Radiation Therapy Professional Curriculum

Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3909.

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, understanding patients have different backgrounds and needs, 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 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 all 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.

Core Content

Clinical Practice

Objectives

- List the essentials of clinical practice.
- Describe the aspects of patient centered, quality care for all.
- Explain and discuss patient care, assessment and education.
- Describe computed tomography and magnetic resonance imaging simulation.
- Discuss treatment planning, treatment delivery, quality assurance and quality management.
- Identify clinical competency requirements.

Content

I. Essentials of Clinical Practice

A. Legal considerations

B. Documentation protocols

C. Regulatory and accreditation agencies (role and purpose)
   1. American College of Radiation Oncology (ACRO)
   2. American College of Radiology (ACR)
   3. American Society for Radiation Oncology (ASTRO) Accreditation Program for Excellence (APEx)

D. Professional behavior
   1. Patients
      a. Needs
      b. Expectations
      c. Rights and responsibilities
   2. Therapists
      a. Responsibilities
      b. Oncology team communication

E. ASRT Practice Standards

F. Patient Care Partnership (formerly Patients' 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 and learning systems (e.g., Radiation Oncology Incident Learning System [RO-ILS], RL Solutions)
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 (e.g., social workers, dieticians)
2. Students
    a. Responsibilities
    b. Expectations
    c. Guidelines for success
3. Scheduling and continuum of clinical procedures
4. Electronic medical records (EMR)
5. Billing and coding

I. Safety
1. Infection prevention
    a. Hand hygiene
    b. Prevention of health care associated infections
2. Emergency procedures
    a. Medical
    b. Fire safety
    c. Hazardous materials and waste

II. Patient Centered, Quality Care for All

A. Societal and individual factors
1. Socioeconomic
    a. Effects on health care
    b. Access to care
    c. Relationship to disease occurrence
2. Varying backgrounds and lived experiences
    a. Social factors
    b. Medical treatment barriers
    c. Cultural differences
3. Family structure and dynamics
4. Geographical factors
    a. Availability of health care services
    b. Social acceptance of cultural differences
5. Religion, spirituality and belief system

6. Lifestyle choices and behaviors
7. Disability
8. Cognitive processing

B. Optimal wellness and quality care for all patients
    1. Barriers
    2. Health outcomes, including morbidity and mortality
    3. Social factors
    4. Patient and family centered care
    5. Adapting to patient needs
        a. Processes
        b. Interpersonal engagement

III. 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. Gender sensitivity
      d. Patient-focused care
      e. Health literacy
      f. Language services

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

C. Care

1. Trauma-informed care
2. Management of side effects
3. Effects of multidisciplinary treatment on the patient
    a. Surgery
    b. Chemotherapy
    c. Hormone therapy
4. Infection control
    a. Standard precautions
    b. Cleaning agents
5. Communicable diseases
6. Medical emergencies
7. Preprocedural and postprocedural education
8. Nutrition
9. Physical activity considerations
10. Safety and transfer positioning
11. End-of-life services
12. Cancer survivorship
13. Financial resources and support

IV. Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) Simulation

A. Safety
    1. Radiation
    2. Magnetic resonance imaging (MRI)
    3. Positron emission tomography (PET)
    4. Environmental protection practices

B. Preparation for simulation
    1. Physician orders (e.g., gating, surface-guided radiation therapy)
    2. Medical and diagnostic information
    3. Consent and procedural time out
    4. Procedure and room preparation

C. Equipment operation
    1. Safety procedures (e.g., emergency switch)
    2. Warm up
        a. Quality assurance (QA)
        b. Accepted tolerances

D. Patient and machine monitoring
    1. CT patient considerations
        a. Verify screening
            1) Pregnancy
            2) Implantable electronic devices (e.g., pacemaker, insulin pump)
            3) Previous radiation exposure

4) Hearing aids
5) Dentures
6) Weight limits

b. Patient preparation (e.g., NPO, full bladder)
c. Claustrophobia

2. MRI patient considerations
   a. Detailed MRI screening form
   b. Patient protection
      1) Hearing
      2) Padding
      3) Communication strategies
         i. Call bell
         ii. Sounds
         iii. Sensation
3. Machine considerations
   a. CT protocol selection
   b. MRI protocol selection
   c. Allergic reaction

E. Patient positioning and immobilization
   1. Immobilization devices
      a. Standard
      b. Custom
      c. Construction
   2. Straightening techniques
   3. Leveling techniques
   4. Patient comfort and reproducibility techniques
   5. Gating
   6. 4D scans
   7. Deep inspiration breath hold radiation therapy (DIBH-RT)
   8. Surface-guided radiation therapy (SGRT)

F. Contrast media administration
   1. History and physical examination
   2. Lab tests
   3. Patient preparation instructions
   4. 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. Radiopaque marker placement (i.e., bb's and wires)
4. Image-guided radiation therapy (IGRT)
5. Surface-guided radiation therapy (SGRT)
6. 4D CT
7. Programmable lasers
8. Surgical clips or fiducial markers

H. Treatment volume localization

I. Treatment field delineation

J. Image processing, capture and export

K. Documentation

V. Treatment Planning

A. Collaboration with team members

B. Software operation to include introduction of the most common applications in the field (inverse vs. forward planning)

C. Procedures
1. Volume definition
2. Inverse vs. forward planning
3. Image fusion
4. Contouring
    a. PET
    b. CT
    c. MRI
5. 3D
6. Intensity-modulated radiation therapy (IMRT)
7. Stereotactic body radiation therapy (SBRT)
8. Volumetric modulated arc therapy (VMAT)
9. Respiratory gating
10. Critical structures
11. Beam energy, arrangement and modification
    a. Dose and fractionation schedule
    b. Parameters of treatment field design and arrangement
    c. Tolerance dose
12. Implementation and verification

