

# NUCLEAR MEDICINE — M D

## 1. Basic Sciences

- (a) Modes of radioactive decay elementary aspect of the structure of matter.
- (b) Emissions accompanying radioactive decay, and their biological implications.
- (c) Interaction of radiation with matter
- (d) Basic physics of Nuclear Medicine imaging, x-ray computed tomography, Nuclear Magnetic Resonance and Ultrasonography, Single Photon Emission Tomography & Positron Emission Tomography.

## 2. Mathematics, Statistics & Computer Sciences

- (a) Basic Mathematical Concepts, Counting Statistics, Probability distribution and parametric and non-parametric statistics.
- (b) Basic aspects of computer structure, function and programming both hardware & software.
- (c) Computer applications with emphasis on digital image acquisition, analysis, processing and enhancement, tomographic reconstruction display and recordings of findings.
- (d) Compartmental analysis and mathematical models of physiologic systems.
- (e) Fundamental of filters, their applications and uses.

## 3. Instrumentation

- (a) Principles of Radiation detection and detectors.
- (b) Nuclear Medicine Instrumentation including Gamma Scintillation cameras, scanners, Single Photon Emission Tomography, Positron Emission Tomography & Cyclotron, Dose Calibrators, Tomography imaging devices, “Positron imaging instruments”, whole body counters, gamma well counters, liquid scintillation counters, monitoring devices.
- (c) Quality Control of nuclear instruments, as mentioned in (b).
- (d) 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.

- (e) Electronic instruments, such as pulse amplifiers, pulse height analyzer, count rate meters and computer interfaces including gating systems.
- (f) Image production and display technology including photographic principles, with special emphasis on sensitivity, resolution, count rate, latitude and film processing.
- (g) Fusion technology, Online transmission, Connectivity, DICOM technology, PACK system.

#### **4. Radiation Biology & Protection**

- (a) The biological effects of radiation exposure with emphasis on the effects of low level exposure, system wise.
- (b) Administrative and technical means of procuring radionuclide.
- (c) Method of reducing unnecessary radiation exposure to patients, personnel and environment.
- (d) Calculation of the radiation dose from internally administered radionuclide.
- (e) The diagnosis, evaluation and treatment of radiation over exposure in any form.
- (f) ICRP- 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.
- (g) Management of radiation accidents, including monitoring, decontamination and subsequent control.
- (h) High dose Iodine therapy, its effects & ways to monitoring for patient wastes like urine, stool, room monitoring shielding, concept of delay tanks, construction & monitoring.
- (i) Protection of relatives of the patients.
- (j) Effect on pregnancy and fertility, subsequent to high dose therapy.

#### **5. Radiopharmaceuticals**

This syllabus explores the chemical, physical and biological properties of radiopharmaceutical used in Nuclear Medicine. Production, Quality Control and Regulations of a Nuclear Pharmacy will be examined. Emphasis will be:

- (a) Physical and Chemical Characteristics of radionuclide used in Nuclear Medicine.
- (b) Radiopharmacy generator produced radiopharmaceutical.
- (c) Criteria for selection of radionuclide.
- (d) Biological behavior of radiopharmaceuticals.
- (e) Quality control.
- (f) Mechanism of localization.
- (g) Radiopharmaceuticals for therapy.
- (h) Positron Emission radio-nuclide their preparation, various modules nuclear reactions, target reactions and chemistry.
- (i) Specific topics on Bone seeking Radiopharmaceutical, Hepatobiliary, Tumor seeking, Cardiac Imaging, Radiopharmaceuticals for Research etc.
- (j) Good Manufacturing Practice, laws etc. related to In house manufacturing Radiopharmaceutical for Radio-immuno-assays and related techniques including Shilling test, RBC survival tests: General Principles, methods, quality control, labeling of ligands, in vitro and in vivo thyroid function

studies etc. Receptor assays.

