Colour Coding
Global GREEN
Regional BLUE
National ORANGE
Local (State) PINK

MD In Nuclear Medicine

Guidelines For Competency-Based Postgraduate Training Programme For MD In Nuclear Medicine

Adapted from NMC D 11011/1/22/AC/Guidelines/ 18 Date:05-09-2022

Program Outcome

The purpose of PG education is to create specialists who would provide high quality Health care and advance the cause of science through research & training. Nuclear medicine is a multi-disciplinary practice, and the training of medical doctors is Critical to the performance of a Nuclear Medicine department. Successful postgraduate Students are awarded a final degree that the government, and local health recognize authority and hospital employer as an assurance of specialist competence in Nuclear Medicine. The postgraduate training program in Nuclear Medicine consists of an Integrated training course of three years duration and would enable the postgraduate Student to practice nuclear medicine safely.

A student pursuing MD (Nuclear Medicine) course will acquire adequate knowledge related to

(a) Basic science should be taught in a practice-oriented manner to enable students to fully understand common and rare clinical conditions related to various aspects of nuclear medicine. This puts students on equal footing with their national and international colleagues in terms of knowledge and skills in the field.

(b) To become proficient in the practice of nuclear medicine, students must undergo clinical, laboratory, investigative, and administrative training. This training should cover the etiology, anatomy, physiology, and clinical spectrum of patients referred for evaluation and treatment.

Familiarity with local disease trends and management practices is also critical to enabling trainees to serve their communities, states, and nations as needed and in a cost-effective manner.

(c) Students should be aware of recent advances in the field of Nuclear Medicine and be provided with up-to-date skills and knowledge to apply skill-based intelligent decision-making algorithms. In this way, they can benefit the region, state, and country by making sound administrative decisions.

(d) Students should be encouraged to train their peers, teach future students, and engage in research in order to contribute to the field of nuclear medicine. It will help develop general knowledge and understanding of Nuclear Medicine, both locally and internationally.

Subject-Specific Learning Objectives

At the end of the MD training program in Nuclear Medicine, the student should meet the following objectives:

1. Acquisition of knowledge

At the end of the MD program in Nuclear medicine, the student should acquire extensive knowledge of the concepts and principles of nuclear medicine in which the nuclear properties of radioactive nuclides are used (a) to make the diagnostic evaluation of the anatomy and/or physiology of the subject, and (b) in providing therapy using unsealed radioactive sources. The student should have acquired the theoretical knowledge needed for a competent nuclear medicine practice.

2. Acquisition of Skills

Nuclear medicine, being the bridge between a specific clinical problem and use of relevant test/s using radionuclides, the student should have acquired the required skills in the technical processes and routine procedures undertaken in this specialty. He/she should be able to apply such skills in nuclear medicine-based services, in self-directed learning for evolving educational needs and scientific information, in the conduct of research and in managerial assignments in the department.

3. Teaching and training

The MD student should be able to effectively teach and assess undergraduate medical students and allied health science courses so that they become competent healthcare professionals and are able to contribute to training of undergraduate and postgraduate trainees.

4. Research

The MD student should acquire research skills to support evidence-based practice in the specialty, be able to conduct a research project (basic/clinical), to pursue academic interests and continue life-long learning, to become more experienced teacher & mentor in all the above areas.

5. Professionalism, Ethics and Communication skills

- The student should acquire communication skills of a high order, so as to report/interact with referring doctors, other health professionals, and with patients and their family members.
- The student should acquire educational skills of a high order to support a teaching role in areas related to the specialty, especially with medical students, junior staff, allied health professionals, and members of the public.
- The student should be able to learn and apply principles of professionalism, ethics and effective communication in the conduct of research, nuclear medicine-based services, educational activities and day-to-day work.

Therefore, the program's overall objective is to enable MD students to perform Nuclear Medicine practice, teaching and research independently and fulfill the manpower needs of the ever-expanding new diagnostic and therapeutic medicine branch.

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Post Graduate Training will consist of Theoretical and Practical Training:

Course outcome for MD Nuclear Medicine

Subject-Specific Competences

By the end of the course, the student should have acquired knowledge (cognitive domain), professionalism (affective domain), and skills (psychomotor domain) as given below:

A. Cognitive domain (Knowledge domain)

1. Should have knowledge of basic principles of radiation physics and its subsequent applications.
2. Should have knowledge of radiation protection principles applicable at a regional, state, and national level.
3. Should have knowledge of safe handling of radionuclides and their disposal at a regional, state and national level.
4. Should have knowledge of the International Commission for Radiological Protection (ICRP) and National Regulatory guidelines pertaining to nuclear medicine practice.
5. Should have knowledge of diagnostic tests, interpretation of results and pitfalls.
6. Knowledge of good clinical practice of therapeutic nuclear medicine and dosimetry.
7. Should be able to conduct clinical research and write a thesis/dissertation under supervision.
8. Should develop good working relationships with user specialties and handling inter-specialty referrals at a regional, state and national level.

B. Affective domain:

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

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2. Always adopt ethical principles and maintain proper etiquette in dealings with patients, relatives and other health personnel and to respect the patient's rights including the right to information and second opinion.
3. Develop communication skills to word reports and professional opinions as well as to interact with patients, relatives, peers, and paramedical staff and for effective teaching. Demonstrate kindness, empathy, and compassion towards all patients and their families
4. Treat all patients in a holistic manner
5. Respect the patients' right to information and second opinion.
6. Communicate well with patients and make all efforts to explain the rationale of diagnostic and treatment approach to patients and their caregivers in their own language for ease of understanding.
7. Spend time with patients explaining to them with thoughtfulness and empathy the pros and cons all options and further course of action.
8. Have the skills to participate in seminars, Continued Medical Education programs, panel discussions, lectures to discuss and review recent scientific data to **further the cause of Nuclear Medicine in the country and increase visibility on national and global platforms**.
9. Should have the ability to pass on such information and knowledge gained to other students and colleagues, especially those working in resource-limited settings to **improve cancer care of the region, state and country**.
10. Should actively cultivate skills to work in a team, with mutual respect, basic human courtesy and a supportive attitude towards others including other clinicians, para-clinical staff, policy makers and health administrators to improve cardiology services **at a regional, state and national level.**
11. Communicate openly and honestly with all patients and their caregivers, hospital administrators, regulatory authorities, peers and researchers of the cardiology fraternity and other allied members of the public and community leaders
12. Develop a habit of maintaining honest, detailed and comprehensive medical records.
13. Maintain principles of etiquette and abide with the country's laws, adopting ethical practices at all times.

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14. Be aware of ethical principles of clinical research as guided by institutional ethical committees.
15. Should demonstrate principles of equality when dealing with individuals of special groups.
16. Should be able to accept feedback and criticisms with an open mind.
17. As a skilled professional, be aware of the value of maintaining punctuality in clinical work.

