Radiation Therapy Professional Curriculum

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Introduction

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

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

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

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 Some content areas have been retitled or reorganized and outdated content eliminated.

The guidance provided by this curriculum document will span the time period prior to and after the projected Jan. 1, 2015, start date of the ARRT's minimum associate degree requirement for candidates seeking professional certification. The focus of this document is on the preprofessional core instructional content that will be expanded with institution-specific course content to fulfill metrics for receipt of an academic degree. It is beyond the scope of this document to outline administrative strategies for programs that are unable to award graduates an academic degree to comply with the ARRT's 2015 degree requirement.

The general education content objectives in this curriculum were purposely labeled "global content objectives" to give program officials flexibility in determining specific credit-bearing course work that will satisfy these objectives. Following 2015, it is expected that this component of the professional curriculum will be satisfied with general education courses needed to fulfill institution-specific degree requirements.

In summary, the new radiation therapy curriculum is based on the latest data relevant to the profession and reflects the dynamic health care environment. The curriculum offers a foundation for individual professional development at a minimum level of a baccalaureate degree. It allows for flexibility in the development of a curriculum designed to meet the needs of the local community yet meet the requirements for the JRCERT Standards and the ARRT examination. The radiation therapy professional curriculum is in line with a baccalaureate education.

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

Required General Education

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

General education provides the intellectual flexibility and knowledge to support continued professional development in a rapidly changing profession.

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

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

Required General Education Content
Note: These are not specific courses, but represent minimal content areas.

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

- Mathematics – This content will include a study of the real number system, algebra of sets, exponents, equations and inequalities, polynomial functions, graphing, radical expressions, operations, inverses of function, equations of lines and systems of linear equations and elementary statistics, logarithmic and trigonometric functions and their applications, and plane analytic geometry.
- Written Communication – This content will include the written expression of thoughts, ideas, perceptions and observations derived from the critical thinking process. Additionally, it may complement the critical thinking process by providing a vehicle for the organization and clarification of thoughts, for the establishment of conceptual relationships, for the analysis of data and for synthesis of conclusions or new ideas.
- Verbal Communication – This content will include the theory and practice of public speaking, development of thought processes necessary to organize speech content for informative and persuasive situations, application of language and delivery skills to specific audiences.
- General Physics – This content will include the application of physical principles, conservation laws, gravitation, electricity, magnetism, wave motion, heat and thermodynamics as it relates to scientific disciplines.

Contents

Clinical Practice

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

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

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

Content

I. Essentials of Clinical Practice

A. Legal and ethical considerations

B. Code of ethics

C. Scope of practice

D. Practice standards

E. Lifelong learning and professional development

F. Patient bill of rights

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

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

II. Patient Assessment, Care and Education

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

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

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

D. Clinical competencies*

III. Simulation

A. Radiation safety and environmental protection practices

B. Equipment operation

C. Patient and machine monitoring

D. Patient positioning and immobilization
    1. Straightening techniques
    2. Leveling techniques
    3. Patient comfort and reproducibility techniques

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

F. Treatment field delineation
    1. Measuring
    2. Proper marking of patient
    3. Permanent marking of patient

G. Treatment volume localization

H. Imaging procedures

I. Image processing, capture and export

J. Documentation

K. Patient assessment, care, management and education

L. Clinical competencies*

IV. Treatment Planning

A. Pertinent patient information

B. Collaboration with team members

C. Equipment operation

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

E. Clinical competencies*

V. Treatment Delivery

A. Radiation safety and environmental protection practices

B. Equipment operation

C. Patient identification

D. Patient and machine monitoring

E. Treatment verification and prescription

F. Monitor dose to critical structures

G. Patient and machine setup

H. Machine malfunctions and troubleshooting

I. Documentation

J. Comparison analysis of images for verification/localization

1. Patient repositioning
2. Dynamic targeting

K. Patient assessment, care, management and education
   1. Interpret treatment plan

L. Clinical competencies*

VI. Quality Assurance and Quality Management

A. Documentation

B. General area conditions

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

D. Accessory and immobilization devices

E. Communication devices

F. Computerization

G. Simulation and treatment units

H. Brachytherapy

I. Treatment planning

J. Device fabrication equipment

K. Clinical competencies*

*Refer to ARRT minimum core clinical competencies.

Ethics in Radiation Therapy Practice

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

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

Content

I. Ethical Theories and Principles

A. Theories
1. Utilitarianism
2. Kantianism
3. Character ethics
4. Liberal individualism
5. Communitarianism
6. Ethics of care
7. Principle-based

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

II. Provider/Patient Relationship

A. Models

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

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

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

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

E. Competency determination

III. Ethical Decision-making in Health Care Dilemmas

A. Process of ethical decision-making

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
   2. Proxy decision-making standards
      a. Durable power of attorney
      b. Medical power of attorney
   3. Informed nonconsent

4. Do-not-resuscitate (DNR) orders
5. Euthanasia
6. Hospice

H. Abortion

I. Genetic science and biomedical technology

J. Justice and the allocation of scarce resources

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

IV. Health Care Policy

V. Role of the Radiation Therapist in Patient Care

Imaging and Processing in Radiation Oncology

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

Objectives
1. Define terminology associated with digital imaging systems.
2. Describe the various types of digital receptors.
3. Discuss the fundamentals of digital imaging.
4. Discuss image acquisition.
5. Describe the evaluative criteria for digital imaging detectors.
6. Describe the histogram and the process or histogram analysis as it relates to automatic rescaling and determining an exposure indicator.
7. Identify the exposure indices for digital imaging receptors.
8. Discuss the response of digital imaging systems to background and scatter radiation.
9. Use appropriate means of scatter control.
10. Explain methods to avoid histogram analysis errors.
11. Describe image processing employed for digital images.
12. Associate the impact of image processing parameters to the image appearance.
13. Associate the effects of inappropriate processing on image clarity or conspicuity.
14. Describe and apply the fundamental physical principles of exposure for digital detectors.
15. Describe the selection of technical factors to ensure appropriate receptor exposure levels for digital detectors.
16. Describe the conditions that cause quantum mottle in a digital image.
17. Explain methods to avoid poor quality images.
18. Examine the potential impact of digital imaging systems on patient exposure and methods of practicing the as low as reasonably achievable (ALARA) concept with digital systems.
19. Describe picture archiving and communications system (PACS) and its function.
20. Identify components of a PACS system.
21. Describe patient benefits gained through the use of telemedicine.
22. Identify modality types that may be incorporated into a PACS.
23. Define digital imaging and communications in medicine (DICOM).
24. Describe data flow for a DICOM image from an imaging modality to a PACS.
25. Describe HIPAA concerns with electronic information.
26. Identify common problems associated with retrieving/viewing images.
27. Describe the components and the operation of a conventional simulator.
28. Analyze relationships of factors affecting image contrast, density and resolution to determine optimal image quality.
29. Apply techniques to enhance image details and reduce image distortion.

