Infection and inflammation

John Buscombe
Infection and inflammation

• The two cannot be separated by bone scanning
• Sensitive but not specific
• Two or three phase bone scan may help
• Infection
  – Spontaneous
  – Malunion of fracture
  – Around prosthetic joints
Imaging infection

• Three phase bone scan
  – Arterial phase, 1 sec frames 30-60 secs
  – Looks at increased blood flow
  – Blood pool phase looks at cap dilatation
  – Images 2-5 mins
  – Static phase looks bone metabolism
  – Sensitive but poor specificity
  – Very good for vertebral OM/discitis
  – May not need first phase
### 3 phase bone scan

<table>
<thead>
<tr>
<th>Disease</th>
<th>Dynamic</th>
<th>Static</th>
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</thead>
<tbody>
<tr>
<td>Osteomyelitis</td>
<td>Pos</td>
<td>Pos</td>
</tr>
<tr>
<td>Cellulitis</td>
<td>Pos</td>
<td>Neg</td>
</tr>
<tr>
<td>Non infected Bone</td>
<td>Neg</td>
<td>Pos</td>
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</tbody>
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False positives in 3 phase bone

- Recent but treated infection
- Fracture
- Non-infected malunion
- Inflammatory arthritis
  - Look for synovial uptake
  - Could be septic arthritis
Need for more specific agents

- Ga-67 may have uptake in fractures, low grade uptake in normal bone and BM
- Labelled WBCs High sensitivity and specificity, not good in vertebral infection
- HIG Ok for arms and legs
- AGAB generally good
- PET non-specific but excellent localisation
- Prosthetic joint may be different
- Charcot’s joints difficult
Ga-67 in bones

- Will be very sensitive
- Problem with imaging as counts can be low in periphery
- Imaging out to 7 days possible
- Some uptake in metabolically active bones
- May be best for vertebral infections
- SPECT possible
Ga-67 in E.coli spinal OM
Prosthetic joints

• Need to exclude infection
• Radiology little help
• CT and MRI affected by metal implant and cement
• Bone scan negative means infection unlikely
• Knee different from hip
• Cemented different from uncemented
infected knee or synovitis
? Infected TKR
infected TKR-SPECT
Ga-67 in infected TKR
Infected knee
Tc-99m HMPAO WBCs
Spinal TB and Pott’s #
Chest Ga-67

- Maybe most commonly used test
- Does not depend on WBC function
- May be best in TB
- However uptake non-specific
- In HIV Bowel uptake very intense-no pathology
- May be looking at more than one pathology
Ga-67 in AIDS
Ga-67 in PCP and KS
Dual Time F-18 FDG Imaging

M. Sathekge Steve Biko Hospital
F-18 FDG PET-CT
F-18 FDG in TB

M. Sathekge Steve Biko Hospital
F-18 FDG lung abscess
Inflammatory bowel disease

- Still probably underused
- Can be used to aid establishing diagnosis
- Esp small bowel Crohn’s
- Mostly used for follow-up
  - ?post op adhesions or reactivated IBD
IBD-agents

• Ga-67
  – Too non specific

• In-111
  – High sensitivity and specificity imaging at 4 & 24 hours, quantifiable

• Tc-99m HMPAO
  – High sensitivity and specificity, imaging 1 & 3 hours, semi quantifiable

• Best of the rest
  – Antibodies not proven maybe Tc-99m Il2
The big battle

- In-111 WBC
- High accuracy
- NO bowel activity
- Years of experience
- Faecal In-111 activity over 48 hours quantifies disease activity

- Tc-99m HMPAO
- High accuracy
- Imaging 1 & 3 hours
- Low dosimetry
- Semiquantification possible
- Years of experience
In-111 WBC in IBD
Small bowel Crohn’s
Tc-99m HMPAO WBC in UC
IBD-special cases

- With Tc-99m HMPAO WBCs
- Later imaging will find Crohn’s abscess
  - Activity in bowel moves, abscess does not image up to 24 hours
- Pelvic disease
  - Do squat/outlet view
- Connecting abscess
  - Focal area of uptake adjacent to bowel that then decreases or disappears
PUO SPECT-CT

• Roach et al 2006 NMC
• Looked at 50 scans including bone and Ga-67 SPECT-CT
• 16% of patients had minor change 11% major change c/w SPECT alone
• Almost all to do with localisation and improved specificity
• Specificity itself improved by 26%
SPECT/CT for suspected bone infection on GS. A 56-y-old woman presented with fever, low back pain, and infected scar 1 mo after spinal surgery and was referred for GS for suspected vertebral osteomyelitis. (A) Planar posterior whole-body GS image (left) shows prominent abnormal uptake in left lower back, corresponding in part to regions of increased irregular uptake seen on planar posterior whole-body $^{99m}$Tc-MDP image (right) along operated vertebrae. (B) Transaxial GS SPECT/CT image (left) localizes abnormal uptake on GS (center) to paravertebral soft-tissue abscess seen on corresponding CT image (right), thus defining soft-tissue infection without osteomyelitis. There was no evidence of vertebral osteomyelitis on follow-up CT 4 wk later.
WBC SPECT-CT showing an infected iliac graft Bar Shalom et al. JNM 2006 48% more accurate than planar WBC imaging
Specific results for infection