C. Psychomotor domain

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

A) Basic Sciences Experiment:

1. Practical related to Physics, Instrumentation and its quality Control.
2. Preparation of radiopharmaceuticals and their quality control.
3. Detection of contamination in various workplaces.
4. Characterization of unknown isotopes.
5. Management of accidental spillage.
6. Practical related to Hybrid Imaging & Fusion Imaging.
7. Practical on qualitative and quantitative aspects of Hybrid Imaging.
8. Practical on optimized and safe operation of Hybrid imaging Instrumentation

B) Clinical Experiments on:

1. GFR Estimation.
2. Esophageal transit time.
3. Gastric emptying time.
4. Renal transplant evaluation.
5. Determination of Ejection Fraction and RWMA (wall motion).
6. Acquisition, Processing, Post Processing of Hybrid Imaging.

Needs: Local : Pink, National : Orange, Regional: light blue, International : green

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SYLLABUS

Cognitive Domain:

The syllabus is divided into the following four parts:

1. Basic Science aspects of Radiation Physics and its application to diagnostic/ therapeutic Nuclear Medicine
2. Diagnostic Nuclear Medicine and its applications
3. Therapeutic Nuclear Medicine and its applications
4. Recent Advances in Nuclear Medicine

At the end of the course, the student should have acquired knowledge in the following:

Part I: Basic Science related to Nuclear Medicine

Mathematics, Statistics & Computer Sciences

- Basic Mathematical Concepts, Counting Statistics, Probability distribution and parametric and non-parametric statistics.
- Mean, Mode, Median, Standard deviation percent standard error - standard error of Mean (SEM)
- Binomial, Poisson & Gaussian distribution, Estimations & confidence limits.
- Null hypothesis & significance tests (students test etc)
- Analysis of variation & covariation, correlation coefficient by curve fitting method of least square fit.
- Basic aspects of Nuclear Medicine acquisition and processing software.
  Brief Introduction to computer applications with emphasis on digital image acquisition, analysis, processing and enhancement, tomographic reconstruction display and recordings of findings.
  Compartmental analysis and mathematical models of physiologic systems.
  Fundamental of filters, their applications and uses.
- Brief introduction to statistical methods of analyzing medical data

Instrumentation

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- Principles of Radiation detection and detectors.
- Nuclear Medicine Instrumentation including Gamma Scintillation cameras, scanners, Single Photon Emission Tomography, Positron Emission Tomography & Cyclotron, SPECT-CT, PET-MRI, Dose Calibrators, whole body counters, gamma well counters, liquid scintillation counters, monitoring devices.
- Quality Control of nuclear instruments, as mentioned
- Collimation of radiation detectors, the characteristics of parallel hole Fan beam collimators, High resolution & High energy collimators and other types of collimators, their response to point, line, and plane sources.
- Electronic instruments, such as pulse amplifiers, pulse height analyzer, count rate meters and computer interfaces including gating systems.
- Image production and display technology including photographic principles, with special emphasis on sensitivity, resolution, count rate, latitude and film processing. Fusion technology, Online transmission, Connectivity, DICOM technology, PACS system.

Radiation Biology & Radiation Protection

- Brief overview of interactions of ionizing radiation with matter.
- Sources of Radiation
  Environmental - Natural , Manmade
  Medical
  Occupational
- Measurement of Radiation and its Effects
  Exposure
  Absorbed dose
  Dose equivalent
- Review of Cell Biology
  Cell structure, Molecular components, Cell reproduction
  Mitosis
  Meiosis DNA synthesis
  Cell replication cycle
  Chemical effects of radiation.
  Radiation effects on Macromolecules.
  Cell survival curves.
  LD 50 effects.
  Relative biological effectiveness (RBE)
  Free radicals
  Target theory
- Radiation Genetics
  Causes and effects of genetic mutations
  Spontaneous mutation
  Mutagenesis

Carcinogenesis
Gene mutations and cancer

Effects of radiation on DNA
Chromosome and chromatid aberrations
Repair versus mutation

- Cellular Responses to Radiation
  Stage of cell replication cycle versus radiosensitivity
  Factors Affecting Cellular Response to Radiation
  RBE and LD
  50/30
  Physical factors
  Chemical factors
  Biological factors
- Radiosensitivity and Cell Populations . Law of Bergonie and Tribondeau
- Calculation of the radiation dose from internally administered radionuclide.
- Tissue and Systemic Responses to Radiation- The biological effects of radiation exposure with emphasis on the effects of low-level exposure, system-wise.
  Acute versus late effects
    Healing of irradiated tissue
    Total-body irradiation
    Sources of information
    Hematopoietic syndrome
    Gastrointestinal syndrome
    Central nervous system syndrome
    Cardiac shock syndrome
  Radiosensitivity of embryo/fetus
  Phases of embryonic/fetal development
  Effects of radiation versus phase of development
- Late Effects of Radiation Exposure
  Relating radiation exposure to specific effects
  Dose versus effect models
  Problems associated with researching radiation-induced effects/disease
    Non-specific life-shortening
    Genetic effects (spontaneous mutation versus radiation induced damage)
    Carcinogenesis
    Cataract instigation
    Other diseases
- Radiation doses
  Factors influencing absorbed dose from internal sources
    Concentration and organ mass
    Effective half-life
    Physical and chemical characteristics of radionuclide

Absorbed fraction
Cross-irradiation
Critical and target organs
Target organs
Non-target critical organs
Gonadal exposure

- Absorbed dose calculations
  Classical and MIRD methods
  Formulas
  Charts and tables
- Risk-to-Benefit Ratios
  Radiation hazard versus medical need
  Diagnostic exposures
  Exposure from various sources (x-ray, computed tomography, etc.)
  Radiation levels in nuclear medicine
  Therapeutic exposures
  Exposure from various sources (radiation therapy, implants, etc.)
  Radiation levels in nuclear medicine
- Radiation sensitization and its utility in Nuclear medicine therapies
- Radiation hormesis

Nuclear Physics

- Structure of atom :Physical & chemical properties. Avogadro's Number, Periodic table, isotopes, isobars & isotones.
- Radioactivity : Nuclear forces, nature & origin of radioactivity, types of radiations, nuclear transitions, units of radioactivity, physical properties of radioactivity, radioactive decay, decay
  schemes, trilinear radionuclide chart, physical half life, decay constant, average life, biological &
  effective half life, radionuclides in equilibrium, natural & artificial radioactivity.
- Production of radioisotopes :- Fission process, nuclear reactions, nuclear reactors, accelerators, medical cyclotrons, nature & properties of medically useful radioisotopes.
- Interaction of radiation with matter :
  - Interaction of particles (alpha & beta and other) with matter, scatter, ionization, bremhstrahlung, cerenkov, annihilation reactions.
    Interaction of gamma radiation with matter : scatter, photoelectric effect, pair production
    Penetration of radiation in matter, half value thickness, absorption coefficient, absorption cross
    section curves with respect to gamma energy & atomic number. Range of radiations in tissue, and detectors

- Modes of radioactive decay elementary aspect of the structure of matter.
  Emissions accompanying radioactive decay, and their biological implications.

