therapy.
10. Summarize the types of insurance, reimbursements and mechanisms necessary for approval of care.
11. Use current ICD and procedural terminology (CPT®) codes for professional and technical charges.
12. Discuss the influence of health care policy on billing and direct patient care.
13. Identify the role of human resources in the work environment.
14. Compare the methods of developing and managing a departmental budget.
15. Differentiate between accreditation, credentialing, certification, registration, licensure and regulations.
16. Explain the purpose of international, national, state and local professional organizations.
17. Discuss the importance of professional and community commitment.
18. Recognize the radiation therapist scope of practice, practice standards and professional code of ethics.
19. List the benefits of continuing education for improving the quality of patient care, as well as professional and personal development and leadership.
20. Identify career advancement opportunities for radiation therapists.

Content

I. Policies and Procedures of the Educational Program

A. Program officials

B. Educational program information

C. Clinical education setting(s)

D. Responsibilities of students
   1. Didactic
   2. Laboratories
   3. Clinical

II. The Health Science Professions

A. Radiologic and imaging sciences

B. Other patient care professionals
   1. Dietician
   2. Health information
   3. Clinical laboratory sciences
   4. Occupational therapy
   5. Pharmacy
   6. Physical therapy
   7. Physician extenders
   8. Midlevel providers
   9. Respiratory therapy
   10. Social services
   11. Dentistry
   12. Spiritual care/clergy
   13. Nursing
   14. 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

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

D. Radiation therapy department organization
    1. Professional personnel
        a. Director/chairman
        b. Departmental administration
            1) Administrative director
            2) Department manager
        c. Radiation oncologists
            1) Attending
            2) Resident
            3) Intern/Fellow
        d. Radiation physicist
            1) Physicist
            2) Engineers
        e. Radiobiologist
        f. Radiation therapist
            1) Clinical supervisor/lead radiation therapist
            2) Chief/senior radiation therapist
            3) Staff radiation therapist
        g. Medical dosimetrist
        h. Researcher
        i. Nursing staff
        j. Social worker
        k. Nutritionist
    2. Support personnel
        a. Clerical staff
        b. Accounting
            1) Billing
            2) Purchasing
        c. Cancer registry
        d. Transportation services
        e. Radiation therapy assistant
        f. Medical records

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. Integrative medicine
        f. Multimodality approach
    6. Research
        a. Clinical trials
        b. Protocols
            1) NRG Oncology/RTOG

C. Key terms
    1. Radiation therapy equipment
        a. External beam delivery systems
        b. Simulators
        c. Oncology information system
            1) Verify and Record
            2) Electronic medical record
            3) Other
        d. Brachytherapy
        e. Other emerging technologies
    2. Equipment components and terms
    3. Dose delivery terms
    4. Positioning terms
        a. Beam positioning
        b. Patient positioning

D. Radiation therapy treatment techniques
    1. External beam
        a. Photons
        b. Electrons
    2. Brachytherapy
        a. HDR/LDR
        b. Electronic (e.g., eBx)
    3. Hyperthermia
    4. Intraoperative

5. Stereotactic
    a. Intracranial
    b. Extracranial (SBRT)

E. Patient rights and responsibilities
    1. HIPAA
    2. Record/chart contents
    3. Confidentiality
    4. Patient Care Partnership
    5. Patient responsibilities
    6. Survivorship plan

F. Radiation safety
    1. Monitoring
    2. Protection

G. Safety
    1. Universal precautions for bloodborne pathogens
    2. Patient safety
    3. Workplace safety
        a. Fire
        b. Electrical
        c. Hazardous materials
        d. Radioactive materials
        e. Occupational Safety and Health Administration (OSHA)

V. Insurance and Billing

A. Insurance
    1. Health Maintenance Organizations (HMOs)
    2. Preferred Provider Organizations (PPOs)
    3. Supplemental insurance
    4. Medicare and Medicaid
    5. Government-based insurance
    6. Other

B. Charity care (e.g., Hill-Burton free and reduced cost health care)

C. Health Care Policy
    1. National (e.g., CMS Quality Payment Program/HITECH)
    2. State
    3. Institutional
    4. Patient satisfaction measures
    5. Electronic Health Record Meaningful Use Certification

a. Institution or facility
b. Practice

D. Billing and coding
1. American Medical Association (AMA)
2. Centers for Medicare and Medicaid Services (CMS)
3. International Classification of Diseases (ICD)
4. Coding perspective
a. Proper coding
b. Documentation
c. Audit procedures
5. CPT Principles
a. Professional charges
b. Technical charges

VI. Human Resources

A. Strategic recruitment
1. Position description and analysis
2. Staffing
a. Human resources surveys
b. Performance evaluations
c. Merit increases
d. Flexible staffing
e. Consolidation of resources
3. Selection of candidate
4. Salary and benefits
5. Full-time equivalent (FTE) and PRN status
6. Interview process
a. Resume writing
b. Resume vs. curriculum vitae
c. Interview skills

B. Education
1. Orientation
a. New employee
b. New procedure
c. New technology
d. Updated technology and procedures
2. Annual in-service training
3. Continuing education
4. Competency assessment

C. Employee relations

1. Employee/job satisfaction surveys
2. Benefits

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

VII. 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

VIII. Professional Organizations

A. Credentialing/Registration
    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

IX. Professional and Community Commitment

A. Organizations

B. Role of radiation therapist

X. Professional Development

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

B. Career opportunities
    1. Administration
    2. Education
    3. Medical dosimetry
    4. Physics
    5. Research
    6. Application specialist
    7. Vendors
    8. Professional associations
    9. Accreditation organizations
    10. Billing and coding specialist

C. Governmental

Pathophysiology

Description

Pathophysiology content introduces concepts of disease processes. This content emphasizes etiological considerations, neoplasia and associated diseases in the radiation therapy patient.

Objectives

1. Describe the physiological response of inflammation and cell injury.
2. Assess predictive factors of cancer and associated disease, including genetics, lifestyle, age and environment.
3. Determine probable diagnostic, prognostic, staging, grading and rationale for the therapeutic pathway for oncologic diseases.
4. Identify common biomarkers and their role in monitoring treatment and disease progression.
5. Determine tumor characteristics of neoplasms based on histology.
6. Anticipate the effects of common diseases on patients.

