DEPARTMENT OF RADIATION ONCOLOGY

AIIMS GUWAHATI

PG Curriculum and Syllabus

SUBJECT SPECIFIC COMPETENCIES

1. Demonstrate the ability to diagnose and treat all cases of malignancies using updated guidelines in medical and radiation oncology with special ability to maintain inter disciplinary coordination.
2. Demonstrate the ability to address all emotional issues in patients and family members in relation to diagnosis, therapy, terminal care and mortality related to malignancies
3. Organise proper promotive and preventive care strategies in the community aimed at reducing the burden of care in malignancies
4. Lead and participate in planning and execution of team work related to establishment and maintenance of infrastructure related to radiation therapy, conforming to the updated guidelines
5. Plan and conduct research related to the topic
6. Demonstrate the ability to organise teaching / training sessions for students and health workers in topics related to cancer prevention and care.

SUBJECT SPECIFIC LEARNING OBJECTIVES

The objectives of the MD programme in Radiation Oncology are to impart knowledge, practical skills andclinical experience in the non-surgical treatment of cancer.

A. Cognitive domain

The students after successful completion of their training, should have acquired knowledge in the following:

1. Theoretical and practical knowledge for competent, safe, compassionate & ethical multidisciplinary practice of oncology and should contribute to the future *developments in oncology.*
2. The epidemiology, etiology, pathology & natural history of human neoplastic diseases.
3. Knowledge, experience & skill in the clinical diagnosis of human neoplastic diseases.
4. Attain knowledge and a high level of technical expertise in all forms of radiation as a therapeutic tool used in radiotherapy
5. Knowledge of the adverse effects of radiation including radiation related accompaniments.
6. Knowledge and comprehension regarding the use of cytotoxic drugs and biological response modifiers etc in all clinical and research settings with detailed knowledge of adverse effects of these drugs.
7. Knowledge and comprehension with the role of surgery in the management of neoplastic diseases.Knowledge and ability to judiciously combine various modalities in comprehensive, multi-disciplinary management of cancer patients; coordinate withother specialty experts in the team and plan for use of radiation and cytotoxic drugs integrated into the overall treatment plan
8. A sound knowledge and capability to manage cancer patients as a whole, including
    a) Management of oncological emergencies,
    b) complications associated with malignant diseases and its management,
    c) psychosocial problems,
    d) prevention, rehabilitation and palliative care.
9. Knowledge and capacity to interpret current advances in cancer management and research (basic, clinical and applied aspects of research including radiobiology & molecular oncology).
10. Knowledge and capability to plan and coordinate community based screening, early detection, and awareness programmes including community-based research projects.
11. Basic knowledge of the different statistical methods used in collection, analysis and interpretation of data related to cancer (with special emphasis on planning & interpretation of clinical trials)
12. Knowledge and capability to set up the specialty department and facilities for Oncology in different parts of India.
13. Able to interact with the Government and other agencies as a nodal person for planning

development of specialty of radiation oncology.

14. A broad knowledge of different types of investigations in the management of patientswith cancer.

B. Affective Domain:

The student:

1. Should be able to function as a part of a team, develop an attitude of cooperation with colleagues, and interact with the patient and the clinician or other colleagues to provide the best possible diagnosis or opinion.

2. Always adopt ethical principles and maintain proper etiquette in dealings with patients, relatives and other health personnel and to respect the rights of the patientincluding the right to information and second opinion.

3. Develop communication skills to word reports and professional opinion as well as to interact with patients, relatives, peers and paramedical staff, and for effective teaching.

C. Psychomotor domain

The student, at the end of the course, should have acquired the following skills:

I.Skills and Clinical Experience:

Considerable familiarity and skills in the application of imaging techniques, nuclear medicine procedures, pathology and other aids in the diagnosis and management of cancers. Post graduate student**s need to have gained a wide range of experience in the areas of patient care which would include** investigation, diagnosis, treatment with radiation, and in palliative and supportive care and to have gained the practical experience detailed below:

1. Radiation Oncology – Basic Techniques

a. Positioning the Patient

- Setting up of a patient in each of the three basic treatment positions (supine, prone and lateral) to allow the patient to be planned and treated effectively and without discomfort,
- Setting up the source skin distance for fixed FSD, and extended FSD treatment,
- Setting up patients using laser beam alignment,

- Making temporary and permanent marks on the patient for field positions (Gentian violet, tattoo).

b. Immobilisation Techniques

- Application of some of the following immobilisation techniques: head clamp, Velcro strap, polystyrene beads, vacuum bag, breast arm rest,
- The construction of thermoplastic beam direction shell.

c. Methods of Target Volume Determination

- Performance of planning
  - using direct vision of the tumour (eg skin tumours),
  - from surface landmarks (eg the parotid bed, breast tumours),
  - with direct screening using simulator (eg lung tumours, bone metastases), including opacification techniques (eg barium swallow, cystogram),
  - by volume transfer to orthogonal radiographs (eg head and neck tumours, brain tumours),
- Volume determination from planning CT scans for creatinga central axis plan and for 3-dimensional CT planning.

d. Outline Techniques

- Use of manual techniques (flexi-curves, plaster of Paris bandage) and CT derived outlines.

e. Basic Field Arrangements

- Planning of treatments (under supervision where necessary) using the following field arrangements:
  - Single direct field,
  - Opposed pair of fields using equal and unequalweightings,
  - Opposed pair using wedges,
  - Wedged right-angled pair,
  - Wedged oblique pair,
  - Plans using 3 and 4 fields,
  - Total body irradiation.

