The effect of topogram orientation on dose and image quality

Avril Weir
Pre-registration Medical Physicist
NHS Lothian
Avril.Weir@nhslothian.scot.nhs.uk

Introduction

- 3 Scan Projection Radiograph tube orientations investigated
  - Top (AP), bottom (PA), PA+Lateral
- Phantom and patient studies conducted
  - Dose and image quality assessed
- Focused on Chest -Abdomen-Pelvis (CAP) CT examinations
- Siemens Somatom Definition AS CT Scanner used

http://www.healthcare.siemens.com

Routine CAP examination 2014

- Patient is positioned on the couch and centred in the bore by the radiographer
- Acquire SPR of patient with tube at bottom of gantry
  - Siemens terminology: topogram
- Scan lengths defined using topogram
  - Chest phase
  - Abdo-Pelvis phase
- Scanners select the exposure parameters for each phase based on patient attenuation profile
- Spiral scan acquisition initiated

Siemens Exposure Control

- CAREkV: tube potential selected prior to spiral CT scan based on patient size, system limits and clinical indication
  - Reference value set for a 75kg standard patient
  - Based on required Contrast to Noise Ratio
  - 80,100,120,140 kV
- CAREDose4D: real time tube current modulation to take into account variation in patient size/attenuation
  - Angular modulation (x- and y- direction)
  - Modulation along z-axis

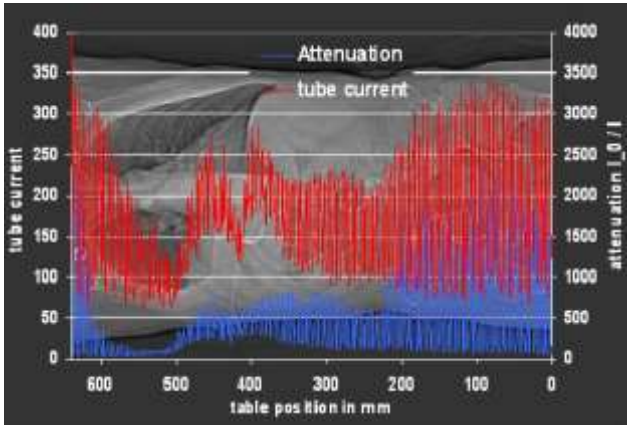


Image taken from CAREDose4D e-learning

mA Modulation Curves

- CAREDose4D uses mA modulation curves
- Relies on quality reference mAs
  - The effective mAs used in a certain body region for a “reference patient” defined as a “typical adult,” weighing 70 kg to 80 kg
- Adapts current based on ratio of body size to reference size
- Body size determined:
  - From topogram (z-axis)
    - Measured x-ray attenuation
    - Estimated using algorithms
  - During each tube rotation
    - Angular attenuation profile

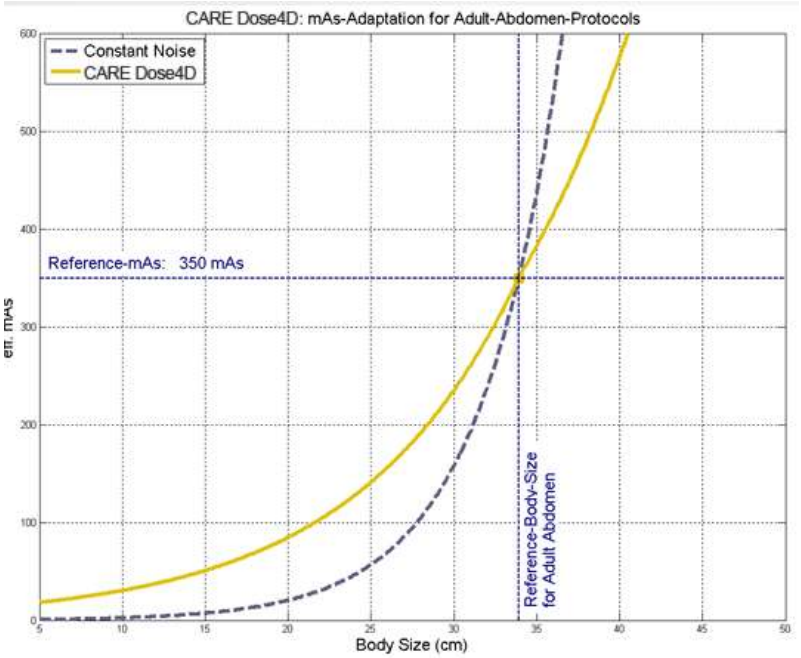
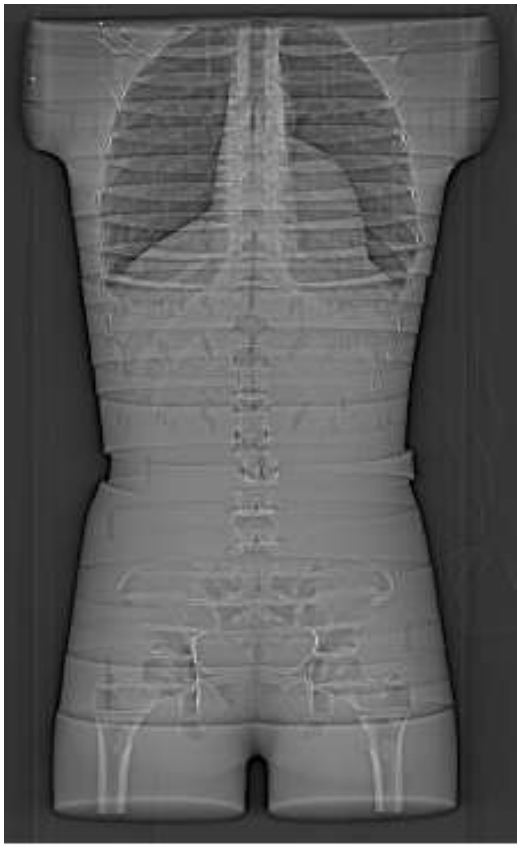