Content

Part I: General Pathology

I. Introduction to Human Disease

A. Pathology 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

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. Vitamin and mineral deficiencies

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 on each body system

Part Two: Neoplasia

I. Introduction

A. Overview

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. Histopathology

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

D. Effect on treatment

VI. Prognostic Factors

A. Tumor-related

B. Host-related

VII. Malignancies, Including:

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

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

Principles and Practice of Radiation Therapy I

Description

The principles and practice content for radiation therapy provides an overview of cancer and the specialty of radiation therapy. Historic and current aspects of cancer treatment are covered, along with the roles and responsibilities of the radiation therapist. In addition, treatment prescription, techniques and delivery are discussed.

Objectives

1. Evaluate the use of radiation therapy as a primary treatment modality for various cancers.
2. Explain the medical and patient information necessary to develop a treatment plan.
3. Determine the treatment energy for various tumor types and locations.
4. Assess beam modifiers and their uses with a variety of treatment energies.
5. Describe the best treatment setup aid, immobilization technique and beam modifier for various treatment techniques.
6. Identify inconsistencies between treatment prescriptions and treatment plans.
7. Develop a simulation plan for a tumor, including necessary steps before, during and after the procedure.
8. Evaluate treatment localization using treatment images in relation to reference images.
9. Recognize the radiation therapist scope of practice and practice standards.
10. Employ auxiliary equipment during treatment (e.g., Calypso, ABC, Surface Imaging).

Content

I. Cancer Perspectives

A. Cancer incidence

B. Cancer management
   1. Surgery
   2. Radiation therapy
   3. Chemotherapy
   4. Immunotherapy
   5. Multidisciplinary and integrative treatment
   6. Personalized medicine

C. Cancer prevention

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. Treatment protocols

I. Clinical trials

J. Evidence-based decision-making

III. Radiation Therapy Treatment

A. Treatment goals

B. Treatment considerations
   1. Primary vs. multidisciplinary treatment
   2. Tumor histology, grade and stage
   3. Tumor location
   4. Radiosensitivity of tumor

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

IV. Radiation Therapy Equipment

A. Simulators
   1. Purpose
   2. Equipment
      a. CT
      b. MR
      c. Fusion imaging
   3. Method of radiation production
   4. Auxiliary devices
   5. Radiation protection
   6. Patient observation and communication
   7. Emergency procedures

B. Imaging devices
   1. Purpose
   2. Methods of radiation production
   3. Components
   4. Radiation protection
   5. Accessories
   6. Patient observation and communication
   7. Emergency procedures

C. External beam
   1. Purpose
   2. Megavoltage
      a. Linear accelerators
         1) Components
         2) Methods of radiation production
            a) Photons
            b) Electrons
         3) Energy
         4) Depth of maximum dose (D_{max})
         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
    a) ^{60}Co
4) Cyber knife
5) Heavy particle accelerators
6) Proton cyclotrons/synchrotrons
    a) Components
    b) Methods of radiation production
    c) Energy deposition/Bragg peak
    d) Compensation
    e) Radiation production
    f) Nonexponential attenuation
    g) Proximal and distal dose gradients
    h) General isodose curve pattern
    i) Percentage depth dose energy dependence
    j) Precision immobilization requirements
    k) Penumbra
    l) Clinical applications
    m) RBE
7) Tomotherapy
8) Emerging units
    a) MR-guided cobalt radiation delivery
    b) MR linac

c. Radioisotope units/Teletherapy
    1) Purpose
    2) Methods of radiation production
    3) Half-life
    4) Energy
    5) Components
    6) Radiation protection
    7) Auxiliary devices
    8) Patient observation and communication
    9) Emergency procedures

3. Kilovoltage units
    a. Purpose
    b. Components
    c. Method of radiation production
    d. Energy
    e. Auxiliary devices
    f. Patient observation and communication

g. Emergency procedures

D. Brachytherapy
1. Purpose
2. Types
   a. High-dose rate (HDR)
   b. Low-dose rate (LDR)
   c. Pulsed-dose rate (PDR)
3. Isotopes
4. Methods of radiation production
5. Half-life
6. Energy
7. Components
8. Radiation protection
9. Auxiliary devices
10. Patient observation and communication
11. Emergency procedures

E. Emerging technologies for patient treatment setup and localization
1. Adaptive Therapy

V. Treatment Delivery Accessories

A. Beam modification devices
1. Purpose
2. Construction
   a. 3D printed
3. Types
   a. Bolus
   b. Filters
      1) Wedges
         a) Dynamic
         b) Physical
      2) Hardening
      3) Compensating
      4) Transmission
4. Beam shaping
   a. Blocks, electron cutouts
   b. Collimators/jaws
   c. Multileaf collimators (MLCs)
   d. Cones
   e. Particle therapy snouts and bolus
   f. Other
5. Applications

6. Other

B. Patient positioning and immobilization devices
    1. Purpose
    2. Positioning
    3. Immobilization
    4. Alignment lasers
    5. Couch indexing
    6. Construction
    7. Applications
    8. Emerging devices

VI. Tumor Localization

A. Purpose

B. Simulation Procedures
    1. Adaptation of treatment protocols to patient-specific conditions

C. Imaging techniques
    1. Image quality factors
    2. CT
    3. MR
    4. 4D imaging
    5. Fusion
    6. Orthogonal films
    7. Fluoroscopy
    8. Ultrasound imaging
    9. Other

VII. Pretreatment Verification Protocol

A. Purpose

B. Components

C. Application

D. Quality assurance

E. Other

VIII. Treatment Delivery Protocol

A. Adaptation of treatment protocols to patient-specific conditions

B. Patient assessment, education and care

C. Patient safety
    1. Radiation protection
    2. Ancillary medical equipment
    3. Patient transfers

D. Time-out, Universal Protocol

E. Treatment parameters

F. Setup and treatment imaging
    1. Isocenter and beam verification
    2. Motion monitoring

G. Withholding treatments when conditions warrant

H. Treatment delivery

I. Documentation of treatment

J. Reporting and documentation of treatment errors and medical events

Principles and Practice of Radiation Therapy II

Description

The principles and practice content for radiation therapy examines the management of neoplastic disease and promotes both critical thinking and ethical decision-making. The epidemiology, etiology, detection, diagnosis, treatment and prognosis of neoplastic disease are 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 specific professional skills within their scope.

Objectives

1. Identify tumor histology and pathways associated with cancer and neoplastic disease.
2. Examine the role of surgery, radiotherapy, immunotherapy, personalized medicine and medical oncology in the management of neoplastic disease.
3. Discuss emerging multidisciplinary approaches to neoplastic disease management.
4. Recognize the role of radiation therapy in the management of patient populations with benign and malignant diseases.
5. List epidemiologic and etiologic information pertinent to each neoplastic site.
6. Describe the clinical presentation for each anatomic neoplastic site.
7. Explain preventive methods and screening tools associated with each neoplastic site.
8. Discuss detection, diagnosis, grading and staging systems for each neoplastic site.
9. Apply treatment field design and arrangement parameters to treat neoplastic diseases.
10. Examine the role of radiation therapy in palliative disease management.
11. Identify treatment regimens and fractionalization schemes used in palliative disease management.
12. Describe the role of radiation therapy in the management of oncology emergencies.