30. Determine artifact types, cause and preventive measures.
31. Explain the basic principles of image formation for each of the following modalities: magnetic resonance (MR), ultrasound imaging and nuclear medicine.
32. Describe and explain functions of the components of the computed tomography (CT) imaging system.
33. Differentiate between conventional and spiral/helical CT scanning.
34. List the CT computer data processing steps.
35. Name the functions of the array processor used for image reconstruction.
36. Explain the difference between reconstructing and reformatting an image
37. Describe the application of the following terms to CT:
    - Pixel.
    - Matrix.
    - Voxel.
    - Linear attenuation coefficient.
    - CT/Hounsfield number.
    - Partial volume averaging.
    - Window width (ww) and window level (wl).
    - Spatial resolution.
    - Contrast resolution.
    - Noise.
    - Annotation.
    - Region of interest (ROI).
    - Standard vs. volumetric data acquisition.
38. Identify the types and appearance of artifacts most commonly affecting CT images.
39. Explain how artifacts can be reduced or eliminated.
40. Describe current data storage techniques used in CT.
41. Name the radiation protection devices that can be used to reduce patient dose in CT and describe the correct application of each.

Content

I. Basic Principles of Digital Imaging

A. Digital image characteristics
   1. Picture elements – pixels
   2. Pixel size
   3. Matrix size
   4. Spatial resolution

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

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

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

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

A. Image-guided radiation therapy (IGRT) for verification/localization
   1. Cine (e.g., motion management)
   2. Single/double exposure
   3. Cone beam (CT)
   4. Fan beam (tomotherapy)
   5. kV/kV matching
   6. MV/MV matching
   7. Ultrasound guided
   8. Fluoroscopic

9. Digital reconstructed radiograph (DRR)
10. Electronic portal imaging device (EPID)

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

C. Image extraction
   1. Rows and columns read line by line
   2. Data transferred to external electronics
   3. Digitized by analog-to-digital converter (ADC)
   4. Histogram created and analyzed by software
   5. Initial image processing
      a. Exposure field recognition
      b. Histogram analysis
      c. Automatic rescaling – risk of failure

D. Image Formation
   1. Image extraction
      a. TFT, CMOS, CCD
      b. PSP plate scanned by laser
   2. Digitized by analog-to-digital converter (ADC)
   3. Exposure field recognition
   4. Histogram created and analyzed by software
   5. Initial image processing
      a. Exposure indicator determination
      b. Automatic rescaling
   6. Initial image processing
      a. Exposure field recognition
      b. Histogram analysis
      c. Automatic rescaling

E. Exposure indicators
   1. Dose area product (DAP)
   2. Vendor-specific values
      a. Relationship to patient exposure
      b. Optimal value ranges

III. Principles of Imaging

A. Image characteristics

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

1) Distance
2) Tube/part (image receptor) relationships

5. Exposure latitude
   a. Definition
   b. Factors
      1) kVp
6. Image receptor scattered/secondary radiation
   a. Definition
   b. Interactions
   c. Factors
      1) kVp
      2) Patient considerations
      3) Distance
      4) Contrast media
   d. Effects
      1) Patient dosage
         a) Adult
         b) Pediatric
         c) Body habitus
      2) Image quality
      3) Occupational exposure

IV. Computed Tomography Equipment in Radiation Oncology

A. Capabilities and limitations

B. Components, Operations and Processes of CT
   1. Data acquisition
      a. Methods
         1) Slice-by-slice
         2) Volumetric
         3) Beam geometry
      b. Data acquisition system (DAS)
         1) Components
         2) Functions
            a) Measurement of transmitted beam
            b) Encoding measurements into binary data
            c) Logarithmic conversion of data
            d) Transmission of data to computer
      c. Data acquisition process
         1) Scanning/raw data/image data
            a) Rays
            b) Views
               i) Beam's eye view (BEV)

ii) Volumes of interest
c) Profiles
i) Pixels
ii) Matrices
iii) Voxels
1) Attenuation
a) Linear attenuation coefficients
b) CT/Hounsfield numbers
(1) Baseline reference number
(a) Water equal to 0
(b) Bone (white) equal to 400 – 1000
(c) Air (black) equal to – 1000
2) Selectable scan factors
a) Scan field of view
b) Display field of view
c) Matrix size
d) Slice thickness
e) Window width
f) Window level
g) mAs and kVp
h) Algorithm
i) Scan time and rotational arc
j) Radiographic tube output
k) Region of interest (ROI)
l) Magnification
m) Focal spot size and tube geometry
n) Pitch
3) Power injectors

C. Factors controlling image appearance

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

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

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

F. Image backup and storage

G. Radiation Protection
   1. Methods for reducing radiation dose to the patient
      a. Technical factor selection
      b. Technical adjustments for children
      c. Scatter radiation reduction

V. Image Acquisition Errors

A. Histogram analysis error
   1. Incorrect anatomic menu selection
   2. Unexpected material in data set (i.e., metal)
   3. Large exposure error – plate saturation

B. Scatter control
   1. Beam limiting
   2. Optimal exposure – overexposure produces more scatter
   3. Background is 40 μR/day to 80 μR/day

VI. Software (Default) Image Processing

A. Final image processing
   1. Gradient processing
      a. Brightness
      b. Contrast
   2. Frequency processing
      a. Smoothing
      b. Edge enhancement
   3. Equalization

B. Recognition of image processing errors that affect image clarity

VII. Fundamental Principles of Exposure

A. Selection of exposure factors
   1. Maintain consistent specific receptor exposure
   2. Control scatter
   3. Adjust for differences in:
      a. Structure composition
      b. Source-to-image receptor distance (SID)

B. Control patient exposure
    1. Higher kVp levels
    2. Additional filtration
    3. Interfacing with automatic exposure control (AEC) systems
    4. ALARA principles
    5. Monitor patient exposure
    6. Dose area product (DAP)
    7. Vendor-specific values
        a. Relationship to patient exposure
        b. Reader calibration
        c. Centering and beam collimation
        d. Optimal value ranges
    8. Exposure indicators