f. Tissue Compensation

- Planning of patients requiring tissue compensation using bolus, wedges and remote tissue compensators

g. Shielding

- Planning of patients using lead cut outs and lead masks for simple superficial tumours.
- Knowledge of the thickness of lead required for superficial, orthovoltage andelectron treatments at various energies,
- Prescription and insertion of eye shields.

h. Megavoltage Techniques

- Planning of patients incorporating simple lead blocking techniques using standard blocks and cast blocks from templates

i. Electrons

- The indications for, and planning of, electron treatments, including the selection of electron energy,
- A technique for total skin electron therapy and experience of its use.

j. Dose Calculation

- Proficiency in the use of equivalent square tables,
- Performance of depth dose calculations for single fields and opposed fields using various energies,
- The principles applied to convert dose to machine units for a range of machines,
- The principles of computer-based treatment planning.

k. Radiotherapy Prescriptions

- Writing radiotherapy prescriptions (countersigned where necessary) for all the field arrangements mentioned above,
- Understanding of dose specification as in ICRU 50 and 62.

l. Radiotherapy Machines

- Planning of patients for treatment on a full spectrum of equipment, including superficial x-ray therapy, megavoltage x-ray therapy and megavoltage electron therapy (also orthovoltage x-ray therapy and cobalt-60 therapy, if

available)

m. Quality Assurance in External Beam Therapy

- Requesting portal imaging and interpreted their appearance satisfactorily in all sites

n. Brachytherapy

- The insertion and removal of radioactive sources manually or using an appropriate after-loading device,
- Interpretation of subsequent check films,
- Interpretation of the corresponding dose calculation and writing of an appropriate prescription,
- Removal of live sources and the after-loading device,
- The placement of implants,
- Principles of oral and intravenous radionuclide therapy.

o. Radiation Safety

- The role of the radiation safety and radiation protection supervisor,
- The meaning of and requirements for controlled and supervised areas and their location,
- The procedure to be adopted in the case of a spill of radioactive material,
- Quality assurance practices in radiotherapy and the procedures for dealing with errors in treatment delivery.

2. Radiation Oncology Assessment and the Care of Patients on Treatment:

a. Treatment Review Clinics

- Regular weekly treatment review clinics

b. Treatment Checks

- Assessment of patient position and treatment field placement(s) in relation to the target volume at the start of treatment,
- Performance of checks during the course of treatment on the implementation of the treatment plan, position of shielding for critical normal structures and the use of portal imaging,
- Assessment of changes occurring in patient parameters during treatment and resultant modification of treatment when appropriate,

- Assessment of normal tissue reactions to radiotherapy,
- Use of dose volume histograms and in vivo radiation dosimetry techniques.

c. Symptom Control

- Giving advice on skin care during radiation treatment and on the management of skin reactions, including desquamation,
- Managing mucosal reactions in oral cavity, oropharynx, nasopharynx, trachea, oesophagus, anus and vagina,
- Giving dietary advice during abdominal radiotherapy,
- Managing radiation induced nausea and vomiting, diarrhoea, dysphagia, xerostomia and cystitis,
- Giving prophylaxis for radiation induced cerebral oedema,
- Giving advice on timing and extent of hair loss with respect to radiation dose,
- Giving advice for hospitalization, if necessary.

d. Follow-up

- Managing acute and chronic radiation sequelae, such as pneumonitis, cystitis, chronic bowel complications, gynecological sequelae (vaginal stenosis, vaginal dryness, infertility and dyspareunia)

3. Supportive and Palliative Care

a. Pain Relief

- Drug treatment
  - A wide range analgesic technique, including simple analgesics, mild and strong opioids, given by a variety of routes,
  - Management of the complications of analgesics, including constipation, nausea, gastro-intestinal discomfort and analgesic intolerance.
- Mechanical methods
  - Prescription, siting and evaluation of TENS analgesia,
  - Referral of patients with refractory pain for procedures such as a nerve block, intrathecal analgesia, rhizotomy or orthopaedic stabilization.
- Radiotherapy
  - Use of radiation to treat painful metastatic disease with single fractions, multiple fractions and hemi- body radiotherapy

b. Nausea and Vomiting

- Treatment of nausea and vomiting arising in advanced illness using anti-emetics,
- Palliative management of sub-acute intestinal obstruction.

c. Anorexia and Dysphagia

- Management, where appropriate, with corticosteroids, progestogens and nasal gastric feeding

d. Pleural Effusions and Ascites

- Drainage of pleural effusions and ascites,
- Other treatments such as pleurodesis.

e. Depression and Anxiety

- Knowledge regarding treatment of depression at all stages of cancer management, using counselling and drug techniques with anti-depressants,
- Knowledge regarding treatment of anxiety with counselling, anxiolytics and major tranquilizers.

f. Hospice Care

- Awareness of local hospice facilities,
- A one-week (at least) attachment to a hospice or palliative care team.

g. Counseling

- Counseling of patients and relatives at all stages of the disease

4. Investigational Techniques

a. Laboratory Investigations

- Interpretation of the results of haematological, biochemical and radioimmunoassay investigations

b. Radiology

- Attendance at regular radiological review sessions involving a consultant clinical radiologist for the examination of plain x-rays, CT scans, magnetic resonance imaging and ultrasound covering the whole spectrum of cancer radiology,
- Current indications and techniques in interventional procedures.

c. Radiation Medicine Procedures

- Diagnostic Imaging – Gamma Camera, SPECT, PET Scanner, PET-CT and PET-MRI image fusion studies in treatment planning, response evaluation

and follow up.

d. Pathology

- Attendance at regular pathological review sessions involving a consultant pathologist

e. Genetics in diagnosis, prognosis and treatment of cancer

f. Other Procedures

- Indirect laryngoscopy
- Lumbar puncture
- Skin biopsy
- Fibre optic naso-endoscopy
- Pelvic EUA and cystoscopy

5. Site or Disease Specific Procedures

- Assessment, treatment and follow-up, in detail, for each of the anatomical sites and types of tumour,
- Presentation and assessment of patients discussed at multidisciplinary teammeeting,
- Staging,
- Radiotherapy – adjuvant, radical and palliative,
- Hormone and biological therapy,
- Palliative care,
- Appropriate follow up,
- Acute and late side effects of treatment.