VI. 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, emergency switch and troubleshooting

K. Radiation oncology charting and 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. IGRT and SGRT
   1. Comparison of images for verification and localization ~~i~~mage guided radiation therapy
   2. Kilovoltage (kV) vs. megavoltage (MV)
   3. Orthogonal images
   4. Cone beam
   5. Patient repositioning
   6. Dynamic targeting
   7. Gating

M. MRI safety

N. PET safety

VII. 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. Motion management devices (e.g., remote patient monitoring, SGRT)
3. Power supply disconnection
4. Emergency switches
5. Critical machine parameters (e.g., pressure, temperature, errors)

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

D. Immobilization devices
    1. Standard
    2. Custom

E. Communication devices
    1. Audio
    2. Visual
    3. Video remote interpreting

F. Simulation and treatment units

G. Brachytherapy

H. Treatment planning

I. Device fabrication equipment

J. Risk-based quality management programs
    1. Quality chart audits
    2. Mapping the process
    3. Failure modes and incidence analysis
    4. Fault tree analysis

K. Emergency treatment procedures
    1. Brachytherapy
    2. External beam radiation therapy (EBRT)

VIII. Clinical Competency

American Registry of Radiologic Technologists (ARRT) competency requirements (refer to the handbook and documents located at www.arrt.org)

Ethics in Radiation Therapy Practice

Objectives

- Recognize and discuss the theories and basic principles of health care ethics.
- Describe and explore the patient and provider relationship, including informed consent.
- Discuss ethical decision-making in health care dilemmas.

Content

I. Ethical Theories and Principles

A. Theories

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
      f. Patient centered care
   2. Nonmaleficence
   3. Beneficence
      a. Hippocratic oath
      b. Cost-benefit ratio
   4. Veracity
      a. Honesty
      b. Nondisclosure and deception
   5. American Registry of Radiologic Technologists (ARRT) Standards of Ethics
      a. ARRT Code of Ethics
      b. 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

C. Informed consent

D. Proper documentation protocols

II. Provider and Patient Relationship

A. Models (e.g., collegial, contractual)

B. Cultural humility
   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. Voluntary-assisted dying
   6. Hospice care

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. Whistleblowing

Imaging and Processing in Radiation Oncology

Objectives

- Discuss basic principles of digital imaging, imaging characteristics and fundamental principles of exposure.
- Employ computed tomography equipment in radiation oncology.
- Describe magnetic resonance imaging and positron emission therapy equipment and safety and imaging considerations.
- Discuss radiation oncology digital imaging applications, imaging modalities and health care informatics applications.

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. Onboard imaging (OBI)
      a. Kilovoltage (kV) imaging/flat-panel detector (FPD)
      b. Megavoltage (MV) imaging/electronic portal imaging device (EPID)
   2. External imaging systems

C. Exposure
   1. Detective quantum efficiency (DQE) predicts dose efficiency
   2. Thin-film transistor detector element size (DEL)
   3. Deviation index (DI)
   4. Exposure indicators
   5. Exposure latitude
   6. Dose creep

II. Image Characteristics

A. Image brightness
   1. Definition
   2. Acceptable range
   3. Technical factors
      a. Milliampere-seconds (mAs)
      b. Kilovoltage peak (kVp)

c. Distance
d. Beam limitation
e. Patient considerations
f. Contrast media

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

C. Magnification

D. Image receptor scattered and 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. Source-to-image receptor distance (SID)
c. Pathology

B. Controlling patient exposure
1. Technical factor selection (e.g., milliamperage [mA], kVp, collimation, jaw size)
2. Filtration
3. ALARA, as low as reasonably achievable, 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 and image data
a) Rays
b) Views
i) Beam's eye view (BEV)
ii) Volumes of interest
c) Profiles
i) Pixels
ii) Matrices
iii) Voxels
2) Attenuation
a) Linear attenuation coefficients
b) Computed tomography (CT)/Hounsfield numbers (e.g., baseline reference number)
3) 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) Computed tomography dose index volume (CTDIvol)
i) Dose length product (DLP)
j) Algorithm
k) Scan time and rotational arc
l) Radiographic tube output
m) ROI
n) Magnification
o) Focal spot size and tube geometry
p) Pitch
q) Dual energy
r) Metal artifact reduction
s) Bolus tracking

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

B. Factors controlling image appearance

C. Image evaluation and anatomical structures
1. Artifacts and preventative measures
2. Window width and window level for display
3. Distortion
4. Noise
5. Spatial resolution

D. Processing evaluation and correction of image quality
1. Image reconstruction
2. Image reformation
3. Image smoothing
4. Edge enhancement
5. Grayscale manipulation

E. Image backup and storage

F. Radiation protection and reducing patient exposure
1. Technical factor selection
2. Pediatric patient considerations (e.g., Image Gently)
3. Scatter radiation reduction
4. Medical Imaging & Technology Alliance (MITA) smart dose

V. Magnetic Resonance Imaging (MRI)

A. Equipment

B. Safety

C. Imaging

VI. Positron Emission Therapy (PET)

A. Equipment

B. Safety

C. Imaging

VII. Radiation Oncology Digital Imaging Applications

A. Image-guided radiation therapy (IGRT) for verification and localization

B. Patient positioning and dynamic targeting
   1. Surface-guided radiation therapy (SGRT) applications
   2. Interfraction motion
   3. Intrafraction motion
   4. Intrafraction monitoring
   5. Respiratory gating
   6. Deep inspiration breath hold
   7. Fiducial markers
   8. Volumetric imaging
   9. Adaptive planning

C. Radiation therapist responsibilities
   1. Order verification
   2. Image acquisition
   3. Processing – image manipulation, image comparison and image matching
   4. Annotation issues
   5. Transmitting image
   6. HIPAA and patient confidentiality
   7. Image orientation to patient anatomy, position and laterality
   8. Adaptive planning

VIII. Imaging Modalities

A. Description, basic principles and advantages and 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
11. SGRT

IX. Health Care Informatics Applications

A. Medical image management and processing system (MIMPS), formerly Picture archiving communication system (PACS)

B. Hospital information system (HIS), radiology information system (RIS) and oncology information system (OIS) (e.g., ARIA, MOSAIQ)

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

D. Health level seven (HL7)

E. Artificial intelligence
   1. Radiation therapy
   2. Medical dosimetry

Introductory Law in Radiation Therapy

Objectives

- Explain sources of law, intentional torts, negligence and discrimination.
- Describe the structure of a lawsuit.
- List components of informed consent, patient rights and standard of care
- Discuss quality, safety, documentation, record maintenance and risk management.
- Describe the role of the code of ethics, scope of practice and practice standards.

