CT dose reduction strategies

What do we have in our toolbox?

Technology – hardware and software

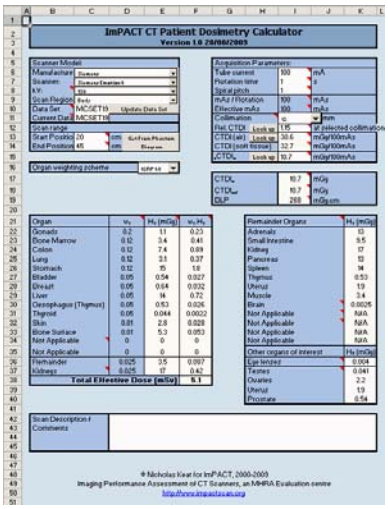
People - IR(ME)R duty holders

- **Referrer** – responsible for providing sufficient clinical information to practitioner to make justification. Clinical question is vital starting point for dose/image quality balance
- **Practitioner** - responsible for justification of medical exposure – net benefit to patient
  - ? Same as ARSAC certificate holder. Advantages and disadvantages
- **Operator** – those carrying our practical aspects in accordance with employer's procedures
  - Technologists, clinical scientists, reporters
- Operator and practitioner - comply with procedures and ensure doses are kept ALARP consistent with intended purpose (AC, localisation,'diagnostic')
- Operator will pay special attention to equipment QA, assessment of patient dose, adherence to DRLS

More people…

- Medical Physics Experts MPEs - Involved as appropriate for consultation on optimisation, including patient dosimetry and quality assurance
  - NM physicists and DR physicists
- All these people need to work together closely to optimise dose
- People need to be supported by protocols and training, particularly for new techniques

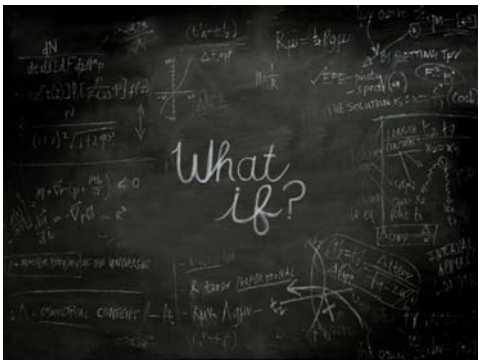
Dose estimation aids



http://www.impactscan.org

Tools exist to made dose predictions based on different exposure parameters

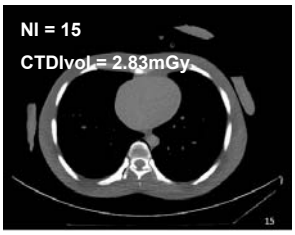
kV, mAs, slice thickness, pitch

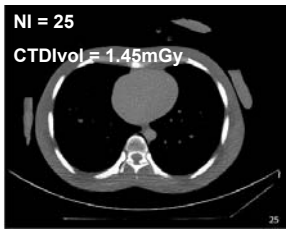


Technology - hardware

- Anthropomorphic phantoms exist to test the image quality at different exposure parameters and different reconstructions
- Ours is called Terry the torso

Terry the Torso





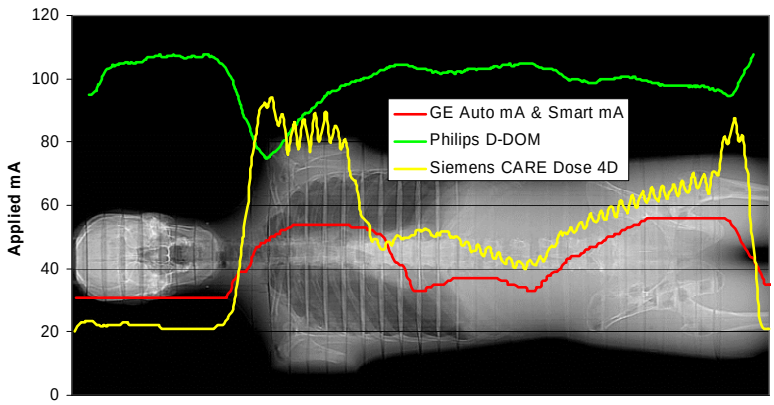
The trouble with Terry:

