Clinical Rotation Summaries

Radiation Oncology Clinical Medical Physics Resident Rotation - Year 1

1	Dosimetric Systems	EP	July + Aug
2	Linac Acceptance	NS/Jon	Sept + Oct
4	TG51 + MU calcs	DP/DR	Nov + Dec
5	TPS Acceptance	DS/Jon	Jan + Feb
6	TPS theory	NS	Mar + Apr
3	Brachy	AH	May + Jun

Radiation Oncology Clinical Medical Physics Resident Rotation - Year 2

July + Aug	8	Simulation	DS
Sept + Oct	9	SRS/SBRT	DP
Nov + Dec	10	Special Topics	EP
Jan + Feb	7	IMRT	NS
Mar + Apr	11	IGRT	DP
May + Jun	12	Shielding	EP/AH

During the first year, residents will alternate each month between ProMedica and UT Dana thus allowing each rotation to be spent half at UT Dana and half at Promedica.

During the second year, one PGY2 will be selected to be the primary contact physicist at Bowling Green but both PGY2s will have access to the site and be given responsibilities including Eclipse planning.

Residents Feedback

For each rotation please complete a residents' rotation feedback form and send it to Ms. Shelby Clauson when complete. This is an opportunity for you to list ant ways we can improve the resident's education or training environment so please be honest. A copy of the feedback form is available in the residents shared folder but please don't save your copies here if you wish to remain anonymous.

Rotation Reports

A template is available in the residents shared folder and one of these should be completed for each rotation. It should include a list of what tasks you completed during the rotation that are relevant to the topic. There is also an *Extracurricular Activities* section for you to list activities not related to the topic. This section should include, amongst other things, any conferences you attended, research you worked on and resident's seminars you presented. In addition, during each rotation you should complete a clinic project and document your work. Projects may be assigned to you or they may be your ideas discussed with the rotation director. The project does not need to be related to the topic of the rotation.

Residency Steering Committee

The steering committee for the residency program is tasked with making sure all residents are on track and getting the best possible education. As part of this role they are also there for you to talk to if you have any concerns. The committee meets twice a year to review residents' progress and also discuss any changes that should be made to the education program to improve your education. These improvements may be based of your rotation feedback reports or your comments to the faculty at periodic meetings that occur between you and the residency leadership.

The steering committee consists of the medical physics faculty of the Dana Cancer Center, a medical physicist from Promedica and a radiation oncologists. The current committee members are listed below.

- David Pearson, PhD (chair) x6789 david.pearson2@utoledo.edu
- E Ishmael Parsai, PhD x5113 e.parsai@utoledo.edu
- Nicholas Sperling, PhD x3599 nicholas.sperling@utoledo.edu
- Diana Shvydka, PhD x5328 diana.shvydka@utoledo.edu
- Merisha Hadziahmetovic, MD x5198 mersiha.hadziahmetovic@utoledo.edu
- Andrea Herrick, MS 419 8294-1860 andrea.herrick@promedica.org

Research & Clinical Project Expectations

Projects should be worked on whenever the clinic schedule allows. At the least, we expect residents to submit abstracts each year to national meetings. Each resident should have at least one abstract where they are the primary contributor. In addition, residents should assist students or other residents with preparing abstracts.

During each rotation the resident is asked to document a project that they have worked on that may or may not be related to the rotation topic. Residents may fill this requirement by documenting progress on research. Alternatively, the rotation project could be clinical. You may discuss a project with your faculty rotation director as they may have a specific assignment in mind. Possible examples of clinical projects include commissioning or acceptance of clinical equipment, teaching and creating a new class presentation for a graduate course, writing a new set of clinical instructions for the wiki or making measurement to verify currently commissioned equipment.

Didactic expectations

All residents should complete and document that they have completed the following didactic courses

- Radiation Safety certificate course taught by the radiation safety office.
    - Deadline: this course must be completed no later than the end of the first year. If it was taken as a graduate student then the course certificate must be copied and placed in the resident's folder for documentation.
- MPHY 6260/8260 Computers in Radiation Therapy. Residents should audit the class, offered each fall, and discuss with Dr Sperling which classes are required.
    - Deadline: The class must have been taken prior to graduation of the resident but can be taken in either fall or, if the class was taken as a graduate student then this will be accepted.
- Professionalism and Ethics. Residents should complete all modules of the course offered by the AAPM/RSNA. At the completion of each module the resident should save the completion certificate in their folder for documentation.
    - Deadline: These modules should be completed prior to December of the second year when the rotation *Special Topics* is due.

Additional Resources

The department wiki can be used to provide written instructions for a number of tasks. It can be found using the link below (a request for access will be generated upon the first attempt to connect; once granted, your university Microsoft account email, e.g. john.dow@rockets.utoledo.edu, is required for access).

RadOncMedicalPhysics

Rotation Plan for 1) Dosimetric Systems and Safety

A. Skills
   a. Linac Operation
      i. Treatment mode for Varian digital linacs with Aria/Varian Treatment Software
      ii. Service mode on Varian digital linacs
   b. Use of an Ionization Chamber and Electrometer to read dose
   c. Introduction to daily QA
      i. Observe daily QA being performed
      ii. Each resident will perform daily QA independently
   d. Safety in Radiation Therapy
      i. Failure Mode Analysis (FMEA)
      ii. Root Cause Analysis (RCA)

B. Knowledge Base
   a. Design and Basic Operation of Dose Measurement Devices
      i. Ion Chambers
      ii. Film
      iii. Metal Oxide Semiconductor Field Effect Transistor (MOSFET)
      iv. Diodes
      v. Thermoluminesence Dosimeters (TLD)
      vi. Optically Stimulated luminescent Dosimters (OSLD)
   b. Radiation Safety Principles
      i. Safety around radiation sources
      ii. Radiation packaging and signage
      iii. National and State Rules and Regulations
   c. Design and Basic Operation of Electrometers
   d. Phantoms
      i. Slabs
      ii. Anthropomorphic
      iii. Water Tanks

C. Clinical Processes
   a. Commissioning of Dose Measurement Systems
      i. Ion Chambers / Electrometers
      ii. Film
      iii. OSLDs
   b. Commissioning of 3D Water Tank
   c. Ion chamber Dosimetry System Effects
      i. Leakage
      ii. Stem Effect
      iii. Signal-to-noise for different chamber volumes
      iv. Variation with bias level and polarity at different dose rates
      v. Variation with changes in water temperature
   d. Perform dose profile measurements with each detector and compare results.
   e. Manual Film Densitometry
      i. Preparation and use of GAF Chromic film for dosimetry
      ii. Use of the film scanner to read film. RIT software use for film dosimetry
   f. Incorporating Safe Practices into the Clinic
      i. Time Out procedures
      ii. Radiation Safety in Practice
      iii. Review of ASTRO's 'Safety is No Accident' and the implementation or accident recording in radiation therapy.

Learning Objectives

1. Describe the basic principle of treatment mode, QA mode and service mode on a Varian digital linac.
2. Describe the difference between QM, QA and QC, as discussed in TG-100. Describe FMEA and RCA.
3. Describe the different types of water phantom used in the clinic
4. Describe the different sizes of ion chambers used in the clinic and describe their limitations with respect to field size
5. Describe the basic concepts of vault design and shielding.

Learning opportunities

Observe physicist measurements performed with ion chamber and phantom: monthly calibration, electron cutout measurements, IMRT QA. Observe dose verification on patient using OSLD dosimeters.

Reading List

1. The Physics of Radiation Therapy, Khan, Chs.6 and 8.
2. Task Group 142 report: Quality assurance of medical accelerators, Eric Klein et al. Med Phys. 36 (9), September 2009, p4197-4212.
3. Diode in Vivo Dosimetry for Patients Receiving External Beam Radiation Therapy (2005) Radiation Therapy Committee Task Group #62; 84pp.
4. Acceptance testing of an automated scanning water phantom David E. Mellenberg, Robert A. Dahl, and C. Robert Blackwell Med. Phys. 17, 311 (1990)
5. Radiochromic Film Dosimetry (Reprinted from Medical Physics, Vol. 25, Issue 11) (1998) Radiation Therapy Committee Task Group #55; 23 pp.

Assessment

The resident will present a report that describes each of these systems, how they operate, and results from their commissioning process. The report must give an overview of all the processes, describing the individual steps conceptually. Finally, the resident will take an oral exam. An understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated.

Rotation for 2) Linear Accelerator Acceptance Testing/Commissioning/Annual QA

Note: This rotation has three major components. The student is expected to devote sufficient time and effort to each area to attain a comprehensive understanding of each area as well as the over-arching synthesis of all 3.