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. Discrimination

A. Conscientious objection

B. Gender

C. Race

D. Ethnicity

V. The Lawsuit

A. Complaint

B. Discovery

C. Health professional as a party

D. Health professional as a witness

E. Deposition

F. Trial

VI. 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 (formerly Patients' Bill of Rights)

D. Standard of care

E. HIPAA

VII. Quality and Safety

A. Developing a safety program

B. Equipment safety

C. Patient safety

D. Continuous process improvement

E. Staff safety

VIII. 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

IX. Risk Management

A. Professional medical liability

B. Risk analysis

C. Role of the radiation therapist in risk management

X. 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

Orientation to Radiation Therapy

Objectives

- Describe the policies and procedures of an educational program.
- Discuss the health science professions and hospital and health care organizations.
- Outline the elements of radiation therapy practice, including cancer management, key terms, treatment techniques and radiation safety.
- Explain professional organizations, including credentialing and registration bodies, associations and federal and state agencies.
- List reasons and opportunities for professional and community commitment and professional development.

Content

I. Policies and Procedures of the Educational Program

A. Program officials

B. Educational program information

C. Clinical education settings

D. Responsibilities of students
   1. Didactic
   2. Laboratories
   3. Clinical
      a. Student expectations
      b. Student guidelines for successful clinical internships

E. Responsibilities of clinical sites and clinical instructors

II. The Health Science Professions

A. Radiologic and imaging sciences

B. Other patient care professionals
   1. Advanced practice radiation therapist (APRT)
   2. Dietician
   3. Health information
   4. Clinical laboratory sciences
   5. Occupational therapy
   6. Pharmacy
   7. Physical therapy
   8. Advanced practice providers

9. Respiratory therapist
10. Speech pathologist
11. Social services
12. Dentistry
13. Spiritual care and clergy
14. Nursing
15. Patient navigator
16. 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 and chairperson
      b. Departmental administration
         1) Administrative director
         2) Department manager
      c. Radiation oncologists
         1) Attending
         2) Resident
         3) Intern or fellow
      d. Radiation physicist
         1) Physicist
         2) Resident
         3) Engineers
         4) Field service engineers
      e. Radiobiologist
      f. Radiation therapist
         1) Clinical supervisor or lead radiation therapist
         2) Chief or 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
3) Charge capture specialist
4) Financial clearance specialists
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. Biotherapy
e. Integrative medicine
f. Multimodality approach
6. Research
a. Clinical trials (e.g., American College of Radiology [ACR])
b. Protocols (e.g., non-profit research organization [NRG] oncology, Radiation Therapy Oncology Group [RTOG])

C. Key terms
1. Radiation therapy equipment
a. External beam delivery systems

b. Image-guided radiation therapy (IGRT)
c. Simulators
    1) Respiratory 4D gating
    2) Contrast media injector
d. Oncology information system
    1) Verify and record
    2) Electronic medical record (e.g., MOSAIQ, ARIA)
    3) Electronic health record (e.g., EPIC)
    4) Other
e. Brachytherapy
f. Surface-guided radiation therapy (SGRT)
g. Volumetric modulated arc therapy (VMAT)
h. FLASH radiation therapy (FLASH-RT)
i. 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

E. Patient rights and responsibilities
    1. HIPAA
    2. Record and chart contents
    3. Confidentiality
    4. Patient Care Partnership (formerly Patients' Bill of Rights)
    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. Professional Organizations

A. Credentialing and 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

VI. Professional and Community Commitment

A. Organizations

B. Role of radiation therapist

VII. 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
      c. Professional growth

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
11. Dermatology clinic (image-guided superficial radiation therapy)

C. Governmental

Pathophysiology

Objectives

- Provide an introduction to human disease, theories of disease causation and the basic principles and mechanisms of disease.
- Discuss common diagnostic tests and procedures and list disorders of nutrition.
- Describe common diseases and disorders of the body systems and explain neoplasia, including diagnosis, grading, staging and prognostic factors.
- Outline malignancies of the body systems.

Content

I. Introduction to Human Disease

A. Pathology terminology

B. Most frequent and significant diseases

II. Theories of Disease Causation

A. Current issues and ongoing research

B. Theories

C. Etiology

D. Epidemiology

E. Prevention and 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

VII. Neoplasia

A. Introduction
1. Overview
2. Terminology

B. Nomenclature
1. Benign neoplasms
   a. Characteristics
   b. Histologic classification
   c. Clinical behavior and effects
2. Malignant neoplasms
   a. Characteristics
   b. Histologic classification
   c. Clinical behavior and effects

C. Carcinogenesis
1. Theories
   a. Genetic
   b. Epigenetic
2. Prevention

D. Diagnosis
1. Medical history
2. Physical examination
3. Biopsy
4. Histopathology
5. Laboratory (other)
   a. Molecular probes
   b. Tumor markers
   c. Flow cytometry
   d. Cytogenetic analysis
6. Diagnostic imaging studies

E. Grading and Staging
1. Definitions
2. Purpose
3. Methods
4. Effect on treatment

F. Prognostic Factors
    1. Tumor-related
    2. Host-related

VIII. 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
    1. Clinical trials
    2. Case studies

G. Prognosis

Principles and Practice of Radiation Therapy I

Objectives

- Recognize cancer perspectives, including cancer incidence and cancer management and prevention.
- Understand treatment determinations for overall cancer management.
- Describe radiation therapy treatment goals and considerations.
- List radiation therapy equipment.
- Discuss the elements of radiation therapy treatments, including treatment delivery accessories, tumor localization, pretreatment verification protocol and treatment delivery protocol.

