Overview

• Nuclear medicine in general

• What is PET / CT ?

• When is PET used ?

• The benefits of PET
Nuclear Medicine Basic Concepts

• Use of radioactive tracers to map particular biological processes for diagnosis, and treatment of disease
• In vivo assessment of physiology and pathophysiology, biochemistry and metabolism
• Functional imaging rather than structural
• Usually organ specific
Nuclear Medicine Basic Concepts

- Tracers = radiopharmaceuticals
  - isotope + chemical
  - isotope – single photon/gamma ray emitter or positron emitter (dual photons)
  - chemical pharmaceutical determines biodistribution

- Gamma camera or PET camera detects gamma rays, stores, processes and displays data

- Dosimetry – radiation dose received comparable to radiological procedures
Radiation dose

- Bone scan - approx. 4mSv
- PET-CT scan – 10 mSv
- Background – 3mSv/yr
- L spine X-ray – 1.5mSv
- CXR – 0.1mSv
- CT chest abdo pelvis – 18mSv
- CT chest – 8mSv
- CT abdo – 10mSv
Radiopharmaceuticals

- Present in only minute amounts (nanograms)
- No allergic response or side effects from administration
- Administration
  - Most commonly intravenous
  - But may be inhaled, oral ingestion, and rarely intraperitoneal, or into shunts
Nuclear Medicine Imaging

- Gamma/SPECT camera or PET camera
- Interaction of gamma ray with crystal detector produces a scintillation photon
- Photomultiplier tube detects this, converts it to electrical signal
- Computer produces digital image of tracer distribution in body
- 2D (planar) or 3D (SPECT – single photon emission computed tomography, and PET – positron emission tomography)
WHAT IS PET / CT ?
PET

• Nuclear medicine imaging technique

• Therefore uses a tracer – F18 FDG, produced by a cyclotron

• Most malignant tumours are FDG avid, as they are metabolically active, so this allows their imaging
FDG Uptake

2-[F-18] fluoro-2-deoxy-D-glucose

- FDG is glucose analog, taken up via glucose transporters (Glut)
- Phosphorylated to FDG-6-phosphate, not metabolised further, trapped in cell
- T 1/2 110 min
Positron Emission Tomography

- Positron released from decay of FDG, annihilates with electron
- Release of two coincidence (180 degree opposed) 511 keV photons
- Detected by scintillation crystals, coupled to PM tubes, input to computer
Understanding CT’s limitations

Where’s Wally?
Understanding PET’s limitations

Here’s Wally, but where’s Wally?
Understanding PET/CT

Here’s Wally!
PET-CT

Fuses or merges the functional information of PET with the anatomical information of CT
- L paratracheal lymph node (< 1cm on CT)
PET/CT vs PET

CT component used for:

- Anatomical localisation
  - confidence of reporting
  - guidance for biopsy
  - radiotherapy planning

- Attenuation correction
PET scan - Technique

• For the patient the procedure involves:
• 6hr fast, but may drink water
• IV cannulation and injection of FDG
• 1hr rest (uptake period) in lead lined room
• Scan – rapid low dose CT followed by PET imaging (20 mins)
WHEN IS PET USED?

- Note specialist referral is required for medicare rebate
- There are a limited number of medicare rebatable conditions
PET SCANS with MEDICARE REBATE

- **Lymphoma** – since July 2011, 5 new item numbers to cover:
  - Staging
  - Assess response to 1\textsuperscript{st} line therapy
  - Restaging
  - Assess response to 2\textsuperscript{nd} line therapy
  - Staging of indolent NHL when XRT planned
PET SCANS with MEDICARE REBATE

- **Solitary pulmonary nodule** – where unsuitable for FNAB or failed attempt at path. characterisation

- **Non-small cell lung cancer** – for staging where curative surgery or radiotherapy is planned

- **Colorectal carcinoma** – suspected residual, metastatic or recurrent disease in patients suitable for active therapy
PET SCANS with MEDICARE REBATE

• **Malignant melanoma** – suspected metastatic or recurrent disease in patients suitable for active therapy

• **Ovarian cancer** – suspected residual, metastatic, or recurrent disease in patients suitable for therapy

