(Early) Experiences of SPECT/CT

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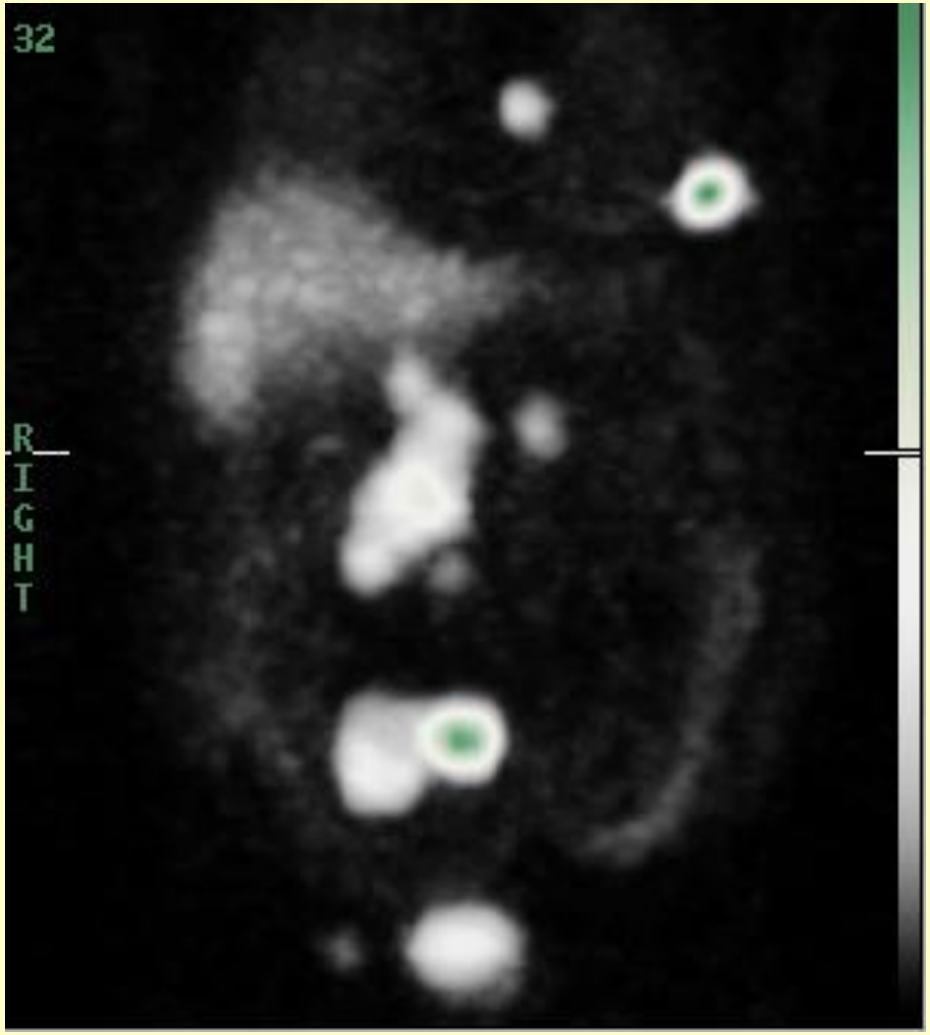
Philips Precedence SPECT/CT

Hard Times
- life without CT

- Need Anatomical context
- Need accurate attenuation correction
  - For quantification
  - Tumour dosimetry
- I-131 MIBG Therapy for:
  - Pheochromocytomas
  - Neuroendocrine tumours
  - Neuroblastomas…
- I-131 SPECT not previously done



Transmission Line Scanning

- Simultaneous acquisition using sealed source
  - 9GBq Gd-153 rods
  - T½=242days
- Only get attenuation correction information (not for quantification)
- Sources need replacing every 18 months

A Tale of Two CT'ies

GE Infinia

- Attenuation Correction
- Axial SPECT/CT localisation
- 2.5mA, 15s rotation time, 10mm thick slices

Philips Precedence

- Fully diagnostic 16 slice Brilliance CT
- 400+mAs, 0.42 rotation time, 0.75mm thin slices

GE Infinia

- This simple Infinia incarnation is only a small step up from a SPECT camera with transmission rods.
- CT like images are possible but at low res.
  - OK for axial localisation but not diagnostic in themselves
- Very little choice in acquisition parameters
- The inflexibility of the acq. software makes CT style testing tricky
  - don't always get HU with ROI measurements!

Bleak House

The Old CurioCT Shop

Spiral CT – It's All-of-a Twist!


PHILIPS

All finished - now we have Great ExSPECTations

Proposed and Possible Uses of SPECT-CT system

a. Double Headed Gamma Camera
b. Full Diagnostic CT Scans
   - no gantry tilt, contrast injector to be delivered
c. Localisation SPECT-CT
d. Attenuation Correction CT
   - NM isotope energies closer to CT energies than PET isotopes
   - Only for Tc-99m (calibration of relationship of HU to atten. Coeff.)

