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 based on research conducted by the Educational Testing Service (ETS) in 1999 (*The Practice of Radiation Therapy*). This document is the product of more than two years of revisions based on input from a variety of communities of interest through meetings, open forums and electronic communications. Input from The American Registry of Radiologic Technologists (ARRT) and the Joint Review Committee on Education in Radiologic Technology (JRCERT) were also 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 post-secondary 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 sectional anatomy, radiation therapy in the health care market and clinical practice content. Clinical and didactic competencies have been correlated. Some content areas have been retitled or reorganized and outdated content eliminated.

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

Required General Education

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

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

General Education Content
College-level prerequisite content provides foundational knowledge on which to build the radiation therapy content. The prerequisite content may also fulfill general education requirements at the college level. It is recommended that the prerequisite content be obtained through credit bearing college course work.

Prerequisite content must build a foundation upon which:

- 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 effect the normal functioning of each of the body systems
- Computer skills can be increased to include understanding of the information technology used in radiation oncology departments and integration of computerization of radiation therapy and treatment planning equipment
- 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
- Human Anatomy
  This content will include terminology, 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
  This content will include a general introduction of the functional integration of all human body systems including: 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.

- College Algebra
  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.

- Precalculus Mathematics
  This content will include a study of polynomial, exponential, logarithmic and trigonometric functions and their applications, ruler and compass constructions, plane analytic geometry, Cartesian and polar coordinates, Pythagorean theorem, Law of Sines, combinations and permutations, algebra of sets and normal distribution.

- Computer Science
  This content will include the study of computers and computing, hardware, software and systems and solution of problems, including problem-solving techniques, algorithm development and programming, information storage and accessibility and computer networking and internetworking.

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

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

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

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

Contents

Orientation to Radiation Therapy

Description

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

Objectives

1. Discuss the policies and procedures of the educational program.
2. Discuss the policies and procedures of clinical education settings.
3. Identify the responsibilities of a radiation therapy student.
4. Identify library/Internet resources pertinent to radiation oncology.
5. Discuss the responsibility of patient, staff and facility confidentiality.
6. Identify the role of other health science professions that participate in the patient's total heath care.
7. Explain the relationship of health care providers in the integrated care of cancer patients.
8. Discuss the philosophy and mission of health care delivery systems and educational programs.
9. Define cancer management principles and radiation therapy techniques.
10. Define key terms in radiation therapy.
11. Identify the contents/sections of the patient's records.
12. Explain radiation safety procedures for radiation therapy.
13. Explain health safety procedures for personnel and patients.
14. Differentiate between accreditation, credentialing, certification, registration, licensure and regulations.
15. Explain the purposes, functions and activities of international, national, state and local professional organizations.
16. Discuss the importance of professional and community commitment.
17. Discuss the radiation therapist Scope of Practice, Practice Standards and the Professional Code of Ethics.
18. Discuss career advancement and opportunities for the radiation therapist.
19. Discuss the benefits of continuing education as related to improved patient care and professional and personal enhancement.

Content

I. Policies and Procedures of the Educational Program

A. Program officials
   1. Director
   2. Clinical supervisors/clinical coordinators
   3. Medical director/advisor
   4. Clinical instructors
   5. Others

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

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

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

II. The Health Science Professions

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

B. Other health care groups
    1. Dietetics
    2. Health information
    3. Medical laboratory sciences
    4. Occupational therapy
    5. Pharmacy
    6. Physical therapy
    7. Respiratory therapy
    8. Social services

9. Nursing
10. Other

III. Hospital Organization

A. Philosophy and mission

B. Administrative services
   1. Governing board
   2. Hospital education setting administration
   3. Admissions
   4. Information systems
   5. Procurement
   6. Accounting
   7. Housekeeping
   8. Laundry
   9. Security
   10. Personnel
   11. Other

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

D. Ancillary services
   1. Clinical laboratories
   2. Rehabilitation
   3. Radiology
   4. Pharmacy
   5. Social services
   6. Dietary
   7. Dental
   8. Pastoral care
   9. Other

E. Radiation therapy services organization
   1. Professional personnel
      a. Director/chairman

b. Radiation oncologists
    1) Attending
    2) Resident
    3) Intern
c. Radiation physicist
    1) Staff physicist
    2) Research assistant
d. Radiobiologist
    1) Staff biologist
    2) Research assistant
e. Radiation therapist
    1) Administrative director
    2) Chief/senior radiation therapist/lead radiation therapist
    3) Staff radiation therapist
    4) Treatment planning radiation therapist
    5) Educational director
        a) Didactic instructor
        b) Clinical instructor
        c) Student therapist
    6) Cast and mold room staff
f. Medical dosimetrist
g. Nurses
    1) Head nurse
    2) Staff nurse
h. Social worker
i. Nutritionist
j. Others

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

IV. Introduction to Radiation Therapy

A. Introduction to the radiation therapist's Scope of Practice and Practice Standards

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. Alternative

C. Key terms
   1. Radiation therapy equipment
      a. Linear accelerator
      b. Simulator/CT simulator
      c. Record and Verify system
      d. HDR
      e. Other
   2. Terms related to the equipment
      a. Collimators
      b. Gantry/gantry angle
      c. Pendant
      d. Backup timer
      e. Wedge/compensators
      f. Isocenter
      g. Rangefinder (ODI)
      h. SSD
      i. SAD
      j. Other
   3. Terms related to the dose to be delivered
      a. Maximum dose (D_{max})
      b. Monitor unit/time
      c. Tumor dose
      d. Fraction
      e. Other
   4. Positional terms
      a. POP
      b. AP/PA
      c. Lateral

d. Superior
e. Inferior
f. Oblique
g. Tangential
h. Other

D. Radiation therapy treatment techniques
1. External
2. Brachytherapy
a. Interstitial
b. Intracavitary
3. Systemic
4. Contact
5. Intraoperative
6. Stereotactic
7. Hyperthermia
8. IMRT
9. Other

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

F. Treatment protocols

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

H. Health safety
1. Prevention of disease spread
a. Hand washing
b. Equipment cleaning
c. Standard precautions

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. Methods of advancement
   1. Continuing education programs
   2. Collegiate programs
   3. Geographical mobility
   4. Economic considerations
   5. Human resources issues
   6. Other

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

C. Industrial
   1. Commercial
   2. Governmental

D. Education
   1. Administration
   2. Clinical
   3. Higher education

E. Continuing education/competency requirements
   1. Definition
   2. Rationale
   3. Requirements
   4. Opportunities

F. Community Organizations

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

Content

I. Ethical Theories and Principles

A. Theories

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

B. Basic principles of health care ethics

1. The right to life
2. The right to receive health care
3. The right to know
4. Autonomy
   a. Three basic elements
   b. Informed consent
   c. Therapeutic privilege
   d. Benevolent deception
   e. Paternalism
   f. Fiduciary relationship
5. Nonmaleficence
   a. Double effect
6. Beneficence
   a. Hippocratic Oath
   b. Cost/benefit ratio
7. Veracity
   a. Truth telling
   b. Nondisclosure and deception
8. Role fidelity
   a. Scope of Practice
9. Confidentiality
   a. Patient's Bill of Rights
   b. Computerized information systems
10. Justice
    a. Distributive justice
    b. Compensatory justice
    c. Retributive justice

II. Provider/Patient Relationship

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

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

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

D. Competency determination

III. Confidentiality and Health Care Information

A. Confidentiality
   1. Record use
   2. Third-party payers
   3. Legal perspective

IV. Clinical Ethics Throughout the Life Span

A. Ages
   1. Pregnancy
   2. Infants
   3. Children and Adolescents
   4. Elderly

B. Treating the family

C. Futility

D. Brain death and organ procurement

E. Death and dying
   1. Advanced Directives

2. Proxy decision-making standards
3. Informed nonconsent
4. DNR orders
5. Euthanasia
6. Hospice

V. Ethical Issues in Health Care

A. Ethical decision-making models

B. Abortion

C. Genetic science and biomedical technology

D. Justice and the allocation of scarce resources

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

VI. Biomedical Ethics and Health Care Policy

VII. Role of the Radiation Therapist in Health Care Issues

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 interrelatedness 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 law

B. Civil law

C. Constitutional law

D. Administrative law

II. Intentional Torts

A. Assault and battery

B. False imprisonment

C. Intentional infliction of emotional distress

D. Defamation

E. Vicarious liability

F. Communication as a deterrent to legal action

III. Negligence

A. Elements of a negligent act

B. Comparative negligence

C. Contributory negligence

D. Medical negligence

E. Doctrine of *res ipsa loquitur*

F. Negligence related to clinical practice issues

G. Elements to reduce charges of negligence

H. Defenses against charges of negligence

IV. The Lawsuit

A. Complaint

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

VI. Safety Issues

A. Developing a safety program

B. Equipment safety

VII. Documentation and Record Maintenance

A. Record requirements of JCAHO accreditation

B. Critical documentation

C. Correction of documentation

D. Ownership of records

VIII. Risk Management

A. Professional medical liability

B. Risk analysis

C. Role of the radiation therapist in risk management

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

Content

I. Introduction to the Origin of Medical Terminology

A. Primary language sources
   1. Greek
   2. Latin

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

II. The Word-building Process

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

B. Combining forms

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

D. Translation of terms into common language

E. Correct pronunciation of medical terms

III. Medical Abbreviations and Symbols

A. Role in communications

B. Abbreviations
   1. Examples
   2. Interpretations

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

Radiation Therapy Patient Care

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

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

Content

I. Introduction

A. The multidisciplinary health care team
   1. Responsibilities
   2. Patient Bill of Rights

B. The radiation oncology team
   1. Responsibilities
   2. Radiation therapist Scope of Practice
   3. Radiation therapist Code of Ethics

II. Communication in Patient Care

A. Health-illness continuum

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

C. Communication
   1. Verbal
   2. Nonverbal
   3. Challenges in patient communication
      a. Hearing, vision and speech problems
      b. Impaired mental function
      c. Altered states of consciousness
      d. Pediatric and adolescent patients
      e. Geriatric patients
      f. Communicating in stressful circumstances
      g. Cultural diversity
      h. Artificial speech
         1) Transesophageal puncture (TEP)
         2) Esophageal speech
         3) Electrolarynx devices
   4. Other factors that impede communication
      a. Colloquialism/slang
      b. Medical jargon
   5. Feedback

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

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

2. Patient's emotional responses
    a. General behavior
    b. Influencing factors
        1) Age
        2) Sex
        3) Marital/family status
        4) Socioeconomic factors
        5) Cultural/religious variations
        6) Physical condition
        7) Self-image
        8) Life experiences
        9) Beliefs/values
        10) Attitudes
        11) Prejudices
        12) Self-awareness

III. Patient Family Interactions

A. Patient identification

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

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

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

IV. Recognizing Daily Side Effects

A. Dose

B. Fractionation

C. Combination with chemotherapy

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

V. Evaluating 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. Normal values
   6. Interfering factors
   7. Terminology
   8. Adult vs. pediatric
   9. Documentation