Content

I. Cancer Perspectives

A. Cancer incidence

B. Cancer management
   1. Surgery
   2. Radiation therapy
   3. Chemotherapy
   4. Biotherapy
   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. Previous radiation therapy treatments
   7. Medical status of patient
   8. Quality of life
   9. Prognosis

IV. Radiation Therapy Equipment

A. Simulators
   1. Purpose
   2. Equipment
      a. Computed tomography (CT)
      b. Positron emission tomography–computed tomography (PET-CT)
      c. Magnetic resonance (MR)
      d. Fusion imaging
   3. Method of radiation production
   4. Operation and protocol selection
   5. Auxiliary devices
   6. Radiation protection
   7. Patient observation and communication
   8. 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. MV
    a. Linear accelerators
        1) Components
        2) Methods of radiation production
            i. Photons
            ii. Electrons
        3) Energy
        4) Depth of maximum dose (D_{max})
        5) Target-to-skin distance (TSD) and 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 (SRS)
        2) Intraoperative
            i. Orthovoltage
            ii. Megavoltage
        3) Gamma knife (e.g., ^{60}Co)
        4) Cyber knife
        5) Heavy particle accelerators
        6) Proton cyclotrons and synchrotrons
        7) Helical and bore-based linear accelerators
        8) Emerging units
            i. MR linear accelerators
            ii. Biology-guided radiation therapy
            iii. Imaged-guided superficial skin radiation therapy (SRT)
            iv. PET linear accelerators
        9) Stereotactic body radiation therapy (SBRT)
        10) FLASH radiation therapy (FLASH-RT)
        11) Volumetric modulated arc therapy (VMAT)
        12) Image-guided radiation therapy (IGRT)
        13) Surface-guided radiation therapy (SGRT) (e.g., respiratory gating)
        14) Adaptive radiation therapy (ART)

3. Radioisotope units and teletherapy
    a. Purpose
    b. Radiation protection
4. Superficial radiation therapy
    a. Purpose
    b. Practices

D. Brachytherapy

1. Purpose
2. Types
3. Isotopes
4. Half-life
5. Radiation protection
6. Emergency procedures

V. Treatment Delivery Accessories

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

B. Patient positioning and immobilization devices
   1. Purpose
   2. Alignment using lasers
   3. Alignment using surface-guided radiation therapy
   4. Couch indexing
   5. Construction
   6. Applications
   7. Emerging devices

VI. Tumor Localization

A. Purpose (e.g., historical perspective)

B. Simulation procedures
   1. Common protocols for different anatomical areas
   2. Head and neck
   3. Thorax

4. Breast
5. Abdomen
6. Pelvis
7. Extremities

C. Adaptation of treatment protocols to patient-specific conditions

D. Imaging techniques
   1. Image quality factors
   2. CT
   3. MR
   4. PET
   5. 4D imaging
   6. Fusion
   7. Orthogonal images
   8. Fluoroscopy
   9. Ultrasound imaging
   10. SGRT

E. Treatment techniques
   1. Single field
   2. Parallel opposed portals
   3. Multiple fields
      a. 3D
      b. Intensity-modulated radiation therapy (IMRT)
      c. VMAT

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 and universal protocol

E. Treatment parameters
   1. Gantry angle
   2. Collimator
   3. Couch kick
   4. Table tilt
   5. Bolus tracking
   6. Wedges
   7. Energy
      a. Photons (e.g., dual energy)
      b. Electrons

F. Setup and treatment imaging
   1. Isocenter and beam verification
   2. Motion monitoring
   3. Surface imaging
   4. Repeat imaging

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

Objectives

- Discuss radiation therapy treatment of neoplastic diseases in different body systems, including epidemiology, etiology, pertinent anatomy and lymphatics and clinical presentation.
- Recognize detection and diagnosis methods.
- Understand the multidisciplinary treatment approach and discuss the role and scope of medical oncology, immunotherapy and radiation oncology, as well as emerging approaches to neoplastic disease management.
- Define metastatic and palliative treatment applications and emergency treatment applications.

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 (e.g., 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

6. Receptors on tissues

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

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

J. Multidisciplinary treatment approach

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 (biotherapy)
    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 of treatment

O. Emerging approaches to neoplastic disease management (e.g., theranostics)

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

Objectives

- Describe quality management and how to create a culture of safety.
- Understand the definitions, standards and components of quality management and discuss the roles of regulating and accreditation agencies and professional organizations.
- List the clinical aspects of quality control checks.
- Explain quality assessment for treatment, simulation and localization, and verification.
- Discuss particle accelerators and brachytherapy.
- Define medical dosimetry and treatment planning.

Resources: Quality, Safety, Practice Parameters and Technical Standards

Content

I. Introduction

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

B. Creating a culture of safety
   1. Radiation therapy errors
   2. Workplace culture
   3. Human factors engineering
   4. Risk analysis (TG 100)
      a. Failure, modes and effects analysis
      b. Fault tree analysis
      c. Process map
   5. Incident learning systems
   6. Process improvement

C. QM programs (e.g., LEAN, Six Sigma, PDCA, TQM, CQI)

II. General Principles

A. Regulating agencies
   1. Federal (e.g., Nuclear Regulatory Commission [NRC])
   2. State
   3. Institutional
   4. Professional

B. Accreditation
   1. Facility (e.g., The Joint Commission [TJC])

2. Radiation oncology department (e.g., American College of Radiology [ACR], American College of Radiation Oncology [ACRO], American Society for Radiation Oncology [ASTRO] Accreditation Program for Excellence [APEx])

C. Professional organizations on safety in radiation oncology
   1. American Society of Radiologic Technologists (ASRT)
   2. American Association of Physicists in Medicine (AAPM) (e.g., Integrating Healthcare Enterprise - Radiation Oncology [IHE-RO])
   3. ASTRO (e.g., Radiation Oncology Incident Learning System [RO-ILS])
   4. ACR
   5. Radiation Oncology Safety Education and Information System (ROSEIS)