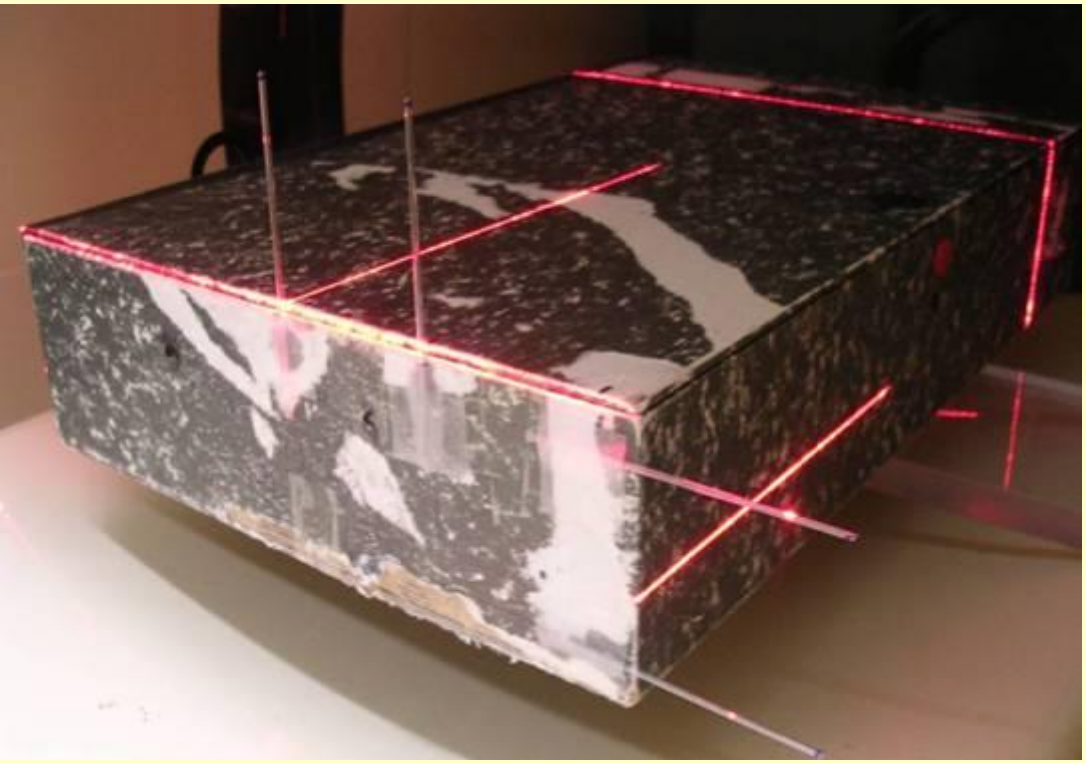
- Extra CT scanner?
  - Political minefield, depends on divisional relationship between NM and Radiology
- Oncology planning?
  - No flat bed yet
- Quantitation, Radionuclide Therapy Dosimetry
  - MIBG, Thyroid

Co-Registration

Philips SPECT/CT Alignment Tool

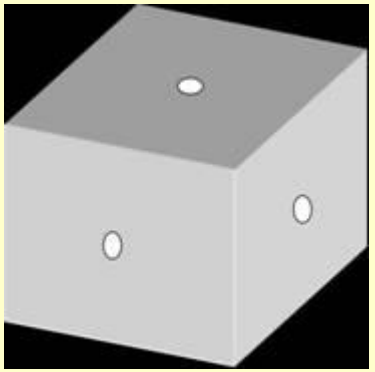
- A simple test using radioactive (^{153}Gd) discs mounted on a special holder
- Syntegra Fusion software used to overlay the coloured SPECT images on the B/W CT
- Test ought to be repeated regularly
  - until confident of stability