- Radiation detection & measurement

  Radiation detectors (gas) : Ionization chamber, proportional counters, GM counter – principles, operation & use in nuclear medicine.
  Scintillation detectors (solid) : NaI (Tl), CsI, BGO, LSO crystals, photomultiplier tube.
  Scintillation detectors (Liquid) : Liquid organic scintillators sample preparation, quenching & its correction.
  Semiconductor detectors : Principle, properties & use
  Gamma ray spectrometer : Principle, operation & use.
  Measurement of radioactivity : Principles, counting geometry, efficience of detection in in-vitro counting.
  Counting statistics : Standard deviation (SD) \, percent error measurement of SD of addition, substraction, multiplication & division of two countrates.
  Alpha counter
  Gamma probe and thyroid probe

- Health Physics

  Units & definitions : Radiation, exposure, absorbed dose in air & in man, SI units.
  Radiation Exposure : Natural radioactivity in man, exposure from natural & artificial sources,
  concept of maximum permissible level, ICRP regulations, exposures in pregnancy, in children & in radiation laboratories.
  Radiation protection : Evaluation of radiation hazards, protection measures, shielding personal & area monitoring, internal radiation hazards, control of contamination waste disposal, permissible levels, techniques of licensing.
  Radiation Measuring instruments : GM counters, contamination monitors, exposure monitors – film badge, TLD, gun monitors, dosimeters. Dose calibrators & quality control of dose calibrators.
  Internal radiation dosimetry : Estimation of radiation dose delivered to various body organs & total body by internally administered radionuclides for diagnostic & therapeutic purposes by MIRD methods.

- Radiation Safety

  Administrative and technical means of procuring radionuclide. Types of Nuclear Medicine Laboratories
  Method of reducing unnecessary radiation exposure to patients, personnel and environment.
  The diagnosis, evaluation and treatment of radiation over exposure in any form.
  ICRP, AERB and other- recommendation & their amendments from time to time & other International recommendations, environmental regulations regarding limits of radiation exposure, handling of radioactive patients, transport of radioactivity material and disposal of radioactive wastes.
  Management of radiation accidents, including monitoring, decontamination and

subsequent control.
High dose radionuclide therapy, its effects & ways to monitoring for patient wastes like urine, stool, room monitoring shielding, concept of delay tanks, construction & monitoring.
Protection of relatives of the patients.
Effect on pregnancy and fertility, subsequent to high dose therapy.

- Scintigraphy (Instrumentation)

  Basic physics of Nuclear Medicine imaging, x-ray computed tomography, Nuclear Magnetic Resonance and Ultrasonography, Single Photon Emission Tomography & Positron Emission Tomography.
  Scintillation cameras: Description of instrument and principle of working collimators & their evaluation, technique of organ imaging on a scintillation camera, limitations & pitfalls, how to choose a scintillation camera.
  Other imaging devices (emission type) : Positron emission tomography system, semiconductor camera, Computerised Tomography with contrast. Basis Principle of USG, MRI Optical Imaging, Photodynamic Therapy
  Collimation of radiation detectors, the characteristics of parallel hole Fan beam collimators, High resolution & High energy collimators and other types of collimators, their response to point, line and plane sources.
  Tomography : Concept of tomography in imaging, emission tomographic cameras.
  Quality assurance & quality control of nuclear medicine imaging instruments scanners &
  scintillation cameras : methods of quality control, guidelines for daily & periodic tests.
  Electronic instruments, such as pulse amplifiers, pulse height analyzer, count rate meters and computer interfaces including gating systems.
  Image production and display technology including photographic principles, with special emphasis on sensitivity, resolution, count rate, latitude and film processing.
  Fusion technology, Online data transmission, Connectivity, DICOM technology, PACS system
  Artifical intelligence in imaging, basic principle of radionomics

Part 2: Diagnostic Nuclear Medicine

Radiopharmaceuticals

- Basic principles of chemical reactions

  Fundamental concepts, oxidation, reduction, acids, bases, hydrogen, Ion concentration,
  dissociation constants, pH value, Ionic equilibria, buffer solutions.
  Fundamental concepts of organic chemistry, hydrocarbons, aliphatic hydroxyl

compounds, non aliphatic hydroxy compounds, aldehydes, ketones, carboxylic acids,
esters amines, amides hydrogen derivatives.
Chemical bonds – electrovalent bond, covalent bond & co-ordinate covalent bond. Chelate compounds.

- Radionclide Production
  Production of Radionuclides – SPECT & PET.
  Reactor & its principle: Production of radionuclides in reactor
  Cyclotron & its principle
  Different generator systems
  Production of radionuclides in cyclotron.
  Linear accelerator
  Betatron

- Choice of radionuclides
  Physical and Chemical Characteristics of radionuclide used in Nuclear Medicine.
  Mechanism of localization.
  Radiopharmaceuticals for therapy
  Criteria for selection of radionuclide
  Primary radionuclides – labeled compounds, Iodination, labeling with other radionuclides.
  Therapeutic radionuclides
- Purity of radiopharmaceuticals.
  Chemical purity, Radiochemical purity, Radionuclide purity, Biological purity.
  Stability of radiopharmaceuticals, parameters which affect stability
  Quality control of radiopharmaceuticals
  Radiochemical & chemical purity – methods used to determine.
  Radionuclidic purity – methods used.
  Sterility testing – methods used.
  Pyrogen testing – methods used.
- Various types of radionuclides generators
  99 Mo -99m Tc generator & preparation of different labeled compounds with Tc 99m.
  113Sn - 113m In generator & preparation of different labeled compounds.
  68Ge – 68 Ga generator & preparation of different labeled compounds.
  Other generators of interest in Nuclear Medicine.
- Other Aspects
  Mechanism of localization of radiopharmaceuticals – modern trends in radiopharmaceuticals.
  Handling of radiopharmaceuticals.
  Safety measures, equipments, shields, remote handling etc.
  Dose preparation, packaging, storage, waste disposal

Economic aspects of radiopharmaceuticals
Legal aspects of radiopharmaceuticals.
Good Manufacturing Practice etc. related to In house manufacturing
Adequate first hand exposure in each Academic year to be spent in Radiopharmacy lab. & quality control