E. Weight

F. Laboratory values

VI. Patient Examination

A. Observation
   1. Patient status evaluation
   2. Records
      a. Diagnostic
      b. Chart information

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

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

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

E. Equipment/instruments
   1. Identification
   2. Care

VII. Health Safety

A. Terminology
   1. Nosocomial

2. Communicable
3. Infectious pathogens

B. Centers for Disease Control (CDC)
   1. Purpose

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. Procedure
         1) Soap
         2) Water
         3) Friction
         4) 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. Techniques
    a. Dress
    b. Hair
    c. Hand-washing
    d. Gloves
    e. Eye protection
    f. Cleaning and proper disposal of contaminated waste
4. Practicum

F. Isolation techniques and communicable diseases
1. Category-specific
2. Disease-specific
3. Universal precautions
4. Examples
    a. Human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS)
    b. Hepatitis
        1) Type A
        2) Type B
        3) Type C
    c. Tuberculosis (TB)
    d. 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. Abbreviations/equivalents
5. Pharmacology
a. Adrenergics
b. Adrenergic blocking agents
c. Analgesics
d. Anesthetics
e. Antiarrhythmics
f. Antibacterials
g. Anticholinergics
h. Anticoagulants
i. Anticonvulsants
j. Antidepressants
k. Antiemetics
l. Antineoplastics
1) Actions and administration
a) Drugs
(1) Alkylating agents
(2) Antimetabolites
(a) Folic acid analogs
(b) Pyrimidine analogs
(c) Cytosine arabinoside (ARA-C)
(d) Purine analogs
(3) Antineoplastic antibiotics
(4) Vinca alkaloids
(5) Hormones

(6) Miscellaneous agents

b) Actions/side effects
   (1) Method of action
      (a) Alopecia
      (b) Bone marrow depression/recombinant DNA technology
      (c) Organ toxicity
         (i) Neurotoxicity
         (ii) Cardiovascular toxicity
      (d) GI disturbances
   (2) Other

c) Administration
   (1) Definition of cycle
   (2) Dosage
   (3) Adjuvant
   (4) Neoadjuvant
   (5) Intense (transplant)
   (6) Directed delivery (e.g., monoclonal antibodies)
   (7) Induction of tumor differentiation
   (8) Clinical research
      (a) Phase I trials
      (b) Phase II trials
      (c) Phase III trials

m. Antifungals
n. Antihistamines
o. Antiperistaltics
p. Antipyretics
q. Antitussives
r. Barbiturates
s. Cardiac depressants
t. Cardiac stimulants
u. Cathartics
v. Contrast media
w. Diuretics
x. Emetics
y. Hypoglycemics
z. Narcotics
   1) Narcotic antagonists
aa. Radioactive materials
bb. Sedatives
cc. Skeletal muscle relaxants
dd. Stimulants
ee. Tranquilizers
ff. Vasodilators

6. Biological response modifiers
    a. Monoclonal antibodies
    b. Immunotherapy
7. Nutrients, fluids and electrolytes
8. Drug absorption

C. Medication administration
1. Five right system
    a. Right dose
    b. Right medication
    c. Right patient
    d. Right time
    e. Right route
2. Routes of administration
    a. Local
        1) Astringent
        2) Antiseptic
        3) Emollient
        4) Cleansing
    b. Systemic
        1) Oral
        2) Sublingual
        3) Rectal
        4) Parenteral
            a) Intradermal
            b) Subcutaneous
            c) Intravenous
            d) Intrathecal
            e) Hypodermoclysis
            f) Other
3. Equipment
4. Special precautions
5. Monitoring intravenous infusions
6. Charting
7. Adverse reactions
    a. Pyrogens
    b. Embolus
        1) Plastic
        2) Air
    c. Circulatory overload
    d. Allergic reactions
    e. Infiltration
    f. Shock
8. Disposal of equipment and drugs

IX. Medical Emergencies

A. Terminology

B. Emergency equipment

C. Latex reactions

D. Shock
   1. Signs and symptoms
   2. Types
      a. Hypovolemic
      b. Septic
      c. Cardiogenic
      d. Neurogenic
      e. Anaphylactic/allergic
   3. Medical intervention

E. Diabetic
   1. Hypoglycemia
      a. Signs and symptoms
      b. Medical intervention
   2. Ketoacidosis
      a. Signs and symptoms
      b. Medical intervention
   3. Hyperosmolar coma
      a. Signs and symptoms
      b. Medical intervention

F. Respiratory and cardiac failure
   1. Symptoms
   2. Medical intervention
   3. Adult vs. pediatric
   4. Crash cart

G. Airway obstruction
   1. Symptoms
   2. Medical intervention
   3. Adult vs. pediatric

H. Cerebral vascular accident (CVA)/stroke
   1. Symptoms
   2. Medical intervention

I. Fainting (syncope)
   1. Symptoms
   2. Medical intervention

J. Convulsive seizures
   1. Types
      a. Petit mal
      b. Grand mal
   2. Symptoms
   3. Medical intervention

K. Other medical conditions
   1. Epistaxis
   2. Nausea
   3. Postural hypotension
   4. Vertigo
   5. Asthma
   6. Wounds

L. Disease specific
   1. Superior vena cava (SVC) syndrome
   2. Spinal cord compression
   3. Severe tumor bleed

X. Dealing With Acute Situations

XI. Care of Patients With Tubes

A. Terminology

B. Nasogastric/nasointestinal
   1. Purpose
   2. Types
   3. Passage
   4. Location
   5. Removal
   6. Special precautions

C. Suction
   1. Purpose
   2. Emergency
   3. Equipment
   4. Procedure

5. Adult vs. pediatric
6. Special precautions

D. Tracheostomy
   1. Purpose
   2. Emergency
   3. Equipment
   4. Procedure
   5. Removal
   6. Special precautions
   7. Suction techniques
   8. Cardiopulmonary resuscitation (CPR)

E. Chest tube
   1. Purpose
   2. Equipment
   3. Procedure
   4. Removal
   5. Special precautions

F. Tissue drains
   1. Purpose
   2. Equipment
   3. Procedure
   4. Removal
   5. Special precautions

G. Oxygen administration
   1. Purpose
   2. Values
   3. Oxygen therapy
   4. Oxygen delivery systems
      a. Low-flow systems
      b. High-flow systems
   5. Documentation
   6. Special precautions

H. Urinary collection
   1. Purpose
   2. Equipment
   3. Procedure
      a. Male
      b. Female

4. Removal
5. Alternative methods of urinary drainage
6. Documentation
7. Special precautions

I. Other ostomies
1. Ileostomy
2. Ureteroileostomy

XII. Patient Care for Diagnostic Exams

A. Cardiac monitoring
1. Preparation for cardiac monitoring
2. Electrocardiogram (ECG) rhythms
3. Patient care considerations
a. Adverse reactions
1) Reactions to contrast media
2) Other medical conditions

B. Computerized tomography
1. Patient education
2. Patient care
3. Drug administration
4. Special precautions

C. Magnetic resonance
1. Patient education
2. Patient care
3. Drug administration

D. Ultrasound
1. Patient education
2. Patient care
3. Special precautions

E. Nuclear medicine
1. Patient education
a. Bone scan
b. Brain scan

F. PET Scan

G. Upper/Lower GI
1. Patient prep

2. Patient procedure
3. Contraindications

H. IVP
1. Patient prep
2. Patient procedure
3. Contraindications

I. Barium studies
1. Preparation for procedure
   a. Diet
   b. Cathartics
   c. Enemas
      1) Saline
      2) Fleet
      3) Oil retention
      4) Tap water
      5) Soap suds
   d. Procedure

XIII. Patient Care During Brachytherapy Procedures

A. Patient care
1. Physical and psychological response to treatment
2. Negative effects, reactions and therapeutic responses
3. Interruption of treatment when conditions warrant
4. Providing patient care as appropriate
5. Detection, documentation and reporting significant changes in patient condition
6. Creating a safe environment for patient
   a. Radiation protection
      1) Time, distance and shielding
      2) Quality control tests for treatment equipment
      3) Detecting equipment malfunctions and taking appropriate action
   b. Universal precautions
   c. Biohazards
7. Interstitial/intracavitary
   a. Safety measures
   b. Respiratory care
   c. Nutritional care
   d. Urinary care
   e. Medications
   f. Contraindications
8. Follow-up patient care
   a. Expected effects

b. Immediate effects
c. Late effects

9. Patients/family caregiving

XIV. Nutrition

A. Counseling

B. Terminology
1. Pharyngitis
2. Mucositis
3. Anorexia
4. Cachexia
5. Xerostomia
6. Dysphagia
7. Early satiety
8. Nausea
9. Vomiting
10. Constipation

C. Types of malnutrition
1. Primary
a. Lack of withholding of food
b. Types
1) Anorexia nervosa
2) Bulimia
2. Secondary (malignancy-related)

D. Association of dietary factors with cancer

E. Benefits of good nutritional support to cancer patients
1. Effect of diet on outcome of therapy

F. Types of diet
1. Sodium regulation
2. Residue regulation
3. Caloric regulation
4. Protein regulation
5. Pre-existing diabetes
6. Renal failure
7. Other

G. Establishing a dietary plan
    1. Eating hints
        a. General
        b. Irradiated site specific
    2. Dietary supplements
    3. Monitor progress
    4. Documentation

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

XV. Physical Activity Considerations

A. Karnofsky scale/performance status

B. Restrictions

C. Limitations

XVI. Safety and Transfer Positioning

A. Safety
    1. Fire
    2. Electrical
    3. Hazardous materials
    4. Radioactive materials
    5. Personal belongings
    6. Occupational Safety and Health Administration (OSHA)

B. Body mechanics
    1. Proper body alignment
    2. Proper movement
    3. Proper balance
    4. Practicum

C. Patient transfer and movement
    1. Assessing the patient's mobility
    2. Rules for safe patient transfer
    3. Wheelchair transfer
    4. Stretcher transfer
        a. Sheer transfer
        b. Three-carrier lift

c. The log roll
d. Positioning for safety, comfort and/or exams

5. Disabled patients
6. Geriatric patients
7. Pediatric patients
8. Patients with intravenous infusion
9. Metastatic disease
10. Practicum

D. Positioning for safety and comfort
1. Positions
a. Supine
b. Protective side-lying
c. Protective prone position
d. Fowler's
e. Semi-Fowler's
f. Sims'
g. Trendelenburg
h. Lithotomy
i. Knee chest
2. Safety straps and rails

E. Restraints and immobilization methods
1. Purpose
2. Adult
a. Types
b. Applications
3. Pediatric
a. Types
b. Applications

F. Accidents and incident reports

XVII. Methods of Patient Education

A. Procedure
1. Written
2. Oral
3. Visual

B. Teaching and Learning Theories

C. Interactions
    1. Verbal
    2. Non-verbal

XVIII. Alternative and Complementary Treatments

A. Types
    1. Machines and devices
    2. Nutrition and diets
    3. Chemicals and potions
    4. Psychic and mystical methods

B. Quackery
    1. Research data and federal/state legislation
    2. Role of radiation therapist in quackery

C. Differences in alternative medicine and quackery

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 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. As low as reasonably achievable (ALARA) concept
   4. Comparable risk
   5. Negligible individual risk level (NIRL)

D. Sources of radiation
   1. Natural
   2. Man-made

E. Legal and ethical responsibilities

II. Units, Detection and Measurement

A. Physical unit of exposure

B. Biologic unit of dose

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

D. Physical unit of radioactivity

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

III. Surveys, Regulatory Agencies and Regulations

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

B. Equipment survey
   1. Conditions
   2. Radiographic and fluoroscopic equipment
   3. Gamma-beam teletherapy equipment
   4. Other teletherapy equipment, i.e., linear accelerators

