Nuclear Medicine: Basics to therapy

RCP Medical careers day

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On behalf of the British Nuclear Medicine Society (BNMS)
Introduction

Basics of nuclear medicine
- Definition
- Applications

Role of nuclear medicine
- Diagnostic procedures
- Therapy
- Theragnostic approach

1903
Nobel Prize for Discovery of Spontaneous Radioactivity

Henri Becquerel
Marie Curie
Pierre Curie
What is Nuclear Medicine?

- Nuclear Medicine is application of tracer technology to medicine.

- WHO definition of nuclear medicine:

  ‘Speciality which embraces all applications of radioactive materials in diagnosis or treatment or in medical research, with the exception of the use of sealed radiation sources in radiotherapy’
Why Nuclear Medicine? Variety and Diversity

- Radiopharmacy
- Functional or Molecular Imaging
- Radionuclide targeted therapy
- ‘In vitro’ Studies
- Multi-Modality Imaging
- PET-CT
- SPECT-CT, PET-MRI
- ‘In vivo’ Nuclear Medicine
- Research
Clinical Radiology
Instrumentation induces signal changes and detects the effects

Nuclear Medicine
Instrumentation detects the signal
The radiotracer is the source of the signal

Courtesy of Prof D C Costa, Fundacao Champalimaud
In Vivo Imaging

- Involves:
  - Radiotracer (Radionuclides + Tracer)
    - Radiopharmacy
    - Generator/Cyclotron
  - Imaging device (gamma camera/ PET camera)
  - Computing

Tracer Principle: George Harvey (1913)
Clinical Applications of Nuclear Medicine

- Wide variety of diseases
- Nuclear Medicine procedures
- Diagnostic ($\gamma$, $\beta+$emitters)
- Therapeutic ($\beta$-emitters and alpha emitter 223Ra-dichloride)
Functional Imaging: Sensitivity depends on magnitude of metabolic change rather than size

ANATOMICAL IMAGING CAN’T SEE EVERYTHING

Courtesy of Prof K Miles, University College London
Molecular imaging is not new to nuclear medicine!

- Radioiodine is longstanding example

123 – Iodine Organification

$^{99m}$Tc pertechnetate Trapping

- Uptake-Sodium/iodide symporter (NIS)
Thyroid Imaging: Clinical Indications

Assessment of Thyrotoxicosis

- Graves’ disease
- Solitary autonomous toxic nodule
- Multinodular goitre

NIS mRNA
Common diagnostic procedures

- Ventilation-perfusion lung imaging
- Bone scanning
- Renal investigations
- Endocrine investigations
Common Diagnostic procedures

- Myocardial Imaging
- Infection/Inflammation Imaging
- Tumour Imaging
- Brain Imaging
- Paediatric Nuclear Medicine
What is behind the Image?

- Anatomical structure does not equal function and vice versa

- Bio-distribution of the tracer

- Distinction between Research Findings and Clinical Use
Same patient: Different Tracers - Different images
MIBG negative Octreotide positive Tumour

MIBG vs Octreotide- Complementary role!
Dg: Cardiac paraganglioma

What’s behind the image?
Different tracers - similar scan appearances
But different clinical meaning

What is behind the Image?

123I-FPCIT (DATSCAN)
18F-FDOPA
123I-IBZM

Dopamine Transporter
I-DOPA
D2/D3 receptors

Pre synaptic level
Post synaptic level
Advantages of Molecular Imaging

- All major organ systems scanned in one procedure
- Functional change can predate structural change
- Can identify local / remote spread > accurate staging
- Lymphatic spread not classified by size criteria
- Therapeutic planning
- Therapy response
- Characterize scar tissue / residual disease
- Identify occult primary site
Common therapeutic procedure

- $^{131}$I (radioiodine) treatment of benign thyroid disease
- Thyroid cancer
- Bone metastases
- Radionuclide Treatment of Neuroendocrine Tumours
- Liver malignancy treatment
- Radiation Synovectomy
Theragnostic strategy

Theragnostic agents can both diagnose and treat disease

Monitoring $^{131}$I targeted treatment response

Thyroid scan pre-radioiodine treatment

Thyroid scan Post-radioiodine treatment
Follicular Cancer In Presumed Benign Thyrotoxicosis

I-131 whole body scan
GMC approved NM curriculum

Competitive Entry Medicine

FY2

CMT2 & MRCP

Competitive Entry Radiology

Core Radiology Training Y1-3

CCT NM CESR CP Radiology

NM Training Y4-6

FRCR

SR NM & CR

PG Diploma NM

CCT Clinical Radiology & CESR CP NM

Workplace Assessments

Courtesy of Dr Brian Neilly, Glasgow Royal Infirmary
Cons

- Relatively long training
- Exams
- Currently underutilised and under promoted
Some issues facing our specialty

- Implementation of a new GMC approved NM Curriculum
- Recruitment - linked to 1.
- PET-CT National Contract
  - Introduction of non-FDG tracers
- Novel molecular radiotherapies
  - (e.g. 223-Ra, SIRT, PSMA, PRRT)
- Funding and commissioning

*Nothing in life is to be feared. It is only to be understood.*
- Marie Curie
Pros and Benefits

✧ Multidisciplinary
✧ Holistic but Individualised ‘precision’ medicine
✧ Clinical benefits - functional and physiological
✧ Decisive and influential - Changing patients’ management
✧ Enables the most appropriate investigation and treatment in a timely manner.
✧ Diagnostic but also therapeutic- Theragnostic approach
✧ Challenging and rapidly developing
✧ Rewarding Medical Career! 😊
Multimodality Imaging (SPECT-CT, PET-CT, PET-MRI), Novel Radiotracers and Radionuclide Molecular Radiotherapies

Range of a $\beta$-particle

Bone marrow

Tumor

Bone

Ra-223

POSITRON EMISSION

$e^+ - 511$ keV

$e^- - 511$ keV

$^{18}_8F$
Future in Nuclear Medicine is bright

Recruitment of junior doctors is our future!

- Increased demand
- The promotion of specialty:
  - RCP and BMJ careers days.
  - EJNMMi, NMC, BMJ editorials.
  
B Neilly, S Dizdarevic, L Prvulovich, J Buscombe, V Lewington.  


‘Only by training in nuclear medicine will the government give you a licence to give both diagnostic and therapeutic radioisotopes – even 007 does not get one of those’!

Dr John Buscombe, Chair of the Joint Specialty Committee for Nuclear Medicine RCP.
Case

30 year old male
Melanoma met to scalp (?primary)

CT – bladder mass. Equivocal liver, lung lesions.
18F-FDG - PET-CT – liver, adrenal, bone FDG avid mets
Bx bladder – melanoma met – surgery cancelled