Diagnostic Imaging

- Detailed anatomy & physiology of body organs considered in scintigraphy & other nuclear medicine investigations
- General clinical indications for and limitations in their appropriate usage, normal and altered anatomy, physiology, biochemistry and metabolism of various organs, to be examined, technical performance of the procedure including proper patient preparation and patient management before, during and after the procedure.
- In vivo imaging and/or function studies, including brain SPECT, cerebrospinal fluid, thyroid using
  both 99mTc & I-131, salivary glands, lung, heart and vessels, esophagus, stomach, Hepatobillary
  system, spleen, kidney, adrenal, tumors and abscesses, bladder, bone & joints, bone marrow etc. Including three phase imaging.
  Difference in SPECT & PET techniques, advantages , disadvantages
  Use of SPECT CT & PET CT PET/MRI
- Scan Interpretation
  Normal scan appearances in planar, SPECT & PET – normal physiological & anatomical variations
  Artifacts in scan interpretations
  Abnormal scans with respect to clinical diagnostics
  Procedures of all planar, SPECT & PET scans
  Indications & usefulness of scan with respect to clinical diagnosis
  Limitations of information obtained by scans
  The use of imaging devices, external detectors and computers for body organ imaging and for
  time-dependent and differential function studies.
  The use of physiologic gating techniques for functional studies.
  Positron Emission Tomography: All indications for use of PET imaging in Oncology, Cardiology,
  Neuro Sciences and psychiatric disorders.
  PET MR imaging (basic instrumentation, protocol, attenuation correction, clinical uses oncological and non oncological)
- Oncology : Staging, diagnosis, management of common malignancies. Basic principle of radiotherapy and chemotherapy.
- Radiomics and Artificial intelligence in imaging
- Other Clinical Aspects

Patient monitoring during intervention such as exercise i.e. using Bruce Protocol and pharmacological Administrations such as short lived intervention and necessary management of any emergency situation interpretation of ECG both at rest & at peak of exercise, analysis of ECG.
Common medical emergencies and their management
Comparative analysis of Nuclear Medicine procedures with X-ray, MRI, ultrasound, CT, Spiral
CT, PET etc.
Nuclear Cardiology, Stress and redistribution studies using Thallium-201 and other myocardial perfusion agents. Myocardial viability, Gated SPECT studies, Bull's Eye Emory Tool box, Coronary overlay.
Whole-Body counting and total body scanning for high dose iodine
Cellular kinetics, absorption and excretion analysis, nuclear hematology and metabolic balance
studies using radiotracers. Body composition tests, including compartmental analysis

In-vitro Studies

- Principles of radioisotope micro-analytical techniques such as RIA, quality control.
- Binding capacity studies such as receptor assays.
- RIA
- Cell labelling
- GFR measurement, B-12 absorption studies Red Cell Survival & Red Cell Mass etc.
- Beta counter for Urea breath test can be added

Part III Therapeutic uses of Radionuclide

Application of radioisotope in therapy in following and other evolving areas, but not limited to Thyrotoxicosis, Cancer Thyroid – both low dose & high dose, Radiosynovectomy, Bone pain Palliation, PRRT, PSMA therapy (Radiolegand therapy, PRLT) , Radioimmunotherapy, TACE/TARE for HCC and Metastasis can be added Hepatic cancer and other therapy like FAPI, PSMA or new molecule under reseach, Uses and principal of alpha therapies, auger electron therapy

- Patient selection, including the diagnostic procedures necessary to establish the need for radionuclide therapy,
- Indications and contra- indications for the use of radionuclide therapeutic procedures and their efficiency in relation to other therapeutic approaches.
- Dose administration in patient management including dose to the target areas, to the surrounding tissues and/or other organ systems and total-body exposure; the range of doses in each specific application
- Patient care caused by radionuclide therapeutic procedure, potential early and late adverse reactions, the timing and parameters of anticipated clinical response, and the follow-up care

and evaluation as needed.

Organizational Considerations

- Planning & scheduling of the patient work load.
- Economic aspects of nuclear medicine and cost-effectiveness of nuclear medicine procedures.
- Cost benefit & efficacy of Nuclear Medicine investigations, role of Nuclear Medicine in diagnostic decision making, professional ethics.
- Public relations
- Design of laboratories or various sizes & capacity as per the norms Role of National and International like AERB, MCI, NMC, BRIT, BARC, IAEA
- Regular participation in the departmental weekly journal club, Seminar, case presentation and Discussion and other periodical CME programs
- Participation in the Seminars and CME programs of allied departments.
- Planning of radioisotope laboratory : Basic considerations, layout, equipment, classification of Nuclear Medicine laboratory, staff, clearance of premises, licensing for use of radionuclides in humans.
- Layout & commissioning of High dose RN Therapy wards
- Layout & commissioning of PET CT, Gamma Camera

Part 4: Recent Advances in Nuclear Medicine

Covering all aspects of the following areas:

4.1 Instrumentation

4.2 Radiopharmaceuticals

4.3 Diagnostic procedures

4.4 Therapeutic procedures

PRACTICALS SYLLABUS

PHYSICS PRATICALS:

1) Charateristics of different radiations
2) Plateau of G.M.Counter
3) Half valve layer,
4) Half life
5) Daughter-parent relationship in radioactive decay and radionuclides,
6) Efficiency of well counter
7) Counting statistics of well counter
8) Gamma ray spectrometry,

9) Identification of an unknown radionuclide,
10) Lines spread function,
11) Radiation exposure : effect of distance
12) Shieliding
13) Radiation survey.
14) Decontamination
15) Radiopharmacy procedures & elution of generators, preparation of different radio pharamacuticils.
16) Phantom studies for scintigraphy,
17) Flood field for scintigraphy.
18) Organ imaging.
19) Dilution principle,
20) In vitro sample measurement of various types,
21) Absorption of the radiation
22) Uniformity Resolution and COR of gamma camera and SPECT system
23) Total performance of SPECT system using SPECT phantom
24) Coregistraion of NM and CT
25) Daily QC of PET
26) Various QC of dose calibrator
27) Uniformty, low and high contrast and slice thickeness of CT
28) Isoresponse curve of flat field collimator
29) Measurement of thyroid uptake.