- (k) 2 months in each Academic year to be spent in Radiopharmacy lab. & quality control

## 6. Diagnostic Imaging

- (a) 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.
- (b) In vivo imaging and/or function studies, including brain SPECT, cerebrospinal fluid, thyroid using both  $^{99m}\text{Tc}$  &  $\text{I-131}$ , salivary glands, lung, heart and vessels, esophagus, stomach, Hepatobiliary system, spleen, kidney, adrenal, tumors and abscesses, bladder, bone & joints, bone marrow etc. including three phase bone imaging.
- (c) The use of imaging devices, external detectors and computers for body organ imaging and for time-dependent and differential function studies.
- (d) The use of physiologic gating techniques for functional studies.
- (e) Patient monitoring during intervention such as exercise i.e. using Bruce Protocol and pharmacological
- (f) 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.
- (g) Cellular kinetics, absorption and excretion analysis, nuclear hematology and metabolic balance studies using radiotracers.
- (h) Body composition tests, including compartmental analysis
- (i) Whole-Body counting and total body scanning for high dose iodine
- (j) Comparative analysis of Nuclear Medicine procedures with X-ray, MRI, ultrasound, CT, Spiral CT, PET etc.
- (k) 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.
- (l) Positron Emission Tomography: All indications for use of PET imaging in Oncology, Cardiology, Neuro Sciences and psychiatric disorders.

## 7. In-vitro Studies

- (a) Principles of radioisotope micro-analytical techniques such as RIA, quality control and data analysis for various hormones, drugs & cyclosporine assays.
- (b) Binding capacity studies such as receptor assays and T-3 Resin uptake etc.
- (c) Principles of activation analysis and auto-radiography.
- (d) GFR estimations, Red Cell Survival & Red Cell Mass using Chromium.

## 8. Therapeutic uses of Radionuclide

Application of isotope in Therapy in following areas:

- 1) Thyrotoxicosis
- 2) Cancer Thyroid – both low dose & high dose

- 3) Radiosynovectomy using Yttrium, Holmium
- 4) Bone Palliation using P32, Sr 89 & Sm 153.
- 5) I-131 Lipidol for Hepatic cancer
  - (a) 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.
  - (b) 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; the special problems of 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.

## 9. Organizational Considerations

- (a) Design of laboratories or various sizes & capacity as per the norms of BARC
- (b) Planning & scheduling of the patient work load.
- (c) Economic aspects of nuclear medicine and cost-effectiveness of nuclear medicine procedures.
- (d) Public relations
- (e) Role of National and International Organizations like AERB, MCI, NMC, BRIT, BARC, IAEA, ICRP

Regular participation in weekly journal club, Seminar and other periodical CME programs

Participation in the Seminars and CME programs of allied departments.

## LOG BOOK

Each candidate should be required to maintain a log book in which following details will be entered:

- (a) Investigations performed by him
- (b) Presentations in journal clubs alongwith Title & Journal & Issue with title.
- (c) Cases presented in clinical meetings with other departments.
- (d) Presentation in departmental seminars
- (e) Schedule of interdepartmental rotation
- (f) Details of apprenticeship
- (g) Conferences attended – National/International
- (h) Papers presented at conferences with title name of the conference, date of presentation
- (i) Paper published with title, name & issue of the journal
- (j) Cases worked up for radionuclide therapy

## Mid term Evaluation

Each candidate shall have mid term evaluation in terms of

1. Presentation of work completed in Thesis
2. Evaluation of the Log book

3. Case presentation session
4. Scan Interpretation session
5. Oral Viva

### **Pre examination Evaluation**

Examination appearing students shall be evaluated by the faculty & observer for following:

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

### **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.

### **THESIS EVALUATION**

The thesis should reflect substantial work for the advancement of scientific knowledge, design or development or applied work. It should show competence in critical analysis of scientific data as well as through familiarity with background literatures.

- I. The evaluation of the thesis will consist of:
  - (a) Evaluation by 2 external examiners
  - (b) Oral examination of the candidate on the thesis during the viva for final examination.
- II. In his/her report, each examiner should highlight the salient features of the thesis and make a clear recommendation regarding its acceptance or rejection for M D Degree. If one of the examiners gives a definite recommendation against the award of the degree, reference to a third examiner will be made. If the report from the third examiner is positive, the oral examination will be held. If his/her report is negative, the thesis will be rejected.
- III. If two examiners recommend against the award of the degree, the thesis will be rejected.

### **REPORT OF EXAMINERS**

- I. Each examiner will be requested to send his report within 2 months of the receipt of the thesis to the registrar. The reports must contain a critical evaluation of the thesis and a clear recommendation as to whether it has attained the standard of M D or not.
- II. In case the examiners are unable to make a definite recommendation they should indicate one of the following alternatives:
  - a) Minor revision, which does not involve retyping or binding of the thesis
  - b) Major revision involving rewriting of one or more sections but not involving additional research
  - c) Rewriting the thesis: If the candidate's work justifies another opportunity being given to him to do further research & rewriting the thesis (this will be treated as a new examination).