Image taken from CAREDose4D e-learning

Initial Assessment: Anthropomorphic Phantom

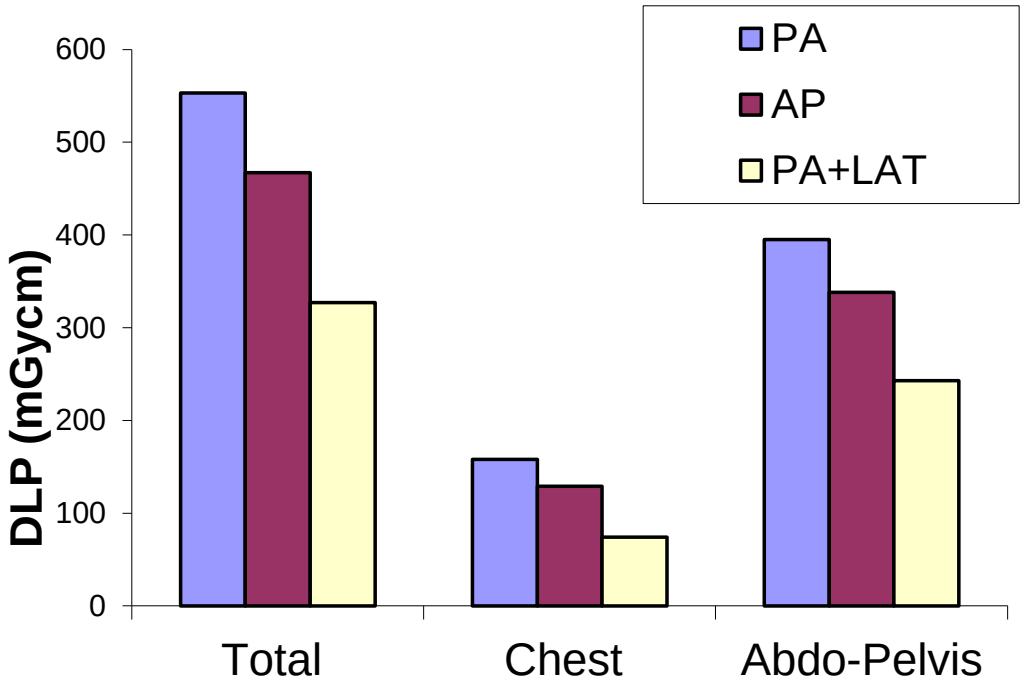
- Rando phantom used
  - The Phantom Laboratory, NY
- Topogram orientations investigated were AP, PA and PA + Lat
  - PA topogram was used clinically
- Phantom centred by a radiographer
- Topogram acquired and spiral scan initiated as per CAP clinical protocol
- Dose Length Product (DLP) was recorded