RADIOPHARMACY PRACTICAL

1. Chromatographic techniques (principle and practice) for quality assurance of the Radiopharmaceuticals such as Paper, ITLC, HPLC, Gas Chromatography,
2. Radiolabeling of 18 F based RPs 18 F-Fluorodeoxyglucose (FDG)/ 18 F-Fluroestradiol (FES), 18 F-NaF, add Cell labelling etc
3. Quality assurance of radiopharmaceuticals such as radiochemical purity, radionuclide purity, sterility and toxicity studies by different methods
4. Radiolabeling of 11C-based tracers such as 11 C -Choline, 11 C –Methionine
5. Radiolabeling of 68 Ga-DOTANOC/PSMA-11& QC.
6. Solid target Preparation for production of 64 Cu, 124/123 Iodine, or 89 Zr
7. Preparation of 99m Tc radiopharamcuticals and its QC

Duties and Responsibilities

1. General Nuclear Medicine

Posting	Duties and Responsibilities
1st	• Common investigations protocols • Processing of Gamma camera studies • MPI Protocol and preparation • RP – observe Elution and common RP synthesis- 10 times • Coordinate with seniors • Compilation of patient data for departmental research
2nd	• Common investigations protocols • Processing of Gamma camera studies • MPI Protocol and preparation • RP – observe Elution and common RP synthesis- 10 times • Gamma Camera Acquisitions - 50 patients (Different protocols) • QC of gamma camera- 10 times • Learn Basic reporting- Planar imaging • Compilation of patient data for departmental research
3rd	• MPI Protocol and preparation- independently • BLS and crash cart maintenance • Gamma Camera Acquisitions and processing of all gamma camera - 100 • Validate study adequacy and patient release • Reporting all common and uncommon Planar and SPECT CT imaging- 200 patients • QC of gamma camera- 10 times • RP –Elution, RP synthesis and QC- 10 times • Radiation safety (Survey and decontamination) • Compilation of patient data for departmental research
4th	• MPI study complete- independently • BLS and crash cart maintenance • All Gamma Camera Acquisitions, processing – 100 patients • QC of gamma camera- 10 times • Independent reporting with validation- total 300 patient • Elution, RP synthesis and QC- 10 times • Radiation safety (Survey and decontamination) • Compilation of patient data for departmental research

*In all postings keep in touch with other areas and shift accordingly

2.In vitro posting

Posting	Duties and Responsibilities

1st	• GFR measurement Procedure and other invitro procedure • RP – observe Elution of generators and common RP synthesis- 10 times • Radiation safety • Coordinate with seniors • Compilation of patient data for departmental research
2nd	• GFR measurement Procedure and other invitro procedure • RP – observe Elution of generators and common RP synthesis- 10 times • Radiation safety • Coordinate with seniors • Compilation of patient data for departmental research

*In all postings keep in touch with other areas and shift accordingly

3. PET CT

Posting	Duties and Responsibilities
1st	• Investigation protocols • PET CT scheduling, protocol and preparation (Completion of relevant clinical history) • RP – observe common RP synthesis (with cyclotron functioning) - 10 times • Handling Automated and contrast injector and learn about side effects and management of contrast reaction. • Coordinate with seniors • Compilation of patient data for departmental research
2nd	• Investigation protocols • PET CT scheduling , protocol and preparation (with completion of relevant clinical history) • Consideration on special protocol (Oral contrast, positioning, delayed images, patient prioritisation etc) • RP – observe common RP synthesis (with cyclotron functioning) - 10 times • Handling Automated and contrast injector • BLS, side effects handling (contrast, hypoglycaemia etc) and crash cart maintenance • Coordinate with seniors for patient preparation and release • Compilation of patient data for departmental research
3rd	• PET CT Protocol and preparation (with completion of relevant clinical history) • Consideration on special protocol (Oral contrast, positioning, delayed images, patient prioritisation etc) • RP – observe common RP synthesis (with cyclotron functioning) - 10 times • Reporting of PET CT- 50

	• Coordinate with seniors and juniors • BLS and crash cart maintenance • Compilation of patient data for departmental research
4th	• RP – observe common RP synthesis (with cyclotron functioning) - 10 times • Reporting and validation of PET CT- total 200 • Coordinate with seniors and juniors • Compilation of patient data for departmental research

*In all postings keep in touch with other areas and shift accordingly

OPD and ward Posting

Posting	Duties and Responsibilities
1st	• Common investigations protocols • History taking- Gamma camera investigations and PET CT • Scheduling and prioritization of studies • RP – observe Elution and common RP synthesis- 10 times • Coordinate with OPD and Reporting room seniors • Compilation of patient data for departmental research
2nd	• Same as 1st posting
3rd	• Above mentioned along with • History taking- Gamma camera investigations, PET CT and therapy • Follow up of patients • Ward rounds and management (admission, medicine prescription, discharge etc) • Scheduling and prioritization of studies and therapies • Independent 15 therapies • Coordinate with OPD and Reporting room seniors and juniors • To enter low and high dose I-131 therapy reports
4th	• Above mentioned along with • Independent 30 therapies • RP – observe Elution and common RP synthesis- 10 times

*In all postings keep in touch with other areas and shift accordingly

SELF ASSESSMENT SHEETS (End of each posting)

Sheets to be pasted in the log books for record and a copy to be submitted

Self assessment sheets 1

Posting Area	
Posting Number	**First**
Date (Period)	

By the end of this posting I can perform the following-

Task	**Confidently**	**Need support**	**Cannot perform**
History taking			
Investigation Protocol			
Patient Management			
Instrument handling			

Self assessment sheet 2

Posting Area	
Posting Number	**Second**
Date (Period)	

By the end of this posting I can perform the following-

Task	**Confidently**	**Need support**	**Cannot perform**
History taking			
Investigation Protocol			
Patient Management			
Instrument handling			
Quality control and QC			

Self assessment sheet 3

Posting Area	

Posting Number	**Third**
Date (Period)	

By the end of this posting I can perform the following-

Task	**Confidently**	**Need support**	**Cannot perform**
History taking			
Investigation Protocol			
Patient Management			
Instrument handling			
Quality control and QC			
Reporting			

Self assessment sheet 4

Posting Area	
Posting Number	Fourth
Date (Period)	

By the end of this posting I can perform the following-

Task	**Confidently**	**Need support**	**Cannot perform**
History taking			
Investigation Protocol			
Patient Management			
Instrument handling			
Quality control and QC			
Reporting			

LOG BOOK

1) A candidate shall maintain a log book of operations (assisted / performed) during the training period, certified by the concerned post graduate teacher / Head of the department / senior consultant. Every candidate, at the time of practical examination, will be required to produce performance record (log book) containing details of the work done by him/her during the entire period of training as per requirements of the log book
2) This log book shall be made available to the board of examiners for their perusal at the time of the final examination.
3) The log book should show evidence that the before mentioned subjects were covered (with dates and the name of teacher(s) The candidate will maintain the record of all academic activities undertaken by him/her in log book. The absence of production of log book, may have an adverse effect of final viva.
    - Personal profile of the candidate
    - Educational qualification/Professional data
    - Record of case histories
    - Procedures learnt and Cases worked up for radionuclide therapy
    - Record of case presentation/ Seminars/Presentations along with Title & Journal & Issue with title with comments of moderator
    - Practical done
    - Schedule of interdepartmental rotation
    - Conferences attended – National/International
    - Papers presented at conferences with title name of the conference and date
    - Paper published with title, name & issue of the journal

