MANGALORE UNIVERSITY

MSc Medical Physics

MPS 503: Physics of Nuclear Medicine

Teaching hours: Each Unit – 12 h

Objectives

Acquainting the students with basic principles of physics involved in production of medical radioisotopes using reactors and cyclotrons. Familiarise the students with diagnosis, therapy and in functional study of organs using radiopharmaceuticals. To make the students understand the physics and operational principal, performance quality control of instruments. Provide knowledge on establishing cyclotron, PET Centre and associated laboratories. The students will be thought radiation safety principles and management.

Outcomes:

- The student will be acquaint with radioisotopes and nuclear medicine including their characteristics.
- They will learn about emission tomography, PET, SPECT, image formation and image construction.
- The student will learn about the basics of production of radionuclides used in diagnosis, therapy and functional study of organs; their production and preparation of radiopharmaceuticals.
- They will be familiar with in-vivo and in-vitro procedures, including thyroid uptake, RIA IRMA.
- They will learn the physics of PET, cyclotron, radioisotope production concepts.
- They will be acquiring adequate knowledge in preliminary design and planning of radio pharmacy lab, Nuclear Medicine unit, PET Centre, cyclotron centers in hospitals.
- The students will have good knowledge on basic physics, working principle, quality control of various imaging instrument such as rectilinear scanner, gamma camera and other associated equipment.

Unit I: Radionuclides and Radiopharmaceuticals

Therapeutic and diagnostic radionuclides for nuclear medicine and their radiation characteristics, decay scheme specification & specific activity, chemical form of radioisotope for nuclear medicine, (Example 131I, 32P, 153Sm, 90Y, 99mTc, 201Tl etc), ideal requirement of radionuclide used in nuclear medicine, storage and handling of radioisotopes, carrier free radioisotope, Cyclotron production and reactor production of radioisotopes,

Distinction between radionuclide, radiochemical and radiopharmaceuticals, Specific activity, radioactivity Concentration, chemical concentration, Carrier concept (carrier-free, carrier added, no carrier added), Generator based radiopharmaceuticals and cold kits concept: 99mTc generator; transient equilibrium, generator operation, types of 99mTc generator, solvent extraction generator, column generator, Technetium chemistry; Oxidation states,

Reduction methods, Hydrolysis, Complexation, etc. 99mTc Specific kits and radiopharmaceuticals. Other common isotope generators, Methods for radio labeling with Tc-99m, few examples of preparation of 99mTc radiopharmaceuticals**.**

Unit II: Emission Tomography

Imaging using radio nuclides, rectilinear scanner, the Anger Camera – Principles of construction, use and maintenance. Different types of Collimators. Basic principles and Problems, Focal planeTomography, Emission Computed Tomography, Single Photon Emission Computed Tomography. Various Image Reconstruction Techniques SPECT, Positron emission tomography(PET), principles of PET imaging, clinical applications.Working of Medical Cyclotron - Various Image Reconstruction Techniques during imageformation such as Back Projection and Fourier based Techniques, IterativeReconstruction method and their drawbacks. Attenuation Correction, ScatterCorrection, Resolution Correction, Other requirements or Sources of Error.

Unit III: In-vitro, In-vivo Procedures

In-vivo Non-imaging procedures: Thyroid Uptake Measurements, Renogram,Life span of RBC, Blood Volume studies, Life span of RBC etc. Generalconcept of Radionuclide imaging and Historical developments.

Gamma Imaging: Other techniques and Instruments; The RectilinearScanner and its operational principle, Basic Principles and Design of the AngerCamera/Scintillation Camera; System components, Detector system andElectronics, Different types of Collimators, Design and PerformanceCharacteristics of the Converging, Diverging and Pin hole Collimator, ImageDisplay and Recording Systems, Digital image Processing Systems, ScanningCamera, Limitation of the Detector System and Electronics.

In-vitro Technique: RIA/IRMA techniques and its principles Physics of PET and Cyclotron: Principles of PET, PET Instrumentations,Annihilation Coincidence Detection, PET Detector and scanner Design, DateAcquisition for PET, Data corrections and Quantitative Aspect of PET,Working of Medical Cyclotron, Radioisotopes produced and theircharacteristics.Treatment of Thyrotoxicosis, Thyroid cancer with I-131, use of P-32 and Y-90for palliative treatment. Radiation Synovectomy and the isotopes used.Concept of Delay Tank and various Waste Disposal Methods used in NuclearMedicine.Planning and Shielding

Calculations during the installation of SPECT, PET/CTand Medical Cyclotron in the Nuclear Medicine Department.

Unit IV: Internal Radiation Dosimetry

Difference Compartmental Model; SingleCompartmental Model, Two Compartmental Model with Back Transference,Two Compartmental Model without Back Transference. Classical Methods ofDose Evaluation; Beta particle Dosimetry; Equilibrium Dose Rate Equation,Beta Dose calculation, Specific Gamma Ray constant, Gamma Ray Dosimetry,Geometrical Factor calculation, Dosimetry of Low Energy ElectromagneticRadiation.

MIRD Technique for Dose calculations; Basic procedure and some practicalproblems, Cumulative Activity, Equilibrium Dose Constant, Absorbed Fraction,Specific Absorbed Fraction, Dose Reciproctiy Theorem, Mean Dose per unitcumulative Activity and Problems related to the Dose Calculations. Limitationof MIRD technique.

Unit V: QA of Nuclear Medicine, Room Design and Safety concern

QA in nuclear imaging (scintigraphy), flood phantom.QA of Gamma Camera Spatial Resolution (intrinsic resolution, collimator resolution, Scatter resolution), geometric efficiency. Radiation protection measures, nuclear medicine special laboratory procedures. Planning, design and radiation protection of nuclear medicine laboratories and radiopharamcylab for diagnostic and therapeutic procedures: Categories of Nuclear Medicine laboratories (category 1, 2, 3, 4), Equipments and accessories, Staff requirements, shielding requirements in diagnostic and therapy nuclear medicine laboratories. Delay tanks system. Site planning for cyclotron – PET/CT facility.Radiation protection in Cyclotron operation and PET radiopahramcy lab, Radiation protection and design in PET and PET/CT.

QA of Nuclear Medicine equipment;QA in nuclear imaging (scintigraphy), flood phantom.QA of Gamma Camera Spatial Resolution (intrinsic resolution, collimator resolution, Scatter resolution), geometric efficiency.

Reference Books:

1. W.H.Blahd, –Nuclear Medicine|, McGraw Hill Co., New Delhi, 1980.
2. H.N.Wagner, –Principles of Nuclear Medicine|, W.B.Saunders Co, London, 1970.
3. Herbert (John) &D.A.Rocha, Text Book of Nuclear Medicine, Vol 2 & 6, Lea and Febiger, Philadelphia, 1984.

4. Ramesh Chandra, ― Nuclear Medicine Physics The Basics Nuclear Medicine Physics: The Basics, 6th Edition‖ 2004
5. Safety Report Series No. 40 –Applying Radiation Safety Standards in Nuclear Medicine‖ – IAEA.
6. ―Nuclear Medicine Resources Manual‖ INTERNATIONAL ATOMIC ENERGY AGENCY VIENNA, 2006.

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