Content

I. 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**
Pediatric neoplasms	**HIV-related neoplasms**	**Benign neoplasms**

A. Epidemiology

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
      a. Receptors on tissues

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

I. Prognosis
   1. Treatment morbidity/toxicity
      a. Acute
      b. Chronic
      c. Survivorship

J. Multidisciplinary treatment approach
   1. Treatment modality combinations

K. 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

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

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

N. Role and scope of radiation oncology
    1. External beam
    2. Brachytherapy
    3. Complications

O. Emerging approaches to neoplastic disease management

II. Metastatic and Palliative Treatment Applications

A. Common sites of metastases

B. Detection and diagnosis

C. Therapeutic management of metastases

III. Emergency Treatment Applications

A. Types of oncologic emergencies

B. Indications for radiation therapy

C. Diagnosis

D. Treatment

Radiation Therapy Quality Management, Quality Assurance, Safety and Operations

Description

Quality management, quality assurance, safety and operations content describes the development of a culture of safety through quality control and assurance checks. This process includes the clinical aspects of patient care, medical records, treatment delivery, localization equipment and treatment planning equipment. The role of the various radiation therapy team members in quality management will be discussed as well as the legal and regulatory implications for maintaining optimal patient care. Accreditation agencies and the radiation therapist's role in the accreditation process will also be covered.

Objectives

1. Describe the role of quality management programs in developing a culture of safety in radiation oncology.
2. Define types of quality management programs.
3. Explain federal, state and institutional accreditation standards and reporting regulations for quality management.
4. Discuss quality control procedures, malfunctions and recommended tolerances for simulation equipment, megavoltage treatment units, treatment planning systems and brachytherapy equipment and sources.
5. Produce treatment documentation and identify common documentation errors.
6. Evaluate the purpose and function of verify and record systems
7. Discuss the significance of documentation of treatment outcomes for patient care and education in radiation oncology.
8. Use local, national and international Incident Learning Systems for error reporting and near misses.
9. Identify simulation or treatment planning errors and determine the effect of these errors on treatment delivery.
10. Recognize quality assurance programs for clinical systems testing.

Content

I. Introduction

A. Quality Management (QM)
   1. Definition
   2. Rationale

B. Types of QM programs
   1. Models (e.g., LEAN, Six Sigma, PDCA, TQM, CQI)

II. General Principles

A. Regulating agencies
   1. Federal (e.g., NRC)
   2. State
   3. Institutional
   4. Professional

B. Accreditation
   1. Facility (e.g., TJC)
   2. Radiation oncology department (e.g., ACR, ASTRO APEx)

C. Professional Organizations on Safety in Radiation Oncology
   1. ASRT
   2. AAPM (e.g. IHE-RO)
   3. ASTRO
   4. ACR
   5. RO-SSI

D. Definitions
   1. Quality assurance
   2. Quality control
   3. Quality assessment
   4. Quality audit
   5. Quality improvement (QI)

E. Standards
   1. Current safety recommendations in radiation oncology
   2. Staffing levels, qualifications and responsibilities
      a. Two credentialed radiation therapists present for any external beam patient treatment
   3. Equipment availability
   4. Dosimetric accuracy

F. Components

1. Team/committee members and responsibilities
2. Patient education
3. QI plan
4. Policies and procedures/guidelines
5. Quality indicators
6. Outcomes
    a. Patient care
    b. Education
    c. Research
7. QI process
8. QI tools
    a. Flow chart
    b. Pareto chart
    c. Cause-and-effect (fishbone) diagram
9. Reporting and evaluating near-misses and errors
    a. Incident Learning System
        1) RO-ILS
        2) SAFRON
        3) ROSEIS
    b. Cognitive biases (e.g., automaticity, multi-tasking)
    c. Potential for errors due to human factors.
10. Implementing corrective actions related to QM data collection and trends

III. Clinical Aspects QC Checks

A. General conditions of patient care area
    1. Purpose, procedure and frequency
    2. Tolerances
    3. Corrective measures
    4. Safety data sheet (SDS)
    5. Documentation

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

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

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

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

F. Treatment verification imaging
    1. Purpose, procedure and frequency
    2. Tolerances
    3. Corrective measures
    4. Documentation
        a. Time out
        b. Checklists

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

IV. QA for Treatment, Simulation/Localization and Verification

A. Commissioning

B. System testing prior to clinical use (e.g., new software versions, information management systems)

C. Routine

D. Purpose, procedure and frequency
    1. Current AAPM Task Group, or equivalent, reports recommendation (e.g., TG-158)
    2. Guidelines to tolerance values

E. Sources of malfunction

F. Materials and methodology

G. Evaluation and interpretation of results

H. Corrective measures

I. Documentation

J. Safety and hazards

K. Preventative maintenance

V. Particle Accelerators

A. Purpose, procedure and frequency of checks
    1. Current AAPM Task Group, or equivalent, reports recommendation (e.g., TG-142, TG-218, TG-51, AAPM Medical Physics Practice Guideline 2.a)

B. Sources of malfunction/error

C. Materials and methodology

D. Safety and hazards

E. Corrective measures

F. Guidelines to tolerance values

G. Documentation

VI. Brachytherapy

A. Current AAPM Task Group, or equivalent, reports recommendation (e.g., TG-59)

B. Purpose, procedure and frequency of checks

C. Sources of malfunction/error

D. Materials and methodology

E. Safety and hazards

F. Corrective measures

G. Guidelines to tolerance values

H. 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

Radiation Biology

Description

Radiation biology content presents basic concepts and principles including interactions of radiation with cells, tissues and the body as a whole, and resultant health effects. This content discusses the theories and principles of tolerance dose, time-dose relationships, fractionation schemes and the relationship of these principles to the clinical practice of radiation therapy.

Objectives

1. Integrate principles of radiation biology with the clinical practice of radiation therapy.
2. Identify radiosensitive components of the cell.
3. Apply units of radiation quantity 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 affecting radiobiologic events at the cellular and subcellular level.
8. Determine biologic damage as a result of radiation-induced chemical reactions.
9. Discuss the effects of radiation on the cell cycle.
10. Compare somatic and genetic effects of radiation.
11. Describe factors influencing the response of cells and tissues to radiation.
12. Discuss the law of Bergonié and Tribondeau.
13. Interpret cell survival curves to determine radiosensitivity under various conditions.
14. Discuss the relationship of radiation quality and dose to systemic responses.
15. Describe radiation syndromes and factors influencing biological 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 $TD5_{/5,}TD_{50/5}$ and QUANTEC.
19. Discuss the concept of $LD_{50/30}$.
20. Compare the relationships 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.