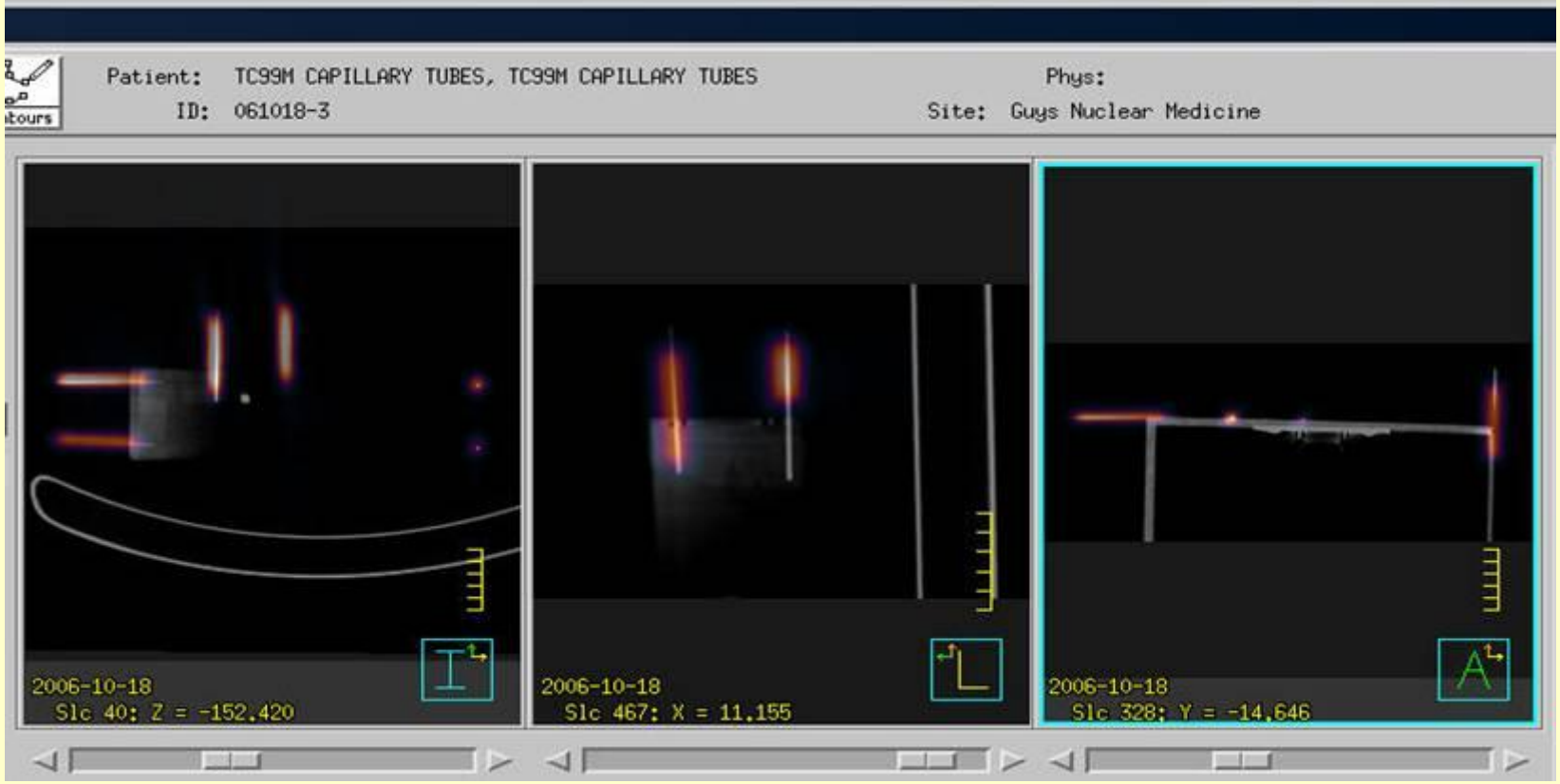
Custom Made Co-Registration Phantoms



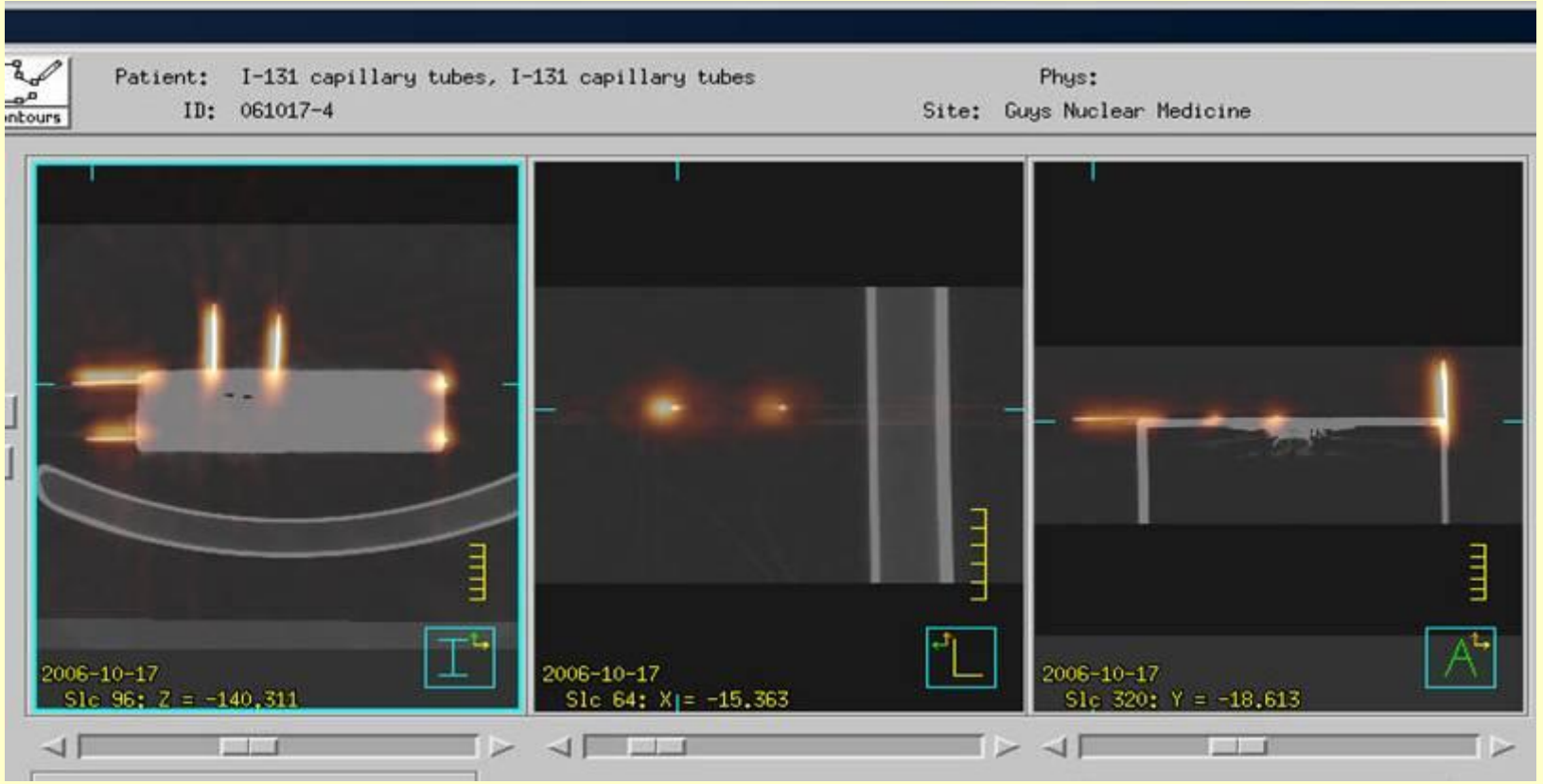
Boxfile phantom – patent pending!

- "Orthogonally" aligned capillary tubes
- Excellent CT contrast to air
- Will use a perspex block with drilled holes for future tests





- Tc-99m (140KeV) filled tubes (<50MBq)
- MPR reconstruction to view fused images
- Good co-registration between SPECT and CT in all three planes
  - The capillary tube's CT image is within the blurred extent of the tube's SPECT image



- I-131 (356KeV) filled tubes (<50MBq)
- Higher energy isotopes have poorer SPECT resolution
- Slight vertical mis-alignment shown in transverse and sagital planes
  - Bed movement with full patient weight loading?
  - Sagging from heavy collimators not corrected by the COR (which determines the SPECT isocentre)

Issues

- Although neither CT or NM SPECT imaging is new, each is new to the other
  - Many similarities to the introduction of CT to PET imaging
- NM often employ Technologists rather than Radiographers
  - Techs have no prior CT experience
  - CT Radiographers not used to unsealed source work
- NM physicists may not be in a position to be the medical physics expert
  - Collaboration with diagnostic radiology physics
- NM clinicians will all have general radiology training but how recent is it?
  - Will they know their limits?