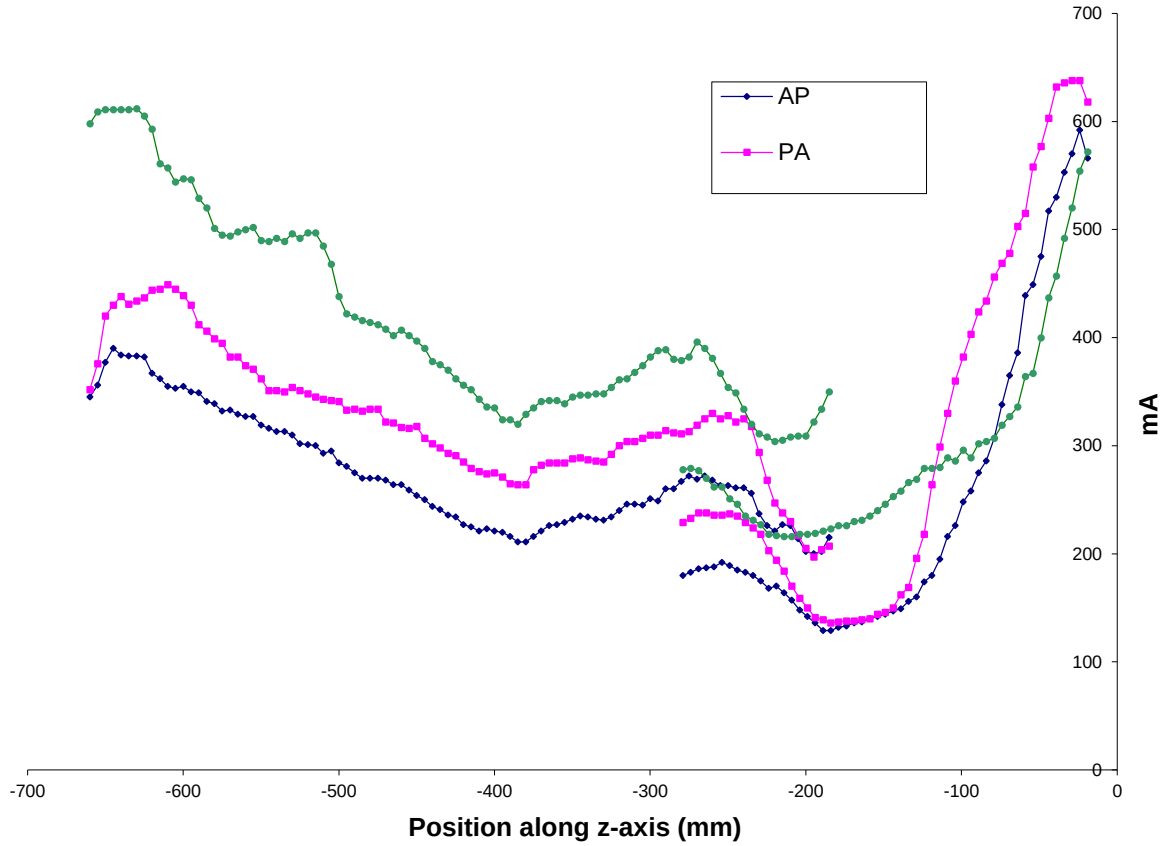
Phantom Results

Tube Orientation	kV Chest	kV Abdo-Pelvis	Avg mAs Chest	Avg mAs Abdo-Pelvis	DLP Chest (mGycm)	DLP Abdo-Pelvis (mGycm)	Total DLP (mGycm)	%diff cf PA
PA	100	100	127	180	158	395	553	-
AP	100	100	103	153	129	338	467	-16
PA+LAT	80	80	127	234	74	243	327	-41

- Using PA+lat topogram decreased DLP by 41%
- Using AP topogram decreased DLP by 16%



Tube Current Modulation



- Tube current consistently lower when AP topogram was instead of PA topogram
- Lower kV selected when PA+Lat topogram used

Patient Dose Audit

- A patient dose audit was then carried out
  - Following national protocol
  - Full data set and restricted data set (adults 50-90 kg) was evaluated
- Restricted data set included 76 patients
  - 24 had PA topogram
  - 25 had AP topogram
  - 27 had PA and Lateral topogram
- Exposure parameters used based on topogram

http://www.healthcare.siemens.com

Patient Dose Audit Results

Tube Orientation	kV Chest	kV Abdo-Pelvis	Avg mAs Chest	Avg mAs Abdo-Pelvis	DLP Chest (mGycm)	DLP Abdo-Pelvis (mGycm)	Total DLP (mGycm)	%diff cf PA
PA	102	104	118	241	199	562	761	-
AP	98	98	114	209	143	390	546	-28±21%
PA+LAT	92	96	105	195	121	341	481	-39 ± 21%

- Using PA+lat topogram decreased DLP by 39%
  - (p=0.000)
- Using AP topogram decreased DLP by 28%
  - (p=0.004)
- No significant difference in the DLP when using AP or PA+Lat topograms
  - (p=0.549).