VIII. Image Evaluation

A. Evidence of appropriate exposure level
    1. Exposure indicator
        a. Low contrast due to overexposure
        b. Noise due to underexposure

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

C. Artifacts
    1. Definitions
    2. Types
        a. Motion
        b. Metal "star" artifacts
        c. Beam hardening
        d. Partial volume
    3. Causes
    4. Effects
    5. Preventative measures

D. Display Contrast
    1. Brightness
    2. Ambient light in view area
    3. Window width and level

IX. Display

A. Information systems
   1. Picture archiving communication system (PACS)
   2. Access to report information
   3. Access from multiple locations
   4. Image retrieval
   5. PACS issues – contingency plans
   6. System components and function
   7. DICOM
   8. HL-7
   9. Image management storage

B. Telemedicine

C. Radiation therapist responsibilities
   1. Order verification
   2. Image acquisition
   3. Postprocessing – image manipulation
   4. Annotation issues
   5. Transmitting image(s)
      a. HIPAA and patient confidentiality
   6. Image orientation to patient anatomy and position

X. Imaging Equipment

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

XI. Other Imaging Modalities

A. Description, basic principles and advantages/disadvantages of each imaging modality
   1. Radiography
   2. CT
   3. MR

4. Mammography
5. Ultrasound imaging
6. Nuclear medicine
7. Hybrid imaging (fusion imaging)
8. Molecular imaging

Introductory Law in Radiation Therapy

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

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

Content

I. Sources of Law

A. Criminal

B. Civil

C. Constitutional

D. Administrative

II. Intentional Torts

A. Assault and battery

B. False imprisonment

C. Intentional infliction of emotional distress

D. Defamation

E. Vicarious liability

F. Communication as a deterrent to legal action

III. Negligence

A. Elements of a negligent act

B. Comparative negligence

C. Contributory negligence

D. Medical negligence

E. Doctrine of *res ipsa loquitur*

F. Doctrine of respondent superior

G. Negligence related to clinical practice issues

H. Elements to reduce charges of negligence

I. Defenses against charges of negligence

IV. The Lawsuit

A. Complaint

B. Discovery

C. Health professional as a party

D. Health professional as a witness

E. Deposition

F. Trial

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

A. Design of consent form

B. Role of the radiation therapist in the consent process

C. Patient's Bill of Rights

D. Standard of care

E. HIPAA

VI. Safety Issues

A. Developing a safety program

B. Equipment safety

VII. Documentation and Record Maintenance

A. Record requirements of The Joint Commission accreditation or equivalent

B. Critical documentation

C. Correction of documentation

D. Ownership of records

E. HIPAA

F. Security of patient information

VIII. Risk Management

A. Professional medical liability

B. Risk analysis

C. Role of the radiation therapist in risk management

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

A. Guides to professional practice

B. Participation in professional development activities

Medical Terminology

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

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

Content

I. Introduction to the Origin of Medical Terminology

A. Primary language sources
   1. Greek
   2. Latin

II. The Word-building Process

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

B. Combining forms

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

D. Health literacy communication
   1. Translation of terms into common language

E. Correct pronunciation of medical terms

F. Cover all anatomical body systems

III. Medical Abbreviations and Symbols

A. Role in communications

B. Abbreviations
   1. Examples
   2. Interpretations
   3. Abbreviations
      a. Appropriate
      b. Inappropriate

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

Operational Issues in Radiation Therapy

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

Objectives
1. Identify CQI opportunities.
2. Explain the differences between CQI and QA.
3. Select appropriate CQI tools for specific situations.
4. Apply CQI principles to specific situations.
5. Discuss human resources' role in the work environment.
6. Discuss the need for organizational and departmental accreditation.
7. Recognize accreditation effects on radiation therapy operations.
8. Use appropriate current procedural terminology (CPT) codes for professional and technical charges.
9. Summarize the various types of insurance and the mechanisms necessary for approval of care.
10. Discuss reimbursement for radiation therapy services.
11. Compare the components and methods of developing and managing a departmental budget.

Content

I. Continuous Quality Improvement

A. Purpose

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

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

II. Human Resources

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

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

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

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

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

III. Accreditation

A. Facility

B. Practice

IV. Insurance and Billing

A. Insurance
    1. Health Maintenance Organizations (HMOs)
    2. Preferred Provider Organizations (PPOs)

3. Supplemental insurance
4. Medicare and Medicaid
5. Other

B. Charity care

C. Health care policy

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

V. Departmental Budget

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

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

Orientation to Radiation Therapy

Description

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

Objectives

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

Content

I. Policies and Procedures of the Educational Program

A. Program officials

B. Educational program information

C. Clinical education setting(s)

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

II. The Health Science Professions

A. Radiologic and imaging sciences

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

III. Hospital and Health Care Organizations

A. Philosophy and mission

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

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

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

IV. Introduction to Radiation Therapy Practice

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

B. Cancer management
    1. Cancer incidence
    2. Epidemiology and etiological studies
    3. Detection and diagnosis
    4. Prevention
    5. Treatment
        a. Radiation oncology
        b. Surgical oncology
        c. Medical oncology
        d. Immunotherapy
        e. Integrative medicine
    6. Research
        a. Clinical trials
        b. Protocols

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

D. Radiation therapy treatment techniques
    1. External beam radiation
        a. Intraoperative
        b. Stereotactic
    2. Brachytherapy
        a. Systemic
    3. Hyperthermia

E. Patient rights and responsibilities
    1. HIPAA
    2. Record/chart contents

3. Confidentiality
4. Bill of Rights
5. Patient responsibilities

F. Radiation safety
   1. Monitoring
   2. Protection

G. Safety
   1. Standard precautions
   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
   1. Purpose
   2. Functions and activities
   3. Agencies

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

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

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

VI. Professional and Community Commitment

A. Organizations

B. Role of radiation therapist

VII. Professional Development

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

B. Career opportunities
   1. Administration
   2. Education
   3. Medical dosimetry
   4. Physics
   5. Research
   6. Application specialist
   7. Vendors

