ADVANCED TRAINING IN NUCLEAR MEDICINE (SINGAPORE)

TRAINING PROGRAM, CURRICULUM AND REQUIREMENTS
ADVANCED TRAINING IN NUCLEAR MEDICINE

Entry Requirements

Specialists in Nuclear Medicine have ultimate responsibility for Nuclear Medicine services and will hold the appropriate certificate to administer radioactive substances for diagnostic studies and radionuclide therapy. Applicants for Advanced Specialty Training in Nuclear Medicine should have completed a minimum of two years general professional training in approved posts and obtained the MRCP (UK), M Med (Internal Medicine) (S’pore), FRCR (UK), or the MMed (Diag Radiology) (S’pore). Other applicants without the MRCP, M Med or FRCR must provide evidence of appropriate knowledge, training and experience, subject to the approval of the Nuclear Medicine Specialist Training Committee.

Duration and Organisation of Training

The duration of Advanced Training in Nuclear Medicine is 2 years and it will be provided in approved centres. The programme to which the trainee is appointed will have named consultant trainers as well as a named Training Director with overall responsibility for the organization of training.

Research

A supervised research study of high quality is an essential part of the programme. The trainee must be the principal investigator and assume full responsibility for the project. The research work must be completed, presented and aimed to be published in a refereed medical journal.

Training Record

A Training Record will be maintained by the trainee. It will be counter-signed as appropriate by the supervisors to confirm the satisfactory fulfillment of the required training experience and the acquisition of the competences that are enumerated in the specialty curriculum. It will remain the property of the trainee and must be produced at the annual assessments.

General Description

Nuclear Medicine is the administration of unsealed radioactive substances to patients for diagnosis, therapy or research. Trainees will require appropriate instruction in the clinical, scientific and legal aspects of the specialty.

Nuclear Medicine training is provided in three main ways.

1. Apprenticeship – learning directly from medical specialists, scientists and others providing a nuclear medicine service.

2. Local education – this will include participation in interdisciplinary meetings e.g. with x-ray departments, clinical meetings and also more formal education, such as lectures and tutorials, courses on radiation protection etc. in the hospitals of training.

3. External education – attending courses, seminars, etc.
Training programmes will include instruction in:

1. **Scientific Principles.** The scientific basis of the specialty requires all trainees to receive instruction on relevant basic science, instrumentation, radiation protection, radiopharmacy and radiochemistry.

2. **Clinical Nuclear Medicine.** The trainee will need to be involved with assessing the clinical need for investigations and the choice of the most appropriate investigation; be able to supervise and ensure that it is performed to a high standard and become experienced in interpreting results and issuing reports. He/she should be familiar with data manipulation and image processing. Training must include paediatric investigations. Experience must be gained in radionuclide therapy, including criteria for patient selection and supervision of follow-up after treatment.

3. **Legal and Regulatory requirements.** There are complex legal and regulatory requirements concerning nuclear medicine. These include the production and administration of radiopharmaceuticals, radiation protection relating to the patient, the general public and hospital staff and requirements for research and patient consent. Trainees will need appropriate instruction in all of these aspects of nuclear medicine.

4. **Related disciplines.** With the rise of the importance of molecular and cellular biology, the trainee is encouraged to pursue learning in related sciences such as cell biology, immunology, cancer biology and biotissue engineering.

**Practical Skills**

Trainees will be required to develop skills in :-

1. The safe administration of unsealed radioactive substances to patients.
2. The practical supervision of patient scanning procedures.
3. Data manipulation and image processing.
NUCLEAR MEDICINE CURRICULUM

BASIC SCIENCE OF NUCLEAR MEDICINE

(A) PHYSICS
   : Atomic structure
   : Radioactive decay
   : Interaction of radiation with matter
   : Biological effects of radiation

(B) MATHEMATICS
   : Probability theory
   : Parametric and non-parametric statistics
   : Compartmental analysis
   : Tracer kinetics

(C) INSTRUMENTATION
   : Principles of radiation detectors
   : Nuclear medicine detectors – gamma cameras (including SPECT), scanners, non-imaging probes,
     whole body counters, monitoring devices, PET, scintillation counters, dose calibrators
   : Collimation
   : Electronic instrumentation, image production and display

(D) COMPUTING & IMAGE PROCESSING
   : Principles
   : Applications to nuclear medicine data acquisition, processing and display.

(E) RADIATION BIOLOGY AND PROTECTION
   : Biological effects of high and low level radiation
   : Calculation of radiation dose from radiopharmaceuticals
   : ALARA and ALARP
   : Diagnosis and treatment of radiation overexposure
   : Management of radiation accidents

(F) RADIOPHARMACY / RADIOCHEMISTRY
   : Properties of commonly used diagnostic and therapeutic radionuclides
   : Production of radionuclides by reactors, cyclotrons and radionuclide generators
   : Principles of localisation of radiopharmaceuticals
   : Quality control

(G) OTHER IMAGING MODALITIES
   : Principles of:
     - radiology, including DEXA scanning, ultrasound
     - computerised tomography
     - magnetic resonance imaging
2. CLINICAL NUCLEAR MEDICINE

(A) DIAGNOSTIC:
Knowledge of radionuclide procedures (imaging and non-imaging) in the following topic areas.