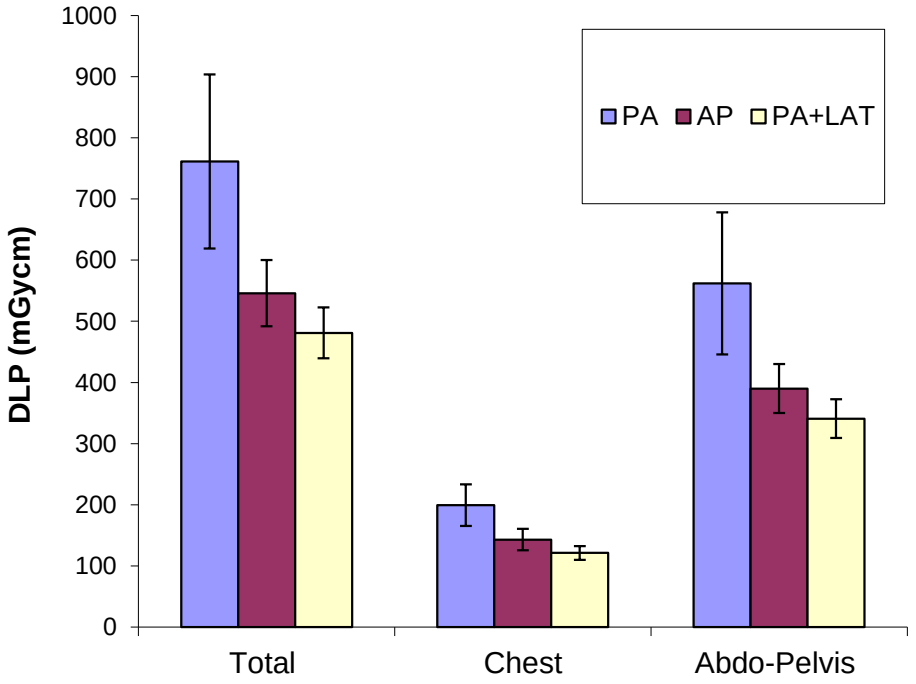


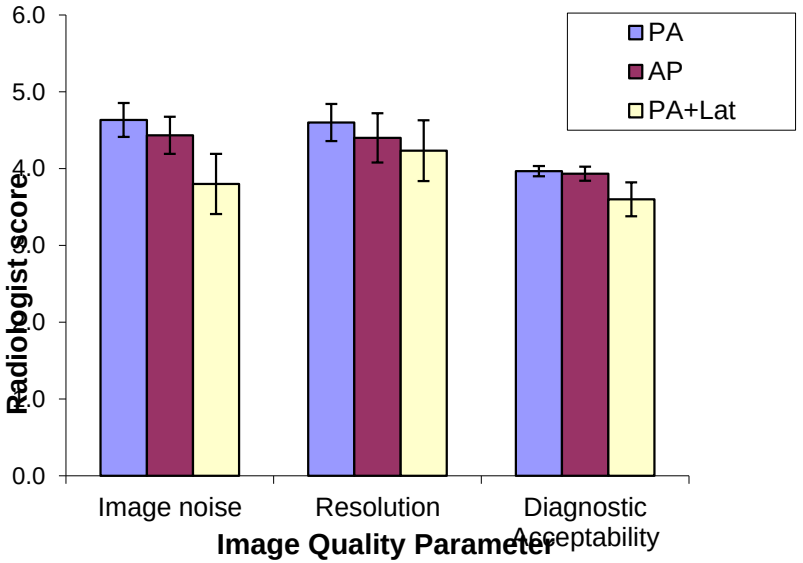
Image Quality Analysis

- Images of a subset of these patients were used in the clinical image quality analysis.
  - Ten sets of three patients matched for weight and height.
  - Anonymised image sets were presented to three consultant radiologists in a random order
- General questions on resolution, noise and general diagnostic acceptability were answered for each patient
  - Questionnaire
  - Additional comments made when appropriate.
  - Scored based on numeric scale
    - Noise and resolution on 1-5 scale, diagnostic acceptability on 1-4 scale.