1. Linear Accelerator Acceptance/Testing
    a. Fundamental concepts of linear accelerators, beam production and control.

    b. Medical linear accelerator safety features.
    c. The acceptance testing process
2. Radiotherapy Beam Data Collection for Commissioning
    a. Data definitions.
    b. Measurement (acquisition) techniques and underlying principles.
3. Medical Radiotherapy Equipment QA
    a. Linac QA
    b. Other treatment machine QA

A. Prerequisite Skills

    a. Radiation Safety –X-ray machine operation
    b. Fundamentals of Radiation Detection/Measurement
        i. Use of ionization chambers, diodes.
        ii. Use of electrometer
    c. Introduction to Monitor Unit calculation parameters.
    d. Use of radiographic films/film scanning.

B. Knowledge Base

    a. Linear Accelerator Fundamentals Relevant to Commissioning
        i. Linac components
        ii. How a linac works
    b. Medical Linear Accelerator Specifications
        i. Non-beam specifications
        ii. Beam specifications
    c. Acceptance Tests
        i. Safety-related tests (Radiation survey).
        ii. Acceptance vs Commissioning Data Collection
        iii. Non-beam tests
        iv. Beam modifier and Accessory testing.
    d. Commissioning Data Acquisition Tasks
        i. Data acquisition using scanning water phantom.
            1. Types and significance of scans
            2. Scans with different detectors
            3. Scans with different beam modifiers

        ii. Point data acquisition
        iii. Film/planar data acquisition.
        iv. Understanding of measurement selection,
    e. Analysis of Measurements and Preparation for Commissioning
        i. Preparation for MU Calc data
        ii. Preparation for TPS beam commissioning
    f. Annual QA
        i. Conceptual understanding of objectives with respect to commissioning.
        ii. Relevant measurement selection, performance and documentation of same.

C. Clinical Processes

    a. On-going QA: Use of constancy values and standards.
    b. Non-routine QA and Commissioning
        i. Post repair QA not requiring recommissioning
        ii. Post-repair QA requiring recommissioning

D. Learning Objectives:
    a. Describe the internals of the accelerator, including functions and features.
    b. Describe machine acceptance tolerances, where they may be found, and how they would be measured.
    c. Determine data necessary to clinically commission 1 photon and 1 electron beam. Collect that data, and format it for commissioning.
    d. Determine the data necessary to perform MU Calculations for 1 photon and 1 electron beam. Collect the data and in a later rotation confirm that MU calculations agree with measurements for a range of depths, field sizes and beam modifiers.
    e. Participate in the Annual QA on a linear accelerator.

Assessment:

The resident will provide a written report of principles and process of Linear Acceptance Testing, Commissioning Measurements and Annual QA with an overview and detailed descriptions of the relevant underlying principles for each major step. The report should also contain data acquired through measurements or experiment as well as analysis thereof. Finally, an understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated in an oral exam setting.

Reading List:

1. Horton, J.L., "Handbook of Radiation Therapy Physics", Prentice-Hall (1987). Chapters 5,6,7.
2. Task Group 142 report: Quality assurance of medical accelerators, Eric Klein et al. Med Phys. 36 (9), September 2009, p4197-4212.

3. Starkschall G., Steadham R., et al, "Beam-commissioning methodology for a three-dimensional convolution/superposition photon dose algorithm," Journal of Applied Clinical Medical Physics, 1:1 p 8 – 27, (2000).

4. AAPM Report #62 TG-53 Report "Quality Assurance for Clinical Radiotherapy Treatment Planning"

5. AAPM Report #56 TG-35 Report "Medical Accelerator Safety Considerations"

6. AAPM Report #7 TG-18 Report on Neutron dosimetry.

7. AAPM Report #13 TG-26 and TG-22 Report "Physical Aspects of Quality Assurance in Radiation Therapy".

8. AAPM Report #19 TG-27 Report "Neutron Measurements Around High Energy X-ray Radiotherapy Machines".

9. "Medical Linear Accelerator Fundamental Principles", Waldron T., Internal Handout/lecture materials.

Rotation Plan for 3) Brachytherapy

A. Skills

1. Brachytherapy Safety
    a. Safe source handling
    b. Time/distance/shielding
    c. Signage and packaging
2. Brachytherapy Dosimetry
    a. Exposure Rate Constant Formalism
    b. Air Kerma Strength Formalism
3. Brachytherapy Treatment Planning
    a. Dose prescription – Written directive
    b. Dose objectives – DVH parameters

B. Knowledge Base
1. Radioactive Decay
    i. Alpha
    ii. Beta
        1. Electron capture
        2. Internal conversion
    iii. Gamma
2. Radioactive Sources Commonly Used in Radiotherapy
    i. Radium
        1. Decay
        2. Source construction
        3. Source specification
        4. Exposure rate constant
        5. Applications
        6. Physical characteristics
    ii. Cesium-137
    iii. Cobalt-60
    iv. Iridium-192
    v. Gold-198
    vi. Iodine-125
    vii. Palladium-103
3. Calibration of Brachytherapy Sources
    i. Specification of source strength

        a. Activity
        b. Exposure rate at distance
        c. Equivalent mass of radium
        d. Apparent activity
        e. Air kerma strength
    ii. Exposure rate calibration
        a. Open-air measurements
        b. Well-type ion chambers

4. Calculation of dose distributions
    i. Exposure rate
        a. Sievert Integral
        b. Effects of inverse square law
    ii. Absorbed dose in tissue
    iii. Modular dose calculation model: TG-43 and TG-43 U1
    iv. Isodose curves
5. Systems of Implant Dosimetry
    i. Paterson-Parker
        a. Planar implants
        b. Volume implants
        c. Paterson-Parker tables
        d. Determination of implant area or volume
    ii. Quimby
    iii. Memorial
    iv. Paris
    v. Computer-based planning
6. Computer Dosimetry
    i. Localization of sources
        a. Orthogonal imaging method
        b. Stereo-shift method
    ii. Dose computation
7. Implantation Techniques
    i. surface molds
    ii. Interstitial therapy
    iii. Intracavitary therapy

a. Uterine cervix
b. Uterine corpus

8. Dose Specification: Cancer of the Cervix
   i. Milligram-hours
   ii. The Manchester System
      a. Bladder dose
      b. Rectum dose
   iii. The International Commission on Radiation Units and Measurements System
      a. Absorbed dose at reference points
9. Remote Afterloading Units
   i. Advantages
   ii. Disadvantages
   iii. High-dose rate versus low-dose rate

10. Prostate Seed Implants
   i. Volume Study
      a. Ultrasound imaging
      b. Volume estimate
      c. Contouring – volume for planning
   ii. Treatment planning
      a. Dose-volume constrained
      b. Nomogram based
   iii. Seed ordering
   iv. Source strength assay
   v. Implant QA checklist
   vi. Implant Procedure
      a. Seed sterilization
      b. Needle placement
      c. Seed placement
      d. Cystoscopy (seed recovery from bladder)
      e. Recovery/disposal of waste seeds
   v. Post Implant Dosimetry
      a. CT-based planning/assessment

b. Dose-volume parameters

11. High Dose Rate Brachytherapy
    a. Source Exchange/Calibration check
    b. Daily (day of treatment) QA
    c. Applicator/catheter placement
    d. Imaging for treatment planning
        i. Orthogonal images
        ii. Reconstruction geometry
        iii. CT-based planning
    e. Dose prescription/fractionation/rational
    f. Treatment planning
        i. Written Directive
        ii. Dose planning objectives
        iii. Critical structure doses
        iv. Treatment planning procedures
        v. Treatment plan QA
    g. Treatment delivery
        i. Pre-treatment survey
        ii. Attach catheters/applicator
        iii. Authorized User/Medical Physicist requirements
        iv. Treatment progress assessment
        v. Post-treatment survey
        vi. Recovery/remove catheters/applicator
    a. Emergency procedures
        i. Annual HDR safety training
        ii. Manual source retract
        iii. Stuck source
        iv. Patient safety

C. Clinical Processes
    1. Source Calibration check
        i. HDR
        ii. LDR seed

2. Low Dose Rate Cesium Implant
    i. Dosimetry planning
    ii. Hand calculation (time)
3. Implant Dosimetry Hand Calculation
    i. Paterson-Parker tables
    ii. Quimby System
    iii. Memorial System
    iv. Paris System
4. Prostate Implant procedure
    a. Volume study
    b. Treatment planning
    c. Source strength assay
    d. Implant procedure
    e. Seed recovery
    f. Post Implant Dosimetry
5. High Dose Rate Procedures
    a. Vaginal Cylinder
    b. Tandem and Ovoids
        i. Fletcher-Suit-Delcos applicator
        ii. Orthogonal Images
        iii. Bladder rectal dose points
        iv. Prescription dose (Point A)
        v. Dose optimization points
        vi. Treatment plan assessment
        vii. Treatment plan QA
        viii. Treatment Delivery
        ix. Patient recovery
    c. Interstitial Implant
        i. CT-based planning
        ii. Dose-Volume assessment
        iii. Manual plan/dose manipulation
    d. Endobronchial
        i. Pre-planned treatment template
        ii. Endoscopic-guided catheter placement

iii. Pre-treatment verification imaging

e. MammoSite (partial breast irradiation)

i. Prescription dose/fractionation/rational

ii. CT-based planning/assessment

iii. Point dose prescription/dwell time calculation

iv. Pre-treatment verification imaging

Learning Opportunities:

This rotation requires reading an extensive amount of background material.