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

D. Regulatory agencies
   1. ICRP
   2. NCRP
   3. NCR
   4. The Consumer-Patient Radiation Health and Safety Act of 1981
   5. State agencies

E. Radiation protection officer
   1. Requirement
   2. Responsibilities

IV. Personnel Monitoring and Maximum Permissible Dose

A. Requirements for personnel monitoring

B. Methods and types of personnel monitors
   1. Film badge
      a. Body badge
      b. Ring badge
   2. Thermoluminescent dosimeters (TLDs)
   3. Pocket ionization chambers
   4. Other

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

D. Maximum permissible dose equivalent
   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
      a. Materials
      b. Primary
      c. Secondary (scatter and leakage)
      d. Mazes/doors/conduits/ducts
   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. X-ray equipment safety
      a. Beam defining equipment
      b. Exposure control devices
      c. On and off switches
      d. Performance standards per design specifications
      e. Calibrations
      f. Quality assurance
      g. Emergency switches/brakers

B. Regulations and recommendations
   1. Current NRC recommendations and/or regulations
   2. Current NCRP recommendations and/or regulations

C. Cardinal principles in protection
   1. Time
   2. Distance
   3. Shielding

D. Emergency procedures

VI. Brachytherapy

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

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

C. Surveys
   1. Leak testing
   2. Area/room surveys
   3. Methods, documentation, frequency

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

E. Management of accidents
   1. Procedures for confinement and decontamination
   2. Notifications
   3. Records

F. Quality assurance for brachytherapy

Pathology

Description
The course content is presented in two parts: general pathology and neoplasia. General pathology introduces basic disease concepts, theories of disease causation and system-by-system pathophysiologic disorders most frequently encountered in clinical practice. Neoplasia provides an in-depth study of new and abnormal development of cells. The processes involved in the development and classification of both benign and malignant tumors and site-specific information on malignant tumors is presented.

Objectives
Part One: General Pathology
1. Define terminology used in the study of disease.
2. Describe the general principles and mechanisms of disease including neoplasms.
3. Describe the physiological response in inflammation and cell injury due to pathological insult.
4. Differentiate between the processes of various types of cellular and tissue injury and adaptive mechanisms.
5. Describe the disorders of fluid and electrolyte balance.
6. Assess the relationship between morphologic and functional changes to the origins of signs and symptoms and to their clinical significance.
7. Differentiate between the mechanisms of tissue repair and healing.
8. Propose appropriate diagnostic tests based upon patient symptoms.
9. Identify common tests used to diagnose disease.
10. Examine the role of genetics in pathophysiologic disorders.
11. Examine the role of nutrition in pathophysiologic disorders.
12. Describe the common etiology, signs and symptoms, diagnostic tests, typical course and management of the common diseases and disorders of body systems.
13. Discuss the common effects of aging on each of the body systems.
14. Identify etiologic influence in the identification of prevention and screening programs for the most common diseases.
15. Assess the epidemiological influence in the identification and treatment of pathophysiological disorders.

Part Two: Neoplasia
1. Define terminology related to neoplasia and neoplasms.
2. Describe the microscopic features of malignant neoplasms and compare them with those of benign neoplasms.
3. Differentiate between the effects of benign and malignant neoplasms.
4. Differentiate between the processes involved in pathogenesis and carcinogenesis.
5. Discuss the genetic and epigenetic theories of cancer.
6. Discuss tumor classification based on histology pathogenesis and tumor characteristics.

7. Compare the techniques and value of light microscopy with those of electron microscopy in the study of neoplasms.
8. Compare the use of hematoxylin and eosin (H & E) staining, immunofluorescence and immunoperoxidase in the study of neoplasms.
9. Describe the uses of radioactive isotopes in the diagnostic and therapeutic aspects of clinical medicine.
10. Describe the role of molecular probes and other markers in the diagnosis of malignancy.
11. Describe the role of radiographic evaluation in the diagnosis of malignancy.
12. Discuss principles of staging and grading disease.
13. Determine the prognostic factors in order of importance for specific cancers.
14. Analyze the methods of spread based upon cancer origin.
15. Evaluate clinical case studies for comparison with published tumor site-specific information.
16. Compare the characteristics of site-specific tumors.
17. Discuss the rationale for therapeutic pathways for site-specific tumors.
18. Discuss the impact of other pathophysiologic disorders on the response of patients to radiation therapy treatment.

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. Genetics

A. Overview

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

C. Effects of aging on system

VII. Immune System

A. Overview

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

C. Effects of aging on system

VIII. Integumentary System

A. Overview

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

C. Effects of aging on system

IX. Musculoskeletal System

A. Overview

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

C. Effects of aging on system

X. Cardiovascular System

A. Overview

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

C. Effects of aging on system

XI. Respiratory System

A. Overview

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

C. Effects of aging on system

XII. Digestive System

A. Overview

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

C. Effects of aging on system

XIII. Liver, Gallbladder and Pancreas

A. Overview

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

C. Effects of aging on system

XIV. Endocrine System

A. Overview

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

C. Effects of aging on system

XV. Urinary System

A. Overview

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

C. Effects of aging on system

XVI. Reproductive System

A. Overview

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

C. Effects of aging on system

XVII. Blood and Blood-Forming Organs

A. Overview

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

C. Effects of aging on system

XVIII. Eye and Ear Organs

A. Overview

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

C. Effects of aging on system

XIX. Nervous System

A. Overview

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

C. Effects of aging on system

XX. Mental Health Disease and Disorders

A. Overview

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

C. Effects of aging on system

Part Two: Neoplasia

I. Introduction

A. Overview

B. Terminology

II. Nomenclature

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

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

III. Carcinogenesis

A. Theories
   1. Genetic
   2. Epigenetic

B. Prevention

IV. Diagnosis

A. Medical history

B. Physical examination

C. Biopsy

D. Microscopy
   1. Light microscope
   2. Electron microscope
   3. Specimen preparation techniques
   4. Malignant morphologic characteristics

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

F. Radiologic 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. Patterns of Spread

A. Direct invasion

B. Lymphatic

C. Blood

D. Seeding

VIII. Head and Neck Malignancies

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread

F. Grading and staging system

G. Treatment rationale

H. Prognosis

IX. Central Nervous System Malignancies

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread

F. Grading and staging system

G. Treatment rationale

H. Prognosis

X. Respiratory System Malignancies

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread

F. Grading and staging system

G. Treatment rationale

H. Prognosis

XI. Digestive System Malignancies

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread

F. Grading and staging system

G. Treatment rationale

H. Prognosis

XII. Reproductive System Malignancies

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread

F. Grading and staging system

G. Treatment rationale

H. Prognosis

XIII. Urinary System Malignancies

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread

F. Grading and staging system

G. Treatment rationale

H. Prognosis

XIV. Endocrine System Malignancies

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread

F. Grading and staging system

G. Treatment rationale

H. Prognosis

XV. Circulatory System Malignancies

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread

F. Grading and staging system

G. Treatment rationale

H. Prognosis

XVI. Lymphatic System Malignancies

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread

F. Grading and staging system

G. Treatment rationale

H. Prognosis

XVII. Integumentary System Malignancies

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread

F. Grading and staging system

G. Treatment rationale

H. Prognosis

XVIII. Musculoskeletal System Malignancies

A. Etiology and epidemiology

B. Histopathology

C. Pathogenesis

D. Presenting symptoms

E. Mechanism and pattern of spread
F. Grading and staging system

G. Treatment rationale

H. Prognosis

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. Identify the components on a schematic resistance circuit diagram.
26. Apply Ohm's Law to resolve direct current problems.
27. Apply power formulas to determine power consumed.
28. Compare electrical measuring devices.
29. Discuss electrical protective devices.
30. Discuss the interaction between electric and magnetic fields.

31. Compare types of electromagnetic induction.
32. Compare types and functions of generators, motors, transformers and rectification systems.
33. Compare single phase, three phase, high frequency and falling load generators in terms of radiation production and efficiency.
34. Explain the purpose of rectification.
35. Compare solid state and vacuum tube rectification.
36. Describe the characteristics and functions of a cathode and rotating anode.
37. Describe the construction and function of tube housing.
38. Identify the parts of an x-ray tube.
39. Calculate the maximum allowable exposure factors for various radiographic procedures using a tube rating chart.
40. Determine heat units and cooling characteristics of x-ray tube housings.
41. Propose methods to extend tube life.
42. Identify the parts of a complete x-ray circuit.
43. Discuss application and components of automatic exposure devices.
44. State the principles of x-ray production.
45. Compare the production of bremsstrahlung with the production of characteristic radiations.
46. Compare various photon interactions in terms of description of interaction, relation to atomic number and applications.
47. Define photodisintegration.
48. Discuss relationships of wavelength and frequency to beam characteristics.
49. 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
   1. Inertia
   2. Momentum

B. Force
   1. Work
   2. Power

C. Energy
   1. Types
   2. Laws of conservation

D. Relationship between matter and energy

E. Forces of nature
   1. Gravitational
   2. Electrical
   3. Magnetic
   4. Nuclear

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 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. Measuring devices
   1. Galvanometer
   2. Ammeter
   3. Voltmeter
   4. Electrometer
   5. Other

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

X. Electromagnetism

A. Interaction between electric/magnetic fields

B. Induction
   1. Self
   2. Mutual

C. Applications
    1. Generators
        a. Types
        b. Function
    2. Motors
        a. Types
        b. Function
    3. Transformers
        a. Types
        b. Function
    4. Coils
        a. Types
        b. Function

XI. Rectification

A. Definition

B. Purpose

C. Devices
    1. Solid state
        a. Function
        b. Advantages/disadvantages
    2. Vacuum tubes
        a. Function
        b. Advantages/disadvantages

D. Types
    1. Half wave
    2. Full wave
    3. Three phase

XII. Diagnostic X-ray Tubes

A. Construction
    1. Anode
        a. Description
        b. Function
        c. Stationary/rotating
    2. Cathode
        a. Description
        b. Function

3. Tube housing
    a. Description
    b. Function
4. Thermal capacity
    a. Tube rating
    b. Anode cooling
    c. Housing cooling

XIII. X-ray Circuits

A. Primary circuit
    1. Components
    2. Function

B. Secondary circuit
    1. Components
    2. Function

C. Filament circuit
    1. Components
    2. Function

XIV. Production and Characteristics of Radiation

A. X-ray production
    1. Historical introduction
    2. Principle
    3. Processes
        a. Bremsstrahlung
        b. Characteristic
    4. Necessary conditions
        a. Source
        b. Acceleration
        c. Deceleration
    5. X-ray energy spectra
    6. 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)
      a. Description of interaction
      b. Relation to atomic number
      c. Energy of incident photon and resulting product
      d. Probability
      e. Application
   3. Photoelectric effect
      a. Description of interaction
      b. Relation to atomic number
      c. Energy of incident photon and resulting product
      d. Probability
      e. Application
   4. Compton scattering
      a. Description of interaction
      b. Relation to atomic number
      c. Energy
      d. Probability
      e. Application
   5. Pair production
      a. Description of interaction
      b. Relation to atomic number
      c. Energy
      d. Probability
      e. Application
      f. Annihilation reaction
   6. 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 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. Explain nuclear stability and types of radioactive decay.
4. Categorize the four fundamental forces of nature.
5. Describe electromagnetic (EM) radiation and the characteristics of the EM spectrum and the various radiations.
6. Describe the processes of ionization and excitation.
7. Define and compare radioactivity, decay constant, activity and half-life.
8. Differentiate between artificially produced and naturally occurring therapeutic nuclides.
9. Examine the radioactive series and the decay schemes for commonly used radiation therapy nuclides.
10. Differentiate between the commonly used radiation therapy nuclides.
11. Explain the various forms of radioactive equilibrium.
12. Calculate rate of decay, change in activity, average life and attenuation requirements for a give isotope.
13. Identify nuclear reactions by recognizing the projectile and radiation emitted.
14. Define fission and fusion.
15. Discuss the activation of nuclides in terms of yield, probability, activity growth and saturation activity.
16. Describe methods of artificial production of radionuclides and their use in medical applications.
17. Discuss the purpose of the major components of a nuclear reactor.
18. Describe x-ray production for linear accelerators.
19. Explain the factors that influence x-ray production and output.
20. Describe the energy ranges and characteristics of the various radiation therapy modalities (Grenz-ray through megavoltage).
21. Describe all components of a linear accelerator.
22. Compare the characteristics of other radiation therapy beams (betatron, cyclotron, microtron and other accelerated particles).
23. State the gamma energies and average gamma energy of Cobalt-60 (^{60}Co).