6. Clinical Trials, Literature and Research

- The aims and format of Phase I to IV clinical trials,
- Obtaining informed consent, following study protocols and using data forms,
- Research programmes (although research experience is not a prerequisite),
- Major areas of current research and of recent important publications,
- Submission of a research project to an Ethics Committee,
- Structure and functioning of local and national clinical and research cancer

networks.

- Ethics guidelines of research

7. Communication and Publication

- Effective communication with colleagues, patients and their carers,
- Giving clear and comprehensive descriptions of disease processes, investigations and treatment,
- Clear expression in English/local script and production of legible script,
- Preparing work for publication.
- Ethics of research publication

8. Outpatient and Joint Clinics

- Participation in joint consultative clinics and regular general oncology outpatient sessions,
- Seeing review and new patients and planning their overall management.

9. Resource Management and Quality Assurance

- Introduction to the resource management and quality assurance of an oncology service, so as to be able to develop these skills at a later stage

10. Prevention

11. Screening

- A broad knowledge of the environmental causes of cancer and possible strategies for prevention
- Details of screening programs for cervical, breast, Head & Neck, Lungs, Prostate, GIT and other cancers which might form a major proportion of cancer cases in the country in the years to come.

12. Genetics

- The familial aspect of some cancers as in colorectal, breast, ovary, retinoblastoma, multiple cancer syndromes etc. and the management of high-risk families and genetic counseling.

SYLLABUS

STRUCTURE

1. Basic Sciences

(a) Anatomy

(b) Pathology

- General Pathology
- Systemic Pathology

(c) Radiotherapeutic physics

(d) Clinical Radiobiology

(e) Statistical basis for planning & interpretation of clinical trials.

2. Clinical Radiation Oncology

3. Clinical Chemotherapy

4. Other disciplines allied to Radiotherapy and Oncology

5. Palliative care

6. Research, Training & Administration

1. BASIC SCIENCES

1.1. Anatomy

1.1.1. Knowledge of surface anatomy pertaining to Oncology

1.1.2. Detailed knowledge of the anatomy of all organs.

1.1.3. Detailed knowledge of the lymphatic system of all regions

1.1.4. Practical familiarity with the radiographic appearance of important regions

1.1.5. Cross sectional anatomy

1.2. Pathology

1. General Pathology

1.1. Definitions of & distinction between different types of growth disorders (i.e. distinction between hyperplasia, hypertrophy, regeneration, malformation & neoplasia)

1.2. Malignant transformation -

Initiation & promotion stages of carcinogenesis

Mode of origin - monoclonal, polyclonal, unifocal, multifocal Structural

&functional changes in the cellular components.

Etiology, mechanisms of carcinogenesis, known types of carcinogens & their effects upon the cell. The relative importance of different factors in the causation of human cancer.

1.3. Rate of growth, methods of measurement Factors affectinggrowth rate Mechanisms of spread

Local effects of tumors
Local & systemic reactions to tumors

Effects of therapy on tumors & normal tissues.

1.4. Criteria for tumor diagnosis - macroscopic, histological & cytological uses & value of biopsy material

1.5. Classification of tumors - histogenic, histological, behavioral & immunological

1.6. Nomenclature - solid tumors, lymphomas, leukemias

1.7. Structure & organization of tumors - vascular supply, stroma etc.

1.8. Systems of grading

1.9. Endocrine aspects of malignancy: - production of hormones by tumors, effect of hormones on tumours, paracrine effects of tumors

1.10. Paraneoplastic syndromes

1.11. Etiology of cancer

Genetic predisposition, congenital syndromes Chromosomal abnormalities, hereditary tumours

Protooncogenes, oncogenes, tumor suppressor genes, viruses & malignancy Multifactorial causation

Nutritional aspects in cancer causation and prevention. Environmental causes of cancer

Biological - protozoal, bacterial, viral

Chemical - Classes of carcinogenic chemicals, smoking

Physical - trauma, irradiation (UV rays, other electromagnetic radiation including X rays and Gammarays and particulate radiations)

Common occupational cancers.

Experimental tumours in animals - relationship to human mutagenicity.

1.12. Tumor immunology

Organisation & development of the immune system & the role of immune response in disease

Cellular basis of immunity & measurement of immune function. Graft versus host reactionTumor immunity, tolerance, enhancement Immune surveillance hypothesis

Immunological markers in diagnosis & monitoring Experimental & clinical immunotherapy

The HLA systems.

1.3. Radiation Oncology Physics

The aim of this subject is to provide the future Clinical Oncologist with the knowledge of physics required in clinical practice.

An understanding of the principles of planning & carrying out treatment is a necessary prerequisite & will be enhanced by the study of this subject.

A familiarity with the ***physics of electricity, atomic structure & electromagnetic radiation*** *will also be required in order to understand parts of the syllabus.*

As they are studied they should be analyzed critically with respect to their implications for accurate dose delivery in clinical radiation therapy. Applicability limitations, advantages, & disadvantages of the various devices & techniques should receive particular attention.

Candidates should be encouraged to observe & gain practical experience with the equipment & techniques used in radiotherapy in clinical oncology departments.

