



**IPEM** Institute of Physics and  
Engineering in Medicine

# The first UK survey of doses from radiotherapy imaging for adult patients

Tim Wood, Anne Davis, James Earley, Sue Edyvean,  
Una Findlay, Rebecca Lindsay, Rosy Plaistow, Andrew  
Nisbet, Antony Palmer, Matt Williams

Working party of Radiotherapy & Diagnostic  
Radiology Special Interest Groups



# Background

- The first phase of the UK audit of imaging dose in RT has been completed (CT planning scans) and results have been published in PMB (<http://iopscience.iop.org/article/10.1088/1361-6560/aacc87/meta>)
- Individual feedback to participating centres has been distributed to those who contributed
  - Thanks to all those who took part!

# CT Planning scans – Reference Values

(3<sup>rd</sup> quartile)

Examination	Phantom diameter (cm)	CTDI <sub>vol</sub> (mGy)	DLP (mGy.cm)	Scan length (mm)
Breast	32	10	390	360
Gynaecological	32	16	610	400
Lung 3D	32	14	550	390
Lung 4D	32	63	1750	340
Prostate	32	16	570	340
Brain	16	50	1500	290
Head and neck	16	49	2150	420

# CT Planning scans – Achievable values

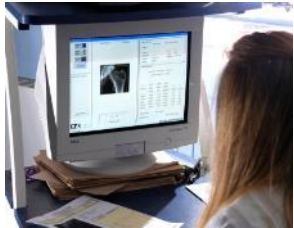
(Median)

Examination	Phantom diameter (cm)	CTDI <sub>vol</sub> (mGy)	DLP (mGy.cm)	Scan length (mm)
Breast	32	8	280	330
Gynaecological	32	12	510	390
Lung 3D	32	10	410	370
Lung 4D	32	36	1170	330
Prostate	32	13	420	310
Brain	16	42	1110	250
Head and neck	16	26	1080	400



**IPEM** Institute of Physics and  
Engineering in Medicine

# The next phase: Treatment verification scans



# On-treatment volumetric scans

- Need to consider use of manufacturer defaults/size-specific protocols, lack of 'dose display' on some systems, differences between Varian and Elekta, Tomotherapy, etc.?
- Currently testing data collection and analysis spreadsheet for CBCT
  - Aim to launch in autumn/winter 2017/18
  
- A quick outline of data collection spreadsheet...
  - For Varian systems

# Protocol data



## Radiotherapy CBCT dose survey - Protocol data

### Instructions & Guidance:

- Data is being collected for 7 different clinical treatment sites: Head and Neck, Brain, Lung3D, Lung4D, Prostate, Pelvis and Breast.
- For each, please provide details of the standard protocol settings used for imaging each clinical site by completing a column in the table below.
- Where more than one imaging preset is available for a given clinical site, please provide details of each by inserting additional data columns as required. In these cases, please describe the selection criteria used to determine which preset is used.
- In some situations, these standard presets may be adapted for specific patients. If this practice is ever carried out, please provide further details.
- If more than one system model and/or software version is in use and these have different presets, please complete separate sheets for each. Otherwise one set of data can be submitted, but all models/software versions should be listed.

### CBCT System Information

Hospital Name*:	
Local system ID*:	
System manufacturer*:	Varian
System model*:	
Software version*:	
Number of equivalent systems at centre:	

### Standard Protocol Settings

Protocol (Clinical site):			
Local protocol name:			
kVp*:			
Bow-tie filter*:			
Titanium filter*:			
FOV*:			
Scan range/length (cm)*:			
mA/frame*:			
ms/frame*:			
Number of projections*:			
Total mAs*:			
Displayed Varian CTDI (cGy):			
Trajectory*:			
Fixed start and stop angles?			
If fixed, start angle:			
If fixed, stop angle:			
Scan direction:			
Pre-scan dark field acquired?:			
Reconstruction filter:			
Matrix size (pixels):			
Image slice thickness (mm)*:			
Ring suppression:			

### Protocol Adaption/Selection

Are there selection criteria for use of this protocol, i.e. patient size*?			
If so, please give details:			
Is this protocol ever adapted for specific patients*?			
If so, please give details:			

\* Denotes a mandatory field

\* This field can be typed in directly, or will be calculated from mA/ms for each projection and the total number of projections

- For each of the standard clinical indication, what protocol is used?
  - e.g. Prostate may use generic 'Pelvis' mode
- What are the settings for that mode?
  - e.g. kVp, mAs, filters, reconstruction parameters, etc.
- Do you adapt for individual patients/patient size? If so, how?



# Patient data (but only if appropriate)



Radiotherapy CBCT dose survey - Patient data

**Instructions & Guidance:**

- The completion of this datasheet is only mandatory where different protocols are available for clinical sites (e.g. using sized based protocols, or protocols adapted for patient size, etc).
- If the same fixed protocol is used on all patients for a clinical site, this information is not mandatory.
- Please create a separate copy of this worksheet for each clinical protocol being audited.