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
   3. Equipment availability
   4. Dosimetric accuracy

F. Components
   1. Team and committee members and responsibilities
   2. Patient education
   3. QI plan
   4. Policies and procedures and 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 systems
         1) RO-ILS
         2) Safety in Radiation Oncology (SAFRON)

b. Cognitive biases (e.g., automaticity, multitasking)
c. Potential for errors due to human factors
d. Importance of self-reporting and nonpunitive outcomes

10. Implementing corrective actions related to QM data collection and trends
11. Application of risk analysis methods in radiation oncology quality management (TG 100)

III. Clinical Aspects Quality Control (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 of errors
1. Purpose, procedure and frequency
2. Corrective measures
3. Documentation
4. Peer review

C. Mold and 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
   a. Time out
   b. Checklists
3. Verify and record
4. Electronic and paper
5. Medical and 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. Quality Assurance (QA) for Treatment, Simulation and 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
    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

B. Sources of malfunction and 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

B. Purpose, procedure and frequency of checks

C. Sources of malfunction and 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 and error

C. Data acquisition

D. Materials and methodology

E. Safety and hazards

F. Corrective measures

G. Documentation

Radiation Biology

Objectives

- Discuss cell biology, types of ionizing radiation and sources of medical radiation exposure.
- Explain biophysical events, including radiation quantities, molecular effects of radiation and the deposition of radiant energy.
- Describe radiation's subcellular, cellular and individual effects.
- Recognize radiosensitivity and response, explain the law of Bergonié and Tribondeau and understand systemic responses to radiation, including tolerance dose, total body irradiation and radiation dose response curves.
- List the biologic principles of radiation therapy.

Content

I. Introduction

A. Cell biology
   1. Basic unit of life
   2. Constituents
   3. Structure
   4. 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

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 (e.g., $TD_{5/5,}$ $TD_{50/5}$, and Quantitative Analysis of Normal Tissue Effects in the Clinic [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
            i. Common procedures
            ii. Dose to surrounding structures
            iii. 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 R's 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. Biologically 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

Objectives

- List units of measurement used in radiation physics.
- Describe the structure of the atom, the structure of matter and the nature of radiation.
- Discuss electromagnetic radiation, electrostatics, magnetism and electrodynamics.
- Explain the production and characteristics of radiation.

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. International System of Units (SI)

II. Structure of the Atom

A. The atom
   1. Periodic table
      a. Rows
      b. Columns
   2. Components and structure

B. The nucleus
   1. Atomic number
   2. Unit charge
   3. Mass number
   4. Categories
      a. Isotopes
      b. Isotones

c. Isobars
d. Isomers

5. Odd and even rules
6. Line of stability

C. Distribution of orbital electrons

D. Atomic mass and energy units

E. Avogadro's number

F. Fundamental forces
1. Strong force
2. Electromagnetic force
3. Weak force
4. Gravitational force

G. Atomic energy levels

H. Nuclear forces

I. Nuclear energy levels

J. Other elementary particles

III. Structure of Matter

A. Compound
1. Definition
2. Molecule

B. Mixtures
1. Definition
2. Examples

IV. 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

V. Electromagnetic Radiation

A. Spectrum

B. Characteristics

VI. 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

VII. Magnetism

A. Fields

B. Interactions with charged particles

C. Magnetic resonance

VIII. 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

IX. Production and Characteristics of Radiation

A. X-ray production
    1. Processes
        a. Bremsstrahlung
        b. Characteristic
    2. Necessary conditions (electron)
        a. Source
        b. Target
        c. Acceleration
        d. 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)
    3. Photoelectric effect
    4. Compton scattering
    5. Pair production
    6. Photodisintegration

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 per kilogram (C/kg)
2. Gray (Gy)
3. Sievert (Sv)
4. Electron volt (eV)
5. Ergs
6. Joules

Radiation Therapy Physics

Objectives

- Define the structure of matter and properties of radiation.
- Describe nuclear transformations.
- Review the production of x-rays.
- Discuss radiation therapy treatment units, the interactions of ionizing radiation and the measurement of ionizing radiation.
- Explain the quality of x-ray beams and measurement of absorb doses.
- Describe dose distribution and scatter analysis.
- Identify emerging treatment methods and trends.

Content

I. Structure of Matter and Properties of Radiation

A. Particle radiation
   1. Types
   2. Characteristics

B. Electromagnetic radiation
   1. Wave model
   2. Quantum model
   3. Ionization and excitation
   4. Nonionizing vs. ionizing electromagnetic (EM) radiation

C. Relevant equations
   1. $E = 1/2mv^2$
   2. $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$
   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 half-value layer (HVL)
      g. Beam characteristics
         1) D_{max}
         2) Depth dose
   2. Megavoltage therapy
      a. Linear accelerator
         1) Accelerator structure design

2) Helical and bore-based accelerator structure design (e.g., TomoTherapy, Halcyon)
3) Basic components

b. Cyclotron
1) Basic design
2) Energy range of accelerated particles
3) Clinical treatment beams
4) Radionuclide production

c. Synchrotron
1) Basic design
2) Energy range of photons and particles
3) Advantages

3. Particle beams
a. Neutrons
1) Deuteron-tritium [D-T] neutron generators
2) Cyclotrons
3) Linear accelerators

b. Charged particles
1) Ions
a) Proton
b) Helium
c) Carbon

2) Properties
a) Nonexponential attenuation
b) Proximal and distal dose gradients
c) General isodose curve pattern
d) Bragg peak advantage
e) Inhomogeneity sensitivity
f) Percentage depth dose energy dependence
g) Precision immobilization requirements
h) Limited penumbra – sparing adjacent structures

3) Clinical applications and treatment delivery
a) Immobilization requirements
b) Simulation
c) Treatment planning
d) Relative biological effectiveness (RBE)
e) Treatment verification