1. *Structure of Matter:* Constituents of atoms, Atomic and mass numbers, Atomic and mass energy units, Electron shells, Atomic energy levels, Nuclear forces, Nuclear energy levels

   Electromagnetic radiation, Electromagnetic spectrum, Energy quantisation, Relationship between Wavelength,Frequency, Energy

2. *Nuclear Transformations:* Natural and artificial radioactivity, Decay constant, Activity, Physical, Biological and Effective half-lives, Mean life, Decay processes, Radioactive series, Radioactive equilibrium

3. *Production of X-rays:* The X-ray tube, Physics of X-ray production, Continuous spectrum, Characteristic spectrum, Efficiency of X-ray production, Distribution of X- rays in space, Specifications of beam quality, Measurement of beam quality, Filters and filtration

4. *Interaction of radiation with matter:* Attenuation, Scattering, Absorption, Transmission, Attenuation coefficient, Half Value Layer (HVL), Energy transfer, Absorption and their coefficients. Photoelectric effect, Compton Effect, Pair-production, Relative importance of different attenuation processes at various photon energies

   Electron interactions with matter: Energy loss mechanisms- Collisional losses, Radiative losses, Ionization, Excitation, Heat production, Delta rays, Polarization effects, Scattering, Stopping power, Absorbed dose, secondary electrons

   Interactions of charged particles: Ionization vs. Energy, Stopping power, Linear Energy Transfer (LET), Braggcurve, Definition of particle range

5. *Measurement of radiation:* Radiation Detectors: Gas, Solid-state, Scintillation, Thermoluminescence, Visual Imaging (Film, Fluorescent screens), and their examples

   Exposure, Dose, Kerma: Definitions, Units (Old, New), Inter-relationships between units, Variation with energy and material. Measurement of exposure (Free air chamber, Thimble chamber), Calibration of therapy beams: Concepts, Phantoms, Protocols (TG 21, IAEA TRS-277, TG 51) Dose determination in practice *(brief outline only, details not required)*

6. *Radiotherapy Equipment:* Grenz ray, Contact, Superficial, Orthovoltage or Deep therapy, Supervoltage, Megavoltage therapy. Therapy and diagnostic X-ray units – comparison. Filters, factors affecting output, principles of cooling. Betatrons.

   Co-60 units: Comprehensive description of the unit, Safety mechanisms, Source capsule

Linear accelerators: History, Development, Detailed description of a modern, dual mode linear accelerator, Linac head and its constituents, Safety mechanisms, Computer controlled linacs, Record and Verify systems

Relative merits and demerits of Co-60 and linac units

Simulators: Need for them, Detailed description of a typical unit, Simulator CT

7. Basic ratios, Factors, Dose distributions, Beam modifications and Shaping in Teletherapy beams

Characteristics of photon beams: Quality of beams, Difference between MV and MeV, Primary and scatteredradiation

Percentage depth dose, Tissue-Air Ratio, Scatter Air Ratio, Tissue-Phantom Ratio, Tissue Maximum Ratio, Scatter Maximum Ratio, Back Scatter Factor, Peak Scatter Factor, Off-Axis Ratio, Variation of these parameters with depth, field size, source- skin distance, beam quality or energy, beam flattening filter, target material. Central axis depth dose profiles for various energies.

Equivalent square concept, Surface dose (entrance and exit), Skin sparing effect, Outputfactors

Practical applications: Co-60 calculations (SSD, and SAD technique), Accelerator calculations (SSD, and SAD technique)

Beam profiles, Isodose curves, Charts, Flatness, Symmetry, Penumbra (Geometric, Transmission, and Physical), Field size definition

Body inhomogeneities: Effects of patient contour, Bone, Lung cavities, Prosthesis on dose distribution. Dose within bone / lung cavities, Interface effects, Electronic disequilibrium

Wedge filters and their use, Wedge angle, Wedge Factors, Wedge systems (External, In-built Universal, Dynamic / Virtual), Wedge isodose curves

Other beam modifying and shaping devices: Methods of compensation for patient contour variation and / or tissue inhomogeneity - Bolus, Buildup material, Compensators, Merits and Demerits. Shielding of dose limiting tissue: Non-divergent and Divergent beam blocks, Independent jaws, Multileaf collimators, Merits and Demerits

8. Principles of Treatment Planning - I

Treatment planning for photon beams: ICRU 50 and NACP terminologies. Determinationof body contour and localization: Plain film, Fluoroscopy, CT, MRI, Ultrasonography, Simulator based

Methods of correction for beam's oblique incidence, and body inhomogeneities

SSD technique and isocentric (SAD) technique: Descriptions and advantages of SAD technique

Combination of fields: Methods of field addition, Parallel opposed fields, Patient thickness vs. Dose uniformity for different energies in a parallel opposed setup, Multiple fields (3fields, 4 field box and other techniques). Examples of above arrangements of fields in SSD and SAD techniques, Integral Dose

Wedge field technique, Rotation Therapy (Arc, and Skip), Tangential fields. Beam balancing by weighting. Total and hemi-body irradiation. Field junctions

9. *Principles of treatment planning – II*

Limitations of manual planning. Description of a treatment planning system (TPS): 2D and 3D TPS. Beam data input, Patient data input (simple contour, CT, MR data, Advantages of transfer through media), Input devices (Digitizer, floppies, DAT devices, Magneto-optical disks, direct link with CT, MR). Beam selection andplacement, Beam's Eye View (BEV), Dose calculation and display (Point dose, Isodose curves, Isodose surfaces, Color wash). Plan optimization, Plan evaluation tools: Dose-Volume Histograms (Cumulative and Differential), Hard copy output, Storage and retrieval of plans.

Alignment and Immobilization: External and internal reference marks, Importance of immobilization in radiotherapy, Immobilization methods (Plaster of Paris casts, Perspex casts, bite block, shells, head rests, neck rolls, Alpha-Cradles, Thermoplastic materials, polyurethane foams), Methods of beam alignment (isocentric marks, laser marks, and front/back pointers).