PROFORMA LOG-BOOK

Name of student :----------
Course duration: Month of --------- Year upto --------
Date of Enrolment: Month of --------- Year upto --------
Log book for the month of: --------- year ---------
Total number of worked up cases :

WORKED UP CASES

CASE NO.
Name:

Age/Sex: CR no:

Clinical Indication:
History
Examination

Salient positive findings
Scintigraphic procedure
Scintigraphic features
Other correlative imaging details

Final diagnosis
Follow up:

REPORTING AND LEARNING RECORD

To be filled monthly in the log book. Added and compiled in last posting of Final Year

1. PLANAR INVESTIGATIONS:

PROCEDURES	NUMBER OF CASES
Technetium Thyroid Scintigraphy	
Diuretic Renography	
Renal Cortical Scan	
GFR measurement	
Whole body Skeletal Scintigraphy	
I-131 Wholebody Scintigraphy	
Tc MIBI Parathyroid Scintigraphy .	
I-131 MIBG Imaging	
Liver colloid & Hepatobiliary Scintigraphy	
Sentinel scintigraphy	
Other scans	

2.SPECT & PET-CT

SPECIAL INVESTIGATIONS	NO. OF CASES	IMPRESSION
MIBI Myocardial Perfusion Scan		
MIBI Parathyroid Scintigraphy		
Bone SPECT		
Liver SPECT		
Brain SPECT		
FDG PET-CT reported		
Other PET-CT reported		

3.PROCEDURES PERFORMED UNDER SUPERVISION

DATE	MRD	PROCEDURE	INDICATION	COMPLICATIONS	FOLLOW UP

4.**THERAPY PROCEDURES**

PROCEDURES	NUMBER OF CASES
Low Dose I 131 Therapy	
High Dose I-131 Ablation	
PSMA	
PRRT/PRLT	
Pain palliation	
Others	

Additions were made to the Syllabus of the MD Nuclear Medicine program after revision and approval by the Board of Studies

- Instrumentation in Nuclear Medicine and related imaging modalities
- Radiation Safety
- Hybrid Imaging
- Radiopharmaceuticals section
- Radionuclide Therapy and recent advancements
- Oncological Applications of the Nuclear Medicine
- PET/MRI principle, instrumentation, function, indications
- Organizational considerations
- Practical Syllabus updated
- Radiopharmacy practicals
- Posting and station wise Duties and Responsibility
- Self Assessment (digital)
- Reporting and Learning Record

PTO

Needs: Local : Pink, National : Orange, Regional: light blue, International : green

The three-year training program's objectives are to **train Indian Medical Practioner as skilled "Nuclear Medicine Physician"** in different aspects of theoretical, clinical and practical spheres of Nuclear Medicine. It will enable them to offer skill based diagnostic, curative and preventive care with the highest professional standards. This training will help to accomplish the local, regional, and national healthcare needs for quality care commensurate with international standards.

Local level	1. **Nuclear medicine plays a critical role in diagnosing and treating a wide range of diseases, including cancer, heart disease, neurological disorders, and more. At the local level, there is a need for effective nuclear medicine strategies to address the growing burden of these diseases in the community. Course curricula should be tailored to these specific disease subsets:** 2. **Cancer:** Nuclear medicine techniques such as PET scans and SPECT scans are commonly used for cancer diagnosis, staging, and treatment monitoring. Specific focus should be given to cancer subtypes prevalent in the local community and their management. 3. **Heart disease:** Nuclear medicine imaging can provide valuable information on heart function and blood flow. Effective prevention and management strategies should be developed to address heart diseases, such as ischemic heart disease, cardiomyopathy, and heart failure. 4. **Neurological disorders:** Nuclear medicine imaging techniques like SPECT and PET scans are used to diagnose and manage neurological disorders like Alzheimer's disease, Parkinson's disease, and epilepsy. 5. **Thyroid disorders:** Nuclear medicine plays a key role in diagnosing and treating thyroid disorders such as hyperthyroidism and thyroid cancer. Effective management strategies should be developed to address the growing burden of these disorders. 6. **Renal disorders:** Nuclear medicine techniques like renal scans are commonly used to diagnose and manage renal disorders such as kidney stones, renal artery stenosis, and renal cancer. Specific focus should be given to these disorders' local burden and management.
National level	1. **Cancer diagnosis and treatment:** Nuclear medicine plays a critical role in diagnosing and treating various types of cancer. **With the increasing incidence of cancer in the country,** there is a need to expand the availability and accessibility of nuclear medicine facilities for early detection and treatment. 2. **Cardiovascular disease:** Nuclear medicine techniques can be used to assess the function of the heart and diagnose conditions such as **ischemic heart disease and heart failure**. There is a need for more nuclear medicine facilities equipped to perform cardiac imaging and image-guided therapy. 3. **Neurological, renal, and gastroenterological disorders:** Nuclear medicine imaging can help diagnose and manage **various inflammatory and infectious disorders.** The availability of such facilities needs to be increased to provide better healthcare for patients. 4. **Infectious disease:** Nuclear medicine can be used to diagnose and monitor **infectious diseases such as tuberculosis and other acute and chronic infections.** There is a need for more nuclear medicine facilities to provide timely diagnosis and treatment for such conditions. 5. **Bone and joint disorders:** Nuclear medicine imaging can help diagnose and

	treat bone and joint disorders such as osteoporosis and arthritis. There is a need for more facilities with specialized equipment for bone imaging and therapy. 6. **Thyroid disorders:** Nuclear medicine is commonly used to diagnose and treat thyroid disorders such as **hyperthyroidism and thyroid cancer.** There is a need for more facilities with specialized equipment for thyroid imaging and therapy. 7. **Radiation safety:** there is a need for radiation safety measures to protect patients and healthcare workers from unnecessary exposure to radiation due to **low occupancy factors in India.** There is a need for increased awareness and training on radiation safety in nuclear medicine.
Regional level	1. Regional epidemiology: There is a need for regional epidemiological studies to assess the prevalence and incidence of various diseases that can be diagnosed and treated using nuclear medicine techniques. This information can be used to guide public health policies and resource allocation. 2. Regional diseases: The prevalence of infectious diseases is higher in certain regions. There is a need for research in the application of nuclear medicine techniques for diagnosing and treating diseases specific to certain regions. 3. Cultural and social factors: Cultural and social factors can influence the uptake and use of nuclear medicine techniques. There is a need for research to understand these factors and developing strategies to improve the uptake and use of nuclear medicine techniques in different regions. 4. Availability and accessibility: The availability and accessibility of nuclear medicine facilities can vary widely between regions. Regional collaborations: Collaborations between different regions can lead to sharing knowledge and resources and developing new diagnostic and therapeutic strategies.
Global level	1. All the areas covered in the MD Program courses are contextual and pertinent to global health issues. Moreover, India being home to appx 17% of the global population, health care decisions and policies based on Indian data will likely create a global impact.