24. Define specific activity and discuss the maximum and average specific activity of a typical ^{60}Co source.
25. Describe the beam and beam edge characteristics of a ^{60}Co beam.
26. Describe the basic components of a ^{60}Co unit.
27. Describe the production and construction of a ^{60}Co source.
28. Compare the characteristics of an isotope beam and an artificially produced beam.
29. Discuss the historical development of external beam radiation therapy.
30. Explain linear energy transfer (LET).
31. Compare photon interactions with matter and classify radiations produced by direct and indirect ionization.
32. Explain major influencing factors of photon beam attenuation.
33. Describe the parameters of narrow beam geometry used in the measurement of attenuation.
34. Plot heteroenergetic and monoenergetic beam attenuation data.
35. Calculate half value layer (HVL).
36. Explain the purpose of *homogeneity coefficient*.
37. Calculate attenuation requirements for beam modification devices.
38. Discuss activation of clinical accessories and alternate shielding materials due to photodisentigration.
39. Explain charged particle interactions with matter, describing dose deposition, energy loss and shielding requirements.
40. Define mass stopping power.
41. Describe a Bragg curve.
42. Discuss the purpose and importance of the National Institute of Standards and Technology (NIST).
43. Discuss the purpose and importance of the Accredited Dosimetry Calibration Labs (ADCL).
44. Choose the appropriate type of radiation detector for given clinical applications.
45. Explain how correction factors for chamber calibration, temperature, pressure and other factors are used to correct a chamber reading.
46. Participate in external beam calibration.
47. Evaluate spot checks of external beam exposure to determine beam consistency and symmetry.
48. Describe the quality of a gamma-ray (γ) beam in terms of HVL, γ energy or mean γ energy/nuclide of origin.
49. 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.
50. Calculate the approximate mean energy of a megavoltage beam.
51. Compare absorbed dose vs. exposure.
52. Discuss the relationship between kinetic energy released in the medium (KERMA), exposure and absorbed dose.

53. Calculate air dose to absorbed dose conversions in tissue, including but not limited to energy considerations, applicable conversion factors, necessary instrumentation and methods.
54. Discuss the clinical importance of phantom material and size when applying the Bragg-Gray Cavity Theory.
55. Critique how dose distribution measured in a phantom is used to predict dose distribution in a patient.
56. Compare the characteristics and composition of various phantoms.
57. 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. Non-ionizing vs. ionizing EM radiation

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

B. Basic x-ray circuit

C. Voltage rectification

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

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

F. Spatial distribution

G. Operating characteristics
   1. Filament current
   2. Anode/cathode potential difference
   3. Output

IV. Radiation Therapy Treatment Units (External Teletherapy)

A. X-ray and/or particle treatment beams
   1. Grenz-ray therapy
      a. Energy range
      b. Beam characteristics
         1) Maximum Dose (D_{max}) Depth
         2) Depth dose
   2. Contact therapy
      ~~a.~~ Tube voltage
      b. Tube current
      c. Treatment distance
      d. Filtration
      e. Beam characteristics
         1) D_{max} Depth
         2) Depth dose
   3. Superficial 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
   4. Orthovoltage therapy 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

5. Supervoltage therapy
    a. Tube voltage
    b. Resonant transformer
        1) Insulation of high voltage
        2) Transmission target
6. Megavoltage therapy
    a. Van de Graaff generator
        1) Basic design
        2) Energy range
        3) Electrical insulation
        4) Transmission target
    b. Linear accelerator
        1) Accelerator structure design
            a) Traveling wave
            b) Stationary wave
        2) Basic components
            a) Power supply
            b) Modulator
            c) Master oscillator
            d) Klystron vs. magnetron
            e) Microwave waveguide
            f) Electron gun
            g) Accelerator waveguide
            h) Circulator
            i) X-ray beam
            j) Electron beam
            k) Treatment head
            l) Target and flattening filter
            m) Beam collimation and monitoring
            n) Bending magnet system
            o) Gantry
        3) Betatron
            a) Basic design
            b) Energy range
            c) Photon and electron beam
            d) Clinical limitations
        4) Cyclotron
            a) Basic design
            b) Energy range of accelerated particles

c) Clinical treatment beams
d) Radionuclide production

5) Microtron
a) Basic design
b) Energy range of photons and electrons
c) Advantages

7. Heavy particle beams
a. Neutrons
1) D-T generators
2) Cyclotrons
3) Linear accelerators
b. Protons and heavy ions
1) Cyclotrons
2) Linear accelerators
c. Negative pions
1) Cyclotron
2) Linear accelerator

B. Isotope beams
1. ^{60}Cobalt
a. Gamma energies and average energy
b. Review of decay scheme
c. Specific activity
d. Typical treatment distances
e. Basic components
1) Source
2) Source housing
a) Beam collimation and penumbra
2. ^{137}Cesium
3. ^{226}Radium

V. Interaction of Ionizing Radiation

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

B. Interaction of photons
1. Photon beam attenuation
a. Influencing factors
1) Absorber atomic number dependence
2) Energy dependence

3) Absorber thickness dependence
b. Measurement of attenuation
1) Narrow beam geometry
2) Plotting of data
a) Semilog paper
(1) Monoenergetic beam
(2) Heterogeneous beam
b) Linear paper
(1) Monoenergetic beam
(2) Heterogeneous beam
c) Half value layer (HVL)
d) Attenuation coefficient (μ)
(1) Linear attenuation coefficient
(2) Mass attenuation coefficient
(3) Electronic attenuation coefficient
(4) Atomic attenuation coefficient
e) Relationship between HVL and μ
f) Homogeneity coefficient
g) 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
        1) Voltage divider
        2) Sphere-gap method
    b. Indirect measurement
        1) Fluorescence method
        2) Attenuation method
        3) Pentameter
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
    a. Rad
    b. Gray

B. Relationship between KERMA, exposure and absorbed dose

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

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

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

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

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

G. Monte Carlo Methods

IX. Dose Distribution and Scatter Analysis Overview

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

B. Depth dose distribution
   1. Percentage depth dose
      a. Dependence on beam quality and depth
         1) Dose build up 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)

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 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 Bergonie 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 4 Rs of radiobiology.
18. Describe the clinical significance of $TD_{5/5}$ and $TD_{50/5}$.
19. Discuss the concept of $LD_{50/30}$.
20. Compare the relationship of time, dose, fractionation, volume 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
      a. Protoplasm and metabolism
      b. Organic and inorganic compounds
      c. Basic cell chemistry
   3. Cell structure
      a. Cell membrane
      b. Cytoplasm
      c. Organelles
      d. Nucleus
   4. Cell growth
      a. Mitosis
      b. Meiosis
      c. Cell cycle
      d. Differentiation

B. Types of ionizing radiations
   1. Electromagnetic radiations
      a. X-rays
      b. Gamma rays
   2. Particulate radiations
      a. Electron
      b. Neutrons
      c. Protons
      d. Negative pi-meson

C. Sources of medical radiation exposure
   1. Diagnostic radiology
   2. Dental radiology
   3. Therapeutic radiology
   4. Nuclear medicine

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
   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. Non-linear
5. Linear quadratic

V. Biologic Principles of Radiation Therapy

A. Tumor cell kinetic clinical radiotherapy concepts
   1. Therapeutic ratio
   2. Cell cycle age response
   3. Radiation type
      a. High LET
      b. Low LET
   4. Four Rs of radiobiology
      a. Repair
      b. Repopulation
      c. Reoxygenation
      d. Redistribution
   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)
   7. Volume
      a. Tumor volume
      b. Treatment volume
      c. Volume vs. complications
      d. Time-dose-volume relationship

B. Chemotherapeutic considerations
   1. Chemotherapy and radiation therapy
   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

Medical Imaging and Processing

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. Describe the components and the operation of a simulator, to include the radiographic, fluoroscopic and CT units.
2. Analyze relationships of factors affecting image contrast, density and resolution to determine optimal image quality.
3. Apply techniques to enhance image details.
4. Apply techniques to reduce image distortion.
5. Select the most appropriate grid, film and screen.
6. Calculate penumbra, magnification factor and percent magnification.
7. Compare various films and intensifying screens available for portal localization and verification in radiation oncology.
8. Describe the factors associated with digital image processing, display and image data storage.
9. Formulate a plan for darkroom safe light illumination.
10. Discuss the possible causes and health implications of darkroom chemical sensitivity.
11. Discuss the effects of processing and storage on image quality.
12. Determine artifact types, cause and preventive measures needed.
13. Compare methods of silver recovery.
14. Describe Occupational Safety and Health Administration (OSHA) standards affecting processing of film.
15. Explain the basic principles of image formation for each of the following modalities: CT, MRI, ultrasound and nuclear medicine.