Treatment execution: Light field, Cross hair, ODIs, Scales in treatment machines

Treatment verification: Port films, Electronic portal imaging devices, In-vivo patient dosimetry (TLD, diode detectors, MOSFET, Film, etc.) Changes in patient position, target volume, and critical volume during course of treatment

10. *Electron Beam Therapy*

Production of electron beams: Production using accelerators, Characteristics of electrons. Surface dose, percentage depth dose, beam profiles, Isodose curves and charts, Flatness and Symmetry. Beam collimation, variation of percentage depth dose and output with field size, and SSD, photon contamination. Energy spectrum, Energy specification, variation of mean energy with depth. Suitability of measuring instruments for electron beam dosimetry

Treatment planning: Energy and field size choice, air gaps, and obliquity, Tissue inhomogeneity – lung, bone, air filled cavities. Field junctions (with either electron or photon beam). External and internal shielding. Arc therapy, Use of bolus in electron beam

Total Skin Electron Irradiation, Intraoperative Radiation Therapy

11. *Physical Principles of Brachytherapy:* Properties of an ideal brachytherapy source, Sources used in brachytherapy: Ra-226, Cs-137, Ir-192, Au-198, Co-60, I-125, Sr- 90, Yt-90, Ru-106, Ta-182 and other new radionuclides, Their complete physical properties, Radium hazards. Source construction including filtration, comparative advantages of these radionuclides

Historical background. Radiation and Dose units: Activity used, Exposure, Absorbed Dose, mg-hr, curie, milli-curie destroyed, milligram Radium equivalent, roentgen, rad, gray. Source strength specification, Brachytherapy Dose calibrator

Techniques: Pre-loaded, Afterloading (manual and remote), Merits and Demerits. Surface, Interstitial, Intracavitary, Intraluminal, Intravascular brachytherapy. Low, Medium, High and Pulsed dose rates. Remote afterloading machines, Detailed description of any one unit

Dosage systems: Manchester System (outline only), Paris System (working knowledge)

Treatment Planning: Patient selection, Volume specification, Geometry of implant, Number, Strength and Distribution of radioactive sources, Source localization, Dose calculation, Dose rate specification, Record keeping. ICRU 38

Radiation Safety: Planning of brachytherapy facility, Rooms and equipment, Storage and Movement control, Source inventory, Disposal, Regulatory requirements

Beta-ray brachytherapy including methods of use, inspection, storage and transport of sources, dose distribution

Unsealed radionuclides: Concepts of uptake, distribution and elimination, Activities used in clinical practice, Estimation of dose to target tissues, and critical organs, Procedures for administering radionuclides to patients

12. *Quality Assurance in radiotherapy (QART)*

Overview of ESTRO QART: Need for a quality system in Radiotherapy, Quality System: Definition and practical advantages, Construction, Development and Implementation of a Quality System

Quality Assurance of Simulator, TPS, Co-60, linear accelerator Acceptance testing of

Simulator, TPS, Co-60, linear accelerator

13. *Radiation Protection and Regulatory Aspects:*

Statutory Framework – Principles underlying International Commission on Radiation Protection (ICRP) recommendations. ICRP and National radiation protection i.e. Atomic Energy Regulatory Board (AERB) standards. Effective dose limits (ICRP and AERB).

Protection mechanisms: Time, Distance and Shielding. Concept of "As Low As Reasonably Achievable" (ALARA)

Personnel and Area Monitoring: Need for personnel monitoring, Principles of film badge, TLD badge used for personnel monitoring. Pocket dosimeter. Need for area monitoring, Gamma Zone monitors, Survey meters

Regulatory aspects: Procedural steps for installation and commissioning of a new radiotherapy facility (Teletherapy and Brachytherapy). Approval of Standing Committee on Radiotherapy Development Programme. Type approval of unit. Site plan, Layout of installation / Associated facility: Primary, Secondary barriers, leakage and scattered radiation. Regulatory requirement in procurement of teletherapy / brachytherapy source(s). Construction of building, Qualified staff, Procurement of instruments, and accessories, Installation of unit and performance tests, Calibration of unit, RP&AD approval for clinical commissioning of the unit.

Other regulatory requirements: Regulatory consent, NOCs, Periodical reports to AERB and Radiological Physics and Advisory Division (RP&AD), Bhabha Atomic Research Centre (BARC).

14. *Advancements in Radiation Oncology:*

Virtual Simulation: Principle, CT-Simulation, TPS based virtual simulation, Differences, Merits and Demerits, Practical considerations

Conformal radiotherapy (CRT): Principles, Advantages over conventional methods, Essential requirements for conformal radiotherapy.

Various methods of CRT:

1. With customized field shaping using conventional coplanar beams
2. Multiple non-coplanar MLC beams conforming to target shape
3. Stereotactic radiotherapy
4. Principle of Inverse planning and Intensity Modulated Radiation Therapy (IMRT)
   - Using 3D compensators
   - Static IMRT (Step and shoot technique)
   - Dynamic IMRT (sliding window technique)
   - Dynamic arc IMRT
   - Micro-MLC
   - Tomotherapy methods
5. Time gated (4D) radiotherapy Merits and demerits

of IMRT

Stereotactic irradiation methods: Physics principles, Techniques, Description of Units (Gamma Knife and Linac based), Merits and demerits, Stereotactic Radiosurgery (SRS) and Stereotactic Radiotherapy (SRT), Whole body stereotactic frame

Networking in radiotherapy: Networking of planning and treatment units in a radiotherapy department including Picture Archival Communication System (PACS), Advantages, Patient Data Management

1.4. Radiobiology

1.4.1. Introduction to Radiation Biology

1.4.1.1. Radiation interaction with matter

Types of radiation, excitation and ionization. Radiation chemistry: direct and indirect effects, free radicals, oxygen effect and free radical scavengers, LET and RBE theory, dual action theory, intracellular repair, general knowledge of repair models.