Content

I. Introduction

A. 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)
      c. Gy (RBE)

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
2. Radiation effects on 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. Deterministic effects
   b. Short-term
   c. Long-term
2. Genetic effects
   a. Mutagenesis
   b. Stochastic effects

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

D. Tolerance dose – $TD_{5/5,}$ $TD_{50/5}$, and QUANTEC
    1. Minimal
    2. Maximal
    3. Mean
    4. Other factors
        a. Biological (e.g., age, anatomic variation, medical conditions)
        b. Medical (e.g., prior surgery, pacemakers)
        c. Contribution from other sources
            1) Chemotherapy
            2) Brachytherapy
                a) Common procedures
                b) Dose to surrounding structures
                c) Radiation protection
            3) Prior or abutting radiation fields

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
    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)
    f. Biological effective dose (BED) calculation
7. Volume
    a. Tumor volume
    b. Treatment volume
    c. Time-dose-volume relationship including complications
    d. Radiobiological effects from radiation therapy techniques

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

Radiation Physics

Description

Radiation physics content establishes a basic knowledge of physics as it applies to the clinical setting. Fundamental physical units and measurements, basic principles, atomic structure and types of radiation are discussed. Also presented are the fundamentals of x-ray generating equipment, x-ray production and x-ray interactions with matter.

Objectives

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

32. State the principles of x-ray production.
33. Compare the production of bremsstrahlung and characteristic radiations.
34. Describe various photon interactions, including relation to atomic number and applications.
35. Correlate wavelength and frequency to beam characteristics.

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

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

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

IX. Electrodynamics

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

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

X. Production and Characteristics of Radiation

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

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

Radiation Protection

Description

Radiation protection content presents the 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 included, as well as the specific responsibilities of radiation therapists.

Objectives

1. Distinguish between somatic and genetic effects of radiation exposure.
2. Differentiate between stochastic and deterministic effects of radiation exposure.
3. Employ the concept of as low as reasonably achievable (ALARA).
4. Describe the concept of negligible individual risk.
5. Recognize the legal and ethical radiation protection responsibilities of radiation workers.
6. Use accurate terminology and units when discussing radiation protection.
7. Select the correct units for exposure, absorbed dose, dose equivalence and radioactivity.
8. Discuss the interrelationship between relative biological effectiveness and quality factors.
9. Explain the theory, operation and limitations of radiation detection devices.
10. Recall the 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 dose monitoring methods for medical personnel.
13. List 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 used when designing treatment rooms.
17. Describe the elements of a radiation protection survey for patients undergoing brachytherapy in the operating room and inpatient settings.
18. Calculate exposure based on time, distance and type of radioactivity.
19. Recall 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 for all required elements.

Content

I. Introduction

A. Justification for radiation protection

B. Biologic damage potential of ionizing radiation
   1. Somatic effects
   2. Genetic effects
   3. Stochastic and deterministic 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
   1. Radioactive sources
   2. Machine-produced

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 (TLD)
   4. Optically stimulated luminescence (OSL) dosimeter
   5. Neutron detector
   6. Geiger-Muller detector
   7. Diodes
   8. Neutron detectors
   9. Other

III. Surveys, Regulatory Agencies and Regulations

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

B. Equipment survey
   1. Treatment
   2. Simulation

C. Area survey
   1. Controlled/uncontrolled areas
   2. Restricted/unrestricted areas
   3. Conditions
   4. Recommendations
   5. "Radiation Area" sign posting
   6. Area monitoring devices

D. Regulatory and advisory agencies

E. Radiation safety officer roles and responsibilities

IV. Personnel Monitoring

A. NCRP recommendations for personnel monitoring (report #116)
   1. Occupational exposure
   2. Public exposure
   3. Embryo/fetus exposure

B. Maintenance and evaluation of personnel dosimetry records

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

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

E. Dose limits – Nuclear Regulatory Commission (NRC), Title 10, CFR parts 20 and 35
   1. Occupational
   2. Nonoccupational limits

3. Critical organ sites
4. Embryo-fetus
5. Lifetime effective dose equivalent limit

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

V. Practical Radiation Protection

A. Design
   1. Barriers
      a. Primary
      b. Secondary
   2. Factors
      a. Use (U) controlled/uncontrolled
      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/breakers

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

C. Cardinal principles in protection (time, distance, shielding)
   1. Inverse square law

D. Emergency procedures

VI. Brachytherapy

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

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

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

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

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

F. Handling and disposal of radioactive waste material

G. Quality assurance for brachytherapy
   1. Treatment documentation

Radiation Therapy Patient Care

Description

Patient care content for radiation therapy provides students with foundational concepts and competencies in evaluation of patients before and after treatment delivery. The various psychological and physical needs and factors affecting treatment outcome will be presented. Both routine and emergency care procedures are discussed.

Objectives

1. Differentiate between the roles and responsibilities of health care team members treating cancer patients.
2. Apply principles of professional self-care.
3. Examine the psychological aspects of dying.
4. Explain techniques for communicating with cancer patients and their families.
5. Recognize radiation side effects, complications and associated medical interventions.
6. Identify factors that influence a patient's emotional response.
7. Formulate answers to questions frequently asked by patients.
8. Assess the condition of patients before, during and after treatment delivery.
9. Apply the principles of health safety.
10. Discuss the principles of medication administration.
11. Recognize common medications and explain their effects and side effects.
12. Evaluate a patient for an adverse reaction to medication.
13. Recall emergency response procedures.
14. Describe the proper care of patients with tubes.
15. Assist patients with personal care (e.g., urinal, bedpan, wound/stoma care).
16. Educate patients about medical procedures.
18. Assess the patient before, during and after brachytherapy procedures.
19. Apply the principles of radiation protection during brachytherapy procedures.
20. Assess the nutritional status of cancer patients to provide education or intervention.
21. Employ the principles of patient safety and transfer.
22. Provide patient education materials for individual patient's needs.
23. Compare conventional and integrative medicine.
24. Examine the role of culture in patient-centered care.