Content

I. Imaging Equipment

A. Simulator

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

II. Principles of Operation

A. Technical factors

1. Radiographic density
   a. Definition
   b. Acceptable range
   c. Factors
      1) mAs
      2) kVp
      3) Distance
      4) Intensifying screens
      5) Grids
      6) Beam limitation
      7) Patient considerations
      8) Processing
      9) Contrast media
      10) Other
2. Radiographic contrast
   a. Definition
   b. Types
      1) Long scale
      2) Short scale
   c. Components
      1) Subject
      2) Film
   d. Factors
      1) kVp
      2) Scattered radiation
      3) Grids

4) Beam limitation
5) Filtration
6) Intensifying screens
7) Patient considerations
8) Distance
9) Processing
10) Fog
11) Contrast media

3. Recorded detail
   a. Definition
   b. Factors
      1) Geometric unsharpness
         a) Focal film distance
         b) Object film distance
         c) Focal spot
      2) Materials unsharpness
         a) Intensifying screens
         b) Film
      3) 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/film (image receptor) relationships
5. Exposure latitude
   a. Definition
   b. Factors
      1) kVp
      2) Intensifying screens
      3) Film
6. Scattered/secondary radiation
   a. Definition
   b. Interactions
   c. Factors
      1) kVp
      2) Patient considerations

3) Beam limitation
4) Grids
5) Distance
6) Contrast media

d. Effects
1) Patient dosage
2) Image quality
3) Occupational exposure

7. Control of the remnant beam
a. kVp selection
b. Grids
1) Purpose
2) Selection
a) kVp
b) Patient considerations
c) Distance
d) Beam alignment
e) Latitude
3) Cut off
a) Definition
b) Factors
4) Artifacts

8. Technique formation
a. Purpose
1) Standardization of exposure
2) Image consistency
b. Considerations
1) Choice of technique system
2) Patient measurement
3) Processing
c. Types
1) Optimum kVp/variable mAs
2) Variable kVp/fixed mAs
3) Automated exposure
d. Applications

III. CT Simulator

A. Components
1. Gantry
a. Tube
b. Detectors
2. Table
3. Operating console

4. CPU, array processor and associated software
    a. Image display
    b. Drawing program to outline volume of interest (VOI)
    c. Beam display
        1) Sectional images
        2) Beams eye view (BEV)
            a) Gantry/table rotation
            b) Dose distributions
        3) Dose volume histograms (DVH)
5. Laser printer

B. Principles of image formation
1. Image detectors
2. Mathematical reconstruction algorithms
3. Image reformatting

C. CT acquisition controls and effects on image
1. Slice thickness
2. Slice spacing and overlap
3. mA
4. Pitch angle in spiral CT

D. CT image characteristics
1. Hounsfield units
2. Matrix size
3. Noise
4. Artifacts
    a. Motion
    b. Metal "star" artifacts
    c. Beam hardening
    d. Partial volume

E. CT image processing controls
1. Processing algorithms
2. Filtration
3. Window width
4. Window level

F. Filming images/digitally reconstructed radiographs (DRR)

G. Reformatting in 3-D

IV. Portal Imaging

A. Electronic portal imaging
   1. Image acquisition
      a. Cine
      b. Double exposure
   2. Image manipulation and display
   3. Image management/storage
      a. Picture archiving and communication systems (PACS)

B. Film for portal imaging and simulation

V. Characteristics of Films Used in Radiographic Procedures

A. Composition
   1. Components
   2. Structure
   3. Function

B. Types
   1. Construction
   2. Applications

C. Properties
   1. Contrast
      a. Definition
      b. Influence
      c. Application
   2. Speed
      a. Definition
      b. Influence
      c. Application
   3. Latitude
      a. Definition
      b. Influence
      c. Application
   4. Recorded detail
      a. Definition
      b. Influence
      c. Application
   5. Latent image formation
      a. Definition
      b. Sensitization specks
         1) Definition
         2) Location

6. Characteristic curve
    a. Definition/purpose
    b. Sensitometric equipment
    c. Graphing
    d. Interpretation
    e. Curve construction and graphing
    f. Evaluation

VI. Film Holders and Intensifying Screens

A. Film holders
    1. Cassettes
        a. Purpose
        b. Construction
        c. Application
        d. Loading/unloading
        e. Maintenance
    2. Disposable
        a. Purpose
        b. Construction
        c. Application

B. Intensifying screens
    1. Purpose
    2. Construction/composition
    3. Principles of function
        a. Fluorescence
        b. Phosphorescence
        c. Quantum noise
        d. Film/screen contact
        e. Technical influences
    4. Classifications/application
        a. Phosphor
        b. Speed
        c. Patient dosage
    5. Maintenance
        a. Handling
        b. Cleaning
        c. Testing
        d. Evaluating

VII. The Automatic Processor

A. Unit
    1. Purpose

2. Structure
    a. Components
    b. Function
3. Systems/functions
    a. Chemical
    b. Transport
    c. Replenishment
    d. Recirculation
    e. Temperature control
    f. Wash
    g. Dry

B. Processing cycle
1. Film feed
    a. Sheet
    b. Roll
2. Development
    a. Action
    b. Time
3. Fixer
    a. Action
    b. Time
4. Wash
    a. Action
    b. Time
5. Dry
    a. Action
    b. Time
6. Film exit

C. Maintenance/cleaning

D. Quality control

E. Documentation

F. Darkroom chemical sensitivity

G. Darkroom lighting
1. Safe light illumination
    a. Definition
    b. Filters

c. Bulb size/color
d. Testing

2. Warning lights

H. Film handling and storage
1. Processing considerations
a. Temperature
b. Humidity
c. Light
d. Radiation
e. Handling
2. Storage considerations
a. Temperature
b. Humidity
c. Light
d. Radiation
e. Gases/fumes
f. Handling
g. Pressure
h. Expiration date
1) Purchase consideration
2) Maximum storage time

VIII. Artifacts

A. Definition

B. Types

C. Causes

D. Effects

E. Preventive measures

IX. Silver Recovery

A. Definition

B. Rationale

C. Methods
1. Electrolytic
a. Process

b. Advantages
c. Disadvantages

2. Metallic replacement/ion exchange
   a. Process
   b. Advantages
   c. Disadvantages
3. Discarded film
   a. Unexposed
   b. Exposed

D. Security
1. Control
2. Theft
3. Misappropriation

X. Other Imaging Modalities

A. Description of each imaging modality
1. Radiography (CT, MRI, mammography, other)
2. Ultrasound
3. Nuclear medicine

B. Basic principles of image formation
1. Radiography (CT, MRI, mammography, other)
2. Ultrasound
3. Nuclear medicine

C. Advantages/disadvantages of procedures
1. Radiography (CT, MRI, mammography, other)
2. Ultrasound
3. Nuclear medicine

Principles and Practice of Radiation Therapy I

Description
Content is designed to provide an overview of cancer and the specialty of radiation therapy. The medical, biological and pathological aspect as well as the physical and technical aspects will be discussed. The roles and responsibilities of the radiation therapist, the treatment prescription, the documentation of treatment parameters and delivery will be also be discussed.

Objectives
1. Describe historical treatment methods in radiation therapy and compare to current treatment methods.
2. Discuss each of the factors taken into consideration prior to recommending that a patient be treated with radiation therapy.
3. Explain the relationship between various anatomic tumor sites and treatment modality selection.
4. Describe the effectiveness of the various types of patient positioning devices.
5. Discuss the purpose and application of beam alignment devices, beam modifiers, patient positioning and immobilization devices.
6. Compare the treatment prescription with the treatment plan.
7. Compare portal images to simulation images for accuracy.
8. Describe the role of the radiation therapist in treatment delivery.

Content

I. Introduction

A. Historical perspectives
   1. Early days (1800)
   2. The golden age (1900)
   3. The nuclear age (1950)
   4. The new millennium (2000)

II. The Cancer Problem

A. Cancer incidence

B. Cancer management

C. Cancer prevention

D. Cancer diagnosis

E. Cancer prognosis

III. Biological and Medical Aspect

A. Radiobiology
   1. Effects upon normal cells
   2. General effects upon living systems
   3. Specific effects upon various organ systems
   4. Sensitivity and tolerance of different cells and tissues
   5. Radiation sickness-symptoms, prevention and treatment

B. Pathology
   1. Terminology
   2. Nature and cause of disease

IV. Malignant Diseases

A. Malignant diseases - their nature, common varieties, common locations, growth characteristics (including differences from normal tissues), etc.

B. Purpose of radiation therapy-primary (only)

C. Treatment for cure or for palliation, adjunct to surgery or chemotherapy, and/or combination

D. Evaluation of patient for radiation therapy

E. Factors to be considered: the tumor, its nature, radiosensitivity, size, accessibility, technical possibility of delivering cancerocidal dose; margin of safety of surrounding normal tissue, general condition of the patient; whether other forms of treatment may be advisable.

V. Patient and personnel safety

A. Patient protection

B. Universal precautions

C. Hazardous materials

VI. Tumor localization

A. Anatomic location

B. Non-radiographic procedures

C. Imaging procedures

D. Topographic anatomy

VII. Treatment considerations

A. Location and extent of disease

B. Age and gender factors

C. Health status

D. Socioeconomic and cultural factors

E. Quality of life

F. Protocols

VIII. Treatment modalities

A. External beam

B. Brachytherapy

C. Systemic

IX. Technical Aspect

A. Radiation therapy equipment

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

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

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

2) Methods of radiation production
3) Half-life
4) Energy
5) Components
6) Radiation protection
7) Auxiliary devices
8) Patient observation and communication
9) Emergency procedures

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

E. Emerging technologies

X. Localization and Simulation

A. Patient caregiving
1. Patient care
2. Patient and family education
3. Patient safety

B. Tumor localization
1. Orthogonal films
2. Fluoroscopy
3. Contrast media
4. CT and MRI scans
5. Sonography
6. Other

C. Patient positioning and reproducibility

D. Radiographic exposure

E. Image processing

F. Treatment field delineation and measuring

G. Documentation of treatment parameters

H. Patient observation and communication

I. Emergency medical procedures

XI. Treatment Delivery Accessories

A. Beam directional devices
   1. Types
      a. Front and back pointers
      b. Field light and cross-hairs
      c. Laser lights
      d. Breast bridge
      e. Applicators and cones
      f. Other
   2. Purposes
   3. Applications

B. Beam modification devices
   1. Types
      a. Bolus
      b. Filters
         1) Wedge – universal, individual variable, dynamic
         2) Compensating
         3) Transmission
         4) Hardening filter
      c. Beam shaping
         1) Standard blocks
         2) Custom blocks
         3) Multileaf collimators
         4) Asymmetric collimators
      d. Other
   2. Purpose
   3. Construction
   4. Applications
   5. Other

C. Patient positioning and immobilization devices
    1. Types
        a. Positioning
            1) Couches
            2) Chairs
            3) Boards
                a) arm
                b) slant
                c) belly
                d) breast
                e) other
        b. Immobilization
            1) Casts
            2) Masks
            3) Bite blocks
            4) Vacuum bags
            5) Stereotactic frames
            6) Other
    2. Purposes
    3. Construction
    4. Applications
    5. Emerging devices

XII. Treatment Delivery

A. Patient caregiving
    1. Monitor physical and psychological response to treatment
    2. Report untoward effects, reactions and therapeutic responses
    3. Withhold treatment when conditions warrant
    4. Provide patient care as appropriate
    5. Detect, document and report significant changes in patient condition
    6. Create safe environment for patient
        a. Radiation protection
        b. Standard precautions
        c. Biohazards
        d. Environmental safety
    7. Follow-up patient care

B. Interpretation of treatment prescription

C. Evaluation and interpretation of treatment plan

D. Patient transfers

E. Patient positioning
   1. Anatomic positioning
   2. Reproducibility
   3. Stability

F. Treatment beam alignment

G. Portal imaging
   1. Manual
   2. Electronic
   3. Emerging technologies

H. Documentation of treatment
   1. Manual
   2. Electronic

I. Patient observation and communication

J. Medical emergency procedures

K. Patient and family education

XIII. Quality Assurance

A. Sources of error

B. Purpose and importance

C. Documentation/charting

D. Recording/report mechanisms

E. Equipment

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 relationship 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 character of the profession.