- He's very skinny and armless
- This gives unrealistically low doses
- He's not very life-like

Technology – Automatic Exposure Control

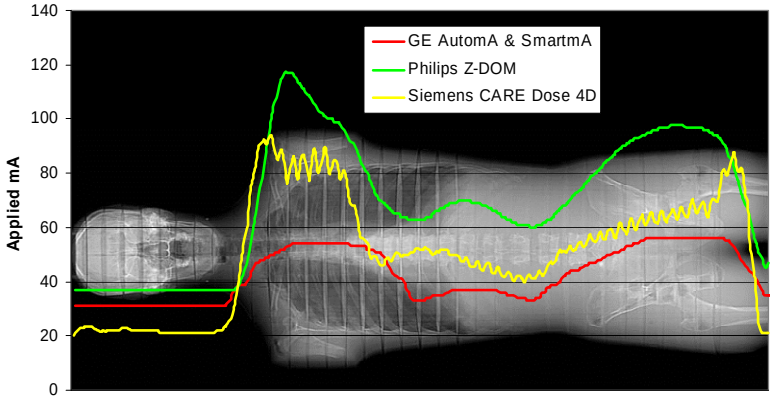
- Bodies come in all shapes and sizes
- Attenuation varies around the patient (x and y directions, AP/lateral) and down the patient (z direction)
- AEC should be able to correct for all this
- Very clever and potentially very powerful in standardising image quality
  - Often requires topogram/scout/surview
  - Need to understand limitations in different circumstances
  - Each manufacturer implements in different ways, with different results

Current clinical protocols



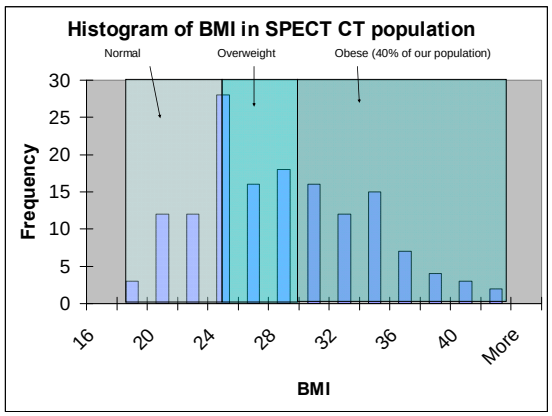
Data courtesy of Gareth Iball and Deborah Tout

“Best” modulation techniques?