### **Oral Examination & Scan Reading Session**

- I. Oral examination is designed to test the general scientific background of the candidate and his/her

own particular contribution embodied by the thesis. The oral examination will be conducted after the thesis has been judged to be satisfactory. The two external examiners and the H.O.D. will conduct the examination, in which a pass is obligatory. They will readout the comments & questions and will seek the answers from the candidate.

- II. Members of the Board for oral examination, he/she may be permitted to appear again after 6 months. If he/she fails in the 2nd attempt, he/she will not be permitted to continue with the M D program.

## Case Presentation

### *Short case and long case presentation*

Practical Physics; Quality control of instrumentation, Preparation of radiopharmaceutical; contamination; unknown isotope management of a spill.

## JOURNALS

1. Indian Journal of Nuclear Medicine
2. European Journal of Nuclear Medicine
3. Annals of Nuclear Medicine
4. Clinical Nuclear Medicine
5. Seminar in Nuclear Medicine
6. International Journal of radiation application instrumentation, part B; Nuclear Medicine and Biology
7. Journal of Nuclear Medicine
8. Nuclear Medicine communication
9. Medical Physics
10. Journal of Nuclear Medicine Technology

## TRAINING PROGRAMME

1. Didactic lecture in physics related in Nuclear Medicine, radiopharmacy, radioisotope techniques, instrumentation data processing and quality control.
2. Participation in the daily routine work of the department including work rounds of patients admitted for radionuclide therapy.
3. Presentation of cases in the reporting sessions of the department
4. Active participation in the combined clinical meetings with other departments for case discussions.
5. Apprenticeship in:
  - (a) Radiodiagnosis - 2 month
  - (b) Cardiology - 1 month
  - (c) Neuro-Sciences - 1 month
  - (d) Nephrology & Urology - 1 month
  - (e) Endocrinology - 1 month

## SUGGESTED BOOKS AND AUTHORS

<i>Sl. No.</i>	<i>Name of Books</i>	<i>Editor's Name</i>
1.	Principles of Nuclear Medicine	Henry N. Wagner (Jr.)
2.	Cerebral Radionuclide Angiography	Deland F. H

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| 3.  | Cardiovascular Nuclear Medicine   | Strauss H. William                                 |
| 4.  | Fundamentals of Nuclear Pharmacy  | Gopal Shah   |
| 5.  | Quality Control in Nuclear Medicine<br>Radiopharmaceutical Instrumentation<br>& In-vitro Assays | Rhodes Buck  |
| 6.  | Intervention of Nuclear Medicine<br>Mosby's Manual of Nuclear<br>Medicine Procedures            | Richard P. Spencer                                 |
| 7.  | Mosby's Manual of Nuclear<br>Medicine Procedures  | D Brucee Sodes<br>Paul J early                     |
| 8.  | Radiopharmaceuticals  | Subramaniam G. et al                               |
| 9.  | Thyroid & its Diseases  | L.J. De Groot                                      |
| 10. | Nuclear Medicine in Vitro   | B. Rothfield                                       |
| 11. | Nuclear Medicine in Clinical<br>Diagnosis and Treatment<br>(2nd Edition)                        | I.P.C. Murray<br>P.J. EII<br>Churchill Livingstone |
| 12. | Nuclear Medicine-The Requisites<br>(2nd Edition)  | James H Thrall<br>Harvey A Ziessman                |
| 13. | An Atlas of Clinical Nuclear Medicine<br>(2nd Edition)  | I. Fogelman<br>M.N. Maisey<br>S.E.M. Clarke        |
| 14. | Nuclear Medicine  | Robert E. Henkin<br>Mark A. Boles                  |
| 15. | Nuclear Oncology-Diagnosis<br>& Therapy   | Iraj Khalkhali                                     |
| 16. | Medical Imaging Physics   | William R. Hendee<br>Russell Ritenour              |
| 17. | Clinical SPECT Imaging  | Elissa Lipeon Kramer<br>Joseph J.Sanger            |
| 18. | Nuclear Cardiac Imaging<br>Principles & Applications  | A.S. Iskandrian<br>Mario S. Verani                 |
| 19. | Nuclear Cardiology –<br>State of the Art & Future Directions                                    | Barry I. Zaret<br>George A. Beller                 |
| 20. | Cardiac Nuclear Medicine  | Myron C. Gerson                                    |