Objectives

1. Use tumor histology to determine pathways associated with cancer and neoplastic disease.
2. Examine the role of surgical, radiation and medical oncology to include immunotherapy in the management of neoplastic disease.
3. Discuss multidisciplinary emerging approaches to neoplastic disease management.
4. Discuss epidemiologic and etiologic information pertinent to each neoplastic site.
5. Identify dose limiting structures and their tolerances.
6. Discuss the clinical presentation for each anatomic neoplastic site.
7. Explain detection, diagnosis, grading and staging systems for each neoplastic site.
8. Implement the principles and practice of simulation to prepare a patient for treatment.
9. Apply the parameters of treatment field design and arrangement used to treat neoplastic diseases.
10. Examine the role of radiation therapy in palliative disease management.
11. Examine treatment regimens and fractionalization schemes used in palliative disease management.
12. Discuss the role of radiation therapy in the management of oncology emergencies.

Content

I. Introduction to Multidisciplinary Approaches to Neoplastic Disease Management

A. Biology of cancer

B. The pathophysiology of cancer

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

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

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

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

G. Emerging approaches to neoplastic disease management

H. Multidisciplinary treatment decisions in the management of neoplastic disease

II. Radiation Therapy Treatment of Neoplastic Disease Originating in the Central Nervous System, Ocular, Head and Neck, Lung, Alimentary Tract, Major Digestive Glands, Urinary System, Reproductive System, Breast, Hematopoietic System, Lymphoreticular System, Bone, Soft Tissue, Skin and Endocrine System

A. Epidemiology of disease site

B. Etiology of disease site

C. Pertinent anatomy and patterns of spread
   1. Dose limiting structures
   2. Routes of spread

D. Clinical presentation

E. Detection and diagnosis
   1. Physical examination
   2. Imaging studies
   3. Tumor markers
   4. Laboratory studies
   5. Surgical reports

F. Histopathology

G. Disease classification
   1. Staging
   2. Grading

H. Role of surgery, radiation therapy, chemotherapy and immunotherapy as a treatment modality

I. Multimodality treatment approach
   1. Treatment modality combinations
   2. Treatment morbidity
      a. Acute
      b. Chronic

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

5. Treatment record keeping
    a. Documentation of simulation procedures
    b. Documentation of treatment plan
    c. Documentation of calculations
    d. Documentation and reporting machine malfunction
    e. Treatment documentation

K. Assessment and management of treatment side effects
    1. Acute
    2. Chronic

L. Radiation therapy in the treatment of pediatric neoplasms
    1. Leukemia
    2. Solid tumors

M. Role of radiation therapy in the management of acquired immunodeficiency syndrome (AIDS) related neoplasms

N. Radiation therapy in the management of benign neoplasm

III. Palliative Treatment Applications

A. Common sites of metastases

B. Detection and diagnosis

C. Therapeutic management of metastases

IV. Emergency Treatment Applications

A. Types of oncologic emergencies

B. Diagnosis

C. Treatment

Quality Management

Description

Content is designed to focus on the evolution of quality management (QM) programs and continuing quality improvements in radiation oncology. Topics will include the need for quality assurance (QA) checks; QA of the clinical aspects and chart checks; film checks; the various types of evaluations and tests performed on simulators, megavoltage therapy equipment and therapy planning units; the role of radiation therapists in quality management programs; legal and regulatory implications for maintaining appropriate QM guidelines as well as the role computers and information systems serve within the radiation oncology department.

Objectives

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

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.

Content

I. Introduction to the Principles of Quality Management

A. Definition and rationale for quality measures
   1. Quality control
   2. Quality assurance
   3. Quality improvement

B. Team approach

C. Radiation therapist's role

D. Accreditation standards
   1. Federal
   2. State
   3. Institutional

E. Reporting regulations

II. Treatment Documentation

A. Methods and materials

B. Common errors

C. Purpose, procedure and frequency of chart checking

D. Charting
   1. Manual
   2. Electronic

E. Record and verify

F. Medical/legal aspects of charting
   1. Mechanical parameters
   2. Personnel parameters

G. Portal imaging
   1. Manual
   2. Electronic

H. Corrective measures

I. Documentation

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

III. General Conditions of Patient Care Area

A. Purpose, procedure and frequency of checks

B. Equipment and supplies

C. Corrective measures

D. Documentation

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

IV. Accessory Devices

A. Purpose, procedures and frequency of checks

B. Immobilizers

C. Beam modifiers

D. Attachments

E. Corrective measures

F. Documentation

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

V. Communication Devices

A. Purpose, procedure and frequency of checks

B. Visual systems

C. Audio systems

D. Corrective measures

E. Documentation

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

VI. Computerization

A. Equipment

B. Data input

C. Data output or reporting

D. Corrective measures

E. Documentation

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

VII. Treatment and Simulation/Localization Units

A. Control panel and indicator lights
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Materials and methodology
   5. Corrective measures
   6. Documentation
   7. Safety and hazards
   8. Guidelines to tolerance values

B. Mechanical and electrical safety devices
   1. Mechanical
      a. Purpose, procedure and frequency
      b. Sources of malfunction
      c. Frequency
      d. Materials and methodology

2. Electrical
    a. Purpose, procedure and frequency
    b. Sources of malfunction
    c. Frequency
    d. Materials and methodology
3. Area radiation monitoring devices
    a. Purpose, procedure and frequency
    b. Sources of malfunction
    c. Frequency
    d. Materials and methodology
4. Planning for emergencies
5. Corrective measures
6. Documentation
7. Safety and hazards
8. Guidelines to tolerance values

C. Distance indicators
1. Purpose, procedure and frequency
2. Sources of malfunction
3. Frequency
4. Materials and methodology
5. Corrective measures
6. Documentation
7. Safety and hazards
8. Guidelines to tolerance values

D. Light field, radiation field and collimator
1. Purpose, procedure and frequency
2. Sources of malfunction
3. Frequency
4. Materials and methodology
5. Corrective measures
6. Documentation
7. Safety and hazards
8. Guidelines to tolerance values

E. Machine dose rate
1. Purpose, procedure and frequency
2. Sources of malfunction
3. Frequency
4. Corrective measures

5. Materials and methodology
6. Documentation
7. Safety and hazards
8. Guidelines to tolerance values

F. Beam penetration quality
1. Purpose, procedure and frequency
2. Sources of malfunction
3. Frequency
4. Corrective measures
5. Materials and methodology
6. Documentation
7. Safety and hazards
8. Guidelines to tolerance values

G. Field symmetry and flatness
1. Purpose, procedure and frequency
2. Sources of malfunction
3. Frequency
4. Corrective measures
5. Materials and methodology
6. Documentation
7. Safety and hazards
8. Guidelines to tolerance values

H. Mechanical and optical patient alignment devices
1. Purpose, procedure and frequency
2. Sources of malfunction
3. Frequency
4. Corrective measures
5. Materials and methodology
6. Documentation
7. Safety and hazards
8. Guidelines to tolerance values

I. Linear scales on treatment tables
1. Purpose, procedure and frequency
2. Sources of malfunction
3. Frequency
4. Corrective measures
5. Materials and methodology
6. Documentation

7. Safety and hazards
8. Guidelines to tolerance values

J. Collimator rotation
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Corrective measures
   5. Materials and methodology
   6. Documentation
   7. Safety and hazards
   8. Guidelines to tolerance values

K. Gantry rotation
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Materials and methodology
   5. Corrective measures
   6. Documentation
   7. Safety and hazards
   8. Guidelines to tolerance values

L. Stability of isocenter under collimator and gantry rotation
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Corrective measures
   5. Materials and methodology
   6. Documentation
   7. Safety and hazards
   8. Guidelines to tolerance values

M. Treatment couch isocenter
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Corrective measures
   5. Materials and methodology
   6. Documentation
   7. Safety and hazards
   8. Guidelines to tolerance values

N. Film processor
   1. Purpose, procedure and frequency
   2. Sources of malfunction
   3. Frequency
   4. Corrective measures
   5. Materials and methodology
   6. Documentation
   7. Safety and hazards
   8. Guidelines to tolerance values

O. Quality measures

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

VIII. Localization/Simulation Unit

A. Output
   1. X-ray tube
      a. Test material and equipment
      b. Test procedures
      c. Evaluation and interpretation
      d. Preventive maintenance
      e. Sources of malfunction
      f. Corrective measures
   2. Fluoroscope
      a. Test material and equipment
      b. Test procedures
      c. Evaluation and interpretation
      d. Preventive maintenance
      e. Sources of malfunction
      f. Corrective measures
   3. CT component of simulator
      a. Test material and equipment
      b. Test procedures
      c. Evaluation and interpretation
      d. Preventive maintenance
      e. Sources of malfunction
      f. Corrective measures
   4. Accessories (film, screens, grids, digital equipment)
      a. Preventative maintenance sources

b. Malfunction
c. Corrective measures

5. Documentation
6. Safety hazards
7. Guidelines to tolerance values

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

IX. LDR, MDR and HDR Brachytherapy

A. Purpose, procedure and frequency of checks

B. Sources of malfunction/error

C. Materials and methodology

D. Safety and hazards

E. Corrective measures

F. Guidelines to tolerance values

G. Documentation

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

X. Medical Dosimetry and Treatment Planning

A. Purpose, procedure and frequency of checks

B. Sources of malfunction/error

C. Data acquisition

D. Materials and methodology

E. Safety and hazards

F. Corrective measures

G. Documentation

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

XI. Device Fabrication

A. Purpose, procedure and frequency of checks

B. Materials and methodology

C. Safety and hazards

D. Guidelines to tolerance values

E. Corrective measures

F. Documentation

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

Treatment Planning

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

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

28. Compare various methods of tissue compensation and the dosimetric impact.
29. Examine the fabrication of 2-D and 3-D compensators.
30. Construct manual and computerized isodose curves for all clinical variations.
31. Differentiate between isodose distributions for all clinical variations.
32. Evaluate possible corrections for treatment errors to correct misadministration of prescribed dose.
33. Differentiate between the treatment planning terms: maximum, minimum, mean, modal and median dose.
34. 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.
35. Analyze dose volume histograms relative to treatment planning.
36. Evaluate patient changes to determine the integrity of a treatment plan.
37. Describe the physical characteristics of an electron beam.
38. Compare electron beam depth dose characteristics for various energies.
39. Identify clinical factors that would influence beam type and energy selection.
40. Differentiate between standard treatment distance and virtual distance.
41. Describe how an electron stream is turned into an electron beam.
42. Discuss why equivalent squares used with photon beams are inappropriate with electron beams.
43. Describe how inhomogeneities influence electron beam path.
44. Discuss the considerations of matching an electron field to other adjacent photon or electron fields.
45. Analyze what shielding materials and what thickness would be needed to attenuate electron beams to appropriate levels in given situations.
46. Describe how electron shielding materials should be arranged for external vs. internal shielding.
47. Discuss changes in dose rate and dose distribution with changes in blocking extent, shielding thickness and electron energy.
48. Compare “rule of thumb” calculations of shielding thicknesses to measured data for electron beams.
49. Determine why specific isodose lines are prescribed for various clinical situations involving critical and non-critical structures.
50. Calculate “rule of thumb” percentage depth dose for 10%, 50%, 80% and 90% lines for various electron energies.
51. Describe the considerations in the clinical application of special electron treatments, including total skin irradiation and arc therapy.
52. Compare the general isodose pattern of other particle beams.
53. Determine clinical usefulness of various beam types and the clinical implications involved.
54. Describe clinical applications of radiosurgery.
55. Discuss the procedure and equipment used to deliver radiosurgery.
56. Describe the various imaging modalities in tumor localization and planning.
57. Discuss planning techniques used to accommodate the treatment volume shape.

