DETAILED SYLLABUS FOR THE POST OF ASSISTANT PROFESSOR IN RADIOTHERAPY IN MEDICAL EDUCATION - DIRECT RECRUITMENT

(Cat.Nos: 346/2023, 361/2023)

Syllabus in Module wise

1. **MODULE 1** Radiotherapy treatment and planning for various cancers including RTOG guidelines Plus Radiobiology

   Radiotherapy planning for Head and Neck cancers, Gynecological malignancies, Prostate, Rectum, Brain tumours, Breast cancer, Lymphomas, Pediatric tumours, Sarcomas including retroperitoneal sarcomas.

   4 Marks

   Interaction of ionizing radiation on mammalian cells. The cell: Structure and function; relative radio sensitivity of nucleus and cytoplasm, mitosis, cell cycle, principle of DNA, RNA and protein synthesis, radiation effects on DNA, strand breakage and repair, common molecular biology and repair, common molecular biology technique.

   1 Marks

   Chromosomes; interphase death, apoptosis, mitotic death, micronucleus induction, SLD, PLD. Oxygen effect: mechanism, hypoxia, OER reoxygenation in tumors, significance in radiotherapy. Effect of low LET and high LET radiation on cell. Cell survival curves.

   1 Marks

   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. 1 Marks

   Acute & late effects on all normal organs & tissue 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.

   1 Marks

Normal tissue tolerances.

Late effects of radiation both Somatic and Genetic.

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

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

Repopulation.

1 Marks

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 limitation, partial tolerance, Means of summating partial tolerance, steepness of dose response curves.

Multi-target, two component and linear quadratic model. Alpha/beta ratios for acute and late effects and means of deriving this value. Isoeffective formulae. Clinical applications of the LQ model, hyper fractionation, accelerated fractionation, hypo fractionation, CHART, split dose treatments.

1 Marks

2. **Module 2**. Chemotherapy for various cancers. New drugs used in the treatment. Imaging in Oncology

Monoclonal antibody therapy, Radioimmunotherapy, Advances in immunotherapy, Gene Therapy, Molecular therapy, Cancer vaccines.

1 Marks

Anti angiogenic factors, Angiogenesis & carcinogenesis, Monoclonal Antibodies - MABs & NIBs, Essentials of Genomics.

2 Marks

Assessment of new agents. Principles of Phase I, II and III studies.

Endocrine manipulation and biological response modifiers

Principles of combination of chemotherapy

1 Marks

Toxicity of drugs, early, intermediate and late genetic and somatic effects of common classes of anticancer drugs. Precaution in the safe handling of cytotoxic drugs.

3 Marks

The principles of cell kill by Chemotherapeutic agents, drug resistance, phase specific and cycle specific action. Drug administration.

1 Marks

Imaging in Oncology.

1 Marks

Chemo-sensitization

1 Marks

3. **Module 3**. Basic Science related to radiotherapy:

Basics of anatomy relevant to clinical practice ie. surface anatomy of various viscera, microanatomy, important structures/organ's anatomical location in the body, details of lymphatic system of all regions, cross sectional anatomy.

2 Marks

Basic functioning of various organ system, pathophysiological alternation in diseased states, interpretation of symptoms & sign in relation to pathophysiology.

1 Marks

Pathological changes in various organs associated with tumors & their correlation with clinical signs, understanding of various pathogenic processes.

1 Marks

Grading immunological effects & genetic alterations.

Knowledge about pharmacokinetics & pharmacodynamics of the Cytotoxic and other drugs used for the management of cancer & common problems in a person & in a patient with disease kidneys /liver etc which may result in alternation in metabolism/excretion of the drugs; rationale use of available drugs.

3 Marks

Palliative and supportive care.