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° 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 (e.g., 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 (Zeff)
                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. National Institute of Standards and Technology (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. Kilovoltage (kV) beams
b. Megavoltage (MV) beams
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. MV 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 MV 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 kinetic energy released in materials (KERMA), exposure and absorbed dose

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

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

E. Calibration of MV 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. Metal Oxide Semiconductor Field Effect Transistor (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. Percentage Depth Dose (PDD)
            b) Standard distance PDD tables
            c) Nonstandard distance
               i. Mayneord F factor
               ii. Formula and limitations
         5) Dependence on beam collimation system
   2. 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)

X. Emerging Treatment Methods and Trends

A. Magnetic resonance (MR) linear accelerator

B. FLASH radiation therapy (FLASH-RT)

C. Cherenkov imaging

Radiation Protection

Objectives

- List the justification for radiation protection, objectives for radiation protection programs and sources of radiation.
- Identify units of radiation and measurement devices.
- Describe surveys, regulatory agencies and regulations.
- Discuss personnel monitoring and practical radiation protection.
- Explain brachytherapy.

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, as low as reasonably achievable, 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 and types
    1. Ion chambers
    2. Proportional counters
    3. Thermoluminescent dosimeter (TLD)
    4. Optically stimulated luminescence (OSL) dosimeter
    5. Neutron detector
    6. Geiger-Müller 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 and uncontrolled areas
    2. Restricted and 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. National Council on Radiation Protection and Measurements (NCRP) recommendations for personnel monitoring (report #116)
    1. Occupational exposure
    2. Public exposure
    3. Embryo and 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 and 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 and breakers

B. Regulation and advisory recommendations
    1. NRC
    2. NCRP
    3. State agency

C. Cardinal principles in protection
    1. Time
    2. Distance (inverse square law)
    3. Shielding

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 and room surveys
    4. Area radiation monitor
    5. Methods, documentation and 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 (treatment documentation)

Magnetic Resonance Imaging

Objectives

- Understand magnetic resonance imaging screening and safety.
- Describe sequence parameters.
- List tissue characteristics.

Content

I. MRI Screening and Safety

A. Patient screening

B. Safety (e.g., 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. Sequence Parameters

A. Repetition time (TR)

B. Echo time (TE)

C. Inversion time (TI)

D. Field of view (FOV)

III. Tissue Characteristics

A. T1 relaxation

B. T2 relaxation

C. T2 (susceptibility artifact)

D. Proton (spin) density

E. Flow

F. Diffusion

G. Perfusion

IV. Magnetic Resonance Curriculum
(Refer to the document located at https://www.asrt.org/educators/asrt-curricula/magnetic-resonance)

Radiation Therapy Patient Care

Objectives

- Overview the multidisciplinary interprofessional health care team and the radiation oncology team.
- Define medical terminology.
- Explain communication in patient care.
- Discuss health care informatics applications.
- Outline patient-family interactions, assessment of side effects, assessment of other physical needs and health safety.
- Demonstrate understanding of medications and their administration, medical emergencies, care of patients with tubes and brachytherapy procedures.
- Recognize how to assess nutritional status.
- Explain physical activity considerations, patient transfer, patient education and integrative medicine.

Content

I. Introduction

A. The multidisciplinary interprofessional health care team

B. The radiation oncology team

II. Medical Terminology

A. Word building process

B. Medical abbreviations and symbols

III. Communication in Patient Care

A. Health-illness continuum

B. Communication
   1. Verbal and written
   2. Nonverbal (e.g., eye contact, touching)
   3. Challenges in patient communication
      a. Hearing, vision and speech impairments
      b. Physical, sensory or mental impairments
      c. Literacy
      d. Altered states of consciousness
      e. Emotional status, acceptance of condition (e.g., stages of grief)
      f. Age-specific communication
         1) Pediatric

2) Adolescent
3) Young adults
4) Middle adults
5) Geriatric

g. Pediatric and adolescent patients
h. Geriatric patients
i. Communicating in stressful circumstances
j. Explanation of medical terms
k. Cultural and socioeconomic differences
l. Gender identity
m. Artificial speech
1) Transesophageal puncture (TEP)
2) Esophageal speech
3) Electrolarynx devices
n. Language barriers
1) Limited English proficiency
2) Colloquialism and slang
3) Medical jargon

4. Feedback
5. Patient interactions and patient education
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

C. Professionalism in patient care
1. Trauma-informed care
2. Avoiding burnout
a. Factors
b. Signs and symptoms
c. Principles of self-care
d. Patient advocacy
3. Patient centered, quality care for all
4. Emotional intelligence
a. Self-awareness
b. Self-regulation
c. Motivation
d. Empathy

e. Social skills

5. Developing professional attitudes
    a. Teamwork
    b. Assertiveness
    c. Interprofessional collaborative practices

D. Psychological considerations
    1. End-of-life issues
        a. Understand the process
        b. Aspects of death
            1) Emotional
            2) Psychological
                i. Depression
                ii. Coping
                iii. Quality of life
            3) Physical
                i. Pain
                ii. Suffering
                iii. Disability
                iv. Deterioration
        c. Stages of grief
            1) Denial
            2) Anger
            3) Bargaining
            4) Depression
            5) Acceptance
        d. Patient support services
            1) Family and 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
            1) Age
            2) Gender
            3) Marital and family status
            4) Socioeconomic factors
            5) Cultural and religious variations

6) Physical condition
7) Self-image
8) Past health care experiences
9) Beliefs

c. Prejudices

IV. Health Care Informatics Applications

A. Telemedicine

B. Patient and provider secure messaging

C. Electronic health records

D. Patient care systems

E. Patient monitoring systems

V. Patient-Family Interactions

A. Patient identification

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

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

VI. 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

VII. 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

VIII. Health Safety

A. Terminology
   1. Health care-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. 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)

E. Isolation techniques and communicable diseases
   1. Category-specific
   2. Disease-specific
   3. Standard precautions
   4. Transmission-based precautions
   5. Examples
      a. Contact precautions
      b. Blood-borne pathogens
      c. Body fluid pathogens
      d. Air-borne pathogens
      e. Antibiotic-resistant infections (e.g., Methicillin-resistant Staphylococcus aureus [MRSA])
      f. Clostridium difficile (C. diff)
      g. Other