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
         5) Patient advocacy
   2. Empathy
   3. Assertiveness

C. Communication
   1. Verbal/written
   2. Nonverbal (e.g., eye contact, touching)
   3. Challenges in patient communication
      a. Hearing, vision and speech problems
      b. Physical, sensory, or mental impairments
      c. Literacy
      d. Altered states of consciousness
      e. Emotional status, acceptance of condition (e.g., stage of grief)
      f. Pediatric and adolescent patients
      g. Geriatric patients
      h. Communicating in stressful circumstances
      i. Explanation of medical terms
      j. Cultural or social diversity
      k. Artificial speech
         1) Transesophageal puncture (TEP)
         2) Esophageal speech
         3) Electrolarynx devices
      l. Language barriers
         1) Foreign
         2) Colloquialism/slang
         3) Medical jargon
   4. Feedback

5. Patient interactions
    a. Establishing therapeutic relationships
        1) Reducing distance
        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 grief
            1) Denial
            2) Anger
            3) Bargaining
            4) Depression
            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) Palliative care
            7) Survivorship
            8) Health professionals (e.g., dietitian, social services)
            9) Community agencies
    2. Patient's emotional responses

a. General behavior

b. Influencing factors

III. Healthcare Informatics Applications

A. Telemedicine

B. Electronic health records

C. Patient care systems

D. Patient monitoring systems

IV. Patient-family Interactions

A. Patient identification

B. Aspects of treatment procedures
   1. Patient /family questions
   2. Other patient concerns
      a. Misconceptions related to radiation
      b. Scheduling
      c. Transportation
      d. Financial

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

V. Assessment of Side Effects

A. Assessment process

B. Influencing factors
   1. Dose
   2. Fractionation
   3. Synergistic treatment effects
   4. Anatomical site

C. Side effects
   1. Overall
   2. Site-specific

VI. Assessment of Other Physical Needs

A. Physical needs of the patient

B. Assessing patient status

C. Delivering compassionate care

D. Physical signs

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

F. Weight

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

VII. 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. Lesion biopsy
2. Cultures
3. Laboratory studies/normal values
    a. Complete blood count
    b. Urinalysis
    c. Electrolytes
4. Aspiration/centesis
5. Other

F. Equipment/instruments (e.g., sphygmomanometer)
    1. Identification
    2. Care

VIII. Health Safety

A. Terminology
    1. Healthcare associated (nosocomial) infections
    2. Communicable
    3. Infectious pathogens

B. Centers for Disease Control (CDC) precautions

C. Cycle of infection
    1. Infectious pathogens
    2. Reservoir of infection
    3. Portal of exit
    4. Transmission of disease
        a. Direct
        b. Indirect
            1) Vehicle
            2) Vector
            3) Airborne
    5. Portal of entry
    6. Susceptible host

D. Asepsis
    1. Medical
        a. Definition
            1) Equipment disinfection
            2) Equipment sterilization
        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 for sterile technique
      1) Opening packs
      2) Gowning/gloving
      3) Skin preparation
      4) Draping
      5) Dressing changes
   e. Types of sterile packaging
   f. Storage
   g. Rules for surgical asepsis

E. Practical asepsis
   1. Hand hygiene
   2. Safe needle practices
   3. Handling contaminated materials
   4. Disposal of contaminated materials
   5. Wound care
      a. Cleansing
      b. Dressing
   6. Personal protective equipment (PPE) (e.g., gloves, gowns, masks)

F. Isolation techniques and communicable diseases
   1. Category-specific
   2. Disease-specific
   3. Standard precautions
   4. Transmission-based precautions
   5. Examples

a. Blood-borne pathogens
b. Body fluid pathogens
c. Air-borne pathogens
d. Antibiotic-resistant infections
e. Clostridium difficile (C diff)
f. Other

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

H. Neutropenic precautions (reverse isolation)
1. Purpose
2. Procedure

I. Psychological considerations

IX. Medications and Their Administration

A. Role of the radiation therapist

B. Medication information
1. Generic name
2. Trade name
3. Drug information
a. *Physician's Desk Reference* (PDR)
b. Product information sheets
4. Appropriate abbreviation usage
5. Pharmacology and administration
a. Adrenergic blocking agents
b. Analgesics
c. Anesthetics
d. Antibacterials
e. Anticonvulsants
f. Antidepressants
g. Antiemetics
h. Antineoplastics
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. Tumor vaccines
d. Other
7. Nutrients, fluids and electrolytes
8. Clinical research
9. Clinical trials

C. Medication administration
1. Time out
2. Six rights system
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

X. Medical Emergencies

A. Emergency equipment

B. Signs, symptoms and medical intervention
1. Shock
a. Types
2. Allergic reactions
a. Contrast media
b. Other (e.g., latex)

c. Stages
3. Diabetic
   a. Hypoglycemia
   b. Ketoacidosis
   c. Hyperosmolar coma
4. Respiratory and cardiac failure
5. Airway obstruction
6. Cerebral vascular accident (CVA)/stroke
7. Fainting (syncope)
8. Seizures

C. Radiation oncology emergencies
   1. Superior vena cava (SVC) syndrome
   2. Spinal cord compression
   3. Severe tumor bleed
   4. Increased intracranial pressure
   5. Neurological impairment
   6. Seizures

D. Other medical conditions

XI. Care of Patients With Tubes

A. Purpose, types and special precautions
   1. Nasogastric/nasointestinal
   2. Percutaneous endoscopic gastrostomy
   3. Tracheostomy
   4. Chest tube
   5. Tissue drains
   6. Ileostomy
   7. Ureteroileostomy
   8. Colostomy
   9. Catheters
   10. Other

B. Procedures and special precautions
   1. Suction
      a. Purpose
      b. Emergency
      c. Equipment
   2. Oxygen administration
      a. Purpose
      b. Values
      c. Delivery systems

d. Safe handling
e. Documentation

3. Urological and rectal devices
   a. Purpose
   b. Equipment
   c. Procedures
   d. Removal
   e. Documentation

XII. Brachytherapy Procedures

A. Patient care
   1. Physical response
      a. Therapeutic
      b. Adverse
   2. Psychological
   3. Interruption of treatment
   4. Reporting changes in patient condition
   5. Site-specific patient care
   6. Medications
   7. Contraindications

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

C. Follow-up patient care

D. Patients/family caregiving

XIII. Assessment of Nutritional Status

A. Site-specific interventions

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

C. Dietary considerations
   1. General
      a. Benefits
      b. Effect on outcome
   2. Irradiated site specific
   3. Types of diet
   4. Dietary supplements

5. Continued assessment
6. Documentation

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

XIV. Physical Activity Considerations

A. Karnofsky scale/performance status

B. Activity as appropriate

C. Recognizing limitations

XV. 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
    6. Use of devices

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

D. Incident reports

XVI. Patient Education

A. Needs assessment

B. Educational methods
    1. Explanation of treatment
    2. Strategies to improve understanding
    3. Treatment compliance (e.g., positioning, skin marks)

C. Implementation and evaluation

D. Treatment procedures

E. Medical imaging procedures

F. Documentation

XVII. Integrative Medicine

A. Mind, body, spirit connection

B. Role in oncology care

Radiation Therapy Physics

Description

Radiation therapy physics content reviews and expands basic physics concepts and theories to include content specific to radiation therapy. Detailed analysis of the structure of matter, properties of radiation, nuclear transformations, x-ray production and interactions of ionizing radiation are included. Also presented are treatment units used in external radiation therapy, quality evaluation of ionizing radiation, absorbed dose measurement, dose distribution and scatter analysis.