TEACHING AND LEARNING METHODS

General principles

Acquisition of competencies being the keystone of doctoral medical education, such training should be skills oriented. Learning in the program, essentially autonomous and self-directed, and emanating from academic and clinical work, shall also include assisted learning. The formal sessions are meant to supplement this core effort. All students joining the postgraduate (PG) courses shall work as full-time (junior) residents during the period of training, attending not less than 80% of the training activity during the calendar year, and participating in all assignments and facets of the educational process. They shall maintain a log book for recording the training they have undergone, and details of the procedures done during laboratory and clinical postings in real time.

TRAINING PROGRAMME

Teaching-Learning methods

This should include a judicious mix of demonstrations, symposia, journal clubs, clinical meetings, seminars, small group discussion, bed-side teaching, case-based learning, simulation-based teaching, self-directed learning, integrated learning, interdepartmental meetings and any other collaborative activity with the allied departments. Methods with exposure to the applied aspects of the subject relevant to basic/clinical sciences should also be used. **The suggested examples of teaching-learning methods are given below but are not limited to these. The frequency of various below mentioned teachinglearning methods can vary based on the subject's requirements, competencies, work load and overall working schedule in the concerned subject.**

A. Lectures: Didactic lectures should be used sparingly. A minimum of 10 lectures per year in the concerned PG department is suggested. Topics to be selected as per subject requirements All postgraduate trainees will be required to attend these lectures. Lectures can cover topics such as:

1. Subject related important topics as per specialty requirement
2. Recent advances
3. Research methodology and biostatistics
4. **Salient features of Undergraduate/Postgraduate medical curriculum**
5. Teaching and assessment methodology.

Topic numbers 3, 4, 5 can be done during research methodology/biostatistics and medical education workshops in the institute.

B. Journal club: Minimum of once in 1-2 weeks is suggested.
Topics will include presentation and critical appraisal of original research papers published in peer reviewed indexed journals. The presenter(s) shall be assessed by faculty and grades recorded in the logbook.

C. Student Seminar: Minimum of once every 1-2 weeks is suggested. Important topics should be selected as per subject requirements and allotted for in-depth study by a postgraduate student. A teacher should be allocated for each seminar as faculty moderator to help the student prepare the topic well. It should aim at comprehensive evidence-based review of the topic. The student should be graded by the faculty and peers.

D. Laboratory work/ console side/ Bedside clinics: Minimum - once every 1-2 weeks. Laboratory work/Clinics/bedside teaching should be coordinated and guided by faculty from the department. Various methods like DOAP (Demonstrate, Observe, Assist, Perform), and case-based discussions etc. are to be used. The very important part of the teaching remain the console side teaching in the department during scan reading and reporting. Faculty from the department should participate in moderating the teaching-learning sessions during clinical rounds.

E. Interdepartmental colloquium

Faculty and students must attend monthly meetings between the main Department and other department/s on topics of current/common interest or clinical cases; eg., combined clinical round with Radiology, Pathology etc.

F Posting under "District Residency Programme" (DRP):

All postgraduate students pursuing MS/MS in broad specialities in all Medical Colleges/Institutions shall undergo a compulsory rotation of three months in District Hospitals/District Health System as a part of the course curriculum, as per the Postgraduate Medical Education (Amendment) Regulations (2020). Such rotation shall take place in the 3rd or 4th or 5th semester of the Postgraduate programme and the rotation shall be termed as "District Residency Programme" and the PG medical student undergoing training shall be termed as "District Resident". Every posting should have its defined learning objectives. It is recommended that the departments draw up objectives and guidelines for every posting offered in conjunction
with the collaborating department/s or unit/s. This will ensure that students acquire expected competencies and are not considered as an additional helping hand for the department / unit in which they are posted. The PG student must be tagged along with those of other relevant departments for bedside case discussion/basic science exercises as needed, under the guidance of an assigned faculty.

Opportunities to present and discuss infectious disease cases through bedside discussion and ward/grand rounds with specialists / clinicians in different hospital settings must be scheduled to address antimicrobial resistance issues and strategies to deal with it.

G. Rotational clinical / institutional postings

The postgraduate trainees are be posted in relevant departments/ units as per details given below: The aim would be to acquire more in-depth knowledge as applicable to the concerned specialty.
Apprenticeship/Rotation in:

a) Radio-diagnosis 03 months [CT 2 months and MR 1 month]
b) Cardiac stress lab 2 weeks
c) Hospital Emergency 4 weeks
d) Endocrinology OPD 2 weeks
e) Oncology / Radiotherapy OPD 4 weeks

THE YEAR-WISE SCHEDULE OF TRAINING

Year 1

(a) Scientific principles:

- Basic physics and mathematics,
- Instrumentation,
- Principles of computing,
- Basic radiation biology and radiation protection,
- Basic radiopharmacy and radiochemistry,
- Principles of tracer technology.

(b) Clinical Nuclear Medicine:

- Diagnostic: Normal and abnormal appearances of images, mode of pharmaceutical uptake; normal variants and common artifacts in bone, heart, lung, kidney, brain, thyroid, tumour and infection images.
- Therapeutic: Basic principles of radionuclide therapy; treatment of hyperthyroidism, thyroid cancer and metastatic bone pain.
- Principles of radiation protection: ALARA (as low as reasonably achievable) ALARP (as low as reasonably practicable).

Year 2

(a) Requirements of Year 1 in greater depth:

- Tracer kinetics;
- Computing and image processing;
- Radiobiology including the biological effects of high and low level radiation;
- Linear hypothesis and the threshold hypothesis of the biological response to low level radiation;
- The effective dose equivalent and the calculation of radiation dose from radiopharmaceuticals.

(b) Radiopharmacy:

- Properties of commonly used diagnostic and therapeutic radiopharmaceuticals;
- Production of radionuclides by reactors, cyclotrons and radionuclide generators;
- Quality assurance and quality control of radiopharmaceuticals.

C. Indepth Study of Diagnostic and therapeutic Nuclear Medicine

Year 3

(a) Requirements of Year 2 in greater depth:

- Principles of radiology including ultrasound, computerized tomography and magnetic resonance imaging.
- Co-registration of nuclear medicine images and those from other imaging techniques.
- Diagnostic: special investigations in cardiology, lung disease, gastroenterology, hepato-biliary diseases, nephro-urology, neurology and psychiatry, endocrinology, haematology, oncology and infection.