58. Discuss isocenter localization for radiosurgery.
59. Identify common neoplasms treatable by radiosurgery.
60. Identify vital structures that must be considered during treatment planning.
61. Compare single dose delivery to fractionated dose delivery schedules.
62. Discuss the need for specific equipment used to deliver radiation for conformal therapy.
63. Discuss the purpose and contents of the ICRU Report 62 and supplements.
64. Discuss the computer system features necessary for conformal therapy treatment planning.
65. Identify common sites amenable to conformal therapy and the typical doses employed for those sites.
66. Compare configurations of multileaf collimation systems.
67. Discuss considerations to be taken when using multileaf collimators.
68. Review the differences between static and dynamic multileaf collimation systems.
69. Identify appropriate clinical applications for brachytherapy.
70. Compare low dose rate (LDR) to high dose rate (HDR) brachytherapy.
71. Describe the techniques and applicators used for intracavitary, interstitial and endovascular brachytherapy procedures.
72. Explain how simulation and CT data is used for source localization.
73. Discuss the objective of treatment planning for brachytherapy procedures.
74. Summarize dose specification and prescription techniques for different types of implants.
75. Compare historical implant calculation methods.
76. Describe optimization techniques used in computer aided dose calculations.
77. Discuss procedural processes and record keeping requirements for radioactive material.
78. State radiation safety requirements for LDR and HDR procedures.
79. Identify appropriate clinical applications for using IMRT.
80. 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. Maximum dose (D_{max}) depth

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

C. Influencing external patient factors
1. Oblique incidence of patient/beam defined
2. Isodose correction methods
   a. Isodose shift (%/*k* factor)
   b. Effective attenuation coefficient
   c. Effective SSD
   d. Tissue-air ratio (TAR)/tissue maximum ratio (TMR) method
   e. Other

3. Limitations of various methods
4. Isodose correction performance exercises

D. Influencing Internal Patient Factors
1. Tissue inhomogeneities
2. Beam type/energy
3. Equivalent path length
4. Isodose correction methods
    a. Isodose shift
        1) Percent
        2) *n* factor
    b. TAR ratio
    c. Power law TAR ratio
    d. Other
5. Isodose correction performance exercises

E. Treatment planning computer
1. Handling of CT (Hounsfield) numbers
2. Algorithms
3. Measured data
4. Patient individualization

II. Patient Contours

A. External contour
1. Methods
    a. Solder wire
    b. Plastics
        1) Aquaplast tube
    c. Casting
        1) Plaster
        2) Lightweight resin materials
        3) Thermal molding
    d. SSD
    e. Electronic
        1) CT
        2) Ultrasound
        3) Laser light
        4) Computer assisted
    f. Pantograph
    g. Other
2. Precautions and comparative accuracy of contouring methods (phantom slice)
3. Contouring demonstration/performance exercises

B. Internal contours
   1. Defining tumor and target volume
      a. Orthogonal radiographs
      b. Diagnostic radiographs
      c. CT images
      d. MR images
      e. Nuclear medicine images
      f. Sonograms
      g. Other
   2. Defining organs and tissues at risk
   3. Performance exercises entering tumor, target and critical structures into contour

III. Radiobiologic Dosimetric Considerations

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

B. Integral dose concepts

C. Edge effect

D. Ret calculation performance exercises

IV. Methods of Dosimetric Calculations

A. SSD techniques (percentage depth dose, PDD)
   1. Definition
   2. Concepts and basic formulas/equations
   3. Influencing factors
      a. Isodose factors
      b. Distance factor application
      c. Mayneord's "F" factor
   4. Percentage depth dose (PDD) calculation performance exercises (manual and computer assisted)
      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 performance exercises (manual and computer assisted)
    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 performance exercises (manual and computer assisted)
            1) Suggested exercises (mantle and “inverted Y” field)
            2) Applicable formulas and equations
            3) "Construct" a TAR
            4) Practical application and fabrication of a SAR ruler
            5) Computer algorithms
            6) Absorbed dose calculation
                a) Entrance dose
                b) Exit dose
                c) Entrance and exit dose summation
                d) Area of interest dose
                    (1) Target volume dose
                    (2) Critical organ dose
                    (3) Dose to multiple patient points/depths
            7) Treatment unit settings calculation
                a) Time
                b) Monitor units
            8) Weighted fields

D. Moving beam techniques
    1. Definition
    2. Concepts, basic formulas and equations
    3. Dose rate at isocenter (average TAR/TMR)
    4. Correction of first and last TAR/TMR ray values
    5. Monitor unit per degree (Gantry rotation speed)
    6. Rotation/arc calculation exercises (manual and computer assisted)
        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 calculation exercises applicable to any technique
1. Equivalent area
2. Sterling's formula and its limitations
3. Dose outside treatment field
4. Dose under block
5. Asymmetric fields

V. Prevention of Overdose and Underdose

A. General beam arrangement

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

C. Methods of field separation to correct for beam divergence into other fields
1. Definitions
2. General guidelines
a. Assessment of tumor/critical organ/surgical scar at junction
b. Surface vs. depth considerations
c. Daily reproducibility guidelines
3. Methods
a. Adjacent field junctions
1) Geometric divergence gap calculation
2) Matching of isodose curves
3) Multiple junction shift methods (moving gap)
4) Asymmetrical jaws
5) Half-beam/rotating beam block (beam splitter)
6) Gantry angulation (non-opposed central axis abutment)
7) Treatment unit head angulation (non-opposed central axis abutment)

8) Penumbra generators (spoilers, wedges)
9) Other

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

VI. Wedge Filters (2-D Compensation)

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

B. Wedge systems—varieties in clinical use
1. Individual
2. Universal
3. Variable
4. Dynamic

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

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

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

F. Mock wedge construction performance exercise

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

A. Definition

B. Purposes

C. Compensator transmission factor

D. Partial field compensation advantage—beam placement

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

F. Demonstration/performance exercises
   1. Construction of 2-D and 3-D tissue compensators
   2. Calculate absorbed dose to points of varying compensation

VIII. Clinical Applications of Treatment Beams and Accessories

A. Selection of appropriate isodose curve for clinical application
   1. Influencing parameters of isodose curve selection
      a. Field separation
      b. Radiation type
      c. Beam energy
      d. Field size
      e. Distance
      f. Penumbra
      g. Treatment outcome goal
      h. Treatment technique (SSD/SAD)
   2. Application of isodose curve to patient contour
      a. Evaluation and assessment of 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. Single beam and summation of isodose curves for multi-beam planning
   1. Single beam delivery
   2. Two beam delivery
      a. Parallel opposed
      b. Orthogonal
      c. Deliverance matched orthogonals
      d. Nonopposed/nonorthogonal
   3. Three beam delivery
      a. Single AP with opposed laterals at central isocenter
      b. Single AP with nonopposed anterior obliques
      c. Single AP with nonopposed posterior obliques
      d. Other
   4. Four beam delivery
      a. AP/PA and lateral opposed pairs with central isocenter (box technique)
      b. Oblique opposed pairs with central isocenter
      c. Oblique gapped opposed pairs with two off-center isocenters
   5. Rotation and arc delivery
      a. 360º rotation
      b. 180º arc
      c. 270º arc
      d. Skipº arcs
   6. Wedged beam delivery
      a. Wedged pair parallel opposed
      b. Single wedge parallel opposed (or tangential)
      c. Wedged pair orthogonal
      d. Open/wedged orthogonal
      e. Open/wedged opposed laterals
      f. Wedged pair and off-center single AP
      g. Wedged arc (flying wedges)

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

D. Planning of combinations
   1. Advantages/disadvantages of combined treatment approaches

a. Beam arrangements
b. Beam energies

E. Manual/computer assisted performance/exercises
1. Demonstration
a. Evaluation and assessment of all listed complex composite computer generated isodose summations
2. Performance
a. Generation of computer assisted composite plans
1) Without wedges
2) With wedges
b. Hand-summed composite plans
1) Parallel opposed
2) Three beam
3) Wedged beam
4) Four beam (optional)
5) Rotation/arc (optional)
c. Hand summation vs. computer-generated comparisons
d. Evaluation and assessment of various wedge angle/hinge angle placements on dose distribution
e. Evaluation and assessment of misadministrations on planned dose distribution
3. Exercises

IX. Optimal Treatment Planning Considerations, Evaluation and Implementation

A. Definitions
1. Tumor volume
2. Target volume
3. Treatment volume
4. Irradiated volume
5. Maximum dose within target volume
6. Minimum dose within target volume
7. Mean (average) dose within target volume
8. Modal dose within target volume
9. Median dose within target volume

B. Evaluation and assessment of dose distribution within target volume

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

D. Evaluation and assessment of dose distribution for non-critical organs/tissues

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

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

G. Dose histograms

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

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

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

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

X. Particle Beams and General Dose Distributions at D_{max}, Central Axis and Off-Axis

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

d. Prescribed dose relative to x-ray dose
e. Reported Bragg peak-like incidences

f. Surface irregularities
    1) Effect on central axis percentage depth dose
    2) Effect on general dose distribution
g. Clinical advantages/disadvantages of electron beam

3. Energy decelerators for special treatment
4. Build up bolus
5. Adjacent fields
6. Shielding materials, thicknesses, energy and dose relationship
    a. Mass stopping power (low vs. high Z)
        1) Density, Z number and electrons per gram
        2) Material choices and rationales
    b. External shielding
    c. Internal shielding (tissue interfaces)
    d. Changes in dose rate and dose distribution
    e. Thickness rule of thumb (MeV/3 = mm pb)
7. Treatment prescriptions and calculations
    a. Physician prescription to specific isodose line
    b. Critical structure
    c. Non-critical structure
    d. Rules of thumb for determining PDD
        1) 0 - 10% isodose line (MeV/2)
        2) 80% isodose line (MeV/3)
        3) 50% isodose line (depth x 2.5)
8. Applications of electron beam
    a. Single beam
        1) With compensation
        2) Without compensation
    b. Multiple beams
        1) Mixed (photon and electron)
        2) Abutting
            a) Electron fields
            b) Electron and photon fields
    c. Complex
        1) Electron arc
        2) Total skin irradiation
9. Electron beam calculation performance exercises (manual and computer assisted)
    a. Basic formulas/equations
    b. Percentage depth dose tables
    c. Virtual source distance (effective SSD)
    d. Output factors

e. Square root method
f. Output tables for blocked field in cone
g. Other
h. Absorbed dose calculation
i. Treatment unit settings calculation
    1) Time
    2) Monitor unit (mu)

B. Other particle beams
1. Neutrons
    a. General isodose curve pattern
    b. Percentage depth dose energy dependence
    c. Penumbra and adjacent structures
    d. Limited use clinically
2. Low LET 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
        9) Clinical applications
    b. Clinical applications
        1) Current
        2) Future
    c. Treatment delivery
        1) Immobilization requirements
        2) Simulation
        3) Treatment planning
        4) Treatment verification
        5) Quality assurance
        6) Equipment
            a) Cyclotron
            b) Beam modifiers
3. High LET charged particles (negative pions)
    a. Nonexponential attenuation
    b. Proximal and distal dose gradients
    c. General isodose curve pattern
    d. Bragg peak/star effect advantage
    e. Percentage depth dose energy dependence

f. Precision immobilization requirements
g. Penumbra
h. Clinical applications

4. Heavy ions
   a. Types
      1) Carbon
      2) Neon
      3) Argon
      4) Silicon
   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