Resident will be evaluated on the following procedures:

HDR

Ability to perform the HDR morning warmup accurately without assistance.
Ability to evaluate an HDR brachytherapy plan.
Knowledge and ability to run a basic HDR plan for a ring and tandem and vaginal cylinder.
Ability to perform a quarterly/annual HDR calibration procedure.
Adherence to radiation safety standards.

I-125

Understanding of the entire prostate seed implant procedure from beginning to end, including pre-implant, seed assay, implant, and post implant procedures.

I-131

Understanding of the entire I-131 procedure and documentation.

Laws and regulations

Understanding of the laws surrounding high and low dose brachytherapy in Ohio including:
Definition and reporting requirements for medical events
ODH Compliance audits
Exposure and contamination surveys

Reading List:

1. Radiation Therapy Physics, Hendee, Ibbott and Hendee, Chapter 1. Chapters 12 & 13, Chapter 15.
2. The Physics of Radiation Therapy, Khan, Chapters 1 & 2, Chapter 15, Chapter 17.
3. The Physics of Radiology (4^{th} Ed.), Johns and Cunningham, Chapter 13.

4. Brachytherapy Physics, 2nd Ed (2005 AAPM Summer School Proceedings), Thomadsen, Rivard, Butler (Eds), Chapters 1, 2, 3, 4, 5 (Overview & Fundamentals), Chapters 12, 13 (Localization), Chapters 14, 15, 16 (Dosimetry).
5. Code of Practice for Brachytherapy Physics (Reprinted from Medical Physics, Vol. 24, Issue 10) (1997) Radiation Therapy Committee Task Group #56; 42 pp. http://www.aapm.org/pubs/reports/rpt_59.pdf
6. ICRU. Dose and volume specification for reporting intracavitary therapy in gynecology. ICRU Report No. 38. Bethesda, MD: International Commission on Radiation Units and Measurements, 1985.
7. Collaborative Ocular Melanoma Study Group, "Collaborative Ocular Melanoma Study (COMS) randomized trial of I-125 brachytherapy for choroidal melanoma", multiple COMS Reports. See Ed Pennington for copies.
8. Radiation Therapy Physics 3rd Ed, Hendee, Ibbott and Hendee, Chapter 13 (focus pp 322-329).
9. The Physics of Radiation Therapy, Khan, Chapter 22 (HDR), Chapter 23 (Prostate Implants) and Chapter 24 (Intravascular Brachytherapy).
10. Code of Practice for Brachytherapy Physics (Reprinted from Medical Physics, Vol. 24, Issue 10) (1997) Radiation Therapy Committee Task Group #56; 42 pp. http://www.aapm.org/pubs/reports/rpt_59.pdf
11. Dosimetry of Interstitial Brachytherapy Sources (Reprinted from Medical Physics, Vol. 22, Issue 2) (1995) Radiation Therapy Committee Task Group #43; 26 pp. http://www.aapm.org/pubs/reports/rpt_51.pdf
12. Update of AAPM Task Group No. 43 Report: A revised AAPM protocol for brachytherapy dose calculations. Medical Physics, Vol. 31, Issue 3 (2004); Radiation Therapy Committee Task Group #43; 42pp. http://www.aapm.org/pubs/reports/rpt_84.pdf
13. High Dose-Rate Brachytherapy Treatment Delivery (Reprinted from Medical Physics, Vol. 25, Issue 4) (1998) Radiation Therapy Committee Task Group #59; 29 pp. http://www.aapm.org/pubs/reports/rpt_61.pdf
14. Permanent Prostate Seed Implant Brachytherapy (Reprinted from Medical Physics, Vol. 26, Issue 10) (1999) Radiation Therapy Committee Task Group #64; 23 pp. http://www.aapm.org/pubs/reports/RPT_68.pdf
15. Intravascular Brachytherapy Physics. Medical Physics, Vol. 26, Issue 2 (1999); 34pp. Radiation Therapy Committee Task Group #60.

In addition, various other research articles of interest selected in consultation with the mentoring physicist should be read in preparation for presentation at the monthly journal club.

Assessment:

There will be no final oral exam for the brachytherapy rotation. Instead, residents will be asked to complete a series of short projects to expand their knowledge on regulations and procedures related to HDR and LDR brachytherapy procedures. The reports for these projects will be due 2 weeks following the completion of the rotation. If residents are required to come back to observe more procedures, the report for that section only will be due 2 weeks following their last day or clinical brachytherapy work.

Rotation Plan for 4a) TG-51 Calibration

This rotation is taught simultaneously with 4b) MU Calculations

A. Skills
   a. Operation of ionization chamber
   b. Operation of electrometer
   c. Operation of linear accelerator
   d. Adjusting linear accelerator output
   e. Spreadsheet development and verification

B. Knowledge Base
   a. TG-51 protocol
   b. Electrometer/Chamber/water tank setup
   c. Chamber/electrometer ADCL calibration
   d. Reference point determination
   e. Calibration point determination
   f. Electrical and mechanical safety
   g. Linac operation

C. Clinical Process
   a. Set up water tank
   b. Position chamber at calibration point
   c. Connect electrometer
   d. Measure ionization
   e. Convert to dose
   f. Convert to dose/MU at reference point
   g. *Demonstrate* ability to change accelerator output *
   h. Document results
   i. Develop TG-51 reference data for future use

Learning opportunities

a. Perform TG-51 calibration for all energies on one accelerator with at least one photon energy > 10 MV. Print report summary and present results to physicist for review.

Reading list

AAPM Task Group 51 Protocol and addendum

https://www.**aapm**.org/pubs/**reports**/RPT_67.pdf

https://www.**aapm**.org/pubs/**reports**/RPT_67_Addendum.pdf

The Physics of Radiation Therapy, Khan, Ch. 8

Assessment

The resident will present a report of his/her TG-51 results for the calibrated accelerator. The report will include a summary of the processes describing the individual steps that were taken to perform the calibration. The resident will take an oral exam at the conclusion of the rotation. The resident should be able to demonstrate knowledge of the calibration process and other relevant information obtained from the reading lists.

** Under no circumstances should any dosimetric parameters be altered on any radiation producing equipment without direct supervision by a staff physicist.*

Rotation Plan 4b) for MU calculations

This rotation is taught simultaneously with 4a) TG51

A. Skills
   a. Read Dosimetry Tables for photons and electrons
   b. Use of an Ionization Chamber and Electrometer to read Dose
   c. Use of a water tank for profile and depth dose measurements
   d. Operate the Record & Verify system
   e. Operate the Linac
   f. Use and understand second check software (RadCalc)
   g. Determine the needed beam data for an MU calculation

B. Knowledge Base
   a. TMR, PDD, scatter factors, OAR, WF, TF, VWOAR, etc.
   b. Clarkson Integration, Day's method, etc.
   c. Calculation Point's Eye View and multiple source models
   d. Surface Irregularities
   e. Tissue inhomogeneities
   f. Electrons: VSID, obliquity, field size limits (range)

C. Clinical Processes
   a. MU calculations for simple field configurations
      i. Whole Brain
      ii. Crainio-spinal axis
      iii. Heterotopic bone
   b. MU calc check for simple plans (e.g. 4 field box)
   c. MU calc check for multiple field-in-field (Forward IMRT) plans
   d. MU calcs for breast (account for flash, off-axis calc points, irregular contour)
   e. MU calcs for electrons, various SSDs, calc points, bolus

D. Learning Objectives

Learning opportunities

Example patient calculations will be provided. Calculation variables will be available in the clinical dosimetry book or from sample dosimetry book. Examples will include MU calculations, field gap calculation and divergence and magnification calculations. A large number of test questions, ranging from simple to complex, will be used to allow the resident to practice.

Reading List

Recommended

The Physics of Radiation Therapy, Khan, all of Chs.9, 10, 11, 12, and 14.

Suggested

Radiation Therapy Physics, Hendee, Ibbott and Hendee, Chs. 7 and 8.

Blackburn’s Introduction to Clinical Radiation Therapy Physics (edited by S. Shahabi), focus on chapters 1 to 12 and 15.

Monitor Unit Calculations for External Photon & Electron Beams

Assessment

The resident will be given a written exam to access their ability to complete these calculations independently.

Rotation for 5) Treatment Planning System Commissioning/Acceptance; Annual/Periodic QA Testing

A. Skills acquired cover two principal aspects:

1. Radiotherapy Beam Data Collection for Commissioning of a Clinical Treatment Planning System (TPS)
    a. Data definitions
    b. Measurement (acquisition) techniques and underlying principles
    c. Data processing and preparation for importing into a Clinical TPS

2. Radiotherapy Beam Data Modeling for a Clinical TPS
    a. Photon Beam modeling
    b. Electron Beam modeling

B. Prerequisite Skills

a. Radiation Safety –X-ray machine operation

b. Fundamentals of Radiation Detection/Measurement

i. Use of ionization chambers, diodes, film-based dosimetry.

ii. Use of electrometer

g. Introduction to Monitor Unit calculation parameters .