Data courtesy of Gareth Iball and Deborah Tout

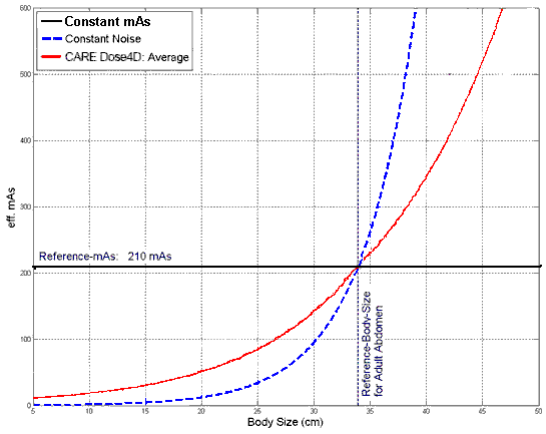
Inter patient variability



Audit of RFH SPECT CT patients in 2011

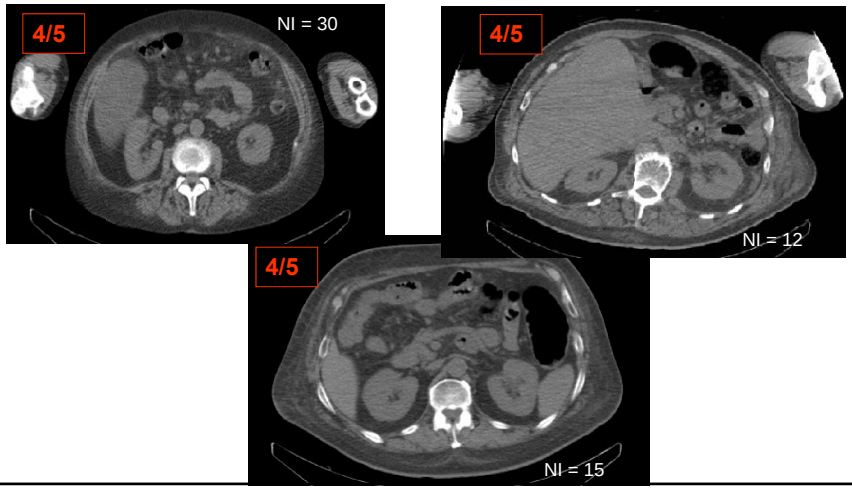
Dose modulation with patient size

- Current needs some modulation to accommodate different sizes, but to what degree should dose be increased/decreased?
- Is the noise of the image a good measure of image quality?



Abdominal protocol

Assessment of image quality as fitness for purpose – answering clinical question, seeing what you need to see – 1-5



Inherent contrast

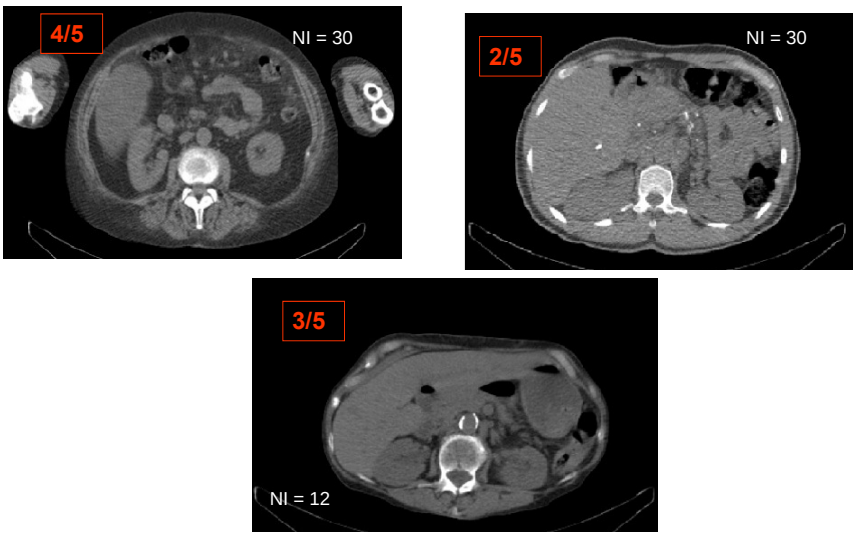


Image quality and patient size

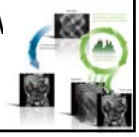
- Image noise is not the only determinant of image quality
- If image noise is kept constant, large patients will receive very large doses which are not always necessary to maintain quality
- If audit demonstrates this, weight based protocols could be adopted, or a cap placed on modulation

Technology – reconstruction algorithms and post reconstruction filtering

- The final presentation of the image is highly dependent on reconstruction and filtering
- In order to enhance conspicuity of lesions, adaptive filters may be used to smooth out high frequency noise, enabling visualisation of low contrast lesions or enhance high frequencies for fine detail
- Test these and use with care

Iterative reconstruction

- All manufacturers use slightly different IR techniques;
- IR techniques can be performed on:
  - image data;
  - raw data;
  - a combination of the two;
- The aim of all is to reduce radiation dose with the same image quality or at improved image quality
- Even with powerful computers this is still slo performed on raw data