Training Issues

- Unfamiliarity with technology
  - **Factory defaults NOT necessarily reliable for localisation use**
  - Creating protocols requires expertise
  - "Just press the button" or "think on your feet"
- Dose differences
  - NM doses are determined by injected activity; this is usually the ARSAC certificate limit for that exam
  - CT dose is extremely variable and depends both on the scan protocol and on the length of scan
  - CT Operators have a much greater role in determining the dose the patient receives. Are the NM operators ready?
- Radiation Protection Differences
  - Need to get used to shutting doors, be aware of warning lights
  - Visiting CT staff need to get used to unsealed sources (no more coffee and biscuits in the control room!)

Some Solutions

- Extra training provided for Technologists
- Initially only allowing trained radiographers to "press the button"
- Cross-fertilisation !
  - Use the expertise of our CT radiographers to train up the technologists and supervise the initial scans
- Combined reporting sessions with NM clinician and CT Radiologist
  - This follows an initial SPECT only report by the NM clinician
  - Learn the lessons from PET/CT, implement double blind reporting
- Physicists, Technicians and Radiologists will need to be trained in both NM and CT

Some IRMER Questions

- Should there be restrictions placed on the CT requests being appended to the referrals? **Yes**
  - There is a great temptation to CT just because you can not because you need to
- Do you need 2 types of Practitioner doing the justification & authorisation **Maybe**
  - 1 for SPECT and 1 for CT
- Do we need to separately identify CT operators from NM operators in our IRMER list? **Maybe**
- Optimising for Localisation SPECT/CT **?**
  - How do we know what we want ?

Optimise for Localisation

Diagnostic CT is a mature imaging modality, even the relatively new MSCT is achieving accepted standards of image quality

- We can readily import "Diagnostic" protocols from other scanners (all Philips at Guy's & St. Thomas') or use the Precedence defaults (with some caution)
- We can turn the wick down to a minimum for Attenuation Correction only scans
- What level of image quality is "right" for Localisation?

Study Optimisation Process

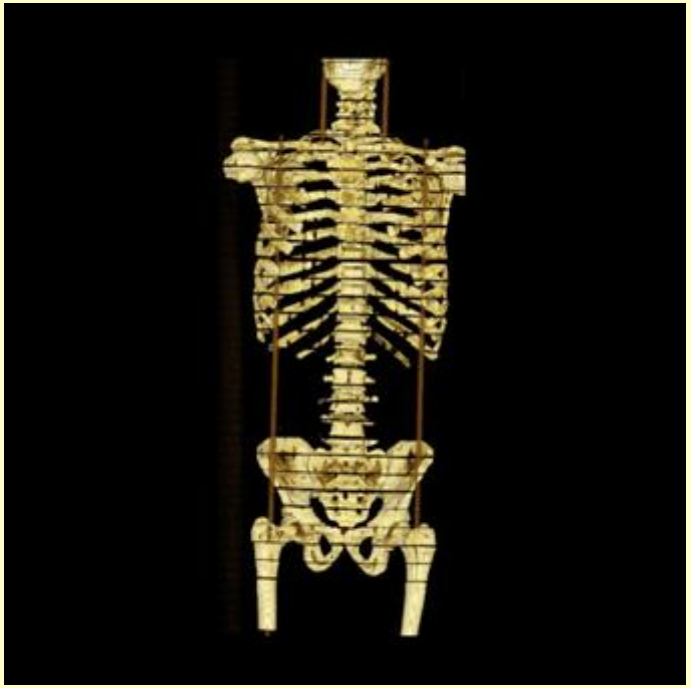
- Established 4 focus groups
  - Clinical and Protocols
  - IT Network & (SPECT) Processing
  - Training
  - Research & Dev

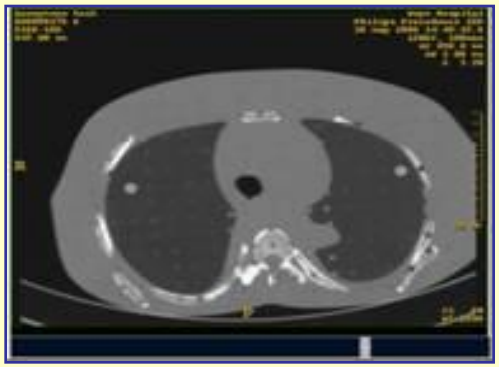
- Clinical and Protocols Focus Group
  - Multi Disciplinary Protocol group established to oversee process of optimisation:
  - Create, use, clinical audit, accept or modify and repeat

- Defined a protocol naming convention to allow the operator to easily distinguish the protocols
  - Diagnostic CT : "D-CT SPECT Neck" etc.
  - Localisation CT : "L-CT SPECT Foot" etc.
  - Attenuation Correction : "AC-CT SPECT Abdo" etc.

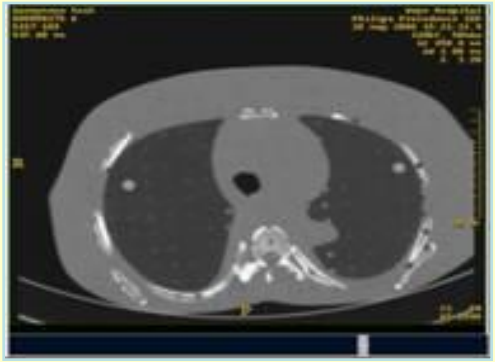
Initial Protocol Creation and Evaluation

- Used Rando phantom to generate clinical style images for evaluation
- Start with "Diagnostic Level" and turn down the mAs & kV
- 2 basic protocols created:
  - Medium slices (3mm) for axial reporting
  - Thin slices (1.5mm) for MPR reporting

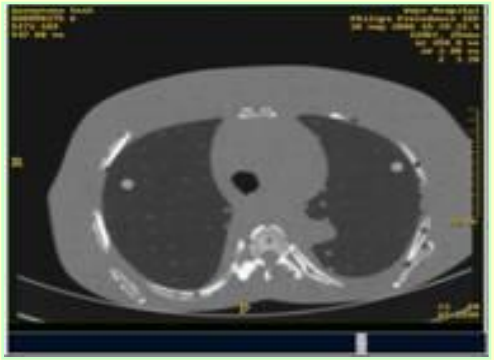




Scan 1: 100mAs



Scan 2: 50mAs



Scan 3: 25mAs

Custom Made Anthropomorphic Phantom

- Vary acquisition and reconstruction parameters
  - mAs, recon slice width & filter
- Aim is to reduce the dose down from "Diagnostic Levels"
- Need to determine the "reportability" of the resulting images
- Clinical audit by CT Radiologist to score the impact of lowering dose and reducing image quality