C. Knowledge Base

a. Linear Accelerator Fundamentals Relevant to TPS Commissioning
    i. Basic beam optics
    ii. Beam flattening
    iii. Significance of beam control parameters.
    iv. Collimation
        1. Rectangular Jaws
        2. MLC
        3. Electron Collimation

b. Medical Linear Accelerator Specifications

i. Non-beam specifications

ii. Beam specifications

c. Commissioning Data Acquisition Tasks

i. Data acquisition using scanning water phantom.

a. Types and significance of scans

b. Scans with different detectors

c. Scans with different beam modifiers

ii. Point data acquisition

iii. Film/planar data acquisition

iv. Understanding of measurement selection

a. Analysis of Measurements and Preparation for TPS Commissioning

i. Preparation for MU Calc data

ii. Preparation for TPS beam commissioning

b. Beam modeling/data table entry in planning system

i. Conceptual understanding of commissioning a TPS

ii. Relevant measurement selection, performance and documentation of same

D. Clinical Processes

a. Periodic QA: Use of constancy values and standards.

b. MU Calcs: Where do those numbers come from, anyway?

c. Non-routine QA and Commissioning

i. Post repair QA not requiring re-commissioning

ii. Post-repair QA requiring re-commissioning

Learning Objectives:

a. Determine data necessary to commission 1 photon and 1 electron beam in a clinically used treatment planning system. Collect that data, and format it for commissioning.

b. Determine the data necessary to perform MU Calculations for 1 photon and 1 electron beam. Collect the data and in a later rotation confirm that MU calculations agree with measurements for a range of depths, field sizes and beam modifiers.

c. Participate in creation of beam model required to commission a treatment planning system.

d. Participate in TPS dosimetry verification testing (e.g., TG-23 test package)

Assessment:

The resident will provide a written report of principles and process of TPS testing, commissioning measurements with an overview and detailed descriptions of the relevant underlying principles for each major step. The report should also contain data acquired through measurements or experiment as well as analysis thereof. The report should reference the relevant TG reports pertinent to planning system QA and commissioning. Finally, an understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated in an oral exam setting.

Reading List:

1. Starkschall G., Steadham R., et al, “Beam-commissioning methodology for a three-dimensional convolution/superposition photon dose algorithm,” Journal of Applied Clinical Medical Physics, 1:1 p. 8 – 27, (2000). http://onlinelibrary.wiley.com/doi/10.1120/jacmp.v1i1.2651/epdf

2. AAPM Report #62 TG-53 Report “Quality Assurance for Clinical Radiotherapy Treatment Planning” http://www.aapm.org/pubs/reports/rpt_62.pdf

3. APPM Report # 55, ‘‘Radiation Treatment Planning Dosimetry Verification, Radiation Therapy Committee Task Group #23,’’ edited by D. Miller (American Institute of Physics, College Park, MD, 1995)

4. TRS #430, “Commissioning and quality assurance of computerized planning systems for radiation treatment of cancer”, IAEA 2004

5. IAEA-TECDOC-1540 “Specification and Acceptance Testing of Radiotherapy Treatment Planning Systems”, IAEA 2007.

6. IAEA-TECDOC-1583 “Commissioning of Radiotherapy Treatment Planning Systems: Testing for Typical External Beam Treatment Techniques”, IAEA 2008.

7. J. B. Smilowitz et al, “AAPM Medical Physics Practice Guideline 5.a.: Commissioning and QA of Treatment Planning Dose Calculations - Megavoltage Photon and Electron Beams”, JACMP 16 p. 14-34 (2015)

8. Lessons learned from accidental exposures in radiotherapy, SAFETY REPORTS SERIES No. 17, IAEA 2004

9. Beam Commissioning Data Specification; RayPhysics Manual, RayStation 6 (or current version), RaySearch Laboratories, 2017.

10. Pinnacle Physics Reference Guide Pinnacle 9.2 (or current version), Philips Medical Systems 2010

11. See "…\Educational materials\Residency Rotations\Residents – TPS commissioning" on the Z drive for additional reading materials

Rotation Plan for 6) Treatment Planning Theory and Practice

A. Skills
   a. Patient dosimetry system operation
      i. Treatment planning systems used clinically at our sites
      ii. Patient Database and medical record systems
      iii. Contouring and fusion systems

B. Knowledge Base
   a. Determination of data required for TPS Modeling
   b. 3D Photon Beam Dose Algorithms
      i. Pencil Beam
      ii. Convolution Method
      iii. Polyenergetic Spectra
      iv. Inhomogeneity Corrections
      v. Collapsed Cone Convolution
      vi. Linear Boltzman Transport Solver
      vii. Clinical Photon Monte Carlo
      viii. Output Factors
      ix. Monitor Units
   c. Electron Beam Dose Algorithms
      i. Hogstrom / Shiu Pencil Beam model
      ii. Clinical Electron Monte Carlo
   d. Non-dosimetric Calculations within Treatment Planning Systems
      i. CT dataset resolution
      ii. CT number to electron density
      iii. Contouring thresholds / expansion / contraction
      iv. Transformations / Projections in Beams-eye-view
      v. Digitally Reconstructed Radiographs
   e. Dose Evaluation Tools
      i. Dose grid resolution
      ii. Isodose lines
      iii. Tolerance of Normal Tissues
      iv. Dose-Volume Histograms

v. TCP/NTCP

f. Operation of Planning System

    i. Treatment Planning Protocols
    ii. Dose Evaluation Tools
    iii. Data transfer and medical record system
    iv. Plan documentation (printing plans)
    v. Independent MU calculations
    vi. Treatment Planning Quality Assurance (Patient Specific QA)
    vii. Record and Verify system data import/approval

C. Clinical Processes

a. Observe Treatment Planning
    i. Brain, Head and Neck, Lung & Esophagus, Breast, Abdominal & Rectum, Pelvis & Bladder, and Prostate.
b. Determine the treatment planning protocol for each anatomical site observed.
    i. Prescription summary (total, fractionation, max/min)
    ii. Typical imaging techniques
    iii. fields, beam energy, blocking,
    iv. Regions of interest and their associated doses
c. Create Treatment Plans
    i. Brain, Head and Neck, Lung, Breast, Rectum, and Prostate.
    ii. IMRT and VMAT; appropriate use and practice
    iii. 3D conformal arcs for SRS and SBRT cases
d. Complete 3D planning competencies (Appendix A)

D. Learning Objectives

a. Create clinically acceptable treatment plans on all practice plans in competencies.
b. Describe common treatment planning dose calculation algorithms and their appropriate uses, including common errors.
c. Select reasonable planning techniques for common treatment sites.
d. Explain appropriateness of the common types of dose evaluation tools, and be able to demonstrate use of each.
e. Perform complete end to end planning process including TPS import and QA delivery for clinical patients.

Learning opportunities

Observe clinical physicist in performing the treatment planning process, and understand the functionality of the planning system. Hands-on time with the planning system to learn functionality of all options. A number of practice plans will be performed and the resident will document each case. Plans will be reviewed and the record signed to document progress. Perform the treatment planning process and understand the functionality of the planning system. Quality assurance of every aspect of the plan, from plan evaluation through verification within the record and verify system.

Reading List

1. Treatment planning system Beam Modeling User Manual
2. A convolution method of calculating dose for 15-MV x rays, TR Mackie, JW Scrimger, JJ Battista, Medical Physics, Vol 12, Issue 2 (1985).
3. Investigation of the convolution method for polyenergetic spectra, N Papanikolaou, T Rockwell Mackie, C Meger-Wells, M Gehring, P Reckwerdt, Medical Physics, Vol. 20, Issue 5 (1993).
4. Separation of Photon Beam Output Factor into its Phantom and Machine Components using the Convolution/Superposition Method, N. Papanikolaou, T. Rockwell Mackie, B.R. Thomadsen, D.M.D. Frye, B. Paliwal and C.M. Sanders, University of Wisconsin Medical School, Madison WI.
5. Monitor Unit Calculations for Convolution and Monte Carlo Dose Planning Systems, R. Mackie, N. Papanikolaou, B. Thomadsen, P. Reckwerdt, T. Holmes, C. Sanders. 1994 AAPM, Anaheim CA.
6. Tolerance of normal tissue to therapeutic irradiation, B Emami, J Lyman, A Brown, L Cola, M Goitein, JE Munzenrider, B Shank, LJ Solin, M Wesson, Int J Radiation Onc Bio Phys, Vol. 21, Issue 1 (1991).
7. Dose-volume histograms, RE Drzymala, R Mohan, L Brewster, J Chu, M Goitein, W Harms, M Urie, Int J Radiation Onc Bio Phys, Vol. 21, Issue 1 (1991).
8. Collapsed cone convolution of radiant energy for photon dose calculation in heterogeneous media, A Ahnesjo, Medical Physics, Vol. 16, Issue 4 (1989).
9. Electron beam dose calculations, K Hogstrom, M Mills, P Almond, Phys. Med. Biol., Vol. 26, Issue 3 (1981).
10. On methods of inhomogeneity corrections for photon transport, J Wong, J Purdy, Medical Physics, Vol. 17, Issue 5 (1990).