C. Governmental

Pathophysiology

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

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

Content

Part I: General Pathology

I. Introduction to Human Disease

A. Pathologic terminology

B. Most frequent and significant diseases

II. Theories of Disease Causation

A. Current issues/ongoing research

B. Theories

C. Etiology

D. Epidemiology

E. Prevention/screening

III. Basic Principles and Mechanisms of Disease

A. Cell injury
   1. Types
   2. Clinicopathologic correlations

B. Inflammatory response

C. Tissue healing and repair

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

E. Neoplasms
   1. Benign
   2. Malignant

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

5. Embolism
6. Infarction
7. Shock

IV. Common Diagnostic Tests and Procedures

A. Medical history

B. Physical examination

C. Screening tests and procedures

D. Laboratory tests and procedures

E. Radiologic tests and procedures

V. Disorders of Nutrition

A. Starvation and obesity

B. Vitamins and mineral

VI. Body Systems and Disorders, Including:

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

A. Overview

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

C. Effects of aging

Part Two: Neoplasia

I. Introduction

A. Overview

B. Terminology

II. Nomenclature

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

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

III. Carcinogenesis

A. Theories
   1. Genetic
   2. Epigenetic

B. Prevention

IV. Diagnosis

A. Medical history

B. Physical examination

C. Biopsy

D. Microscopy

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

F. Diagnostic imaging studies

V. Grading and Staging

A. Definitions

B. Purpose

C. Methods

D. Effect on treatment

VI. Prognostic Factors

A. Tumor-related

B. Host-related

VII. Malignancies, Including:

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

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

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

F. Treatment rationale

G. Prognosis

Principles and Practice of Radiation Therapy I

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

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

Content

I. Cancer Perspectives

A. Cancer incidence

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

C. Cancer prevention

II. Treatment Determination for Overall Cancer Management

A. Medical considerations

B. Tumor histology and grade

C. Tumor location

D. Tumor natural history

E. Medical resources

F. Patient considerations

G. Quality of life

H. Treatment protocols

I. Clinical trials

J. Evidence-based decision-making

III. Radiation Therapy Treatment

A. Treatment goals

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

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

IV. Radiation Therapy Equipment

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

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

C. External beam
   1. Purpose
   2. Megavoltage
      a. Linear accelerators
         1) Components
         2) Methods of radiation production
            a) Photons
            b) Electrons
         3) Energy
         4) Depth of maximum dose
         5) Target-to-skin distance (TSD)/target-to-axis distance (TAD)
         6) Auxiliary devices
         7) Radiation protection
         8) Patient observation and communication
         9) Emergency procedures
      b. Specialized units

1) Stereotactic radiosurgery
2) Intraoperative
    a) Orthovoltage
    b) Megavoltage
3) Gamma knife
4) Cyber knife
5) Heavy particle accelerators
6) Proton cyclotrons/synchrotrons
    a) Components
    b) Methods of radiation production
    c) Energy deposition/Bragg peak
    d) Compensation
    e) Radiation production
7) Tomotherapy
8) Emerging units

c. Kilovoltage units
    1) Purpose
    2) Components
    3) Method of radiation production
    4) Energy
    5) Auxiliary devices
    6) Patient observation and communication
    7) Emergency procedures
d. Radioisotope units
    1) Teletherapy
        a) Purpose
        b) Methods of radiation production
        c) Half-life
        d) Energy
        e) Components
        f) Radiation protection
        g) Auxiliary devices
        h) Patient observation and communication
        i) Emergency procedures

3. Brachytherapy
    a. Purpose
    b. Types
        1) High-dose rate (HDR)
        2) Low-dose rate (LDR)
        3) Pulsed-dose rate (PDR)
    c. Isotopes
    d. Methods of radiation production
    e. Half-life

f. Energy
g. Components
h. Radiation protection
i. Auxiliary devices
j. Patient observation and communication
k. Emergency procedures

D. Emerging technologies with patient treatment setup and localization

V. Treatment Delivery Accessories

A. Beam modification devices
1. Purpose
2. Construction
3. Types
a. Bolus
b. Filters
1) Wedges
a) Dynamic
b) Physical
2) Hardening
3) Compensating
4) Transmission
4. Beam shaping
a. Blocks
b. Collimators
c. Multileaf collimators (MLCs)
d. Apertures
e. Snout
f. Other
5. Applications
6. Other

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

VI. Tumor Localization

A. Purpose

B. Procedures
   1. Preparation for simulation
      a. Medical and diagnostic information
      b. Physician orders
      c. Procedure and room preparation
   2. Adaption of treatment protocols to patient-specific conditions
   3. Simulation
      a. Patient assessment and evaluation
      b. Patient education
      c. Patient safety
      d. Construction of immobilization devices
      e. Patient positioning
      f. Determination of isocenter
         1) Programmable lasers
      g. Treatment field delineation
      h. Measurements
      i. Imaging techniques
         1) Image quality factors
         2) CT
         3) MR
         4) 4-D imaging
         5) Fusion
         6) Orthogonal films
         7) Fluoroscopy
         8) Ultrasound imaging
         9) Other
      j. Contrast
   4. Conceptual conventional simulation

C. Image processing, acquisition and retrieval

D. Image assessment, evaluation and correction

E. Treatment field delineation and measurements

F. Documentation of simulation information

G. Patient observation and communication

VII. Pretreatment Verification Protocol

A. Purpose

B. Components

C. Application

D. Quality assurance

E. Other

VIII. Treatment Delivery Protocol

A. Adaption of treatment protocols to patient-specific conditions

B. Patient assessment, education and care

C. Patient safety
   1. Setup and verification
   2. Radiation protection

D. Treatment parameters

E. Treatment imaging

F. Time-out

G. Withholding treatments when conditions warrant

H. Treatment delivery

I. Documentation of treatment

J. Reporting and documentation of treatment errors

Principles and Practice of Radiation Therapy II

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

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

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	**AIDS-related neoplasms**	**Benign neoplasms**

A. Epidemiology

B. Etiology

C. Prevention methods and screening tools

D. Pertinent anatomy and lymphatics
   1. Dose-limiting structures

E. Natural history of disease

F. Clinical presentation

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

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

I. Multidisciplinary treatment approach
   1. Treatment modality combinations

J. 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

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

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

M. Role and scope of personalized medicine
    1. Role and scope of radiation oncology

N. Emerging approaches to neoplastic disease management

O. Simulation and treatment principles and practice
    1. Treatment volume localization
    2. Interpretation and implementation of treatment plan
    3. Treatment delivery
        a. Patient positioning
        b. Immobilization devices
        c. Parameters of treatment field design and arrangement
        d. Beam energy
        e. Dose schedule
    4. Prognosis
        a. Treatment morbidity/toxicity
            1) Acute
            2) Chronic
            3) Survivorship

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

Quality Management

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

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

25. Discuss quality control procedures and recommended tolerances for simulation equipment, megavoltage treatment units and treatment planning systems.
26. Discuss quality control procedures and recommended tolerances for the safe handling of brachytherapy sources and remote afterloading equipment.
27. Defend the rational for near miss and error report.
28. Critique the safety in radiation oncology.