Objectives

1. Compare and contrast atomic structures and compositions.
2. Describe types of electromagnetic (EM) radiation and their characteristics.
3. Recognize applications in radiation therapy for commonly-used radioactive isotopes.
4. Explain nuclear reactions.
5. Describe photon, electron and particle production, energy ranges and beam characteristics.
6. Discuss the components and functions of radiation therapy equipment.
7. Describe photon and particle interactions with matter.
8. Calculate attenuation requirements for beam modification and beam hardening devices.
9. Discuss clinical accessories and alternate shielding materials.
10. Recognize the purpose and standards of influencing organizations.
11. Explain the clinical applications of radiation detection devices.
12. Calculate correction factors for measuring radiation.
13. Discuss protocols used for beam calibration.
14. Calculate absorbed dose and exposure.
15. Measure dose distribution in phantom material, air and tissue.
16. Explain source-skin distance (SSD) and isocentric principles.

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

D. Relevant Equations
   1. $E = 1/2mv^2$
   2. $m = \frac{m_o}{\sqrt{1-\frac{v^2}{c^2}}}$
   3. $E = mc^2$
   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

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
1. Yield
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

III. Review of Production of X-rays

A. The x-ray tube

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

C. X-ray energy spectra
1. Unfiltered
2. Filtered
    a. Inherent filtration
    b. Added filtration

D. Spectral distribution

E. Operating characteristics

IV. Radiation Therapy Treatment Units (External Teletherapy)

A. Historical Equipment

B. Equipment in current use

1. Contact, superficial, orthovoltage or deep therapy
    a. Tube voltage
    b. Tube current
    c. Reflection target
    d. Typical treatment distance
    e. Typical filtration
    f. Typical HVL
    g. Beam characteristics
        1) D_{max}
        2) Depth dose
2. Megavoltage therapy
    a. Linear accelerator
        1) Accelerator structure design
        2) Basic components
    b. Cyclotron
        a) Basic design
        b) Energy range of accelerated particles
        c) Clinical treatment beams
        d) Radionuclide production
    c. Synchrotron
        a) Basic design
        b) Energy range of photons and particles
        c) Advantages
3. Particle beams
    a. Neutrons
        1) D-T generators
        2) Cyclotrons
        3) Linear accelerators
    b. Heavy ions
        1) Cyclotrons
        2) Linear accelerators
        3) Types
            a) Carbon
            b) Neon
            c) Argon
            d) Silicon

e) Other

4. Isotope beams
   a. ^{60}Co
   b. Gamma energies and average energy
   c. Review of decay scheme
   d. Specific activity
   e. Typical treatment distances
   f. 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
            a) Heteroenergetic
            b) Monoenergetic
         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
      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

d. Compton effect
1) Associated energy range
2) Probability
a) Energy dependence
b) Z dependence
3) Electrons per gram
4) Special cases of Compton
a) Direct hit
b) Grazing hit
c) 90^{o} photon scatter
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

C. Interaction of charged particles
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
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
        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

4. Diodes

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)

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
c. Average energy

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
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. Current American Association of Physicists in Medicine (AAPM) RTC Task Group report
    2. Current International Atomic Energy Agency report

F. Other methods of measurement of absorbed dose
    1. Calorimetry
    2. Chemical dosimetry
    3. Solid state
        a. Thermoluminescence dosimetry (TLD)
        b. Film dosimetry
        c. MOSFET dosimeters

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

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)

Research Methods, Evidence-Based Practice and Information Literacy

Description

Research methods and information literacy content is important because the health care profession is continually changing, which requires the radiation therapist to learn new methods to function competently. Radiation therapists should contribute to the available body of knowledge and be able to effectively analyze new resources to promote growth in the profession. Professional development enables radiation therapists to stay in step with the current health care environment, foster future development and increase awareness of the profession in the global community. This content emphasizes intellectual inquiry, information literacy and the use of scholarly research methods in support of evidence-based practice.

Objectives

1. Analyze research articles to determine the accuracy and validity of findings.
2. Research and evaluate sources of information to be used in evidence-based practice.
3. Improve patient care and clinical outcomes through integration and dissemination of evidence-based research.
4. Conduct a comprehensive literature review to determine best practices.
5. Integrate information literacy concepts into a research project.

Content

I. Analysis of Research Articles

A. Assessing appropriateness of article for source material
   1. Scholarly (peer-reviewed) publications
   2. News magazines, other nonpeer-reviewed material

B. Assessing quality of information
   1. Research design
   2. Research bias
   3. Study validity
   4. Study reliability

C. Assessing value of article
   1. Application for future research and recommendations
   2. Implications for evidence-based professional practice

II. Information Literacy Concepts

A. Research quality
   1. Technical accuracy
   2. Reader comprehension
   3. Scholarly
   4. Relevance to professional practice
   5. Effectiveness of writing style
   6. Appropriateness of form and style

B. Systematic literature analysis
   1. Determining sources of information
   2. Using information search strategies
   3. Assessing value and appropriateness of source material

C. Paper organization
   1. Proper title
   2. Title page
   3. Abstract
   4. Introduction
   5. Definition of terms
   6. Literature review
   7. Research design or methodology
   8. Hypothesis or purpose of research
   9. Results or analysis
   10. Conclusions, discussions and recommendations

III. Types of Research Projects

A. Literature review

B. Survey

C. Descriptive/technical

D. Case studies

E. Posters

F. Qualitative (observation or interview)

G. Quantitative

IV. Preparing a Research Project

A. Topic selection
   1. Analysis of current literature on topic
   2. Identification of clinical practice issues

B. Information search strategies
   1. Identifying information sources
   2. Types of searches (manual, electronic – Ovid, PubMed, etc.)