Model Based Iterative Reconstruction

- Most advanced form of IR;
- Attempts to model the entire X-ray system from X-ray production to detection;
- Very time consuming, full reconstruction takes up to 2 hours;
- Dose reduction of 60-70% compared to FBP have been quoted;
- Some centres quote patient doses equivalent to plain -ray using this technique;

Advantages and Disadvantages

Advantages

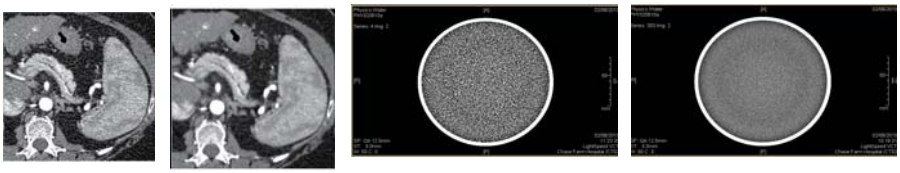
•Reduction in patient dose;

•Improvement in low contrast resolution due to reduction in noise;

Disadvantages

•Reconstructions can be time consuming;

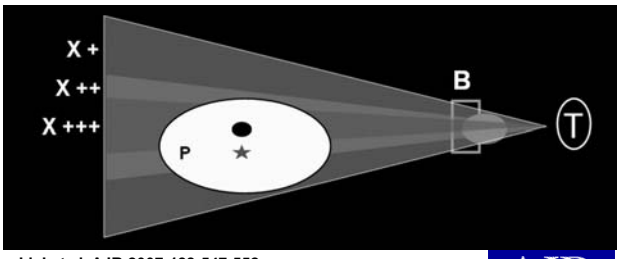
•Can alter the appearance on the final image;



Dose reduction in practice

- Most manufacturers quote up to 40% dose reduction;
- Some centres are reportedly seeing no change in doses, some are even seeing increases with iterative reconstruction. RFH experience is average 9% reduction
- Sometimes difficult to get clear advice about baseline for quoted dose reduction

Importance of patient centring



Li J et al. AJR 2007;188:547-552

Bow tie filter – designed to reduce surface dose

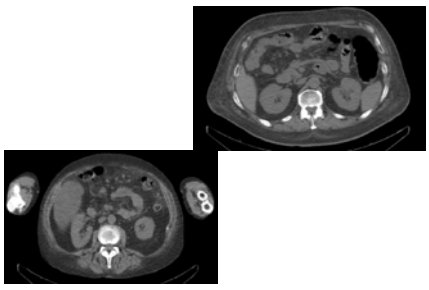
If patient mis-centred, surface dose will be increased again

Noise will be increased in lower part of patient, reduced in upper part

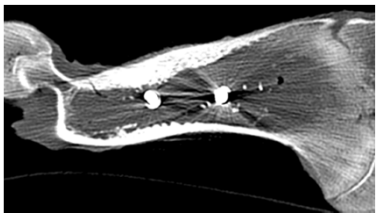
Errors in centring also affect size of patient on topogram which may have dose implications

Other factors to consider

- **Arm position**
  - Arms down will give rise to significant dose increases (20-30%)
  - ? unavoidable with long SPECTS and elderly/immobile patients

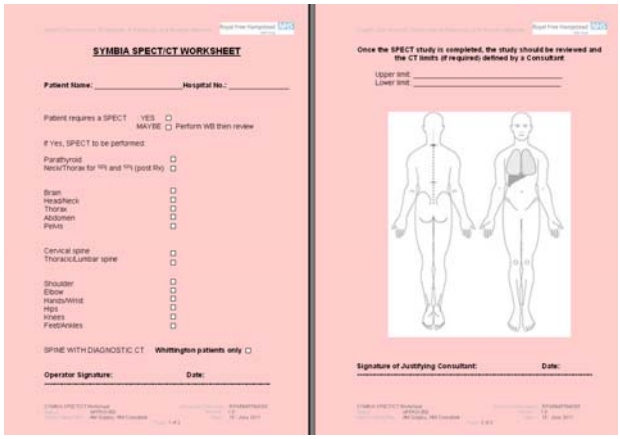


Metalwork →artefacts



- Effects minimised via exposure parameters and reconstruction techniques
- Ask applications specialist
- Beware of induced artefacts