Content

I. Introduction

A. QM or QI
   1. Definition
   2. Rationale

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

C. Goals
   1. Comprehensive assessment
   2. Team approach

II. General Principles

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

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

C. Standards
   1. Current safety recommendations in radiation oncology
   2. Staffing levels, qualifications, responsibilities
   3. Equipment availability
   4. Dosimetric accuracy

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

7. Reporting and evaluating near-misses and errors
8. Implementing corrective actions related to QM data collection

III. Clinical Aspects QI Checks

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

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

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

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

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

F. Portal/onboard imaging
   1. Purpose, procedure and frequency
   2. Corrective measures
   3. Documentation
   4. Reject analysis

G. Outcomes
   1. Patient care

2. Educational
3. Research

IV. QA, QC for Treatment, Simulation/Localization and Verification

A. Commissioning

B. Routine

C. Special circumstance

D. Purpose, procedure and frequency
   1. Current AAPM Task Group, or equivalent, reports recommendation

E. Sources of malfunction

F. Materials and methodology

G. Evaluation and interpretation of results

H. Corrective measures

I. Documentation

J. Safety and hazards

K. Guidelines to tolerance values

L. Preventative maintenance

V. Particle Accelerators

A. Purpose, procedure and frequency of checks
   1. Current AAPM Task Group, or equivalent, reports recommendation

B. Sources of malfunction/error

C. Materials and methodology

D. Safety and hazards

E. Corrective measures

F. Guidelines to tolerance values

G. Documentation

VI. Brachytherapy

A. Current AAPM Task Group, or equivalent, reports recommendation

B. Purpose, procedure and frequency of checks

C. Sources of malfunction/error

D. Materials and methodology

E. Safety and hazards

F. Corrective measures

G. Guidelines to tolerance values

H. Documentation

VII. Medical Dosimetry and Treatment Planning

A. Purpose, procedure and frequency of checks

B. Sources of malfunction/error

C. Data acquisition

D. Materials and methodology

E. Safety and hazards

F. Corrective measures

G. Documentation

VIII. Quality Assurance and Maintenance Issues

A. Initial acceptance testing

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

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

Radiation Biology

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

Objectives
1. Integrate laws and principles of radiation biology to the clinical practice of radiation therapy.
2. Identify radiosensitive components of the cell.
3. Distinguish between units of radiation quantities and radiobiologic measures.
4. Differentiate between direct and indirect effects of ionizing radiation.
5. Explain factors affecting relative biological effectiveness (RBE).
6. Discuss the effects of electromagnetic and particulate radiations on cellular interactions.
7. Evaluate factors influencing radiobiologic/biophysical events at the cellular and subcellular level.
8. Determine biologic damage due to radiation-induced chemical reactions.
9. Discuss radiation effects on the cell cycle.
10. Compare somatic and genetic effects of radiation.
11. Describe factors influencing radiation response of cells and tissues.
12. Discuss the laws of Bergonié and Tribondeau.
13. Interpret cell survival curves to determine radiosensitivity under numerous conditions.
14. Discuss the relationship of radiation quality and dose to systemic responses.
15. Describe radiation syndromes and factors influencing response.
16. Differentiate between linear, nonlinear, and threshold and nonthreshold dose response curves.
17. Describe the 5 Rs of radiobiology.
18. Describe the clinical significance of $TD5_{/5,}TD_{50/5}$ and QUANTEC.
19. Discuss the concept of $LD_{50/30}$.
20. Compare the relationship of time, dose, fractionation, volume, distance and site to radiation effects.
21. Discuss the use of radiation response modifiers.
22. Describe the influence of chemotherapy and hyperthermia alone and in combination with radiation therapy.

Content

I. Introduction

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

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

C. Sources of medical radiation exposure

II. Biophysical Events

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

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

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

III. Radiation Effects

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

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

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

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

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

IV. Radiosensitivity and Response

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

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

C. Systemic response to radiation

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

D. Tolerance dose – $TD_{5/5,}$ $TD_{50/5}$, and QUANTEC
   1. Minimal
   2. Maximal
   3. Mean

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

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

V. Biologic Principles of Radiation Therapy

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

b. Rationale
c. Types

6. Time-dose relationships
   a. Nominal standard dose (NSD)
   b. Isoeffect curves
   c. Rad equivalent therapy (RETS)
   d. Dose rate
   e. Alpha-beta ratios (α-β ratios)
   f. Biological effective dose (BED) calculation
7. Volume
   a. Tumor volume
   b. Treatment volume
   c. Volume vs. complications
   d. Time-dose-volume relationship
   e. Radiobiological effects from radiation therapy techniques

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

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

Radiation Physics

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

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

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

Content

I. Units of Measurement

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

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

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

II. General Principles

A. Mass

B. Force

C. Energy

D. Relationship between matter and energy

E. Forces of nature

III. Structure of the Atom

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

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

b. Neutron/proton ratio
c. Binding energy

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

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

IV. Structure of Matter

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

B. Compound
1. Definition
2. Molecule

C. Mixtures
1. Definition
2. Examples

V. Nature of Radiation

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

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

VI. Electromagnetic Radiation

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

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

VII. Electrostatics

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

B. Electrical field
    1. Definition
    2. Source

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

D. Laws of electrostatics

VIII. Magnetism

A. Fields

B. Interactions with charged particles

C. Magnetic resonance

IX. Electrodynamics

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

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

X. Electromagnetism

A. Interaction between electric/magnetic fields

B. Induction
   1. Self
   2. Mutual

XI. Production and Characteristics of Radiation

A. X-ray production
   1. Processes
      a. Bremsstrahlung
      b. Characteristic
   2. Necessary conditions (electron)
      a. Source
      b. Acceleration
      c. Deceleration
   3. X-ray energy spectra
   4. Factors affecting x-ray exposure rate
      a. Tube potential
      b. Tube current
      c. Filament current
      d. Time
      e. Distance
      f. Filtration