C. Ethical principles and legal consideration

D. Review of the literature
   1. Analysis of source material
   2. Integration of material into project

E. Research design and data collection
   1. Qualitative
   2. Quantitative
   3. Mixed methods

F. Data Analysis
   1. Terms (e.g., sensitivity, specificity, predictor values, false-positive, false-negative, Type I and Type II errors)
   2. Statistical methods – determine significance of data
   3. Qualitative methods
   4. Triangulation of multiple data sources
   5. Correlation

G. Dissemination of findings

1. Format
    a. Abstract
    b. Article
    c. Poster
    d. PowerPoint presentation
    e. Others
2. Reference formats, (e.g., American Medical Association or AMA, American Psychological Association or APA, etc.)
3. Illustrations (images, charts, etc.)

H. Preparation of draft and revisions of project

I. Submission for publication
    1. Peer-reviewed
    2. Other (editorial, columns, etc.)

Sectional Anatomy

Description

Sectional anatomy content introduces 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. Recognize the importance of imaging with CT, MRI and PET-CT for radiation therapy.
2. Differentiate between sagittal, coronal and axial planes of the body.
3. Review the principles of imaging for various imaging modalities.
4. Compare various 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.
7. Describe image formation and orientation for CT, MRI, PET, sonography and fusion imaging.

Content

I. Anatomic Planes of the Body

II. Image Formation and Orientation

A. Computed tomography (CT)

B. Magnetic resonance (MR)

C. Positron emission tomography (PET)

D. Ultrasound imaging

E. Image fusion

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 imaging

E. Other modalities

Treatment Planning

Description

Treatment planning content explains factors that influence clinical planning of patient treatment. This includes isodose descriptions, patient contouring, radiobiologic considerations, dosimetric calculations, compensation and clinical application of treatment beams. Optimal treatment planning is emphasized, and 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. Determine a patient's external contour, internal structures and volumes of interest used in treatment planning.
5. Identify organs and tissues at risk and their dose limitations using 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. Apply accurate factors to 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 and 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.
21. Evaluate a variety of treatment plans for clinical use.
22. Identify 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 various matching methods, and describe how to eliminate them.
25. Describe procedures for 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 their dosimetric impact.

28. Explain the fabrication of 2D and 3D compensators.
29. Construct isodose curves.
30. Differentiate between isodose distributions for all clinical variations.
31. Evaluate possible corrections for misadministration of prescribed dose.
32. Differentiate between 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. Describe how inhomogeneities influence electron beam path.
40. Discuss the considerations of matching an electron field to other adjacent photon or electron fields.
41. Analyze which shielding materials and thickness would be needed to attenuate the electron beam.
42. Describe how electron shielding materials should be arranged for external vs. internal shielding.
43. Discuss changes in dose rate and dose distribution with changes in blocking and electron energy.
44. Compare calculations of shielding thicknesses to measured data for electron beams.
45. Determine why specific isodose lines are prescribed for various clinical situations involving critical and noncritical structures.
46. Calculate percentage depth dose for 10%, 50%, 80% and 90% lines for various electron energies.
47. Describe the considerations in the clinical application of special electron treatments, including total skin irradiation and arc therapy.
48. Compare the general isodose pattern of particle beams.
49. Determine clinical usefulness of various beam types and the clinical implications.
50. Explain the use of various imaging modalities in tumor localization and planning.
51. Discuss planning techniques used to accommodate the treatment volume shape.
52. Discuss isocenter localization for radiosurgery.
53. Identify vital structures considered during treatment planning.
54. Compare single dose delivery to fractionated dose delivery schedules.
55. Discuss the need for specific equipment used to deliver radiation for conformal therapy.
56. Discuss the purpose and contents of the ICRU Report 62 and supplements.
57. Discuss the computer system features necessary for conformal therapy treatment planning.
58. Identify common sites amenable to conformal therapy and the typical doses employed for those sites.
59. Compare configurations of multileaf collimation systems.
60. Discuss considerations for multileaf collimators.

61. Review the differences between static and dynamic multileaf collimation systems.
62. Identify clinical applications for brachytherapy.
63. Compare and contrast brachytherapy delivery systems.
64. Describe the techniques and applicators used for intracavitary, interstitial, surface and endovascular brachytherapy procedures.
65. Explain how simulation and CT data is used for source localization.
66. Discuss the objective of treatment planning for brachytherapy procedures.
67. Summarize dose specification and prescription techniques for different types of implants.
68. Describe optimization techniques used in computer-aided dose calculations.
69. Discuss record keeping requirements for radioactive material.
70. Identify clinical applications for using intensity modulated radiation therapy (IMRT) and volumetric arc therapy (VMAT).
71. Describe the general flow of the IMRT process from patient immobilization through treatment delivery.

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 dose distributions and general dose distributions at D_{max}, central axis and off-axis
   1. Low energy x-ray
   2. Gamma ^{60}Co
   3. Megavoltage x-ray
   4. Influencing Factors
      a. D_{max}
      b. Central axis
      c. Off axis
      d. Without flattening filter (FFF)
      e. With flattening filter
      f. Flatness and symmetry
      g. Overflattening/underflattening
   5. Field size definition (50% isodose line)
   6. 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
   4. Isodose correction methods

E. Treatment planning system
    1. Algorithms
    2. Measured data
    3. Control Points
    4. Patient individualization
    5. Simulation factors
        a. Patient body habitus
        b. Contrast
        c. Use of anatomic markers
        d. Patient alignment (e.g., programmable lasers)

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
    3. Manual vs auto segmentation

III. Radiobiologic Dosimetric Considerations

A. Alternate fractionation schedules
    1. TDF/rad equivalent therapy (rets)
    2. Alphabeta- ratios
    3. Limitations of concepts
    4. BED calculation

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

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

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) Algorithms
2) 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
3) Treatment unit settings calculation
a) Time
b) Monitor units (MU)
4) 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)
6. Rotation/arc calculations
a. Absorbed dose calculation

1) Dose at isocenter
2) Target dose specifications
3) Maximum dose displacement (Arcs, pastpointing-)

b. Treatment unit settings calculation
1) Time
2) Monitor units (MU)
3) Monitor unit/degree

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

V. Prevention of Overdose and Underdose

A. General beam arrangement

B. Management of hot and cold spots
1. Additional treatment ports
a. Traditional
b. 3D 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. Field separation and beam divergence
1. Definitions
2. General guidelines
a. Junction consideration
1) Tumor
2) Critical organ
3) Surgical scar
b. Surface vs. depth considerations
c. Reproducibility
3. Methods
a. Adjacent field junctions
b. Orthogonal field junctions
4. Documentation considerations
a. Permanent records

b. Gap verification images
c. Record and verify

VI. Wedge Filters (2D 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. Dose calculation
1. Comparisons – wedged vs. nonwedged
2. Clinical application