• **Oesophageal or gastro-oesophageal cancer** – staging in patients suitable for therapy
PET SCANS with MEDICARE REBATE

- **Head and neck cancer** – staging of biopsy proven newly diagnosed or recurrent disease, suspected residual disease after treatment, suitable for further therapy

- **Metastatic squamous cell carcinoma** – in cervical lymph nodes with unknown primary
PET SCANS with MEDICARE REBATE

- **Carcinoma of uterine cervix** – staging at FIGO IB2 or greater, and restaging when confirmed local recurrence

- **Sarcoma** – staging and restaging (NB excludes GIST)

- **Brain** – suspected residual or recurrent malignant brain tumour, and evaluation of refractory epilepsy (when being evaluated for surgery)
PET SCANS with CLINICAL UTILITY but NO MEDICARE REBATE

- Adenocarcinoma of unknown primary – identify primary

- Bone cancer – assessment of metastases

- Breast cancer – assessment of mets in locally advanced disease, pre- and post chemo monitoring, not staging of axilla

  Medicare rebate awaited? soon
PET SCANS with CLINICAL UTILITY but NO MEDICARE REBATE

- **Gastric cancer** – staging
- **Gastrointestinal stromal tumour (GIST)** – staging and assessment of treatment

- **Merkel cell cancer** - staging, assessment recurrent disease

- **Thyroid cancer** – restaging after surgery and I-131 Rx with negative I-131 scan and elevated Tg
THE BENEFITS OF PET
BENEFITS of PET

• Improved staging and restaging of malignancy
• Overall management impact in 20-60% depending on clinical context
• Guide biopsy of lesions
• Guide radiotherapy field
• Detection of recurrence
• Monitor response to therapy
PET and LYMPHOMA
LYMPHOMA

- Widely accepted as superior for staging, with change in Mx 20-30% (NHL & HD)

- Early treatment response evaluation

- End treatment evaluation

- Restaging
LYMPHOMA

- Cancer of lymphatic system
- Non-Hodgkin’s lymphoma (NHL) – 85%
  - 10yr survival 50%
  - heterogeneous set of lymphomas
  - 2 prognostic groups – aggressive and indolent lymphomas

- Hodgkins lymphoma / disease (HD) – 15%
  -10 yr survival 80%
NON-HODGKINS LYMPHOMA

- Aggressive NHL includes:
  - Diffuse large B cell (DLBCL) – 30%
  - Mantle cell (MCL) – 6-8%
  - Peripheral T cell (PTCL) – 6-8%
NON-HODGKINS LYMPHOMA

• Indolent NHL includes:
  - Follicular lymphoma (FL) – 22%
  - Marginal zone B cell – 6-8% (includes MALT – mucosa associated lymphoid tissue)
  - Small cell – 6-8%
FDG Uptake in lymphoma

- Generally the degree of uptake is much greater in aggressive NHL and HD than indolent NHL, although there can be overlap.
- Nevertheless the majority of indolent NHL are seen on PET, but MALT and small cell can be negative.
Gallium and lymphoma

• Prior to PET, gallium scanning used for lymphoma

• Now PET is standard of care

• PET 30% more sensitive and 20% more specific than gallium
Uses of PET in Lymphoma

- Staging and restaging (dictates prognosis and treatment)
  - More accurate than CT alone, particularly for extranodal disease (spleen, bone marrow etc)
  - One-third of patients will have a change in stage and management of their lymphoma following a PET scan
AA JULY 2011
71yo female
Follicular NHL in mesenteric mass
EM AUG 2011
77yo female
Lymphoma staging
CG FEB 2011
35yo female
Staging – presented with chest pain
Ax LN Bx - lymphoma
69yo female
Pancreatic mass – Bx
diffuse large B cell
lymphoma, staging
CT Transaxials

PET Transaxials

Fused Transaxials

MIP Navigate

- JS
LT MAR 2011
62yo female
Gastric MALT 6ya, now B symptoms, and PE, suspected recurrence
BR AUG 2011
82yo female
Lymphoma staging
Note spleen
BR
Uses of PET in Lymphoma