B. Wave model

C. Quantum model

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

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

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

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

Radiation Protection

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

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

Content

I. Introduction

A. Justification for radiation protection

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

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

D. Sources of radiation

E. Legal and ethical responsibilities

II. Units, Detection and Measurement

A. Physical unit of exposure

B. Biologic unit of dose

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

D. Physical unit of radioactivity

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

III. Surveys, Regulatory Agencies and Regulations

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

B. Equipment survey
    1. Treatment
    2. Simulation

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

D. Regulatory and advisory agencies

E. Radiation safety officer roles and responsibilities

IV. Personnel Monitoring

A. Requirements for personnel monitoring

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

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

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

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

V. Practical Radiation Protection

A. Design
    1. Barriers
    2. Factors

a. Use (U) controlled/uncontrolled
b. Workload (W)
c. Occupancy (T)
d. Distance (d)

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

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

C. Cardinal principles in protection

D. Emergency procedures

VI. Brachytherapy

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

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

C. Surveys
   1. Patient
   2. Leak testing
   3. Area/room surveys

4. Area radiation monitor
5. Methods, documentation, frequency

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

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

F. Disposal of radioactive waste material

G. Quality assurance for brachytherapy

Radiation Therapy Patient Care

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

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

Content

I. Introduction

A. The multidisciplinary health care team

B. The radiation oncology team

II. Communication in Patient Care

A. Health-illness continuum

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

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

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

b. Body language

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

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

b. Influencing factors

III. Patient-family Interactions

A. Patient identification

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

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

IV. 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

V. Assessment of Other Physical Needs

A. Physical needs of the patient

B. Assessing patient status

C. Physical signs

D. Vital signs
   1. Temperature
   2. Pulse
   3. Respiration

4. Blood pressure
5. Pain

E. Weight

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

VI. Patient Examination

A. Initial assessment

B. Records
1. Diagnostic
2. Medical record

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

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

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

F. Equipment/instruments
1. Identification
2. Care

VII. Health Safety

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

B. Centers for Disease Control (CDC)

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

D. Asepsis
   1. Medical
      a. Definition
      b. Methods
         1) Heat
         2) Chemical
      c. Hand washing
         1) Soap
         2) Water
         3) Friction
         4) Time
         5) Chemical disinfectants
   2. Surgical
      a. Definition
      b. Growth requirements for microorganisms
      c. Methods used to control microorganisms
         1) Moist heat
            a) Steam under pressure
         2) Dry heat
            a) Incineration
            b) Dry heat oven
               (1) Gas

(2) Chemicals
(3) Ionizing radiation

d. Procedures
1) Opening packs
2) Gowning/gloving
3) Skin preparation
4) Draping
5) Dressing changes

e. Packing
f. Storage
g. Rules for surgical asepsis

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

F. Isolation techniques and communicable diseases
1. Category-specific
2. Disease-specific
3. Standard precautions
4. Examples
a. Blood-borne pathogens
b. Body fluid pathogens
c. Air-borne pathogens
d. Antibiotic-resistant infections
e. Clostridium difficile (C diff)
f. Other

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

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

I. Psychological considerations

VIII. Medications and Their Administration

A. Role of the radiation therapist

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

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

3. Routes of administration
    a. Topical
    b. Systemic
        1) Oral
        2) Sublingual
        3) Rectal
        4) Parenteral
4. Equipment
5. Special precautions
6. Monitoring IV infusions
7. documentation
8. Adverse reactions
9. Disposal of equipment and drugs

IX. Medical Emergencies

A. Emergency equipment

B. Latex reactions

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

D. Signs, symptoms and medical intervention
    1. Diabetic
        a. Hypoglycemia
        b. Ketoacidosis
        c. Hyperosmolar coma
    2. Respiratory and cardiac failure
    3. Airway obstruction
    4. Cerebral vascular accident (CVA)/stroke
    5. Fainting (syncope)
    6. Seizures
    7. Radiation oncology emergencies
        a. Superior vena cava (SVC) syndrome
        b. Spinal cord compression
        c. Severe tumor bleed
        d. Increased intracranial pressure
    8. Other medical conditions

X. Care of Patients With Tubes

A. Purpose, types and special precautions

1. Nasogastric/nasointestinal
2. 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. Documentation
   3. Urological devices
      a. Purpose
      b. Equipment
      c. Procedures
      d. Removal
      e. Documentation

XI. Brachytherapy Procedures

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

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

C. Follow-up patient care

D. Patients/family caregiving

XII. Assessment of Nutritional Status

A. Site-specific interventions

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

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

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

XIII. Physical Activity Considerations

A. Karnofsky scale/performance status

B. Activity as appropriate

C. Recognizing limitations

XIV. Patient Transfer

A. Body mechanics

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

6. Use of devices

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

D. Incident reports

XV. Patient Education

A. Needs assessment

B. Educational methods

C. Implementation and evaluation

D. Treatment procedures

E. Medical imaging procedures

F. Documentation

XVI. Integrative Medicine

Radiation Therapy Physics

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

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

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

Content

I. Structure of Matter and Properties of Radiation

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

B. Particle radiation
   1. Types
   2. Characteristics

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

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

II. Nuclear Transformations

A. Radioactivity

B. Decay constant

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

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

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

F. Radioactive series

G. Radioactive equilibrium
   1. Transient
   2. Secular

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

c. Electron capture decay

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

I. Decay equations and problems

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

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

L. Nuclear reactors

M. Charged particle accelerators

III. Review of Production of X-rays

A. The x-ray tube

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

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

D. Spectral distribution

E. Operating characteristics

IV. Radiation Therapy Treatment Units (External Teletherapy)

A. Historical Equipment

B. Equipment in current use

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

C. Isotope beams

1. ^{60}Co
    a. Gamma energies and average energy
    b. Review of decay scheme

c. Specific activity
d. Typical treatment distances
e. Basic components

V. Interaction of Ionizing Radiation

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

B. Interaction of photons
1. Photon beam attenuation
a. Influencing factors
1) Absorber atomic number dependence
2) Energy dependence
3) Absorber thickness dependence
b. Measurement of attenuation
1) Narrow beam geometry
2) Plotting of data
3) HVL
4) Attenuation coefficient (μ)
a) Linear attenuation coefficient
b) Mass attenuation coefficient
c) Electronic attenuation coefficient
d) Atomic attenuation coefficient
5) Relationship between HVL and μ
6) Homogeneity coefficient
7) Attenuation differential equation
2. Interactions of photons with matter
a. Transmission
b. Coherent scattering\
c. Photoelectric effect
1) Associated energy range
2) Absorption edges
3) Probability
a) Energy dependence
b) Z dependence
4) Angular distribution of photoelectrons
5) Clinical association and significance
d. Compton effect
1) Associated energy range
2) Probability