Bringing it all together -RFH “Pink form”


SYMBIA SPECT/CT WORKSHEET

Patient Name: _____ Hospital No.: _____

Patient requires a SPECT : YES ☐
MAYBE ☐ Perform WB then review

If Yes, SPECT to be performed:

Parathyroid ☐
Neck/Thorax for ^{123}I and ^{131}I (post Rx) ☐

Brain ☐
Head/Neck ☐
Thorax ☐
Abdomen ☐
Pelvis ☐

Cervical spine ☐
Thoracic/Lumbar spine ☐

Shoulder ☐
Elbow ☐
Hands/Wrist ☐
Hips ☐
Knees ☐
Feet/Ankles ☐

SPINE WITH DIAGNOSTIC CT Whittington patients only ☐

Operator Signature: _____ Date: _____

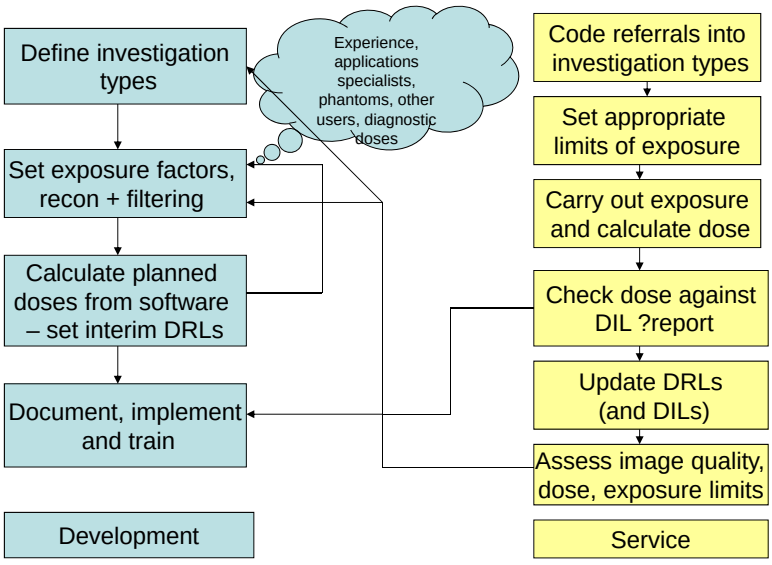
Once the SPECT study is completed, the study should be reviewed and the CT limits (if required) defined by a Consultant

Upper limit: _____
Lower limit: _____

Signature of Justifying Consultant: _____ Date: _____

- •Ensures all exposures are justified
- •Ensures limits of exposure are minimised – this can have a very significant dose implication
- • Provides IRMER audit trail

Audit as dose reduction tool



The road to optimisation

• Hitting the sweet spot on the quality/dose trade off is difficult

• Have to accept some aspects are more art than science but…

• We need to have some evidence of optimisation for IRMER

Road A – Start with very low dose images and gradually increase
Risk of images being inadequate for clinical question

Road B – Start with images higher dose - gradually reduce until images more difficult to interpret

Temptation to settle for higher quality images than clinical question requires

Isn't all this like a lot of hard work?

- At present this is all uncharted territory
  - Freedoms with challenges
- Very few protocols ready to apply 'out of the box'
- Not generally developed for British/European market
- No national DRLs as yet, but plans to set up a working party
  - Make sure that you are ready to have your say!

- My thanks to the multi-disciplinary team at RFH, particularly Jane Edwards and to Gareth Iball, Leeds Teaching Hospitals Trust and Deborah Tout, Manchester Royal Infirmary