Patient	Acceptable Image Noise				Acceptable Spatial Resolution				Diagnostic Acceptability			
	Too much	Too Little	Optimum	Overall	Too Much	Too Little	Optimum	Overall	Fully Acceptable	Probably Acceptable	Only acceptable under certain conditions	Unacceptable
1			✓	1 2 3 4 (5)			✓	1 2 3 4 (5)	✓			

Image Quality Results

- PA+L had poorer image noise than both AP and PA topograms
  - Both p=0.000
- PA+L had poorer overall diagnostic acceptability than when using either the AP or PA topogram
  - p=0.007, p=0.003
- No significant difference in the perceived image noise, resolution or diagnostic acceptability when using AP or PA topograms
  - p=0.27, 0.233, 0.94.
- Increased noise may result in subtle liver lesions being missed.



Reasons for change in DLP/IQ

- Differences in magnification of both the patient and couch arising from inaccuracies in patient centring
- If the patient is closer to the x-ray tube then they appear larger in the topogram image
  - Increases the mA/kV
  - Higher dose
- CAREDose4D optimised for using one topogram only

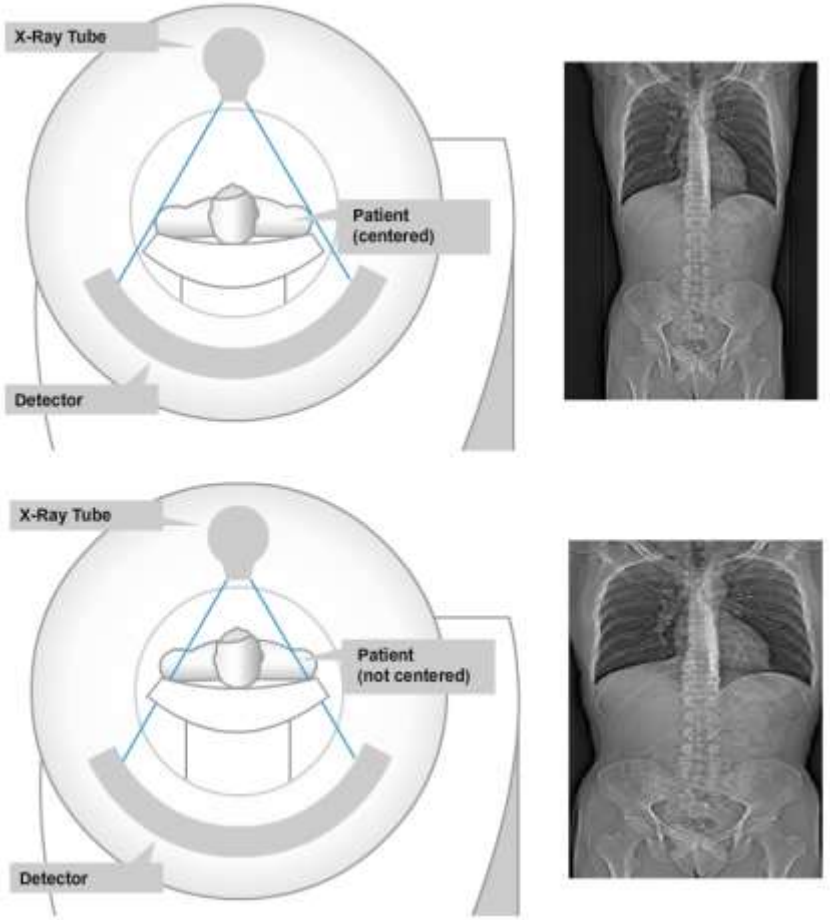
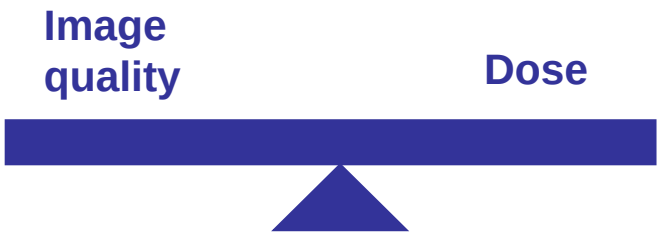


Image taken from CAREDose4D e-learning

Conclusion from Study

- DLP can be reduced by using either an AP or PA+L topogram instead of a PA topogram
- The image quality of the CT image sets acquired using exposure parameters based on the PA+L topogram was poorer than when using either an AP or PA topogram.
- Using an AP topogram optimises the radiation dose and image quality of the CAP CT examination.



Outcome and Future Work

- AP topograms are now used for all trunk area examinations on Siemens Somatom Definition AS CT scanners in NHS Lothian and NHS Fife.
  - Similar decrease in DLP was found for each of these scanners
- Future work includes:
  - Investigating optimal SPR orientation for other body regions and manufacturers
  - Determining how to optimally centre a patient
  - Training of the importance of patient centring

NHS Lothian

NHS Lothian Healthcare Science

Thank you for listening