11. TPS Beam Modeling User Manual and training presentations
12. Aria documentation
13. LBTE solver documentation

Assessment

Each resident will maintain a list of plan types that they have completed and this list must be reviewed at the end of this rotation. Finally, the resident will take an oral exam. An understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated.

Rotation Plan for 7) IMRT

A. Skills
    a. Treatment planning
        i. Theory of IMRT optimization
        ii. Types of optimization (traditional vs Direct Machine Parameter Optimization (DMPO), Multi Criteria Optimization (MCO))
        iii. Specify Dose-Volume constraints
        iv. Review of constraints from common sources such as Emami, Timmerman, NCCI, Quantec, and RTOG protocols
    b. QA
        i. Planar diode arrays
        ii. Planar ion chamber arrays
        iii. Cylindrical diode arrays
        iv. EPID based
        v. QA of IMRT, VMAT, IMAT plans
    c. Use of an Ionization Chamber and Electrometer to read Dose
    d. Operate the Record & Verify system
    e. Operation of the Linac
    f. CT scanning a phantom and importing it into the planning system
    g. Positioning a phantom – determining shifts from fiducials to isocenter

B. Knowledge Base
    a. Optimization – an introduction
    b. Critical organ doses, parallel vs serial organs, typical dose-volume constraints
    c. Dose calculation algorithms specific to IMRT
    d. Film as a dose measuring device
    e. Small field dosimetry – measurement and modeling in the planning system
    f. Imaging for IMRT – CT basics

C. Clinical Processes
    a. IMRT planning
    b. IMRT chart check (ARIA)

c. IMRT QA
    i. Patient specific
    ii. Delivery system specific
d. IMRT boosts (simultaneously integrated vs consecutive)
e. IMRT delivery

D. Learning Objectives
    a. Complete IMRT treatment plans for clinical use.
    b. Describe appropriate planning objectives and clinical goals.
    c. Describe different algorithms used in optimization and the benefits of each type.
    d. Perform patient specific QA on clinical treatment plans.
    e. Evaluate and perform calibration of patient specific QA equipment.

Learning opportunities

Residents will use practice patients to hone their planning skills. Following this, residents will work on patient plans, while being supervised by their physics mentor. The resident compiles a written report detailing the learning opportunities that were experienced during each rotation section. The rotation concludes with an oral exam given by the physics staff.

Review the list of IMRT planning competencies. Each resident will be responsible for ensuring that all non-SRS/SBRT plan competencies should be completed and signed by a mentor by the end of the rotation.

Reading List

Recommended

1. Radiation Therapy Physics, Hendee, Ibbott and Hendee, Ch. 11, focus on pp 270 to 277, Ch. 15, focus on pp. 394-397
2. The Physics of Radiation Therapy, 3rd ed., Khan, Chs.19 and 20, Ch 8 (focus on pp 151-153) and ch 14 (pp 304-305).

Suggested

1. Treatment Planning in Radiation Oncology, Khan and Potish, editors, Chs. 8 (focus on pp172-176), 9, 12,
2. Radiation Therapy Planning, Bentel, see the summaries ("Morbidity") at the end of the various anatomical sections in chapters 9 through 13 to get a good idea of dose tolerances for various organs.
3. http://www.sprawls.org/resources/CTIMG/module.htm-This is a nice intro to CT image acquisition. Needed to understand the data acquisition requirements for IMRT.

Assessment

The resident will present a report that includes printouts of the relevant steps for the phantom plan: The IMRT QA report (SNC Patient), the ion chamber measurement spreadsheet, and the relevant pages from the treatment plan (dose distributions in various planes, constraints used in the optimization, plan parameters for the beams). In addition to this, the resident will create a dose calibration and array calibration for a diode based IMRT QA system such as the MapCheck or ArcCheck. The report must also give an overview of all the processes, describing the individual steps conceptually (i.e. not the details of which buttons to push but rather an overview that indicates how one might go about the same steps on a different planning system or with a different tool set). Finally, the resident will take an oral exam. An understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated.

Rotation Plan for 8) Radiotherapy Simulation

During this rotation the medical physics resident will gain an understanding of the Radiotherapy Simulation process, ranging from conventional simulation using planar images and fluoroscopy, through CT based virtual simulation, to 4DCT and the utility of multimodality imaging. While participating in this rotation, the resident will attend simulations for external beam radiation therapy, observe patient setup, use of the moving laser system, and the CT image acquisition process. Also, the resident will follow the process of setup geometry specification, immobilization, marking, tattoos, acquiring CT, including technique, and transfer to planning system. The resident is expected to understand the virtual simulation process and perform a virtual simulation procedure on a phantom, from start to finish with portal image/CBCT verification. Finally, the resident will observe the use of combined imaging modalities in the simulation process (such as PET/CT for metastatic disease, and MRI/CT for SRS treatments) and follow a patient through the Optical Image guided setup simulation process (optional). The resident compiles a written report detailing the learning opportunities that were experienced during the rotation. The rotation concludes with an oral exam given by the physics staff.

- A. Prerequisite Skills
  - a. Radiation Safety – CT machine operation
  - b. Human Anatomy – common bony landmarks
  - c. Fundamental Physics of Radiographic Imaging
    - i. Radiation Interactions with Matter
      - 1. Photoelectric Effect, Compton, Pair Production
      - 2. Attenuation and Scatter
    - ii. Basic Imaging Parameters
      - 3. Contrast
      - 4. Detective Quantum Efficiency
      - 5. Signal to Noise Ratio
      - 6. MTF
  - d. Introductory Imaging Technologies
    - i. Imaging Detector Concepts
      - 7. Films
      - 8. Fluoroscopy
      - 9. Computed Radiography
      - 10. Ion Chamber Arrays
      - 11. Diode Arrays (a-Si)
      - 12. Other planar Xray imagers
    - ii. X-ray CT
    - iii. PET
    - iv. MRI
    - v. Ultrasound
- B. Knowledge Base
  - a. Principle understanding of simulation process.
  - b. Fundamental Principles of Simulation Equipment

i. Discuss "Conventional Simulator" –Plane Films and Fluoroscopy
ii. CT Simulation
iii. Immobilization and Localization, Gating, Surface contour acquisition for motion management
iv. Other simulation technologies: PET/CT, MR, US
v. Image co-registration ("fusion") and the role of multimodality imagery in simulation; temporally-registered imagery (4D, Max/Mean/Min IP).

c. Medical Physicist Role in Simulation and Equipment Management
    i. *Conventional* Simulation
        13. Process emphasizing physicist role (i.e. historical breast)
        14. QA of Simulator
        15. QA of imaging chain
        16. QA of X-ray generator
    ii. CT Simulation
        17. CT numbers, electron density, and relationship to Radiation Oncology treatment planning; heterogeneity correction tables
        18. Diagnostic CT v. Simulator
        19. TG-66 protocol and CTSim QA
            a. Mechanicals, lasers
            b. Imaging
            c. ACR phantom
    iii. PET/CT
        20. Radiation isotope safety, QA - overview
        21. Issues in utilizing PET images in simulation
    iv. MRI
        22. Application as image set for fusion
        23. Potential as primary simulation modality
        24. QA for RTMRI
    v. Use of "other" modes in RT Simulation (such as Ultrasound, setup "aids").

C. Clinical Processes
    a. Conventional Simulation and Planning from Plane Films (literature review)
    b. CT Simulation
    c. ICRU target definitions of GTC, CTV, ITV and PTV
    d. VSIM as an alternative to CT Sim
    e. Simulations ancillary devices: LAP laser system, gating training
    f. Prepare for targeting processes: 4DCT handling, PET/CT and MRI/CT fusions

Learning Opportunities:

Attend a CT simulation for EBRT. Observe patient setup, use of scout image, CT capture, storage and transmission to other clinical systems.

Follow a patient through the CT (PET/CT) simulation process. Emphasis should be on geometric aspects of the process (setup geometry specification, immobilization, marking, tattoos, CT including x-ray technique, and transfer to planning system).
Note: Much of this is done for phantom as part of monthly CT simulator QA.
Follow a patient and then take a phantom through the VSIM process.
Observe the use of combined imaging modalities (perform fusions as appropriate) in the simulation process (such as MRI and CT for SRS).
Follow a patient through the Optical Image guided setup simulation process, attend CT, biteblock registration, and initial treatment.
Perform QA on all relevant systems.
Observe/Perform CT QA, include using the ACR phantom.
Observe PET morning warm-up QA

Learning Objectives:

1) Describe the process and equipement relavent to CT simulation and PET imaging.
2) Describe ICRU defination of GTV, ITV, PTV
3) Apply the methods of TG-66 to the CT-Simulation QAs including annual meaurements of CTDI.
4) Describe the difference between detectors used in CT vs PET
5) Describe the difernce in resolution between body site protocols.