F. Isolation patient in the department
   1. Procedure (donning and doffing)
      a. Gowning
      b. Gloving
      c. Masking
   2. Patient transfer
   3. Clean-up

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

H. Psychological considerations

IX. Medications and Their Administration

A. Role of the radiation therapist

B. Medications for symptom management

X. Medical Emergencies

A. Emergency equipment

B. Signs, symptoms and medical intervention
   1. Shock
   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. Cerebrovascular accident (CVA), or stroke
   7. Syncope (fainting)
   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 and 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
    4. IV lines
        a. Procedure
        b. Maintenance
        c. Removal

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
    3. Emergency protocols

C. Follow-up patient care

D. Patients and 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
   7. Dietician (e.g., nutrition oncology)

D. Total parenteral alimentation

E. Nutritional dysfunctions
      a. Anorexia
      b. Cachexia

XIV. Physical Activity Considerations

A. Karnofsky scale and 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 (e.g., number of providers needed)
   3. Wheelchair transfer
   4. Stretcher transfer
   5. Patients with tubes and catheters
   6. Use of devices
      a. Lifts
      b. Slide boards
      c. Hoyer Lift
      d. Maxi-Mover

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 (e.g., what to expect, walkthroughs, educational materials)
    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 and spirit connection

B. Role in oncology care

Research Methods, Evidence-Based Practice and Information Literacy

Objectives

- Discuss how to analyze research articles.
- Describe information literacy concepts, including research quality, systematic literature analysis and paper organization.
- Identify types of research projects.
- Outline how to prepare 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 and 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
11. Sources Referenced

III. Types of Research Projects

A. Literature review

B. Survey

C. Descriptive and 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
   3. Emerging technologies

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

C. Ethical principles and legal consideration (e.g., conflict of interests)

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 – statistical 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 with slides
        e. Others
    2. Reference formats, (e.g., American Medical Association [AMA], American Psychological Association [APA])
    3. Illustrations (e.g., images, charts)

H. Preparation of draft and revisions of project

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

Sectional Anatomy

Objectives

- Describe anatomic planes of the body.
- Understand image formation and orientation.
- Identify other sectional imaging modalities.
- Discuss computed tomography, magnetic resonance and fusion imaging in relation to topographic and sectional anatomy.

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. Fusion (CT, MR, PET)

Treatment Planning

Objectives

- Provide isodose descriptions and explain general influencing factors.
- Overview patient contours, radiobiologic dosimetric considerations and methods of dosimetric calculations.
- Discuss prevention of overdose and underdose.
- Describe the purpose and use of wedge filters and tissue compensators.
- Understand the clinical applications of treatment beams and accessories.
- Identify optimal treatment planning considerations, evaluation and implementation.
- Explain 3D conformal radiation therapy, intensity-modulated radiation therapy, electron beam, stereotactic radiation therapy and brachytherapy, including characteristics, treatment planning and applications.

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 (MV) 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 and 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
2. Comparative accuracy

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. Time-dose-fractionation (TDF)/rad equivalent therapy (rets)
2. Alpha/beta (α/β) ratios
3. Limitations of concepts
4. Biologically effective dose (BED) calculation

B. Integral dose concepts

C. Edge effect

D. Nominal standard dose calculation

IV. Methods of Dosimetric Calculations

A. SSD techniques (e.g., percentage depth dose, [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) (e.g., weighted fields)

B. Isocentric techniques (i.e., 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 (Sc)
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) 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. Dose calculations
1) Algorithms
2) Absorbed dose calculation
a) Entrance dose
b) Exit dose
c) Entrance and exit dose summation
d) Area of interest dose
i. Target volume dose
ii. Critical organ dose
iii. Dose to multiple patient points/depths
3) Treatment unit settings calculation
a) Time

b) 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 (e.g., Arc, past pointing)
b. Treatment unit settings calculation
1) Time
2) 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 radiation therapy (CRT)
c. Intensity-modulated radiation therapy (IMRT)
d. Stereotactic body radiation therapy (SBRT)
e. Volumetric modulated arc therapy (VMAT)
f. FLASH radiation therapy (FLASH-RT)
2. Field reduction
3. Boost ports/field-in-field
4. Past pointing
5. Wedges/tissue compensators/bolus
6. Shadow blocks
7. Table angulation
8. Respiratory gating

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. Verify and record

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 (e.g., SSD, SAD)
   2. Special considerations for adjusting to patient contour
      a. Oblique incidence
      b. Tissue inhomogeneity
      c. Weighting
      d. Wedge/compensator placement
      e. Blocking of normal tissue
      f. Partial blocking of low tolerance diseased tissue (e.g., half-value layer [HVL], renal blocking)
      g. 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 of current International Commission on Radiation Units and Measurements (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 and tissues

E. ICRU recommendations for dose distribution variance within target volume

F. Dose distribution effects on cure rates, local control and tolerance

G. Dose volume histograms

H. Evaluation and assessment of treatment plan

I. Review of prior radiation treatment plan

J. Retreatment

K. Adaptive treatment planning

L. Dose painting

M. Simultaneous integrated boost

N. Consequences and recording of dosimetric errors

O. Implementation of error correction

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

X. 3D Conformal Radiation Therapy

A. Simulation
1. Immobilization devices

2. Imaging

B. Treatment forward 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 and dose volume histogram (DVH)
        e. BED
        f. Plan output and interpretation
            1) Setup information
            2) Beam parameters
            3) Digitally reconstructed radiographs (DRR), beam's eye view (BEV) and room's eye view (REV)
        g. Artificial intelligence

C. Treatment execution
    1. Isocenter placement
    2. Port verification
        a. Coplanar
        b. Noncoplanar
    3. Field shaping
        a. Alloy blocking
        b. Multileaf collimation (MLC)
            1) Configuration and 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 (e.g., VMAT)
    1. Conventional
    2. Hypofractionation
    3. VMAT
        a. Static field IMRT
        b. Stereotactic ablative radiation therapy (SABR)