1.4.1.2. Introduction to factors influencing radiation response

Physical factors: dose, dose quality, dose rate, temperature *Chemical factors*: Oxygen, radiosensitizers, radioprotectors

Biological factors: type of organism, cell type and stage, cell density and configuration, age, sex.

Host factors: partial or whole-body exposure.

1.4.1.3. Relevance of radiation biology to radiotherapy

1.4.1.4. Interaction of ionizing radiation on mammalian cells.

The cell: structure and function; relative radiosensitivity of nucleus and cytoplasm, mitosis, cell cycle, principles of DNA, RNA and protein synthesis, radiation effects on DNA, strand breakage and repair, common molecular biology techniques.

Cell injury by radiation: damage to cell organelle like chromatids, chromosomes; interphase death, apoptosis, mitotic death, micronucleus induction, SLD, PLD. Oxygen

effect: mechanism, hypoxia, OER, reoxygenation in tumors, significance in radiotherapy. Dose rate. Brachytherapy sources including 252Cf. Radiobiology of low, high dose rate & pulsed brachytherapy, hyperfractionation, significance in radiotherapy.

Effects of low LET and high LET radiation on cell. Cell survival curves.

Effect of sensitizing and protective agents. Dose modifying factors and their determination. Variation of response with growth and the progression of cell through the phases of cell cycle.

Physical factors influencing cell survival; relative biological effectiveness (RBE); its definition and determination, dependence upon linear energy transfer, dose, dose rate and fractionation. Hyperthermic and photodynamic injury.

Biological hazards of irradiation; dose protection and LET, effects on the embryo and the fetus, life shortening, leukaemogenesis and carcinogenesis, genetic and somatic hazards for exposed individuals and population. Biological basis of radiological protection.

1.4.1.5. Organ radiosensitivity and radioresponsiveness, concept of therapeutic index.

1.4.1.6. Acute effects on Radiation Concept of mean lethal

dose

Radiation Syndromes: BM, GI, CNS, cutaneous Suppression of immune System:

mechanism, consequences Total Body irradiation

Biological dosimetry: Blood counts, BM mitotic index. Chromosome aberrations in peripheral blood lymphocytes

Radiation accidents: typical examples

1.4.2. Radiation Effects on Major Organs/tissues

Acute & late effects on all normal organs & tissues including connective tissue, bone marrow, bones, gonads, eye, skin, lung, heart, central nervous system tissues, peripheral nerves, esophagus, intestine, kidney, liver & thyroid with special reference to treatment-induced sequelae after doses employed in radiotherapy

Normal tissue tolerances

1.4.2.1. Late effects of radiation (somatic)Sterility, cataracts and

cancer

Carcinogenesis: mechanisms in vitro and in vivo, oncogenes and anti oncogenes Radiation induced cancer of occupational, medical or military origin

Recent controversial results for low level exposure, risk estimates

1.4.2.2. Late Effects of Radiation (Genetic) Mutations: definition, types,

potential hazards.

Low level radiation: sources, potential hazards, stochastic and deterministic (non- stochastic) effects, high background areas and cancer.

1.4.2.3. Effects of Radiation on Human Embryo & Fetus

Lethality, congenital abnormalities and late effects (Leukemia and childhood cancer),

1.4.2.4. Biology and Radiation Response of Tumors

Tumor growth; kinetics of tumor response. Growth fraction, cell loss factor.

Volume doubling times, potential volume doubling times, repopulation, and accelerated repopulation.

Radiocurability: definition, factors involved, tumor control probability curves.

Factors determining tumor regression rates. Causes of failure to control tumors by radiation: tumor related, host related technical/mechanical errors.

Relationship between clonogen numbers and tumor control probability. Local tumor control and impact on survival.

1.4.3. Applied Radiobiology

Fractionation: rationale, factors involved (4 R's).

Time, dose, and fractionation relationship: isoeffect curves, isoeffect relationships,
e.g. NSD, CRE formalisms and their limitations, partial tolerance, means of summating partial tolerance, steepness of dose response curves.

Multi-target, two component and linear quadratic model. a/b ratios for acute and late effects and means of deriving these values. Isoeffective formulae. Clinical applications of the L-Q model, hyperfractionation, accelerated fractionation, hypofractionation, CHART, split dose treatments.

Bracthytherapy - low dose rate, high dose rate and pulsed treatments.

Introduction to new techniques to optimize radio-curability; combination therapy (adjuvant surgery or chemotherapy), hyperthermia, hypoxic cell radio-sensitizes, highLET radiation. Photodynamic therapy.

The volume effect, general principles and current hypotheses. Shrinking Field

technique.

Combination Radiation -Surgery

Pre-, post- and intra-operative radiation.

Rationale, radiobiological factors, current clinical results.

Irradiation of sub-clinical disease, debulking surgery, importance of clonogen numbers.

Combination Radiation -Chemotherapy

Definitions of radiosensitiser, synergism, potentiation, antagonism.Radiosensitisers:

types, mechanism.

Hyperthermia

Sources, rationale (historical examples), advantages and disadvantages, thermotolerance.

Cellular damage: comparison and contrast with radiation, thermal and non-thermal effects of ultrasound, microwaves, radiofrequency, etc. General host responses (immunology, metastases).

Use along with radiotherapy and chemotherapy: optimum sequencing of combined modalities. Current limitations to the clinical use of hyperthermia.