1 Marks

Supportive care for Chemotherapy

1 Marks

Fundamental basis of chemo-radiation

1 Marks

4. **Module 4**. Physics related to Radiotherapy

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 quantization, Relationship

between wavelengths, Frequency, Energy Attenuation, scattering, absorption, Transmission, Attenuation coefficient, Half Value (HVL), Energy transfer, Absorption and their coefficients, Photoelectric effect, Compton effect, Pair-production, relative importance for different attenuation processes at various energies.

5 Marks

Electron interactions with matter: Energy loss mechanism - Collisional losses, radioactive losses, Ionisation, Excitation, Heat production.

1 Marks

Interaction of radiation with matter. Various effects with its clinical significance. Scattering, stopping power, absorbed dose, secondary electrons.

Interactions of charged particles: Ionization vs. Energy, stopping power, Linear Energy

Transfer (LET) , Bragg curve, Definition of particle range.

2 Marks

Measurement of radiation: Radiation Detectors: Gas. Solid state, Scintillation, Thermo

luminescence, 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 are chamber,

Thimble chamber,) Calibration of therapy beams

2 Marks

5. **Module 5**. Radiotherapy machines

Co-60 units: Comprehensive description of the unit, Safety mechanism, source capsule. Relative merits and demerits of Co-60 and Linac units

1 Marks

Linear accelerators: History, development, detailed description of modern, dual mode

linear accelerator, Linac head and its constituents, safety mechanisms, computer controlled linacs, record and verify systems.

1 Marks

Simulators: Need for them, detailed description of typical unit, CT Simulator. Basic ratios, Factors, Dose distribution, Beam modifications and shaping in Teletherapy Beams.

1 Marks

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

Primary and scattered radiations. Percentage depth dose, Tissue-Air Ratio, Scatter Air Ratio, Tissue-Phantom Ratio, Tissue Maximum Ratio, Scatter Maximum Ration, 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 flattering filter, target material. Central axis depth dose profiles for various energies.

2 Marks

Equivalent square concept, surface dose (entrance and exist), skin sparing effect, Output

factors. Practical applications: Co-60 calculations (SSD and SAD technique), Acceleration

calculations (SSD and SAD technique). Beam profiles, Isodose curves, Charts Flatness, Symmetry, Penumbra (Geometric, Transmission and Physical), Field size definition.

2 Marks

Body in homogeneities: 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, Inbuilt Universal, Dynamic /Virtual), Wedge Isodose curves

Other beam modifying and shaping devices: Methods of compensation for patient

contour variation and /or tissue in homogeneity- Bolus, Buildup material, Compensators,

Shielding of dose limiting tissue: Non-divergent and Divergent beam blocks, independent jaws, Multileaf collimators, Merits and Demerits.

3 Marks

6. **Module 6**. Principles of Treatment Planning

Treatment planning for photon beams: ICRU 50 and NACP terminologies. Determination

of body contour and localization: Plain film, Fluoroscopy, CT, MRI, Ultrasonography,

Simulator based. Conventional simulator.

1 Marks

Methods of correction for beam’s oblique incidence, and body in homogeneities

SSD technique and Isocentric (SAD) technique: Description and advantages SAD

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

2 Marks

Wedge field technique, rotation Therapy (Arc, and skip), tangential fields, Beam

balancing by weighting. Total and hemi-body irradiation, field junctions.

Limitations of manual planning. Description of a treatment planning system (TPS): 2D

and 3D TPS.

2 Marks

Beam selection and placement, 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

BATHOS as applied to linear accelerator calculations modified BATHOS as applied to

clinical radiotherapy.

2 Marks

Alignment and Immobilization: External and internal reference marks, Importance of

Immobilization in radiotherapy, Immobilization methods (Plaster or Paris casts, Perspex

casts, bite blocks, shells, head rests, neck rolls, Alpha –Cradles, Thermoplastic materials, polyurethane foams), Method of beam alignment (Isocentric marks, laser marks and front/ back pointers)

2 Marks

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.

1 Marks

7. **Module 7**. Electron beam therapy

Electron Beam Therapy

Production of electron beams: Production of electron beams 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.