- Inquie et al J Comp Assist Tom 2007
- 16 patients (11 In-111 WBC and 6 Ga--67)
- SPECT/CT images yielded "added value" for anatomical localization in 65%, diagnostic confidence in 71%, and altered interpretations in 47% of cases
Ga-67 in infected Tx

Nowosinska CNM in press 2013
Patient with Ga-67 SPECT-CT

Patient with infected renal transplant SPECT-CT confirms uptake in peri-nephric fat
In-111 WBC in iliac A mycotic aneurysm
PET in FUO

- Blockmans et al Clin Infect Dis
- Leuven department
- 58 patients with FUO studies, final diagnosis in 38
- 40% of scans unhelpful in diagnosis
- Results similar to those from Ga-67 in 40 patients studied with both scans only helpful in 42% for each tracer
PET and FUO

- Bleeker-Rovers et al EJNMMI 2004
- Nijmegen group
- 35 patients with FUO imaged
- Diagnosis conformed in 19
- 37% of scans clinically useful
- 65% of the positive scans clinically useful
- PPV 87%, NPV 95%
PET vs In-111 WBC

• Kjaer et al EJNMMI 2004
• Copenhagen group
• 19 patients had In-111 WBC and F-18 FDG
• FDG counted as useful if found infection or malignancy (WBC infection)
Image from Blockmans et al

Showing F-18 FDG uptake in spinal TB
Image from Blockmans et al
Showing F-18 FDG uptake in infective aortitis
Cryptococcus in patient with HD treated with Chemo
Giant cell arteritis
Peritonitis
FDG PET in inflammation

- Increasing use in non infected inflammation
- Quantifying uptake can monitor progress
- Able to look at burden of inflammation
- Some special cases
  - Cardiac sarcoid
  - RA on peripheral joints
Sarcoid

- Disseminated inflammatory disease
- Characterised by granuloma
- Various patterns
  - Salivary/lacrimal glands
  - Lymph nodes
  - CNS
  - Skin
  - Joint
  - Pulmonary- the most dangerous
Imaging in sarcoid

• Normally diagnosis clinical followed by biopsy
• 50% of patients have raised serum ACE
• If lymph nodes involved may see symmetrical enlarged mediastinal/hilar nodes the lambda pattern
• Since 1966 Ga-67 citrate used
  – Not very trendy
  – High radiation dose
Ga-67 in sarcoid

Panda sign, lacrimal and salivary glands
Lamba sign mediastinum and hilar nodes
Diffuse lung uptake
Lymphadonopathy (symmetrical)
Joints
Liver-diffuse
Bitran grading in sarcoid-Ga-67
Use of F-18 FDG

- Lymphocytes very FDG avid
- Much improved resolution
- Lower radiation dose (5mSv vs 18mSv)
- Confirm sites of active disease esp in the abdomen
- Quantify uptake which may be useful in treatment monitoring
FDG vs Ga-67

- Nishiyama et al. JNM 2006
- 18 sarcoid patients imaged with Ga-67 and FDG.
- Pulmonary disease Ga-67 81%, FDG 100% - mean SUVmax 7
- Extra-pulmonary disease Ga 48%, FDG 90% mean SUVmax 5

A = Ga-67
B = F-18 FDG
C = F-18 FDG post therapy
Using FDG to monitor therapy

- Sobic-Saronovic, Clin Nucl Med 2013
- 30 patients imaged before and after steroids for active sarcoid
- Observed reduction in sites and intensity of activity
- Correlated well with clinical symptoms
- SUVmax 8.5 to 4.9 (p<0.05)
- Serum ACE did not predict response
Cardiac sarcoid

• Cardiac sarcoid may occur with other sites or be isolated
• Can result in heart failure and arrhythmias
• Cause of unexpected cardiac death
• Recently a growing role for cardiac F-18 FDG
• Has been proposed both for diagnosis and to monitor any response to therapy
Imaging cardiac sarcoid

• Patient preparation vital
• Patient need 24hrs high fat/low carbohydrate diet
• IHD should be excluded by MIBI/Rb-82
• Images should be gated
• No myocardial uptake or diffuse uptake normal.
• Focal uptake is cardiac sarcoid
Review of FDG in cardiac sarcoid

- Youssef et al JNM 2012
- Systematic review of 7 studies of FDG in cardiac sarcoid
- 164 patients with sarcoid scanned 50% had cardiac involvement
- Sensitivity of FDG 89% (95% CI 76-06%)
- Specificity of FDG 78% (95% CI 68-86%)
Using FDG in RA

• Beckers et al JNM 2004
• 21 patients with active RA
• FDG imaging with views of knees and hands
• FDG positive in 68% joints though 75% of joints swollen and 79% painful
• Good correlation with increased blood flow on Doppler ultrasound
FDG uptake in RA
Beckers et al JNM 2004

Normal

Patient with RA
Monitoring response

- Vijavant et al WJR 2012. 17 newly diagnosed RA and 11 newly diagnosed sero-neg arthropathy
- Good correlation between symptoms and sites of increased uptake of FDG
- Change in SUVmax correlated well with clinical response and change in CRP
FDG before and after Tx
Vijavant et al WJR 2012
RA and PET in 2004-still true 2013

• However, much work remains to be done to gain more detailed information and to clarify the impact of $^{18}$F-FDG PET on diagnosis and therapy of RA, in comparison with state-of-the-art MRI, ultrasound, and three-phase bone scanning. Eventually, we may be able to define indications for $^{18}$F-FDG PET to improve and adjust RA management.

-Wilfred Brenner