- skeletal disorders
- cardiology
- lung diseases
- gastroenterology
- hepato-biliary diseases
- nephro-urology
- neurology and psychiatry
- endocrinology
- haematology
- oncology
- infection
- paediatrics
- breast imaging
- clinical applications of PET imaging

: Including
- radiopharmaceuticals and principles of localisation
- imaging and counting devices
- protocols for study performance and analysis
- preparations of patients, precautions (including drug effects), complications
- special protocols for paediatric studies
- quality assurance
- significance of normal/abnormal findings
- correlation with other diagnostic tests
- test evaluation
  o sensitivity / specificity / predictive value
  o Bayes’ theorem
  o concepts of risk-benefit and cost-benefit analysis

(B) THERAPEUTIC
: Knowledge of radionuclide therapy in
- hyperthyroidism
- thyroid cancer
- bone metastases
- neural crest tumours
- liver cancer
- polycythaemia
- other soft tissue tumours (monoclonal antibodies)
- synovitis

: Including
- radiopharmaceuticals and mechanisms of action
- patient selection and preparation
- complications / side-effects
- protection of staff / family etc

(C) OTHER CLINICAL EXPERIENCE
: Knowledge of other diagnostic imaging techniques
- range and limitations
- choice of diagnostic procedures

Assessment of bone densitometry

3. **LEGAL / REGULATORY REQUIREMENTS**

Including:
- product licenses
- radiopharmacy aspects
- waste disposal
- radiopharmaceutical transport

4. **RESEARCH AND DEVELOPMENT**

: Designing research
: Research techniques
: Analysing results
: Publication
: Legal and ethical considerations
: Developing research findings into practice
: Principles of evidence based medicine

5. **TEACHING**

: Identifying learning needs
: Preparing teaching materials
: Using training aids
: Delivering training
: Assessment
APPENDIX 1

CORE OF CLINICAL EXPERIENCE

1. IN VIVO DIAGNOSTIC PROCEDURES

This must include responsibility (including indication, performance, interpretation) for a sufficient number of various in vivo diagnostic radionuclide procedures. Trainees will be expected to be able to demonstrate competence as well as experience in these procedures.

A minimum total number of 1800 procedures must be supervised and reported by the trainee and the quality of these audited. These should include a wide range of pathology and include paediatric studies. The minimum recommended number for each procedure is as follows:-

<table>
<thead>
<tr>
<th>No. of studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. central nervous system</td>
</tr>
<tr>
<td>b. skeletal system</td>
</tr>
<tr>
<td>c. cardiovascular system</td>
</tr>
<tr>
<td>d. pulmonary system</td>
</tr>
<tr>
<td>e. gastro-intestinal system</td>
</tr>
<tr>
<td>f. urogenital system</td>
</tr>
<tr>
<td>g. endocrine system</td>
</tr>
<tr>
<td>h. haemopoietic and lymphatic system(s)</td>
</tr>
<tr>
<td>i. infection and inflammation</td>
</tr>
<tr>
<td>j. oncology imaging (including PET studies)</td>
</tr>
</tbody>
</table>

2. THERAPY

Training in therapeutic applications must include clinical evaluation, supervision and follow up of patients having therapeutic doses of radionuclides, including aspects of dosimetry and radiation protection. Trainees will expected to participate in thyroid clinics (both new patient and follow-up) and may need to attend joint clinics with other disciplines, e.g. oncologists, to gain experience in the less common procedures.

<table>
<thead>
<tr>
<th>No. of treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid disease</td>
</tr>
<tr>
<td>Thyrotoxicosis</td>
</tr>
<tr>
<td>Thyroid carcinoma</td>
</tr>
</tbody>
</table>

| Other radionuclide treatments | 30 |
NUCLEAR MEDICINE TRAINING PROGRAMME

Advanced Training in Nuclear Medicine is a two-year post-graduate training programme, typically post-FRCR, MRCP or other equivalent degrees. Trainees are encouraged to develop areas of special interest and expertise in addition to being trained in the basic core curriculum. Individual training programmes will be supervised by the Specialist Training Committee. This two-year programme is designed for those who have already acquired at least 2 years of radiological/internal medicine training.

NUCLEAR MEDICINE TRAINING PROGRAMME – YEAR 1

Training Objectives

Obtain introduction to:
- basic science (to include physics, chemistry, pharmacology, immunology)
- clinical procedures
- radiation protection

Complete basic science training
Achieve competency in basic clinical techniques – including clinical PET, cardiac, brain and bone SPECT, renal interventional studies, paediatrics
Become knowledgeable on radiation protection

Competency achieved

Knowledge of understanding of basic sciences
Ability to supervise & report some simple procedures
Draw up and inject radiopharmaceuticals
Perform simple computer data manipulation of nuclear medicine studies
Vetting of requests and selecting appropriate investigations
Report accurately range of simple diagnostic investigations unsupervised (prior to reports being verified by consultant)
Perform physical / pharmacological challenge testing for cardiac studies
Manage uncomplicated therapy cases eg 1131 for thyrotoxicosis
Management of complications following radionuclide administration
Perform more advanced data manipulation
Produce research paper (regionally or nationally)
Give oral presentation

Training

Perform clinical studies with varying degrees of supervision
Review images (brought by radiographer / technical staff)
Participate in departmental / hospital training programmes

Assessment

Training record
Objective

To become competent in most clinical procedures and PET/CT imaging
To become competent in more advanced radionuclide therapy
To start to develop at least one area of special interest
To develop an area of research

Competencies achieved

Select, perform and interpret most diagnostic procedures
Manage most therapeutic procedures, including P-32, 1131 for thyroid carcinoma, joint and bone palliation, 1131 MIBG therapy
Presentation of oral and written data for teaching or research

Training

Receive training and supervision appropriate for the difficulty of the procedure
Attend advanced courses / conferences
Spend periods of attachment to other specialized departments eg, paediatric imaging, diagnostic radiology, nuclear cardiology.

Assessment

KEY ASSESSMENT and EXIT INTERVIEW by NUCLEAR MEDICINE STC.
**Required Reading**


6) Von Schulthess G K. *Clinical Molecular Anatomic Imaging. PET, PET/CT and SPECT/CT*. Lippincott Williams & Wilkins (2003).