3 Marks

Energy spectrum, Energy specification, variation of mean energy with depth. Suitability of measuring instruments for electron beam dosimetry.

2 Marks

Treatment planning: Energy and field size choice, air gaps, and obliquity, Tissue in

homogeneity 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.

2 Marks

Total skin Electron Irradiation, Intraoperative Radiation Therapy

3 Marks

8. **Module 8**. Brachytherapy and its physical principles

Properties of an ideal Brachy therapy source, source used in Brachy therapy: Ra-226, Cs-

137, Ir-192, Au-198, Co-60, I-125, Sr-90/Yt-90, Ru-106, Ta-182 and other new radio nuclides. Their complete physical properties. Radium hazards. Source construction

including filtration, comparative advantages /disadvantages of these radio nuclides.

2 Marks

Historical background: Radiation and Dose units: Activity used, Exposure, Absorbed Dose, Mg-hr curie, Radium equivalent, roentgen, rad, gray. Source strength

specification, Brachytherapy Dose calibration.

1 Marks

Technique: Pre-loaded, after loading (manual and remote), Merits and Demerits,

surface, Interstitial, Intracavitary, Intraluminal, Intravascular brachy therapy, Low,

Medium, High and Pulsed dose rates. Remote after loading machines.

3 Marks

Dosage systems: Paris System, Stockholm system, Manchester system. Newly developed

systems e.g. Monte Carlo algorithms etc.

1 Marks

Treatment Planning: Patient selection, volume specifications, Geometry of implant,

Number, strength and distribution of radioactive sources, Sources localization, Dose

calculating, Dose rate specification, record keeping ICRU 38.

1 Marks

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: Concept 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.

2 Marks

9. **Module 9**. Quality assurance in Radiotherapy and Radiation Protection and regulatory aspect

Statutory Framework – Principle 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).

2 Marks

Protection mechanisms: Time, Distance and shielding. Concept of “As Low as Reasonably Achievable” (ALARA)

Personnel and Area Monitoring: Need for personnel monitoring, Principle of film badge.

TLD badge used for personnel monitoring. Pocket dosimeter, Need for area monitoring,

Gamma Zone Monitors, Survey meters.

3 Marks

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

sources(s). Construction of building, qualified staff, Procurement of instruments and

accessories of unit and performance tests, Calibration of units, RP & AD approval for

clinical commissioning of the unit.

3 Marks

Other regulatory requirements: Regulatory consent NOCs, periodical report to AERB and

Radiological Physics and Advisory Division (RP & AD) Bhabha Atomic Research

Centre (BARC)

2 Marks

10. **Module 10**. Advancements in Radiation Oncology

Virtual Simulation: Principles, CT-simulation, TPS based simulation, Differences, Merits

and Demerits, Practical considerations.

2 Marks

Conformal radiotherapy ((CRT): Principles, Advantages over conventional methods

Essential requirements for conformal radiotherapy.

2 Marks

Various methods of CRT: With customized field shaping using conventional coplanar beams, Multiple non-coplanar MLC beans conforming to target shape, Stereotactic radiotherapy, Principle of inverse planning and Intensity Modulated Radiation Therapy (IMRT).

2 Marks

Static IMRT (Step and shoot technique), Dynamic IMRT (sliding window technique Dynamic arc IMRT, Micro-MLC, Tomotherapy methods.

1 Marks

Time gated (4 D) radiotherapy, Merits and demerits of IMRT

1 Marks

Stereo tactic irradiation methods: Physics principles, Techniques, Description of units

(Gamma Knife and Linac based) Merits and demerits, stereo tactic Radio surgery

(SRS) and stereo tactic Radiotherapy (SRT), whole body stereo tactic frame.

2 Marks

NOTE: - It may be noted that apart from the topics detailed above, questions from other topics prescribed for the educational qualification of the post may also appear in the question paper. There is no undertaking that all the topics above may be covered in the question paper.