

MPH 552: PHYSICS OF ADVANCED RADIOTHERAPY

Teaching hours: Each Unit – 12 h

Objectives: To familiarise the students various aspects radiation therapy, different techniques and instruments used in planning radiation therapy and treating the patients.

Outcomes:

- Students will be able to analyse the imaging data and planning the treatment process.
- They will learn about stereotactic radiosurgery and radiotherapy and quality analysis procedures.
- They will learn in detail all the aspects of intensity modulated radiation therapy and quality analysis protocols.
- Students will be able to plan and deliver tumor specific dose using external photon beam.
- Students develop acquaintance with patient positioning guidelines and isocentric setup for radiation therapy.
- Familiarise with all aspects of brachytherapy including planning, dose calculation and treatment.
- Also familiarise with all aspects of electron beam therapy including planning, dose calculation and treatment.

Unit I: 3D conformal radiotherapy and special techniques of radiotherapy

Advantage of 3DCRT over classical/conventional techniques, Indications for 3DCRT - patient data acquisition - imaging - CT simulation imaging - MRI imaging – PET imaging - image registration (Rigid and deformal) - image segmentation - contouring - beam selection - dose calculation - dose calculation algorithms- dose distribution and plan optimization - plan evaluation - dose volume histogram (DVH) - treatment chart and treatment setups.

Special techniques in radiation therapy - Total body irradiation (TBI) and Total marrow irradiation (TMI) - large field dosimetry - total skin electron therapy (TSET) - electron arc treatment and dosimetry - intraoperative radiotherapy.

UNIT II: Intensity modulated radiotherapy and Image guided radiotherapy

Intensity modulated radiation therapy (IMRT) - principles - MLC based IMRT - step and shoot and sliding window techniques - Compensator based IMRT - planning process - inverse treatment planning - immobilization for IMRT - dose verification phantoms, dosimeters, protocols and procedures - machine and patient specific QA.

Concept of Intensity Modulated Arc Therapy (IMAT/VMAT), Image Guided Radiotherapy

(IGRT) - Imaging modality, kV cone beam CT (kVCT), MV cone beam CT (MVCT), image registration, plan adaptation, QA protocol and procedures - special phantom, 4DCT.

Principles of Serial and Helical irradiation – equipment design and working principle - commissioning - imaging - planning and dosimetry - dose delivery - plan adaptation - QA protocol and procedures.

Fundamentals of Ring gantry accelerators for radiotherapy.

UNIT III: Stereotactic Radiosurgery and Stereotactic Radiotherapy

Stereotactic radiosurgery / stereotactic radiotherapy (SRS/SRT) - cone and MLC based X-Knife systems- accessories of X-knife – Multi source radiosurgery device (Gamma Knife) - various models and accessories of Gamma Knife systems - immobilization devices for SRS/SRT – Frame and frameless radiosurgery techniques - dosimetry and planning procedures - Evaluation of SRS/SRT treatment plans - QA protocols and procedures for X-knife and Gamma Knife units - Patient specific QA.

Principles of stereotactic body radiotherapy (SBRT) - indications for SBRT. Simulation Imaging - Data acquisition for mobile tumors - patient-specific tumor-motion determination - respiratory motion management - Imaging artefacts. Treatment planning - Dose heterogeneity - gradient and fall-off - beam selection and beam geometry - calculation grid size - bio-effect based treatment planning. Immobilization - image guided localization - tumour tracking and gating techniques for motion management - dose delivery data reporting. Dosimetry techniques of small and narrow fields - calculation under heterogeneous conditions. Requirements for clinical commissioning of SBRT - acceptance, commissioning and quality assurance.

Frameless radiosurgery systems – Robotic radiosurgery device (Cyber Knife) - Systems descriptions - Indications for cyber knife treatments - systems for beam collimation and beam shaping - imaging - patient monitoring and treatment - dose calculation techniques - clinical commissioning and quality assurance.

UNIT IV: Proton Therapy

Proton therapy accelerator - acceleration and transport of proton beam - treatment nozzle - characteristics of therapy proton beam - Spread Out Bragg Peak (SOBP) - beam quality - pencil beam - spot scanning – Intensity Modulated Proton Therapy (IMPT) - dosimetry - phantoms and dosimeters - ionization chambers, calorimeters and film dosimetry methods - relative dosimetry methods - dosimetry using TLD/OSLD, semiconductor diodes and radiochromic

films. Treatment planning system - dose calculation algorithms - dose optimization approaches - intensity modulated proton therapy - imaging and motion management. Quality assurance, commissioning and reporting of proton therapy treatments.

UNIT V: Neutron and Heavy Ion Therapy

Principles of neutron capture therapy (NCT) - Boron and Gallium capture therapy - NCT systems and beam shaping - indications for NCT - treatment planning and dose computation - clinical commissioning and QA of NCT systems.

Heavy ions for radiotherapy - heavy ion accelerator - design and working principle -energy specification and beam quality - indications for heavy ion therapy – imaging, treatment planning and dosimetry - plan optimization and dose delivery approaches. Beam characteristics, commissioning and quality assurance.

Reference Books:

1. R.F.Mould, “Radiotherapy Treatment Planning Medical Physics Hand book series No.7, Adam Hilger Ltd, Bristol, 1981.
2. S.C.Klevenhagen “Physics of Electron Beam Therapy” Medical Physics Hand Book Series No.6 Adam Hilger Ltd, Bristol, 1981.
3. F.A.Attix “Radiation Dosimetry” Vol III, Academic press New York, 1985.
1. FahizM.Khan, Treatment Planning in Radiation Oncology, LWW publication, Second Edition
4. Ann Barrett, Jane Dobbs, Stephen Morris and Tom Roques. “Practical Radiotherapy Planning” Fourth Edition 2009
5. “3D Conformal and Intensity Modulated Radiation Therapy Physics and Clinical Applications” by James A Pondy
6. “Contemporary IMRT Developing Physics and Clinical Implementation”, S. Webb.
7. New Technologies in Radiation Oncology” W. Schlegel • T. Bortfeld • A.L.Grosu.
8. “The Physics of Conformal Therapy Advances in Technology” by S.Webb
9. A Practical Guide to CT simulation”, by Lawrence Coy.
10. The Physics of Medical Imaging, S.Webb, Medical Science Series, Adam Hilger, Bristol,1984.
11. Therapeutic Applications of Monte Carlo Calculations in Nuclear Medicine” HabibZaidi, George Sgouros IOP, Institute of Physics Publishing, Bristol and Philadelphia.