Assessment:
The resident will present a report that describes the simulation process and equipment in Radiation Therapy. This report should include descriptions of the relevant underlying principles of the systems used, and an overview of all the processes, describing the individual steps conceptually. The report should also contain descriptions of any experiments or measurements performed and analyses of same. Finally, the resident will take an oral exam. An understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated.
Resident should come up with their own schedule for the rotation, which has to include regular participation is simulations taking place in the department, monthly and annual QA's.
Complete a mini-project on

- Design shielding for our PET-CT (use TG-108).
- Calculate EQD2 for re-irradiation case with the objective of making a recommendation to physician/planner (deformable fusion, use Quantec for OAR's dose limits vs Timmerman's, define regions of allowable EQD2, possibly with dose adjustment for the number of months since irradiation)

Reading List:

1. "Quality assurance for computed-tomography simulators and the computed-tomography simulation process: Report of the AAPM Radiation Therapy Committee Task Group No. 66," Med Phys 30 (10), 2003, p. 2762.
2. T.S. Curry, J.E. Dowdey, R.E. Murry, Christensen's Physics of Diagnostic Radiology, 4th edition, 1990, Chapters 14, 15, 19, 22, 24.
3. J.T. Bushberg, "The Essential Physics of Medical Imaging", 3rd edition, 2011, Chapters 4, 6, 7, 10, 12, 14.
4. Perry Sprawl' On-line lectures:
    4.1. http://www.sprawls.org/ppmi2/IMGCHAR/
    4.2. http://www.sprawls.org/resources/CTIMG/module.htm
5. Johns & Cunningham, "The Physics of Radiology," Chapter 16.
6. S. Mutic, J. A. Purdy et al., "The Simulation Process in the Determination and Definition of the Treatment Volume and Treatment Planning", Chapter 7 of Technical Basis of Radiation Therapy: Practical Clinical Applications, Eds.: James Purdy, Carlos Pérez et al., 4th edition, 2006.
7. "The phantom portion of the American College of Radiology (ACR) Computed Tomography (CT) accreditation program: Practical tips, artifact examples, and pitfalls to avoid", Med Phys 31(9), 2004 p. 2423.
8. See "…\Educational materials\Residency Rotations\Residents - Radiotherapy Simulations" on the Z drive for additional reading materials

Rotation Plan for 9) Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy

A. Prerequisite Skills
   a. SRS/SBRT Principles
      i. Dose fall-off
      ii. radiobiology
   b. Operation of Linac in SRS mode
   c. MU calculation (TPR, PSF, CF, ISF) for conventional treatments
   d. Use of ion chamber/electrometer/diodes/MOSFETs
   e. Film dosimetry
   f. Imaging systems for pretreatment positioning
   g. Imaging systems for during-treatment positioning

B. Knowledge Base
   a. Small field dosimetry
   b. Film measurements for small fields
   c. SRS Beam modeling (treatment planning systems)
   d. Localization
   e. Patient immobilization
      i. Frame
      ii. Frameless
   f. Treatment Planning (treatment planning systems)
      i. Reference frame coordinate system
      ii. Image fusion
      iii. Target localization
      iv. Isocenter selection
      v. Dose verification
   g. Delivery
      i. Gantry/collimator/6D or 3D couch alignment
      ii. Floor stand isocenter location for frame systems
   h. Verification (QA) of delivery process

C. Clinical Process
    a. Geometrical Alignment
        i. Position floor stand (for stand systems)
        ii. Verify alignment using CT
        iii. Verify target localization accuracy using absolute phantom
        iv. Patient Immobilization
            1. Frame placement
            2. Frameless
    b. Beam data acquisition
        i. Measure small field profiles
        ii. Measure small field output factors
    c. Planning system commissioning
        i. Enter beam data into planning system
        ii. Verify planning system beam data
        iii. Verify localization for frame treatments
        iv. Verify localization for frameless treatments
    d. Treatment planning
        i. Perform image fusion
        ii. Create single isocenter plan
            1. Identify arc/couch limitations
            2. Establish arc/couch angle presets
        iii. Create multiple isocenter plan
            1. Explain isodose line normalization
            2. Explain isodose line prescription
    e. Plan Transfer to Record System/Linac
        i. Transfer data to ARIA
        ii. Perform independent MU calculations
    f. Delivery
        i. Identify patient safety precautions
        ii. Perform pre-treatment QA
        iii. Participate/observe frameless delivery
        iv. Participate/observe frame delivery
        v. Operate linac (simulated treatment)
    g. Workflow and Plan Qulaity

i. Generate SRS/SBRT workflow diagram

ii. Calculate plan quality metrics such as the gradient index and conformity index and compared to published quality metrics and department standards.

Learning opportunities

Perform QA using a stereotactic/cube phantom for treatment isocenter vs imaging isocenter verification.

Perform QA using a phantom and micro-ion chamber.

Measure SRS cone concentricity with film.

Verify physics data in planning system.

Establish mechanism for independent MU calculations.

Create and execute a single isocenter plan on a phantom. Measure the dose delivered to the phantom and compare it to the planned dose.

Follow a frame patient through all steps of process (frame placement, imaging, planning and delivery.) See item C. above.

Follow a frameless patient through all steps of process (bite plate generation, imaging, planning and delivery.) See item C. above.

Using workflow diagram, identify critical failure points and make recommendations on how to minimize or eliminate critical failures.

Calculate plan quality metrics such as the gradient index and conformity index and compared to published quality metrics and department standards

Reading list

1. AAPM report 54, Stereotactic Radiosurgery
2. Radiosurgery Vol 4, Kondizielka ed., Karger 2002, pages 251-261
3. The Physics of Radiation Therapy, 3rd ed., Khan, Ch.21 (or equivalent later edition)
4. Retrospective dosimetric analysis of brain lesions planned in Pinnacle 9.8 via a HDMLC linac

Assessment:

The resident will acquire output factors for 2 small collimator fields. Upon successful demonstration of the acquired data, the staff physicist will give the resident data for all other collimator sizes. The resident will assemble a data book of the SRS planning data. He/she will format the measurement data appropriate to enter into the planning system and to use for independent calculations.

The resident will perform end-to-end QA on the stereotactic system, from imagining and localization to IGRT and delivery, giving quantitative analysis of the geometrical errors at each step of the process.
The resident will be expected to observe as many actual SRS treatments as possible during their rotation.

The resident will take an oral exam at the conclusion of the rotation. The resident should be able to demonstrate knowledge of these processes and other relevant information obtained from the reading lists.

Rotation Plan for 10) Special Topics and Procedures in Radiation Therapy

A. Prerequisite Skills

a. Radiation Safety –Treatment machine operation
b. Human Anatomy –common bony landmarks
c. Introduction to custom shielding used in Radiation Therapy.
d. Introduction to electron beam dosimetry.

B. Knowledge Base

a. Dosimetry of electron beams
b. Clinical Basis for Total Body (TBI), Total Skin Irradiation (TSET) and Intraoperative Radiation Therapy (IORT).
c. Equipment used for special procedures
d. Dosimetry issues in TBI, TSET and IORT
    i. Field uniformity
    ii. Beam energy/penetration
    iii. Field Shaping
        1. Collimation and patient alignment (IORT).
        2. Collimation and energy adjustment (TSET).
        3. Collimation and beam profile (TBI)

e. Beam Data for TSET, TBI and IORT – hand calculations

f. Ethics and Professionalism – each resident should complete the online course modules for Professionalism and Ethics offered by the RSNA and the AAPM.

Professionalism and Ethics	**How covered**	**Comments**
Professionalism	RSNA/AAPM Course and Seminar	All aspects of professionalism are covered in a 1 hour seminar. The seminar of ethics and professionalism is given on the first seminar day of each fall semester to all graduates and residents
○ Definition of a profession and professionalism		
○ Elements of a profession		
○ Definition of a professional		
○ Elements of professionalism		
○ How is professionalism judged?		

○ Do's and don'ts of professionalism		
○ Physician's charter and applicability to physicists		
Leadership		
○ Vision and charisma	Group discussion	
○ Qualities of leaders	Group discussion	
○ Rules of leadership	Group discussion	
○ Causes of leadership failure	Group discussion	
Ethics	RSNA/AAPM Course and Seminar	All aspects of professionalism are covered in a 1 hour seminar. The seminar of ethics and professionalism is given on the first seminar day of each fall semester to all graduates and residents
○ Ethics of a profession		
○ Ethics of an individual		
○ Interactions with colleagues and co-workers		
○ Interactions with patients and the public		
○ Confidentiality		
○ Peer review		
○ Negotiation skills		
○ Relationships with employers		
○ Conflicts of interest		
○ Ethics in research		
○ Use of animals in research		
○ Use of humans in research		
○ Relationships with vendors		
○ Publication ethics		
○ Ethics in graduate and resident education		
○ Selected case studies		

C. Clinical Processes

a. Clinical indications and conditions treated
b. Simulation and Field shaping
c. MU calculations
d. In-vivo dose measurement
e. Custom compensators

D. Commissioning of a TBI Program

a. General electron beam commissioning
b. Specifics related to TSET commissioning.