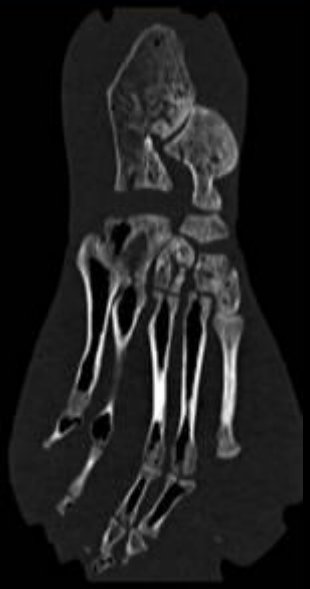
Series 526

Series 528

Series 530

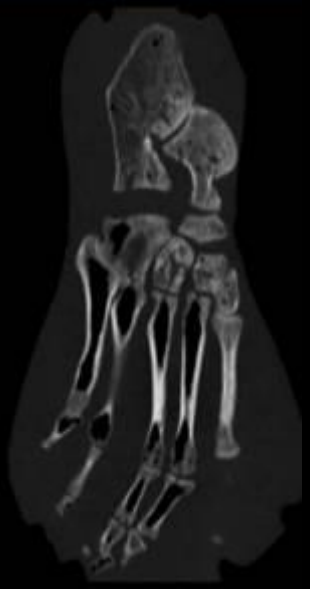
Series 532

Series 534



Series 536

Series 538



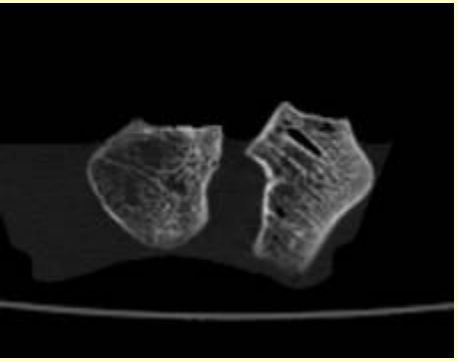
Series 539

Coronal as seen on acquisition slab viewer

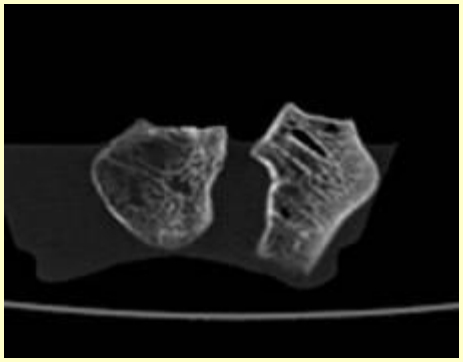
Slice thickness 0.49mm

Slice 362

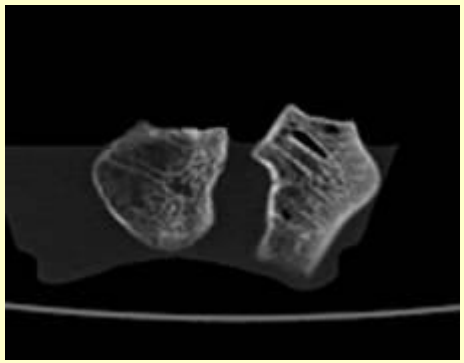
Bone windows 800/2000



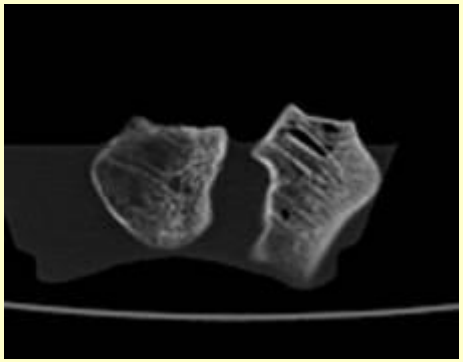
Series 526
Slice 163,
thickness 0.8mm



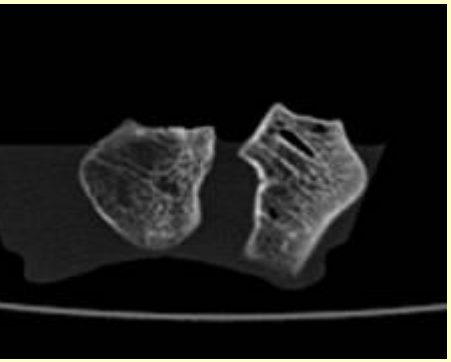
Series 528
Slice 130,
thickness 1mm



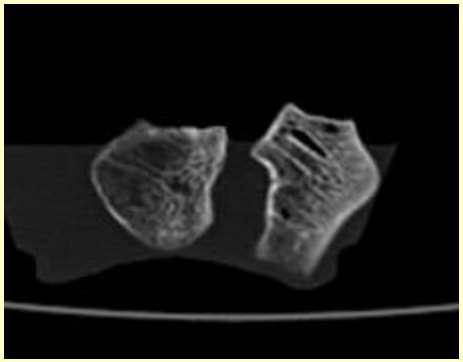
Series 530
Slice 93,
thickness 1.5mm



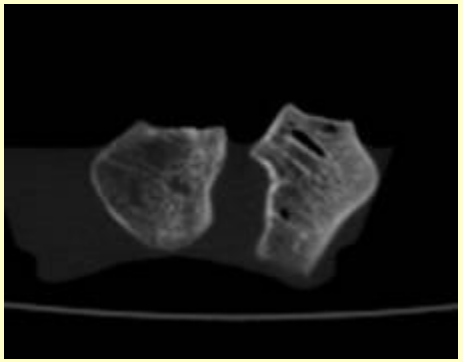
Series 532
Slice 65,
thickness 2mm



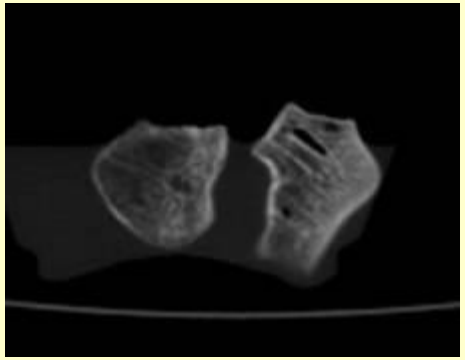
Series 534
Slice 130,
thickness 1mm



Series 536
Slice 193,
thickness 1.5mm



Series 538
Slice 130,
thickness 1mm



Series 539
Slice 93,
thickness 1.5mm

1 Axial slice as seen on acquisition slab viewer