4. Hyperfractionation

D. Quality assurance
   1. Multileaf collimator
      a. Design
      b. Divergence
      c. Penumbra
      d. Interleaf leakage
         1) Collimator angle optimization
         2) Jaw tracking
   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. Electron Beam

A. Physical characteristics
   1. Rapid dose buildup (ratio of surface to D_{max} dose)
   2. Dose fall-off (low vs. high energy)
   3. Dose distribution
      a. Central axis
      b. Off axis
   4. Constriction of isodose curve at depth (field size)
   5. Ballooning of isodose curve at depth
   6. Percentage depth dose data unique to treatment unit, cone and field size
   7. Field size relationship to central axis PDD
      a. Energy ≤ 20 megaelectronvolt (MeV)
      b. Energy > 20 MeV
   8. Distance (standard vs. virtual)
   9. Scatter
      a. Scattering foils, scanning magnet, air
      b. Brems photon contamination of electron beam
      c. Collimator opening effect on dose rate
   10. Equivalent area
      a. Equivalent squares
      b. Square root method
      c. Measured data
   11. Equivalent path length

B. Beam energy selection

C. Biological considerations in patient treatment

D. Energy decelerators for special treatment

E. Build-up bolus

F. Adjacent fields

G. Shielding materials, thicknesses, energy and dose relationship
    1. Mass stopping power (low vs. high Z)
        a. Density, Z number and electrons per gram
        b. Material choices and rationales
    2. External shielding
    3. Internal shielding (tissue interfaces)
    4. Changes in dose rate and dose distribution
    5. Thickness (MeV/3 = mm pb)

H. Treatment prescriptions and calculations
    1. Physician prescription to specific isodose line
    2. Critical structure
    3. Noncritical structure
    4. Determining PDD

I. Applications of electron beam
    1. Single beam
    2. Multiple beams
        a. Mixed (photon and electron)
        b. Abutting
            1) Electron fields
            2) Electron and photon fields
    3. Complex
        a. Electron arc
        b. Total skin irradiation

J. Electron beam calculations

XIII. Stereotactic Radiation Therapy

A. Equipment
    1. Gamma Knife
    2. Linear accelerator based
        a. Tomotherapy
        b. CyberKnife
        c. ZAP-X stereotactic radiosurgery (SRS) gantry system
    3. Isocenter localization
        a. Kilovoltage (kV)

b. Cone beam computed tomography (CBCT)

B. Immobilization
1. Brain stereotactic radiosurgery (SRS)
2. Head frame
3. Frameless with surface-guided radiation therapy (SGRT)
a. Body/Full body vacuum bags
b. Boards
4. SGRT utilization and considerations
5. Gating
6. Compression

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

D. Advantages and disadvantages

XIV. Brachytherapy

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

B. Source/applicator/catheter localization

C. Implant dosimetry systems
1. Dose specification and 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 calculation optimization

Optional Content

Artificial Intelligence

The content in this section is a developing area of science, and the language used to describe and differentiate these technologies and techniques is similarly developing. Programs and educators are encouraged to frequently re-examine content in this field to stay current with the latest developments.

Objectives

- Define terminology associated with artificial intelligence (AI).
- Discuss data and data sets as they apply to AI.
- Explain the principles of machine learning, deep learning, natural language processing and neural networks.
- Outline AI applications in health care and medical imaging.
- Recognize the standards and ethics applicable to AI in medical imaging.
- Describe AI regulation and workflow integration.
- Discuss the role of AI in precision medicine.

Content

I. Terminology and concepts

A. Algorithm

B. Automation

C. Artificial intelligence (AI)
   1. Artificial narrow intelligence
   2. Artificial general intelligence
   3. Artificial super intelligence

D. AI-enabled

E. AI-bias

F. Machine learning (ML)
   1. Supervised
   2. Unsupervised
   3. Deep learning (DL)

G. Neural networks
   1. Artificial neural networks (ANN)
   2. Convolutional neural networks (CNN)
   3. Recurrent neural networks (RNN)

H. Software as a medical device (SaMD)

I. Recursion

J. Natural language processing (NLP)
   1. Pattern recognition
   2. Visual perception
   3. Decision-making

II. Data and Data Sets

III. Applications in Health Care

A. Radiation Therapy

B. Medical Dosimetry

IV. AI in Medical Imaging

A. Order scheduling and patient screening

B. Exam protocoling

C. Image acquisition

D. Image analysis
   1. Automated detection of findings
   2. Automated interpretation of findings

E. Automated clinical decision support (CDS)

F. Image post-processing

V. Ethics, Legality and Liability

VI. Regulation and Workflow Integration

VII. Precision Medicine

Additional Magnetic Resonance Imaging Content

Objectives

- Discuss pulse sequence configurations.
- Review postprocessing techniques.
- Describe functional imaging protocols and techniques.

I. Pulse Sequence Configurations

A. Partial saturation and saturation recovery sequence

B. Spin echo

C. Inversion recovery
   1. Types of inversion recovery (IR) sequences
      a. Spin echo IR
      b. Fast spin echo IR (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. 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

II. Postprocessing

A. Maximum intensity projection (MIP)

B. Multiplanar reconstruction techniques (MPR)

C. Cardiac analysis

D. SynCT

III. Functional Imaging

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

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

C. Dynamic imaging

IV. Magnetic Resonance Curriculum

(Refer to the document located at https://www.asrt.org/educators/asrt-curricula/magnetic-resonance)

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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Additional Resources

https://www.acr.org/Clinical-Resources/Practice-Parameters-and-Technical-Standards

https://www.aapm.org/pubs/MPPG/

https://www.aapm.org/pubs/reports/tabular.asp

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5800761/

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6986460/

https://pubs.rsna.org/doi/full/10.1148/radiol.2020202747

Appendix

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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