Learning Opportunities:

Perform measurements of

- Effect of SSD change on electron beam characteristics.
- Electron beam collimation and effects of surface shielding.
- Obliquity effects.

Assessment:

The resident will provide a written report of principles and process of Total Skin Electron Irradiation, Total Body Irradiation and Intraoperative Irradiation with an overview and detailed descriptions of the relevant underlying principles for each major step. Some emphasis should also be placed on practical issues in establishing TSET, TBI and IORT programs. The report should also contain data acquired through measurements or experiment as well as analysis thereof. Finally, the resident will take an oral exam. An understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated.

This rotation will also serve as a foundation in the ethics and professionalism in the field of medical physics.

Reading List:

1. Perez & Brady, "Principles and Practice of Radiation Oncology", Lippincott, 2nd ed, 1992, Chapters 10 and 22.

2. Khan, F.M., "The Physics of Radiation Therapy", Williams & Wilkins (3rd Ed. or equivalent later edition), Chapter 14.

3. Clinical Electron-Beam Dosimetry, Reprinted from Medical Physics (Vol. 18, Issue 1) (1991) Radiation Therapy Committee Task Group #25; 40 pp.

4. Intraoperative radiation therapy using mobile electron linear accelerators: Report of AAPM Radiation Therapy Committee Task Group No. 72. (2006); 43pp.

5. Commissioning of a mobile electron accelerator for intraoperative radiotherapy
Michael D. Mills, Liliosa C. Fajardo, David L. Wilson, Jodi L. Daves, and William J. Spanos
J. Appl. Clin. Med. Phys. 2, 121 (2001)

6. Use of routine quality assurance procedures to detect the loss of a linear accelerator primary scattering foil
M. G. Davis, C. E. Nyerick, J. L. Horton, and K. R. Hogstrom
Med. Phys. 23, 521 (1996)

7. A study of the effect of cone shielding in intraoperative radiotherapy
Nikos Papanikolaou and Bhudatt Paliwal
Med. Phys. 22, 571 (1995)

8. The dosimetric properties of an intraoperative radiation therapy applicator system for a Mevatron-80
Charles E. Nelson, Richard Cook, and Susan Rakfal
Med. Phys. 16, 794 (1989)

9. The dosimetric properties of an applicator system for intraoperative electron-beam therapy utilizing a Clinac–18 accelerator
Edwin C. McCullough and Joseph A. Anderson
Med. Phys. 9, 261 (1982)

10. Khan, F.M., "The Physics of Radiation Therapy", Williams & Wilkins (3rd Ed. or equivalent later edition), Chapter 14, particularly section 14.8.

11. Total Skin Electron Therapy: Technique and Dosimetry(1987)

12. Multiple scattering theory for total skin electron beam design
John A. Antolak and Kenneth R. Hogstrom
Med. Phys. 25, 851 (1998)

13. Spatial distribution of bremsstrahlung in a dual electron beam used in total skin electron treatments: Errors due to ionization chamber cable irradiation
Indra J. Das, John F. Copeland, and Harry S. Bushe
Med. Phys. 21, 1733 (1994)

14. Dosimetric study of total skin irradiation with a scanning beam electron accelerator
Subhash C. Sharma and David L. Wilson
Med. Phys. 14, 355 (1987)

15. Physical aspects of a rotational total skin electron irradiation
E. B. Podgorsak, C. Pla, M. Pla, P. Y. Lefebvre, and R. Heese
Med. Phys. 10, 159 (1983)

16. Van Dyk et al, AAPM Report 17 /TG-29 "Physical Aspects of Total and Half Body Irradiation"

17. Johns & Cunningham, "The Physics of Radiology," Chapter 11.

18. Perez CA, "Principles and Practice of Radiation Oncology" Chapter 11.

19. Zierhut, Dietmar et al, "Cataract incidence after total-body irradation", IJBORP 45(1) p. 131, 2000.

20. Thomas, Oliver et al, "Long-term complications of total body irradiation in adults", IJBORP 49 (1) p.125, 2001.

21. Faraci, Maura, et al, "Very late nonfatal consequences of fractionated TBI in children undergoing bone marrow transplant", IJORBP 63(5) p. 1568, 2005.

A literature review is strongly suggested for this topic.

Rotation Plan for Rotation in 11a) Imaging for Planning and Treatment Verification

A. Skills
  1. Fundamental Understanding of Basic Radiotherapy Process
     a. Simulation imaging
     b. Treatment planning
     c. Treatment delivery/verification
  2. Basic Understanding of Radiological Imaging Modalities
     a. X-ray film/fluoroscopy
     b. X-ray CT
     c. MRI
     d. PET (PET/CT)
  3. Basic Imaging Science
     a. Contrast Resolution
     b. Signal to Noise
     c. Image Quality
        i. Point/Line spread function
        ii. Modulation transfer function
     d. Digital imaging
        i. Quantum mottle
        ii. Noise frequency/spectrum
        iii. Detective Quantum Efficiency

B. Knowledge Base
  1. Radiotherapy Simulation
     a. CT simulation/virtual simulation
     b. DRR generation
        i. Set-up verification
        ii. Portal image verification
     c. X-ray simulator
        i. Set-up verification
        ii. Portal image verification

2. Verification Imaging in Radiotherapy
    a. Kilovoltage x-ray images
        i. Simulator set-up images
        ii. Simulator portal images
        iii. Beams eye view DRR from CT
        iv. Set-up/Portal verification
    b. Megavoltage x-ray images
        i. X-ray film/cassette
        ii. Comparison to hardcopy DRR
        iii. Electronic portal images
    d. kV conebeam CT
        i. 3-d localization
        ii. Adaptive targeting
3. Electronic Portal Imaging Devices
    a. Fluoroscopic screen/camera based systems
        i. Principles of operation
        ii. Disadvantages/Limitations
        iii. Clinical prevalence
    b. EPID Flat Panel (aSi) based systems
        i. Principles of operation
        ii. Advantages/Limitations
        iii. Clinical prevalence
    c. kV 'port films'
        i. Principles of operation
        ii. Advantages/Limitations
        iii. Clinical prevalence

B. Clinical Processes
1. CT simulation
    a. Patient set-up
    b. Iscocenter localization
2. Digital Reconstructed Radiograph
    a. Generation
    b. Clinical use

3. Electronic Portal Imaging Devices
    a. Principles of operation
    b. Daily/monthly quality assurance testing
    c. Set-up/portal image verification
    d. Megavoltage cone-beam computed tomography

Learning Opportunities:

Clinical Use of Images

Portal Imaging Detector Systems

Image Quality

Commissioning and QA

The resident will develop knowledge of portal imaging systems used during the simulation/planning process and during treatment verification. The application of different electronic portal imaging systems will be studied by comparison of systems from Varian and Siemens. The resident will perform the necessary processes for commissioning the EPID systems, as well as identify and perform continuing quality assurance. During the rotation the resident will perform monthly and annual quality assurance on different portal imaging systems.

Reading List:

1. Radiation Therapy Physics 3rd Ed, Hendee, Ibbott and Hendee, Chapter 9.
2. The Physics of Radiation Therapy, 3rd Ed (or equivalent later edition), Khan, Chapter 12, Section 12.7 (Patient Positioning), Chapter19.
3. Marks JE, et al. “Localization error in the radiotherapy of Hodgkin’s disease and malignant lymphoma with extended mantle fields,” Cancer (NY) 34, 83-90 (9174).
4. Rabinowitz J, et al. “Accuracy of radiation field alignment in clinical practice,” Int. J. Radiat Oncol., Biol., Phys. 11, 1857-67 (1985).
5. Nixon E. “Hydrogenated Amorphous Silicon Active Matrix Flat Panel Imagers (a-Si:H AMFPI) Electronic Portal Imaging Devices. Graduate Research Paper. University of Iowa. 2005.
6. Pang G and Rowlands J A Electronic portal imaging with an avalanche-multiplication-based video camera *Med.Phys.* 27 676–84. 2000.