1.4.4. High LET Radiation

Comparison and contrast with low LET radiation.

Neutrons: source (including 252 Cf) and boron neutron capture (outline only). Advantages and disadvantages of neutrons, RBE values, hazards of low dose and low energy neutron, use in radiotherapy, combination with low LET, current clinical results.

Other high LET particles: protons, mesons, high-energy heavy nuclei, application to radiotherapy, current clinical results.

1.5. Clinical trials - Statistical basis for planning & interpretation

Clinical Trials.

- Advantages & disadvantages
- Retrospective & prospective studies
- Controlled & uncontrolled trials
- Single-blind & double-blind studies
- Phase I, II & III trials
- Ethics (Helsinki declaration).

Planning a trial

- Establishing objectives- short term and long term
- Determining the appropriate criteria.
- Establishing grounds for inclusion and exclusion of patients
- Determining how many treatment schedules are to be completed
- Determining the treatment schedules and any appropriate modifications
- Determining the method of allocation of treatments; the allocation ratio and the method and timing of randomization
- Determining what measures are to be taken, how they will be taken, who will take them, at what time(s) andwhere they will be recorded
- Designing the appropriate forms of documentation
- Determining the proposed duration of the trial, either in terms of a fixed closing date, or the entry of a pre-determined number of patients.
- Establishing conditions under which the trial may be terminated earlier than planned &procedures for detecting these conditions.
- Re-assessing the proposed trial in terms of ethics, appropriateness to the short- & long-term objectives, feasibility& the availability of resources.
- Writing the protocol
- Running a pilot study

2. CLINICAL RADIATION ONCOLOGY

2.1. Cancer Epidemiology & Etiology

2.1.1. Cancer Statistics - worldwide & India

2.1.2. Cancer Registries & National Cancer Control Programme.

2.1.3. Analysis of data in cancer registries.

2.1.4. Regional Cancer Centers

2.1.5. Cancer Screening & Prevention.

2.2. Patient Care

2.2.1. Assessment & referral systems for radiotherapy

2.2.2. Diagnosis & workup.

2.2.3. Staging

2.2.4. Care & evaluation during & after treatment

2.2.5. Emergencies in Oncology

2.2.6. Management of different malignancies

2.3. Treatment Response & Result

2.3.1. Guidelines for treatment response assessment - Complete Response, Partial Response, No Response, Stabledisease.

2.3.2. End points of treatment results: Loco-regional control, recurrence, metastasis, survival, quality of life.

2.3.3. Treatment related morbidity assessment

(i) Radiation morbidity (early & late)

(ii) Morbidities of combined treatment

(iii) Grading Systems.

3. CLINICAL CHEMOTHERAPY

3.1. Basic principles of chemotherapy

3.1.1. Chemotherapy drugs.

3.1.2. Newer chemotherapeutic agents.

3.1.3. Basis for designing different chemotherapy schedules. Standard chemotherapy schedules.

3.1.4. Chemotherapy practice in various malignancies

3.1.5. Chemotherapy practice & results/ toxicities in sequential & concomitant chemoradiotherapy.

3.1.6. Supportive care for chemotherapy.

3.1.7. The basic principles underlying the use of chemotherapeutic agents.

(i) Classification and mode of action of cytotoxic drugs. The principles of cell kill by chemotherapeutic agents, drug resistance, phase specific and cycle specific action.

(ii) Drug administration. The general principles of pharmacokinetics; factors affecting drug concentration 'in vivo' including route and timing of administration, drug activation, plasma concentration, metabolism and clearance.

(iii) Principles of combinations of therapy, dose response curves, adjuvant and neo-

adjuvant chemotherapy, sanctuary sites, high dose chemotherapy, and regional chemotherapy.

(iv) Toxicity of drugs. Early, intermediate and late genetic and somatic effects of common classes of anticancer drugs. Precautions in the safe handling of cytotoxic drugs.

(v) Endocrine manipulation and biological response modifiers. An understanding of the mode of action and side effects of common hormonal preparations used in cancer therapy (including corticosteroids). Use of the major biological response modifiers such as interferons, interleukins and growth factors andknowledge of their side effects.

(vi) Assessment of New Agents. Principles of phase I, II, and III studies.

(vii) Gene Therapy

3.2. Other Disciplines Allied to Radiotherapy and Oncology

3.2.1. Surgical Oncology.

1. Basic principles of surgical oncology, biopsy, conservation surgery, radical surgery, palliative surgery.
2. Basics of surgical techniques - head & neck, breast, thorax, abdomen, gynecological, genitourinary,musculoskeletal, CNS.
3. Combined treatments: with radiotherapy, chemotherapy, and hormone therapy.

3..2.2. Preventive oncology

4. PALLIATIVE CARE

4.1. Guidelines for palliative care

4.2. Symptoms of advanced cancer

4.3. Management of terminally ill patients.

4.4. Different pharmacologic & non-pharmacologic methods

4.5. Pain control, WHO guidelines for adults & children.

4.6. Palliative radiotherapy

4.7. Palliative chemotherapy

4.8. Home care

4.9. Hospice care

4.10. Physical, social, spiritual & other aspects.

5. RESEARCH, TRAINING & ADMINISTRATION

5.1. Research in Oncology

5.1.1. How to conduct research

5.1.2. Guidelines for biomedical research: Animal studies, drug studies, human trial.

5.1.3. Cancer clinical trials. Phase I/II, III

5.1.4. Ethics of clinical research

5.1.5. Evidence based medicine.

5.2. Training in Oncology

5.2.1 Residency in Radiotherapy and Oncology

2. Theory, clinical & practical modes of training

3. Structured training: lectures, seminar, Journal club, Ward-round, Physics demonstration, Practical, Case Presentations (e.g., Long Case; Short Case)

4. Participation in various procedures, techniques (e.g., Brachytherapy, Radiotherapy Planning, Mould Room Procedures etc.)