a) Energy dependence
b) Z dependence
3) Electrons per gram
4) Special cases of Compton
a) Direct hit
b) Grazing hit
c) 90^{o} photon scatter
5) Clinical association and significance

e. Pair production
1) Associated energy range and energy threshold
2) Probability
a) Energy dependence
b) Z dependence
3) $E=mc^2$
4) Annihilation radiation
5) Clinical association and significance

f. Photodisintegration

g. Relative importance of photon interactions

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

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

E. Overview of comparative beam characteristics

VI. Measurement of Ionizing Radiation

A. Introduction

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

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

4. Diodes

D. Electrometers
   1. Charge measurement
   2. String electrometer
      a. Schematic
      b. Use with condenser chamber
         1) Charging
         2) Measuring loss of charge
   3. Baldwin-Farmer type electrometer
   4. Others

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

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

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

VII. Quality of X-Ray Beams

A. Energy fluence (spectral distribution)

B. Clinically practical expression of beam quality
   1. Gamma ray energy or stating nuclide of origin
   2. X-ray beams
      a. Low energy beams
         1) HVL
         2) Peak kVp
      b. Megavoltage beams
         1) HVL
         2) Peak energy
      c. Average energy

C. Filters
   1. Inherent filtration
   2. Added filtration
   3. Combination filters (Thoraeus)
   4. Clinical use with low energy x-ray beams
      a. Proper placement
      b. Typical material for low energy ranges
   5. Megavoltage x-ray beams
      a. Transmission target
      b. Beam-flattening filter

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

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

F. Measurement of energy spectrum

VIII. Measurement of Absorbed Dose

A. Radiation absorbed dose
   1. Definition
   2. Advantages over exposure units
   3. Units

B. Relationship between KERMA, exposure and absorbed dose

C. Calculation of absorbed dose from exposure
   1. Absorbed dose to air
   2. Absorbed dose to any medium
      a. Roentgen-to-rad conversion factor (*f* factor)
         1) Photon energy
         2) Atomic number of medium

b. Clinical impact
3. Dose calibration with ion chamber
4. Dose measurement of exposure with ion chamber in a medium

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

E. Calibration of megavoltage beams overview
1. Current American Association of Physicists in Medicine (AAPM) RTC Task Group report
2. Current International Atomic Energy Agency report

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

G. Monte Carlo Methods

IX. Dose Distribution and Scatter Analysis Overview

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

B. Depth dose distribution
1. Percentage depth dose
a. Dependence on beam quality and depth
1) Dose buildup and skin sparing
2) KERMA vs. absorbed dose
b. Effect of field size and shape
1) Geometric field size
2) PDD function of field size and beam quality
3) Square fields vs. rectangular, irregular and circular fields
a) Equivalent square tables
b) Sterling's "Rule of Thumb" equation

c) Precautions in use of approximation equations
4) Dependence on source-surface distance
a) Dose rate vs. PDD
b) Standard distance PDD tables
c) Nonstandard distance
(1) Mayneord F factor
(2) Formula and limitations
5) Dependence on beam collimation system
2. Tissue-air ratio (TAR)
a. Effect of distance
b. Variation with energy, depth and field size
3. Backscatter factor (BSF)
a. Effect of distance
b. Effect of beam energy and field size
4. Scatter-air ratio (SAR)

Research Methods and Information Literacy

Description
Research methods and information literacy are important because the health care profession is continually changing, which requires the radiation therapist to possess new knowledge to function competently. The radiation therapist should contribute to the body of knowledge and be able to effectively analyze resources to promote growth in the profession. The attitude of professional development enables the radiation therapist to stay in step with the current health care environment and be prepared to help foster the future and increase awareness of the profession in the global community. This content is geared to increase and disseminate intellectual inquiry, information literacy and the use of scholarly research methods.

Objectives
1. Analyze research articles to determine the accuracy and validity of findings.
2. Integrate information literacy concepts into a research project.
3. Critique research projects to determine appropriateness and usefulness to the profession.

Content

I. Analysis of Research Articles

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

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

C. Assessing value of article
   1. Application for future research and recommendations
   2. Implications for 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. Appropriate title
   2. Title page
   3. Abstract
   4. Introduction
   5. Definition of terms
   6. Literature review
   7. Research design or methodology
   8. Hypothesis or purpose of research
   9. Results or analysis
   10. Conclusions, discussions and recommendations

III. Types of Research Projects

A. Literature review

B. Survey

C. Descriptive/technical

D. Case studies

E. Posters

F. Qualitative (observation or interview)

IV. Preparing a Research Project

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

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

C. Ethical principles and legal consideration

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

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

F. Data Analysis
   1. Terms (sensitivity, specificity, predictor values, false-positive, false-negative, etc.)
   2. Statistical methods – determine significance of data
   3. Qualitative methods
   4. Triangulation of multiple data sources

G. Dissemination of findings
   1. Format
      a. Abstract
      b. Article
      c. Poster

d. PowerPoint presentation
e. Others

2. Reference formats, (e.g. American Medical Association or AMA, American Psychological Association or APA, etc.)
3. Illustrations (images, charts, etc.)

H. Preparation of draft and revisions of project

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

Sectional Anatomy

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

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

Content

I. Anatomic Planes of the Body

II. Image Formation and Orientation

A. Computed tomography (CT)

B. Magnetic resonance (MR)

C. Positron emission tomography (PET)

D. Ultrasound imaging

E. Image fusion

III. Other Sectional Imaging Modalities

IV. Topographic and Sectional Anatomy to Include:

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

A. CT

B. MR

C. PET-CT

D. Ultrasound imaging

E. Other modalities

Treatment Planning

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

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

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

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

Content

I. Isodose Descriptions and General Influencing Factors

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

B. Photon beams dose distributions and general dose distributions at D_{max}, central axis and off-axis
1. Low energy x-ray
2. Gamma ^{60}Co
3. Megavoltage x-ray
4. Influencing Factors
   a. D_{max}
   b. Central axis
   c. Off axis
   d. Without flattening filter
   e. With flattening filter
   f. Flatness and symmetry
   g. Overflattenting/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