Bone windows 800/2000

Precedence Foot L-CT Image Quality Audit

Scan Details

Scan date	
Patient Name	

Image Quality Criteria

Scorers initials	
Workstation scan scored	Philips Brilliance in Precedence Room

No.	Criterion	Score
1	Visually sharp reproduction of the cortical bone	
2	Visually sharp reproduction of the trabecular bone	
3	Visually sharp reproduction of the visualised joint space	
4	Noise assessment in the image (quantum mottle)	
5	Image meets Referral requirements	
6	Image free from Artefacts such as streaking or step artefacts)	
7		
8		

Scoring criterion

Definition of terms

Visualisation – an anatomical feature is detectable but details are not fully reproduced
Reproduction – the details of anatomical features are visible but not necessarily clearly defined
Visually sharp reproduction – the anatomical details are clearly defined

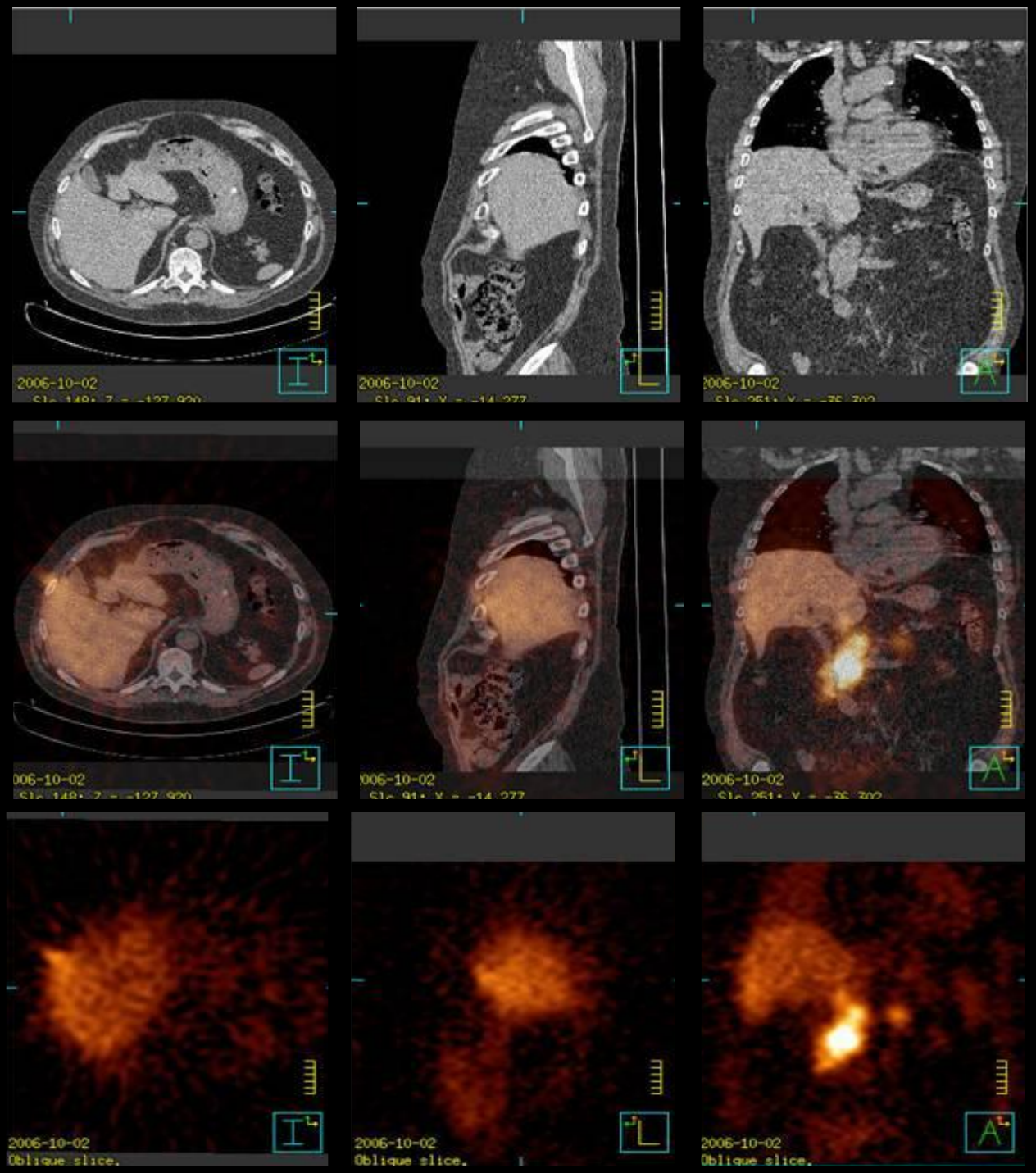
Scoring scheme: 1 to 5 score on each criterion