- Identify site for biopsy
  - PET can help identify a biopsy site in patients where an obviously accessible site is not seen on other imaging
Uses of PET in Lymphoma

• Assess during treatment response
• Interim PET scans (after 1-3 cycles of treatment) can identify responders vs non-responders
• Can predict progression free survival (PFS) and overall survival
  • PET –ve, 5yr PFS – 90%
  • PET minimal residual disease, 5yr PFS – 60%
  • PET +ve, 5yr PFS – 15%
• Studies are on-going to assess if +ve interim PET should be used to change chemotherapy
YV AUG 2011
75yo female
MALT lymphoma recurrence, now post 3 cycles chemo
KN MAR 2011
62 yo male
NHL relapse

KN JULY 2011
Post 3 cycle chemo
MC MAY 2011
71yo female
Peripheral T cell lymphoma

MC JULY 2011
Post 3 cycles chemo
SD JUN 2011
45yo male
Small bowel NHL

SD AUG 2011
Post 3 cycles chemo
Uses of PET in Lymphoma

- Assess end treatment response
- PET performed at end of treatment provides powerful prognostic information
- PET +ve – all relapse
- PET –ve – 80-85% remain in clinical remission
- Do 6-8 weeks post completion chemo (else get false –ve and +ve) and 3 months post DXRT
Uses of PET in Lymphoma

- Differentiation between residual lymphoma and necrosis / fibrosis in post-therapy mass
- PET is more accurate than CT
Uses of PET in Lymphoma

- Identify transformation from indolent to aggressive forms of NHL
- Observation of greater than 3 fold increase in SUV (standardised uptake value – measure of degree of FDG uptake) on serial studies
COLORECTAL CANCER

- 2\textsuperscript{nd} most common cause of cancer death
- PET 15% more accurate in staging and restaging than conventional imaging
- Change in patient management in 30-35%
- Helps identify surgical candidates if hepatic mets, and post-surgical recurrence
Rectal Ca

- Liver mets
Ca rectum

- Scans 3/12 apart pre- and post-chemo
- Marked change in liver mets
COLORECTAL CA
Australian PET Data Collection Project (1)

- Recurrent CRC - 2 groups
- **Group A** – 93 pts residual structural lesion ? Recurrence
- PET additional disease sites 48%
- Planned management change 66%
- High impact rating on Mx 65%
- Intent of Mx changed 29% (curative to palliative, palliative to curative)
COLORECTAL CA
Australian PET Data Collection Project (3)

- Group B – 97 patients with pulmonary or hepatic mets – potentially resectable
- PET additional disease sites 44%
- Planned management change 49%
- High impact rating on Mx 42%
- Intent of Mx changed 24% (curative to palliative, palliative to curative)

Scott et al, Abstract ASCO 2007
LUNG CANCER (NSCLC)

- Most common cause of cancer death

- PET 15-20% more accurate in staging cf conventional imaging (detects more LN mets, unsuspected distant mets)

- Additional information in 40% patients, more appropriate Rx selection – 50% reduction in futile surgery
BREAST CANCER

• No role in primary diagnosis or staging axilla

But role in the following:

• Detection of locoregional recurrence (accuracy 87%)
• Detection distant metastases (accuracy 98%)
• Assessment of treatment response (accuracy 88%)
Radiation Dose

- PET scan 7 mSv
- Low dose CT 2-4 mSV (for ACAL)
- Diagnostic CT 14-18 mSV
PET timing

• Post chemo – wait 2 weeks to look for response
• Post DXRT – wait 3/12 else may get false +ve
• Post surgery - wait 3/12
• Post Bx – nil definite time, can increase uptake
PET/CT SUMMARY

- PET/CT provides fusion of metabolic and anatomical data

- Highly valuable in assessment of wide range of malignancies - staging, restaging, treatment response assessment

- Management impact in 40% patients
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Diagnostics GP Conference

CONVENOR
Dr James Cheatham

SPEAKERS
Dr Ross Bradbury – Antibiotic Therapy for GPs: An Update
Dr David McHarg – Overview of PET-CT
Dr Andrew Stuart – MRI Imaging of Conditions that are Medicare Eligible for GP Referral

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