XI. Stereotactic

A. Theory of radiosurgery

B. Equipment
   1. Gamma knife
   2. Linear accelerator

C. Immobilization
   1. Head frame
      a. Relocatable
      b. Non-relocatable

D. Tumor localization and planning
   1. Computed tomography
   2. MRI and linear distortion effect
   3. Digitizing images and tumor outlines
   4. Entering isocenters and implications of isocenters with placement
   5. Beam shaping
   6. Treatment planning system requirements

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

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

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

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

XII. 3-D Conformal Therapy

A. Simulation
   1. Immobilization devices
   2. Data collection
      a. Computed tomography
      b. MRI
      c. Nuclear Medicine
      d. Other

B. Treatment planning
   1. Treatment planning system
      a. System capabilities
         1) Image registration and image fusion
         2) Calculation algorithms
      b. Volume definition/nomenclature
         1) ICRU Report 62 or most current report
            a) Gross Target Volume (GTV)
            b) Clinical Target Volume (CTV)
            c) Coplanar treatment plans
      c. Plan optimization
      d. Volume analysis/Dose volume histogram (DVH)
      e. Plan output/interpretation
         1) Setup information
         2) Beam parameters
         3) Digitally reconstructed radiographs (DRR)/beams eye view (BEV)/rooms eye view (REV)

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

XIII. Brachytherapy

A. Low dose rate (LDR)/high dose rate (HDR)
    1. Definitions
    2. Applications
    3. Commonly used sources
        a. Review of source characteristics

B. Intracavitary
    1. Procedures and implant techniques
    2. Applicators

C. Interstitial
    1. Procedures and implant techniques
    2. Applicators

D. Endovascular
    1. Procedures and implant techniques
    2. Applicators

E. Source/applicator/catheter localization
    1. Orthogonal films
    2. Simulator
    3. CT

F. Implant dosimetry systems
    1. Objective of treatment planning
        a. Dose specification/prescription
            1) Point specification
            2) Volume specification

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

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

H. Radiation Safety
1. LDR procedures
   a. Quality assurance
   b. Documentation
2. HDR procedures
   a. Quality assurance
   b. Documentation

XIV. Emerging Technologies

A. Intensity modulated radiation therapy (IMRT)
1. Immobilization
2. Treatment planning
   a. Forward planning
   b. Inverse planning
3. Delivery techniques
   a. Physical compensators
   b. Multiple static segments (step and shoot)
   c. Dynamic treatment (sliding window)
   d. Dynamic conformal arcing (CD-ARC)
   e. Intensity modulated arc treatment (IMAT)
   f. Tomotherapy
4. Quality assurance
   a. Multileaf collimator
      1) Design
      2) Divergence
      3) Penumbra
      4) Interleaf leakage
      5) Intraleaf leakage
   b. Small segment dosimetry/treatment verification
      1) Dose per segment

2) Energy stability
3) Flatness and symmetry stability

4) Beam interruption effects
5) Verification of ports

B. Other

Operational Issues in Radiation Therapy

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

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

Content

I. Continuous Quality Improvement

A. Purpose

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

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

II. Human Resources

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

6. Interview process
    a. Resume writing

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

C. Employee relations

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

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

III. Accreditation

A. Joint Commission on Accreditation of Healthcare Organizations (JCAHO)

B. American College of Radiology (ACR)

C. State agencies

IV. Insurance and Billing

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

B. Supplemental insurance

C. Medicare

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

V. Departmental Budget

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

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

VI. Professional Societies and Participation Opportunities

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

Sectional Anatomy

Description
Content is designed to study normal sectional anatomy via diagrams and radiologic images.

Objectives
1. Differentiate between sagittal, coronal and axial planes of the body.
2. Review the principles of imaging for imaging modalities using relevant terminology.
3. Compare the imaging modalities for application to radiation therapy.
4. Identify normal anatomical structures on sectional images.
5. Identify topographic anatomy used to locate underlying internal structures.

Content

I. Anatomic Planes of the Body

A. Sagittal (median)

B. Coronal (frontal)

C. Axial (transverse)

II. CT Overview

A. Image formation

B. Image orientation

C. Pros and cons

III. MR Overview

A. Image formation

B. Image orientation

C. Pros and cons

IV. PET Overview

A. Image formation

B. Image orientation

C. Pros and cons

V. Ultrasound Overview

A. Image formation

B. Image orientation

C. Pros and cons

VI. Other Sectional Imaging Modalities

VII. Topographic Anatomy

A. Head and neck

B. Chest

C. Abdomen

D. Pelvis (male and female)

E. Spine and extremities

VIII. Sectional Anatomy of the Head and Neck

A. CT

B. MR

C. PET

D. Ultrasound

E. Other modalities

IX. Sectional Anatomy of the Chest

A. CT

B. MR

C. PET

D. Ultrasound

E. Other modalities

X. Sectional Anatomy of the Abdomen

A. CT

B. MR

C. PET

D. Ultrasound

E. Other modalities

XI. Sectional of the Male and Female Pelvis

A. CT

B. MR

C. PET

D. Ultrasound

E. Other modalities

XII. Sectional Anatomy of the Spine and Extremities

A. CT

B. MR

C. Other modalities

Clinical Practice

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

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

Content

I. Clinical Practice

A. Code of Ethics
   1. Scope of Practice
   2. Practice Standards
   3. Patient Bill of Rights
   4. Incident reporting mechanisms
   5. Standards for direct supervision

B. Role of health care team members
   1. Professional staff
   2. Support services

C. 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. Infection control
   2. Medications
      a. Administration
      b. Indications and contraindications
      c. Interaction
   3. Medical emergencies
   4. Pre- and postprocedural education
   5. Nutrition
   6. Physical activity considerations
   7. Safety and transfer positioning

D. Clinical competencies*

III. Simulation

A. Radiation safety and environmental protection practices

B. Equipment operation, quality control and quality assurance

C. Patient and machine monitoring

D. Patient positioning and immobilization

E. Treatment field delineation and measuring

F. Treatment volume localization

G. Imaging procedures

H. Image processing

I. Record keeping

J. Patient assessment, care, management and education

K. Clinical competencies*

IV. Treatment Planning

A. Pertinent patient information

B. Collaboration with team members

C. Equipment operation, quality control and quality assurance

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, quality control and quality assurance

C. Patient and machine monitoring

D. Treatment verification and prescription verification (port films and other appropriate mechanisms)

E. Treatment volume localization

F. Consideration of dose to critical structures

G. Patient and machine setup

H. Record keeping

I. Patient assessment, care, management and education

J. Clinical competencies*

VI. Quality Assurance and Quality Management

A. Documentation

B. General area conditions

C. Accessory devices

D. Communication devices

E. Computerization

F. Simulation and treatment units

G. Brachytherapy

H. Medical dosimetry and treatment planning

I. Device fabrication equipment

J. Clinical competencies*

*Refer to ARRT minimum core clinical competencies.

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CA - A cancer journal of clinicians. 6 issues/year. Philadelphia, Pa: Lippincott-Raven Publishers.

Cancer. 30 issues/year. New York, NY: Wiley-Liss Inc.

Health physics. 12 issues/year. Baltimore, Md: Williams & Wilkins.

International journal of radiation oncology, biology, physics. 15 issues/year. Elmsford, NY: Pergamon Press Inc.

International journal of cancer. 36 issues/year. New York, NY: Wiley-Liss.

Journal of cancer education: the official journal of the American Association for Cancer Education. 4 issues/year. Philadelphia, PA : Hanley & Belfus.

Medical dosimetry: official journal of the American Association of Medical Dosimetrists. 4 issues/year. New York, NY: Elsevier Science.

Medical physics. 12 issues/year. College Park, Md: AAPM

Oncology research. 12 issues/year. New York, NY: Pergamon Press Inc.

Radiation therapist: the journal of the radiation oncology sciences. 2 issues/year. Albuquerque, NM: American Society of Radiologic Technologists.

Radiation physics and chemistry. 12 issues/year. New York, NY: Pergamon Press Inc.

Radiologic technology. 6 issues/year. Albuquerque, NM: American Society of Radiologic Technologists.

Websites

American Registry of Radiologic Technologists
http://www.arrt.org

American Society of Radiologic Technologists
https://www.asrt.org/asrt.htm

Aunt Minnie: Radiology Daily Case Studies
http://www.auntminnie.com

Australian Institute of Radiography
http://www.a-i-r.com.au/index.html

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

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

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

Digital Radiography Home Page
http://www.bh.rmit.edu.au/mrs/DigitalRadiography/

EduMed Corporation
http://www.edumed.com

Educating Teachers for Diversity
http://www.ncrel.org/sdrs/areas/issues/educatrs/presrvce/pe300.htm

International Medical Multimedia Essentials Radiology Image Bank
http://www.immeurope.com/

Joint Review Committee on Education in Radiologic Technology
http://www.jrcert.org

MedWeb at Emory University Search Site
http://www.medweb.emory.edu/
Medical Imaging References
http://www.medtechcon.com/imaginglinks.html

National Council on Radiation Protection and Measurements (NCRP), NCRP Reports
http://www.ncrp.com

Radiation and Health Physics
http://www.umich.edu/~radinfo/

Radiography Discussion Forum
http://www.radiography.com/

Radiology Info: Terminology Glossary
http://www.radiologyinfo.org/glossary/glossary1.asp?Term=A

General Information and Radiology Search Sites
Research Center for Excellence in the Radiologic Sciences
http://www.radsciresearch.org.

Altavista
http://www.altavista.com/

Dogpile
http://dogpile.com

Google
http://google.com

Hotbot
http://hotbot.lycos.com/?query=

Metacrawler
http://www.cs.washington.edu/research/projects/WebWare1/www/metacrawler/

The Medical Radiography Home Page
http://web.wn.net/~usr/ricter/web/medradhome.html

Webcrawler
http://web.webcrawler.com/d/search/p/webcrawler/

Yahoo
http://www.yahoo.com

Yahoo Directory
http://dir.yahoo.com/Health/Medicine/Radiology/

Resources for Instructional Design and Media
Cognitive Approaches to Instructional Design
http://carbon.cudenver.edu/~bwilson/training.html

Models for Instructional Design
http://student.seas.gwu.edu/~sbraxton/ISD/design_models.html

Association of Educators in Radiological Sciences Instructional Resources
http://www.aers.org/resources.html

List of Tutorials for Educators
Learning Styles Tutorials
http://7-12educators.about.com/cs/learningstyles/index.htm

On Line Training Resources
http://library.hilton.kzn.school.za/Online/onlinetrain.html

PowerPoint Tutorials
http://www.actden.com/pp/
http://www.soniacoleman.com/Tutorials/Tutorials.htm
http://www.electricteacher.com/tutorial3.htm
http://www.powerpointbackgrounds.com/powerpointtutorials.htm
http://www.scc.rutgers.edu/lrnlinks/powerpoint.html

Land Grant Training Alliance: Software Tutorials
http://www.lgta.org/