7. Rajapakshe R, Luchka, and Shalev S, "A quality control test for electronic portal imaging devices," Med. Phys. 23, 137-1244 !996).
8. Gilhuijs KG, et al. "Optimization of automatic portal image analysis." Med. Phys. 22, 1089-1099 (1995).
9. Fristch DS, et al. "Core based portal image registration for automatic radiotherapy treatment verification." Int. J. Radiat. Oncol., Biol., Phys. 33, 1287-300 (1995).
10. Herman MG, "Clinical use of on-line portal imaging for daily patient treatment verification," Int. J. Radiat. Oncol., Biol., Phys. 28 (4) 1017-1023 (1994).
11. Herman MG, et al. "Effects of respiration on target and critical structure positions during treatment assessed with movie-loop electronic portal imaging," Int. J. Radiat. Oncol., Biol., Phys. 39, 163 (1997).
12. Mubata CD, et al., "Portal imaging protocol for radical dose-escalation radiotherapy treatment of prostate cancer," Int. J. Radiat. Oncol., Biol., Phys. 40, 221-231 (1998).
13. Lebesques JV, et al., "Clinical evaluation of setup verification and correction protocols: Results of multicenter Studies fo the Dutch cooperative EPID Group," The Fifth International EPID Workshop, Phoenix AZ, 1998. p. 20.
14. Kirby MC, et al. "The use of an electronic portal imaging device for exit dosimetry and quality control measurements." Int. J. Radiat. Oncol., Biol., Phys 31, 593-603 (1995).
15. Hansen VN, "The application of transit dosimetry to precision radiotherapy," Med Phys. 23, 713-721 (1996).

Assessment:

The resident will prepare a written report summarizing their experiences and present this information to the physics faculty during an oral exam.

Rotation Plan for 11b) Image Guided Radiation Therapy (IGRT)

A. Skills
    a. TPS system operation
    b. Linear Accelerator operation
    c. Varian planar x-ray and CBCT operation
    d. Philips Gemini Big Bore 4D PET/CT operation

B. Knowledge Base
    a. Prospective and Retrospective CT principles
    b. Gated treatment delivery principles
    c. Treatment planning process for IGRT
    d. Data export/import into each system

C. Clinical Processes
    a. Perform Quality Assurance on each of the IGRT components
        i. VisionRT infra-red optical guidance system
        ii. 4D image acquisition
        iii. gated delivery
        iv. megavoltage cone-beam
    b. Export IGRT Treatment Plans for
        i. Brain, Head and Neck, Lung, and Prostate.
    c. Perform image registration and fusion for multimodality imaging utilized in treatment planning
        i. CBCT with CT
        ii. PET with CT
        iii. MRI with CT

Learning opportunities

Observe and participate in the IGRT treatment planning and delivery process and understand the functionality of the systems utilized. Quality assurance of every aspect of each IGRT system studied, from image acquisition through verification and treatment delivery.

Reading List

1. Quality Assurance for Clinical Radiotherapy Treatment Planning (Reprinted from Medical Physics, Vol. 25, Issue 10) (1998)

2. Radiation Therapy Committee Task Group #53; 57 pp.

3. Z-Med SonArray and Radiocam user manual

4. Sanford L. Meeks, Wolfgang A. Tomé, Lionel G. Bouchet, et al. Patient Positioning Using Optical And Ultrasound Techniques. AAPM Summer School 2003

5. Jean Pouliot, Ph.D., Ali Bani-Hashemi, Ph.D., Josephine Chen, Ph.D., et al. Low-Dose Megavoltage Cone-Beam CT For Radiation Therapy. Int. J. Radiation Oncology Biol. Phys., Vol. 61, No. 2, pp. 552–560, 2005

6. Nicole M Wink, Michael F McNitt-Gray and Timothy D Solberg. Optimization of multi-slice helical respiration-correlated CT: the effects of table speed and rotation time. Phys. Med. Biol. 50 (2005) 5717–5729

7. X. Allen Li,a_ Christopher Stepaniak, and Elizabeth Gore, Technical and dosimetric aspects of respiratory gating using a pressure-sensor motion monitoring system, Med. Phys. 33 (1):145-54, 2006

8. Vincent Gregoire, Jean-François Daisne and Xavier Geets, Comparison of CT- and FDG-PET-defined GT: In regard to Paulino et al. (Int J Radiat Oncol Biol Phys 2005;61:1385-1392), International Journal of Radiation Oncology*Biology*Physics, Volume 63, Issue 1, , 1 September 2005, Pages 308-309.;

9. Arnold C. Paulino and Mary Koshy, In Response to Dr. Gregoire et al., International Journal of Radiation Oncology*Biology*Physics, Volume 63, Issue 1, 1 September 2005, Page 309.

10. Clifton Ling, John Humm, Steven Larson, Howard Amols, Zvi Fuks, Steven Leibel and Jason A. Koutcher. Towards multidimensional radiotherapy (MD-CRT): biological imaging

and biological conformality. International Journal of Radiation Oncology*Biology*Physics, Volume 47, Issue 3, Pages 547-857 (1 June 2000)

Assessment

The resident will present a report giving an overview of all the processes, describing the individual steps conceptually, and results from their experimental studies and quality assurance verification measurements in IGRT. Current capabilities and remaining challenges of the use of multimodality imaging in radiation therapy treatment planning should be discussed. Finally, the resident will take an oral exam. An understanding of the principles behind the processes as well as comprehension of other relevant information from the reading lists must be demonstrated.

Rotation Plan for 12) Room Design, Radiation Protection and Radiation Safety

A. Skills
   a. Interpretation of architectural drawings
   b. Survey meter operation
   c. Use of spreadsheet for data analysis
   d. Linac/HDR operation

B. Knowledge Base
   a. Understand radiation safety principles
   b. Understand dose limits/regulatory requirements
   c. Understand barrier material composition and preferences
   d. Understand process of neutron production
   e. Barrier HVL/TVL values
   f. Methodology of barrier thickness computation
   g. Understand differences between head leakage, scatter and primary radiation

C. Clinical Process
   a. Apply radiation safety principles to situations found in a radiation oncology clinic
      i. Time-Distance-Shielding
      ii. Brachytherapy safety and source accountability
      iii. Operational safety practices for linac, CT, PET, HDR, and MR
      iv. Patient safety
   b. Identify allowable radiation limits for occupationally exposed individuals
   c. Identify allowable radiation limits for members of the general public
   d. Identify/define controlled areas vs. non controlled areas
   e. Identify sources of radiation exposure found in typical radiation therapy facility
   f. Compute workloads
      i. Accelerator
      ii. HDR
      iii. LDR

iv. CT scanner

g. Determine use factors for various radiation sources
h. Determine occupancy factors for regions adjacent to sources of radiation
i. Calculate barrier thickness
j. Measure actual exposure outside treatment vault/HDR unit.

D. Learning opportunities

a. The resident will demonstrate to the mentor that he/she has developed a solid grasp of radiation safety practices that need to be implemented in a typical radiation oncology facility.
b. Compute barrier thicknesses for a typical linear accelerator room layout.
c. Compute barrier thicknesses for a typical HDR suite
d. Measure exposure at door and in rooms adjacent to linear accelerator
e. HDR room survey
f. Neutron survey
g. Film Badge area monitoring

Reading list

NCRP Report 49
NCRP Report 151
The Physics of Radiation Therapy, 3rd ed (or equivalent), Khan, Ch. 16
Ohio Department of Health regulations
Shielding Techniques, 2nd ed McGinley
AAPM task group 32 – Fetal Dose
AAPM online refresher courses

Assessment

The resident will compile a report describing the individual steps that were taken to perform the shielding analysis. A second report should be written of the shielding requirements for the linear accelerator vault and HDR suite assigned in the learning opportunities. This report should be written as if the intended recipient was the architect in charge of designing the facility. A third report will be created estimating the yearly dose that one would expect in selected areas based on actual measurements. Residents will aslo take the certification class offered by the radiation safety office and present the certificate to the rotation mentor.

While the bulk of this rotation involves a shielding design project, the resident's overall understanding of radiation safety will be evaluated during this rotation. Radiation safety training is a continuous process throughout the 2 year rotation. Specific safety topics should have been addressed in previous rotations. The mentor will use this rotation to evaluate the resident on their understanding of safety issues by asking pertinent questions that the resident should be able to answer. Should the resident fail to answer any questions to the mentor's satisfaction he/she will be asked write a report covering the specific safety issues that need further study.

The resident will take an oral exam at the conclusion of the rotation. The resident should be able to demonstrate knowledge of these processes and other relevant information obtained from the reading lists.

Appendix A: Practice Treatment Plan List

Plan Name/site
Brain
SRS Brain Regular
SRS Brain 1 Met Advanced
SRS Brain Multimet Single Iso
Whole Brain
Head and Neck
Bilateral Neck
Lung Mediastinum
Esophagus
Lung SBRT
Mediastinum Large 1
Mediastinum Large 2
Mediastinum Large Challenge
Breast
Breast 4fld challenge
Breast 4fld scv1
Breast Challenge
Breast DIBH Boost
Breast DIBH
Breast VMAT Challenge
Breast VMAT Simple
Simple Breast
Simple Breast Boost
Abdomen

Liver SBRT
Pancreas SBRT
Pelvis
Pelvis 3D
Pelvis 3D Large
Prostate
Prostate Bed
ProstateBedandLNs
Spine
3d conformal spine
Spine SBRT
Appendage
APPA femur
Femur 3d
Femur 3d2
Oblique Arm