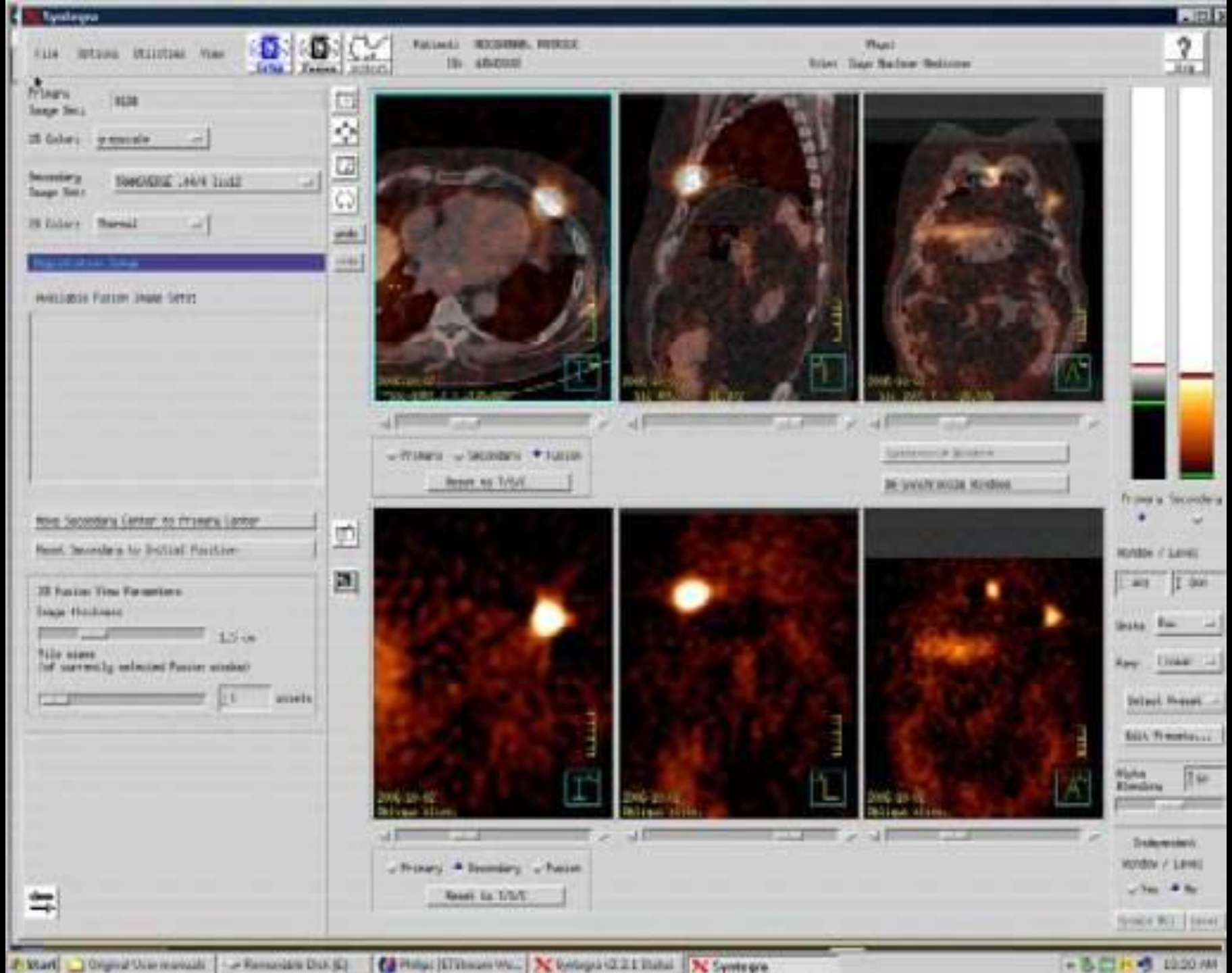
1 = fails to meet required standard
2 = relatively poor
3 = meets the basic requirement
4 = exceeds the basic requirement
5 = far exceeds basic requirement

Guy's and St Thomas' NHS
NHS Foundation Trust

Clinical Audit to Evaluate Image Quality

- Most SPECT/CT patients to date have been for localisation
- Almost all done with the thin slice MPR protocol

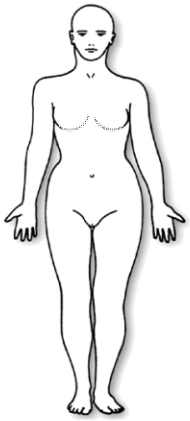




Precedence L-CT Requirement Questionnaire

Please complete this form for each L-CT.

Scan date	
Patient Name	
Scan details	



Please mark the scanned area on the diagram.

Please circle the most appropriate answer

1) Which of the following views were required for reporting?
   a) Axial slices (thick slabs, interleaving not required)
   b) Multi-planar reconstruction (MPR) (slice width axial resolution)

2) What detail size did you really need to see?
   a) <1mm b) 1-2mm c) 2-5mm d) 5-10mm e) >10mm

3) What noise level did you need?
   a) Smooth background showing low contrast objects
   b) Medium level tolerated
   c) Only need to see high contrast objects

4) Was the CT of adequate image quality?
   a) Yes b) no
   If no, please give more details.
   Neck:

   Lung/Chest:

   Liver:

   Abdomen:

   Feet:

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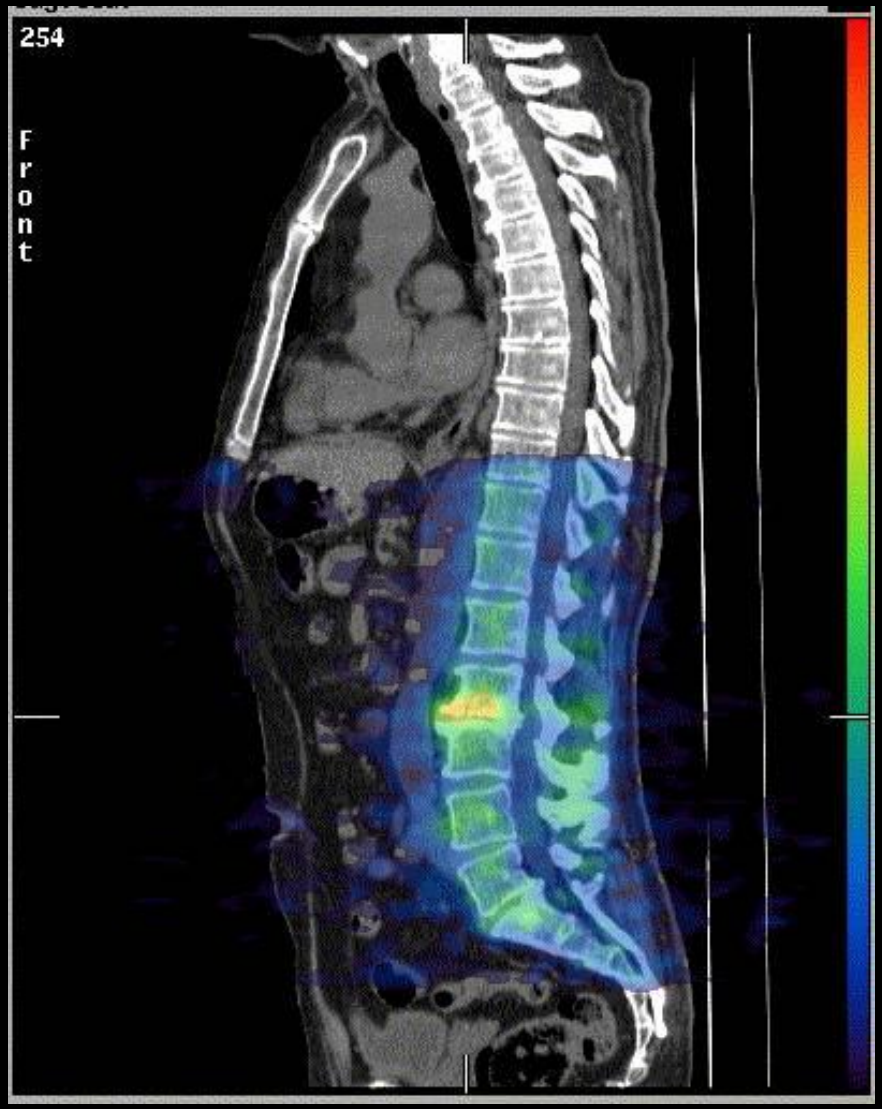
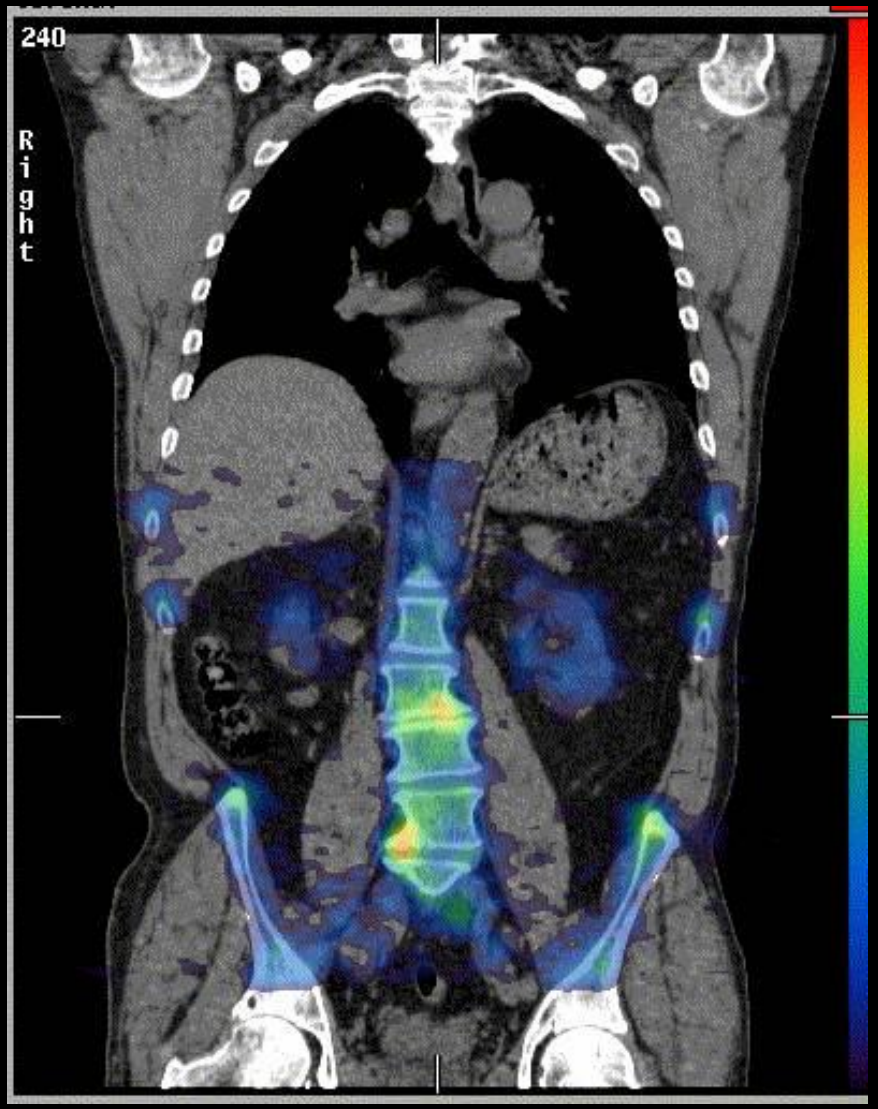
Clinical Audit to Determine Image Quality Requirements

Retrospective questionnaire to determine what was actually needed to answer the clinical referral

? Bone Mets -

why CT the whole body and only SPECT the abdomen?





Conclusion

- SPECT/CT may seem like an expensive luxury but it will inevitably find it's uses
- Has a potential for enhancing NM reporting
- Can streamline patient throughput in the hospital and improve patient management
  - Can save on 2 separate trips to NM and CT
- Yet another drive for more radiation dose to the population
- Will only work well with good interdepartmental co-operation at all levels