5. CME-conference, symposium, workshop, seminar

5.2.6 Visiting other cancer centers & radiotherapy departments

5.3. Administration in Radiotherapy and Oncology.

5.3.1 Clinical Oncologists' role as an administrator.

2. How to set up a Radiotherapy and Oncology department, planning of infrastructure, &equipments

3. Role in cancer control programme.

4. Responsibilities towards safety & quality assurance. Administration aspects of training, academic, patient care & research.

PAPERWISE DISTRIBUTION OF SYLLABUS FOR PURPOSE OF MD (RADIATION ONCOLOGY)EXAMINATION

Paper I- Radiation physics and radiobiology, basic sciences related to oncology and Biostatistics

Paper II- Clinical Radiation Oncology

Paper III- Radiotherapy including Chemotherapy

Paper IV- Recent Advances in Radiotherapy and Oncology

YEAR WISE TRAINING DETAILS

1st year	Phase I (0-6 months)
	Phase II (7-12 months)
2nd year	Phase III (13-18 months)
	Phase IV (19-24 months)
3rd year	Phase V (25-30 months)
	Phase VI (31-36 months)

Phase I 0-6 months	**Phase II 7-12 months**
Radiation Physics • Atomic and Nuclear Structure • Radioactivity • Production of X-rays • Interactions of X - and Gamma-rays • Interactions of Particulate Radiations • High Energy Treatment Machines • Measurement of Radiation Exposure • Measurement of Absorbed Dose	• Distribution, External Beam Therapy • Dose Distribution, Sealed Source Therapy • Computerized Treatment Planning • Radiation Protection • Planning of a Radiotherapy Department • New Radiation Modalities

<table>
<tr>
<td>Radiation Biology
• Radiation-induced cellular damage
• DNA double strand break repair
• Quantifying cell survival following irradiation
• Factors that Modify Radiation Response
• Linear Energy Transfer
• Relative Biological Effectiveness (RBE)
• Cell and Tissue Kinetics
• Tissue Radiosensitivity
• Time-Dose and Fractionations
• Hyperthermia
• Total Body Irradiation: Effects</td>
<td>
• Mechanisms of Radiation Carcinogenesis
• Radiation Effects in the Developing Embryo and Foetus
• Radiation Quality
• Dose response for tumour control
• Effects of radiation on normal tissues
• Quantification of radiation effects on normal tissues
• Combination of radiation with other therapies
• Retreatment with radiation therapy</td>
</tr>
<tr>
<td>Anatomy
• Neuro-anatomy
• Head and neck anatomy
• Thoracic anatomy
• Abdominal anatomy</td>
<td>
• Pelvic anatomy
• Extremities</td>
</tr>
<tr>
<td>Pathology
• Introduction to cancer pathology
❖ Introduction to neoplasms
❖ Molecular basis of cancer and cancer genetics
❖ Carcinogenesis
• Mechanisms of cell death</td>
<td>• Pathology of Specific Cancers
❖ Epidemiology
❖ Aetiology
❖ Natural History
❖ Effects of the tumour on the host</td>
</tr>
<tr>
<td>Clinical
• Staging & Classification</td>
<td>Chemotherapy
• Basics of Chemotherapy</td>
</tr>
<tr>
<td colspan="2">• Tumour board Meetings
• Case presentation
• Journal Club
• Seminar</td>
</tr>
</table>

Phase III **13-18 months**	**Phase IV** **19-24 months**
Clinical Topics: 1. Breast 2. Head & Neck 3. Lung 4. Cervix 5. Uterus 6. Ovarian cancer	 7. Prostate Cancer 8. Testicular malignancy 9. Bladder Cancer 10. Oesophageal Cancer 11. Gastric Carcinoma 12. Pancreatic Cancer
Cancer Chemotherapy	
• Tumour board Meetings • Case presentation • Journal Club • Seminar	
• Establish diagnosis and management plan • 2D RT planning • Brachytherapy assisted	

Phase V **25-30 months**	**Phase VI** **31-36 months**
Academic 13. Colon cancer 14. Rectal Cancer 15. Anal Cancer 16. Central Nervous System 17. Thyroid Cancer 18. Hodgkin Lymphoma 19. Non-Hodgkin Lymphoma	 20. Soft Tissue Sarcoma 21. Primary Tumours of the Bone 22. Paediatric Cancers 23. Kidney & Ureter 24. Penile cancer 25. Vulval cancer 26. GTN

- Tumour board Meetings
- Case presentation
- Journal Club
- Seminar

Clinical

- Contouring
- 3D planning
- IMRT Planning and evaluation
- Brachytherapy

RECOMEND

Sl. No.	Editor/Author(s)	Title	Edition
1	Joel E Tepper	Clinical Radiation Oncology	5th
2	Mahul B Amin	AJCC cancer staging manual	8th
3	Edward C Halperin, Carlos A Perez, Brady.	Principles and Practice of Radiation Oncology	7th
4	Gregory Videtic	Handbook of Treatment Planning in Radiation Oncology	3rd
5	Lee, Riaz and Lee	Target Volume Delineation for Conformal and Intensity-Modulated Radiation Therapy	1st
6	Dr.Faiz Khan, John.P.Gibbons	The Physics of Radiation Therapy	6th
7	Eric J Hall	Radiobiology for the Radiologist	8th
8	Daniel M triRiletti	Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy- A comprehensive Guide	1st
9	Eric Hansen	Handbook of Evidence Based Radiation Oncology	3rd
10	Boris Hristov	Radiation Oncology: A question-based review by Boris Hristov	3rd