(b) Therapeutic applications:

- Treatment of bone metastases, neural crest tumors, prostate malignancies, solid malignancies;
- Use of radionuclide monoclonal antibodies and radionuclide 33abelled peptides for tumor therapy.

© Further practice and experience of work accomplished in years 1 to 3:

- Legal and regulatory requirements,
- Audit,
- Departmental management,
- Research techniques and evaluation,
- Teaching and training.

MID-TERM SIX MONTHLY RESIDENT EVALUATION

Each candidate shall have mid term evaluations in terms of

Presentation of work completed in Thesis
2. Evaluation of the Log book
3. Case presentation session
4. Scan Interpretation session
5. Oral Viva

Attributes

Personal attributes:

• Behavior and Emotional Stability: Dependable, disciplined, dedicated, stable in emergency situations, shows positive approach.
• Motivation and Initiative: Takes on responsibility, innovative, enterprising, does not shirk duties or leave any work pending.
• Honesty and Integrity: Truthful, admits mistakes, does not cook up information, has ethical conduct, exhibits good moral values, loyal to the institution.
• Interpersonal Skills and Leadership Quality: Has compassionate attitude towards patients and attendants, gets on well with colleagues and paramedical staff, is respectful to seniors, has good communication skills

Sl.No.	Point to be considered	Score
1	Punctuality	
2	Regularity of attendance	
3	Quality of ward work	
4	Presentation of clinical cases	
5	Bedside manners	
6	Rapport with patients	
7	Rapport with colleagues	
8	Physics & instrumentation	
9	Understanding the concept	
10	Demonstrating the procedure	
11	Analysis of result	
12	Record Maintenance	

2. Clinical Work

• Availability: Punctual, available continuously on duty, responds promptly on calls and takes proper permission for leave.

• Diligence: Dedicated, hardworking, does not shirk duties, leaves no work pending, does not sit idle, competent in clinical case work up and management.
• Academic ability: Intelligent, shows sound knowledge and skills, participates adequately in academic activities, and performs well in oral presentation and departmental tests.
• Clinical Performance: Proficient in clinical presentations and case discussion during rounds and OPD work up. Preparing Documents of the case history/examination and progress notes in the file (daily notes, round discussion, investigations and management) Skill of performing bed side procedures and handling emergencies.

3. Academic Activity:

- Performance during presentation at Journal club/Seminar/ Case discussion/Stat meeting and other academic sessions.
- Proficiency in skills as mentioned in job responsibilities

Sl.No.	**Point to be considered**	Scoring
1	Clinical Presentations	
2	Whether all relevant points elicited	
3	Cogency of presentation	
4	Logical order	
5	Mentioned all positive and negative points of importance	
6	Whether any major signs missed or misinterpreted	
7	Diagnosis: whether it follows logically from history and findings	
8	Investigations required: - complete list - relevant order - interpretation of investigations	
Overall:		
1	Ability to react to questioning – whether answers relevant and complete	
2	Ability to defend diagnosis	
3	Ability to justify differential diagnosis	
4	Confidence	

Guidance for scoring:

0 Poor	*1 Below average*	*2 Average*	*3 Good*	*4 Very good*

(For internal assessment generalised guidelines as proposed by the Institute)

4. Mid -term Examination

The exam may include following subjects but not limited to

6 Month assessment

- Thesis protocol (self and other residents)
- Taking basic history of the patient
- Performing basic Nuclear Medicine Investigation (Protocol)
- Basic knowledge about the instrumentation, radiation protection and quality control
- Basis knowledge about the few basic RP, their physiological distribution, intervention and scan identification

12 Month (1 year assessment) Above mentioned with

- Instrumentation
- Basic radiation biology and radiation protection
- Basic radiopharmacy and radiochemistry,
- Principles of tracer technology.
- Diagnostic: Normal and abnormal appearances of images, mode of pharmaceutical uptake; normal variants and common artifacts in bone, heart, lung, kidney, brain, thyroid, tumour and infection images.
- Therapeutic: Basic principles of radionuclide therapy; treatment of hyperthyroidism, thyroid cancer and metastatic bone pain.
- Principles of radiation protection: ALARA (as low as reasonably achievable) ALARP (as low as reasonably practicable).

18 Months Above mentioned with

- Tracer kinetics
- Computing and image processing;
- Radiobiology including the biological effects of radiation
- The effective dose equivalent and radiation dose from radiopharmaceuticals.
- Properties of commonly used diagnostic and therapeutic radiopharmaceuticals;
- Production of radionuclides by reactors, cyclotrons and radionuclide generators; Quality assurance and quality control of radiopharmaceuticals.

24 Months Above mentioned with

- QC of instrument with all practical
- Basic knowledge of hybrid imaging
- Special investigations in cardiology, lung disease, gastroenterology, hepato-biliary diseases, nephro-urology, neurology and psychiatry, endocrinology, haematology, oncology and infection.

Pre examination Evaluation (~30 Months)

Examination appearing students shall be evaluated for following:

1. Case presentation
2. Scan Interpretation
3. Oral Viva
4. Summary of results of thesis experiments

The examination will include the above mentioned with

- Requirements in greater depth of clinical, NM physics, Radiopharmacy and radiation safety.
- Principles of radiology including ultrasound, computerized tomography and magnetic resonance imaging.
- All Nuclear medicine investigations, procedure, common and pathological findings, reporting etc.
- Therapeutic applications
- Further practice and experience of work accomplished in years 1 to 3
- Legal and regulatory requirements,
  Audit,
  Departmental management,
  Research techniques and evaluation,
  Teaching and training.

Sl.No.	Faculty Name (clinical, radiopharmacy, Radiation physics) /Physicist
1	
2	
3	

THESIS

Each candidate has to submit a thesis, which should be accepted by the Board of Examiners before appearing in the final examination. With one Chief guide & Co-guide. The Protocol should be submitted 6 months of admission & presented to entire faculty.

RECOMMENDED TEXT BOOKS AND JOURNALS

a. Textbooks

1. *Neuro PET,* by Herholz
2. *Molecular anatomic Imaging,* by Von Schulthess
3. *Principles and Practice of Nuclear Medicine* ,by Paul, J. Early, D. Bruce Sodee
4. *Diagnostic Nuclear Medicine,* by Sandler and Gottchalk
5. *Nuclear Medicine in Clinical Diagnosis and Treatment,* by Ell and Gambhir
6. *Positron Emission Tomography,* by Valk, Bailey, Townsend
7. *Practical FDG Imaging A teaching File,* by Debelke, Martin, Patton, Sandler.
8. *Functional Cerebral SPECT and PE Imaging*