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

A. Definition

B. Purposes

C. Compensator transmission factor

D. Partial field compensation advantage – beam placement

VIII. Clinical Applications of Treatment Beams and Accessories

A. Selection of isodose curves
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 (e.g., HVL, renal blocking)
7) Bolus

B. Isodose summation
   1. Single beam delivery
   2. Multiple beam delivery
   3. Rotation and arc delivery
   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. Treatment beam techniques
   1. Advantages/disadvantages of combined treatment approaches
      a. Beam arrangements
      b. Beam energies

IX. Optimal Treatment Planning Considerations, Evaluation and Implementation

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

B. Evaluation of dose distribution within target volume

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

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 volume histograms

H. Evaluation and assessment of treatment plan

I. Adaptive treatment planning

J. Consequences and recording of dosimetric errors

K. Implementation of error correction

L. Evaluation of patient impact (e.g., short and long-term side effects)

X. 3D Conformal Therapy

A. Simulation
   1. Immobilization devices
   2. Imaging

B. Treatment planning
   1. Treatment planning system
      a. System capabilities
         1) Image registration
         2) Image fusion
         3) Calculation algorithms
      b. Volume definition
      c. Plan optimization
      d. Volume analysis/dose volume histogram (DVH)
      e. BED
      f. 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

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

A. Electron beam
    1. Physical characteristics
        a. Rapid dose buildup (ratio of surface to D_{max} dose)
        b. Dose fall-off (low vs. high energy)
        c. Dose distribution
            1) Central axis
            2) Off axis
        d. Constriction of isodose curve at depth (field size)

e. Ballooning of isodose curve at depth
f. Percentage depth dose data unique to treatment unit, cone and field size
g. Field size relationship to central axis PDD
    1) Energy ≤ 20 MeV
    2) Energy > 20 MeV
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. Beam energy selection
3. Biological considerations in patient treatment
4. Energy decelerators for special treatment
5. Build up bolus
6. Adjacent fields
7. 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 (MeV/3 = mm pb)
8. Treatment prescriptions and calculations
    a. Physician prescription to specific isodose line
    b. Critical structure
    c. Noncritical structure
    d. Determining PDD
9. 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

10. 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
        e. RBE
    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
            8) Limited penumbra – sparing adjacent structures
        b. Clinical applications and treatment delivery
            1) Immobilization requirements
            2) Simulation
            3) Treatment planning
            4) RBE
            5) Treatment verification
    3. High LET charged particles (negative ions)
        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
        i. RBE

XIII. Stereotactic Radiation Therapy

A. Equipment
    1. Gamma knife
    2. Linear accelerator based
        a. Tomotherapy
        b. Cyberknife
    3. Isocenter localization

B. Immobilization
    1. Head frame
    2. Frameless
    3. Gating
    4. Compression

C. Tumor localization and planning
    1. CT
    2. MR
    3. Digitizing images and tumor outlines
    4. Image guided techniques
    5. Isocenter placement implications
    6. Beam shaping
    7. Treatment planning system requirements

D. Advantages and disadvantages

XIV. Brachytherapy

A. Intracavitary, interstitial, endovascular, surface
    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. Dose specification/prescription
        a. Point specification
        b. Volume specification
    2. Critical structures
    3. Calculation methods
        a. Patterson-Parker (Manchester) system
        b. Quimby system
        c. Paris system
    4. Computer aided dose calculations
        a. Optimization techniques

XV. Emerging Treatment Methods and Planning

Optional Content

Content in this section will assist educators wishing to enhance the curriculum with select topics of instruction intended to satisfy the mission of their program or local employment market.

Magnetic Resonance Imaging

Content

I. MRI Screening and Safety

A. Patient screening

B. Safety (i.e., nonferromagnetic ancillary equipment, quenching)
   1. MRI safety zones
   2. Five Gauss line
   3. Identifying and screening for potential hazards
      a. Patients
      b. Personnel
   4. MRI-compatible devices and implants
      a. Safe
      b. Unsafe
      c. Conditional

C. Environment (i.e., magnetic and radiofrequency [RF] shielding)

D. Biological considerations
   1. RF field
   2. Static and gradient magnetic fields
   3. Acoustic noise

II. Pulse sequence configurations

A. Partial saturation/saturation recovery sequence

B. Spin echo

C. Inversion recovery
   1. Types of inversion recovery (IR) sequences
      a. Spin echo IR
      b. Fast spin-echo inversion recovery FSE – IR
      c. Double IR (driven equilibrium)
      d. Gradient echo – IR
   2. IR sequence image contrast
      a. Short tau inversion recovery (STIR)
      b. Fluid-attenuated inversion recovery (FLAIR)
      c. Spectral selected attenuation inversion recovery (SPAIR)

D. Rapid acquisition recalled echo (RARE)
   1. Types

a. Fast spin-echo (FSE)
b. Turbo spin-echo

E. Gradient echo
1. Steady-state coherence (SSC)
2. Spoiled gradient recall (SPGR)
3. Rapid gradient echo – echo-planar imaging (EPI)

F. Spectroscopy sequences
1. Single voxel
2. Multivoxel

III. Postprocessing

A. Maximum intensity projection (MIP)

B. Multiplanar reconstruction techniques (MPR)

C. Cardiac analysis

IV. Functional imaging

A. Magnetic resonance angiography (MRA)/magnetic resonance venography (MRV)

B. Techniques
1. Diffusion
2. Perfusion
3. Spectroscopy
4. fMRI

C. Dynamic imaging

V. Sequence parameters and options

A. Imaging parameters
1. Repetition time (TR)
2. Echo time (TE)
3. Inversion time (TI)
4. Field of view (FOV)

B. Imaging options (i.e., suppression techniques, physiologic gating and triggering, saturation pulse)

VI. Tissue characteristics

A. T1 relaxation

B. T2 relaxation

C. T2 (susceptibility artifact)

D. Proton (spin) density

E. Flow

F. Diffusion

G. Perfusion

VII. Additional Resources

Magnetic Resonance Curriculum
(refer to the document located at www.asrt.org/educators/asrt-curricula)

Resources

This list of resources will assist educators in sampling the pool of references and study materials that pertain to medical imaging and radiation therapy. The resources list should be viewed as a snapshot of available materials. Omission of any one title is not intentional. Because the creation of literature and media related to the field is dynamic, educators are encouraged to search additional sources for recent updates, revisions and additions to this collection of titles.

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