II. Patient Contours

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

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

III. Radiobiologic Dosimetric Considerations

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

B. Integral dose concepts

C. Edge effect

D. Nominal standard dose calculation

IV. Methods of Dosimetric Calculations

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

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

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

5. Monitor unit
a. Weighted fields

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

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

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

c. Weighted fields

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

b. SAR, SMR and approximation calculation
1) Algorithms
2) Absorbed dose calculation
a) Entrance dose
b) Exit dose
c) Entrance and exit dose summation
d) Area of interest dose
(1) Target volume dose
(2) Critical organ dose
(3) Dose to multiple patient points/depths
3) Treatment unit settings calculation
a) Time
b) Monitor units
4) Weighted fields

D. Moving beam techniques
1. Definition
2. Concepts, basic formulas and equations
3. Dose rate at isocenter (average TAR/TMR)
4. Correction of first and last TAR/TMR ray values
5. Monitor unit per degree (Gantry rotation speed)
6. Rotation/arc calculations
a. Absorbed dose calculation
1) Dose at isocenter
2) Target dose specifications

3) Maximum dose displacement (Arcs, past-pointing)
b. Treatment unit settings calculation
1) Time
2) Monitor units
3) Monitor unit/degree

E. General dosimetric calculations
1. Equivalent area
2. Sterling's formula
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. 3-D conformal therapy/IMRT
2. Field reduction
3. Boost ports/field in field
4. Past pointing
5. Wedges/tissue compensators/bolus
6. Shadow blocks
7. Table angulation

C. Field separation and beam divergence
1. Definitions
2. General guidelines
a. Junction consideration
1) Tumor
2) Critical organ
3) Surgical scar
b. Surface vs. depth considerations
c. Reproducibility
3. Methods
a. Adjacent field junctions
b. Orthogonal field junctions
4. Documentation considerations
a. Permanent records
b. Gap verification images
c. Record and verify

VI. Wedge Filters (2-D Compensation)

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

B. Wedge systems

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

D. Dose calculation
   1. Comparisons – wedged vs. nonwedged
   2. Clinical application

VII. Tissue Compensators (2-D and 3-D 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 appropriate isodose curves
   1. Influencing parameters of isodose curve selection
      a. Field separation
      b. Radiation type
      c. Beam energy
      d. Field size
      e. Distance
      f. Penumbra
      g. Treatment outcome goal
      h. Treatment technique (SSD/SAD)
   2. Application of isodose curve to patient contour
      a. Special considerations requiring adjustment
         1) Oblique incidence
         2) Tissue inhomogeneity

3) Weighting
4) Wedge/compensator placement
5) Blocking of normal tissue
6) Partial blocking of low tolerance diseased tissue
7) Bolus

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

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

D. Treatment beam techniques
1. Advantages/disadvantages of combined treatment approaches
a. Beam arrangements
b. Beam energies

IX. Optimal Treatment Planning Considerations, Evaluation and Implementation

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

B. Evaluation of dose distribution within target volume

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

D. Evaluation of dose distribution for noncritical organs/tissues

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

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

G. Dose volume histograms

H. Evaluation and assessment of treatment plan

I. Adaptive treatment planning

J. Consequences and recording of dosimetric errors

K. Implementation of error correction

L. Evaluation of patient impact

X. 3-D Conformal Therapy

A. Simulation
   1. Immobilization devices
   2. Imaging

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

C. Treatment execution
   1. Isocenter placement
   2. Port verification
      a. Coplanar vs. noncoplanar
   3. Field shaping

a. Alloy blocking
b. Multileaf collimation (MLC)
    1) Configuration/leaf attributes
    2) Limitations
    3) Quality assurance of leaf positions

XI. Intensity Modulated Radiation Therapy (IMRT)

A. Immobilization

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

C. Delivery techniques

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

XII. Particle Beams and General Dose Distributions

A. Electron beam
    1. Physical characteristics
        a. Rapid dose build-up (ratio of surface to D_{max} dose)
        b. Dose fall-off (low vs. high energy)
        c. Dose distribution
            1) Central axis
            2) Off axis
        d. Constriction of isodose curve at depth (field size)
        e. Ballooning of isodose curve at depth
        f. Percentage depth dose data unique to treatment unit, cone and field size
        g. Field size relationship to central axis PDD
            1) Energy $\leq$ 20 MeV
            2) Energy > 20 MeV

h. Distance (standard vs. virtual)
i. Scatter
    1) Scattering foil(s), scanning magnet, air
    2) Brems photon contamination of electron beam
    3) Collimator opening effect on dose rate
j. Equivalent area
    1) Equivalent squares
    2) Square root method
    3) Measured data
k. Equivalent path length

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

B. Other particle beams
    1. Neutrons
        a. General isodose curve pattern

b. Percentage depth dose energy dependence
c. Penumbra and adjacent structures
d. Clinical use

2. Charged particles (protons/helium ions)
   a. Properties
      1) Nonexponential attenuation
      2) Proximal and distal dose gradients
      3) General isodose curve pattern
      4) Bragg peak advantage
      5) Inhomogeneity sensitivity
      6) Percentage depth dose energy dependence
      7) Precision immobilization requirements
      8) Limited penumbra – sparing adjacent structures
   b. Clinical applications and treatment delivery
      1) Immobilization requirements
      2) Simulation
      3) Treatment planning
      4) Treatment verification
3. High LET charged particles (negative ions)
   a. Nonexponential attenuation
   b. Proximal and distal dose gradients
   c. General isodose curve pattern
   d. Bragg peak/star effect advantage
   e. Percentage depth dose energy dependence
   f. Precision immobilization requirements
   g. Penumbra
   h. Clinical applications
4. Heavy ions
   a. Types
      1) Carbon
      2) Neon
      3) Argon
      4) Silicon
      5) Other
   b. Nonexponential attenuation
   c. Proximal and distal dose gradients
   d. General isodose curve pattern
   e. Bragg peak advantage
   f. Percentage depth dose energy dependence
   g. Precision immobilization requirements
   h. Penumbra
   i. Clinical applications

XIII. Stereotactic Radiation Therapy

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

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

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

D. Advantages and disadvantages

XIV. Brachytherapy

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

B. Source/applicator/catheter localization

C. Implant dosimetry systems
   1. Dose specification/prescription
      a. Point specification
      b. Volume specification
   2. Critical structures
   3. Calculation methods
      a. Patterson-Parker (Manchester) system
      b. Quimby system
      c. Paris system

4. Computer aided dose calculations
    a. Optimization techniques

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

XV. Emerging Treatment Methods and Planning

Resources

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