**CBCT System Information**

Hospital name*:	
Local system ID*:	
System manufacturer*:	Varian
System model*:	
Software version*:	
Number of equivalent systems at centre:	

Protocol (clinical site)\*:

**Audit data**

Patient Number	Age at treatment (yrs)	Weight (kg)	Pt size at isocentre (AP cm)	Pt size at isocentre (LAT cm)	PTV length (cm)	Local protocol used*	Scan range/length (cm)*	Number of scheduled CBCT scans	kVp (if different from protocol)	Total mAs (if different from protocol)	Comments
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											

Please complete for as many patients as possible  
\* Denotes a mandatory field

- If any protocol adaptation is done for patients (e.g. size protocols, individual adaption, scan length adjustment, etc), give a sample of patient data
  - Size, protocol used, scan length, etc

- **If same protocol is used on every patient this will not be required**





# 'Dose index'

- Highly desirable, but not mandatory for taking part in audit
  - Want as many participants as possible
- The **provisional** plan is to give typical doses as **standard**  $CTDI_w$  values (i.e. not wide beam dosimetry)
  - **Rationale;**
    - Gives an indication of how the dose is distributed in a phantom
    - Wide beam dosimetry more 'correct', but also time consuming and prone to errors depending on measurement technique
    - **Easy** to measure with readily available equipment
    - Easy to compare metric – highlight differences in practice e.g. protocol A may be about double the dose of protocol B, size specific protocol C gives average dose that is lower than manufacturer defaults, etc
  - **Limitations;**
    - Values will not be directly applicable to estimating absolute values of patient dose
- Full instructions given in spreadsheet

# 'Dose index' measurement



## Radiotherapy CBCT dose survey - Dosimetry data

### Guidelines:

The completion of this spreadsheet is non-mandatory. Where more than one system of a given type is in clinical use, if possible, please provide data for each, by copying this spreadsheet as necessary. Data that has previously been acquired during commissioning can be submitted, but please ensure that this has followed the exact measurement protocol and equipment as specified below. Measure at least one head and body and/or different kV energy modes.

### Equipment:

- **Essential**
  - 16 cm head & 32 cm body CTDI phantom.
  - 100 mm pencil ionisation chamber.
- **Optional**
  - Laptop/PC.
  - Micro-pore (or equivalent).

### Instructions:

- Measure dose indices for the kVp/filter combinations used in current clinical protocols.
- Ensure blade positions are set to maximum for all measurements.
- Doses will be normalised to the mAs values, so it should not be necessary to measure dose indices for each protocol that uses a given kVp and filter combination.
- Use the head CTDI phantom for kVp/filter combinations used to image heads, and the body CTDI phantom for kVp/filter combinations used to image the body.
- If kVp values other than those available in manufacturer default protocols are used on your imaging systems, please adapt the table appropriately via copy & paste.
- Place the appropriate CTDI phantom on the couch top and position at the isocentre with the room lasers. The peripheral positions should be on the lasers at the top (12 o'clock), bottom (6 o'clock), left (9 o'clock) and right (3 o'clock). Take necessary precautions to prevent the phantom from rolling off the couch (e.g. micro-pore tape over the top to hold in place).
- Place the 100 mm pencil chamber in the centre of the phantom and measure the accumulated dose for a single exposure and record in the table below. Beware of using 'automatic' trigger modes on dosimeters as these can 're-trigger' during exposure.
- Place the chamber in each of the peripheral positions in turn and measure the dose; ensure that the number of frames delivered is recorded.
- Enter the CBCT system information and type of couch used below.

### CBCT System Information

Hospital Name*:	
Local system ID*:	
System manufacturer*:	Varian
System model*:	
Software version*:	
Couch Type:	

\* Denotes a mandatory field

### CBCT Dose Measurements in Head & Body Phantom

Phantom	Filter*	Ti filter*?	FOV	Scan range/length (cm):	kV†	No. of projections	mA	ms	Total mAs††	Start angle (degrees)	Stop angle (degrees)	Dose (mGy)	Position					Central dose index /mAs (mGy/mAs)	Weighted dose index /mAs (mGy/mAs)
													Centre	Top	Right	Bottom	Left		
Head																			
Head																			
Body																			
Body																			
Body																			

\* Denotes a mandatory field

† This field can be typed in directly, or will be calculated from mA/ms for each projection and the total number of projections

- Will use protocol settings to convert measurements to a typical 'dose index' for each protocol
- For those that don't provide dose data, may use 'average' system data (for each model)



# Summary

- The first phase of the IPEM 'Dose to patients from X-ray imaging in Radiotherapy' Working Party has been completed!
  - Proposed CT planning reference and achievable levels have been published in PMB
  - PHE working party considering the results for ratification as national reference values
- We are aiming to launch (the delayed) **CBCT audit in autumn/winter 2017/18**
  - Data collection spreadsheet undergoing final testing
- **We would greatly appreciate everyone taking the time to contribute to this work**
  - Again, we will aim to provide individual feedback to centres who take part

# The paper...

<http://iopscience.iop.org/article/10.1088/1361-6560/aacc87/meta>

Physics in Medicine & Biology

---

PAPER

IPEM topical report: the first UK survey of dose indices from radiotherapy treatment planning computed tomography scans for adult patients

Tim J Wood<sup>1,2,3</sup>, Anne T Davis<sup>1,4,5</sup>, James Earley<sup>1,6</sup>, Sue Edyvean<sup>7</sup>, Una Findlay<sup>8</sup>, Rebecca Lindsay<sup>1,9</sup>, Andrew Nisbet<sup>1,5,6</sup>, Antony L Palmer<sup>1,4,5</sup>, Rosaleen Plaistow<sup>1,10</sup> and Matthew Williams<sup>1,11</sup>

Published 10 September 2018 • © 2018 Institute of Physics and Engineering in Medicine

[Physics in Medicine & Biology, Volume 63, Number 18](#)

PMB (so free to all IPEM members)





**IPeM** Institute of Physics and  
Engineering in Medicine

[IPeMRTimaging@gmail.com](mailto:IPeMRTimaging@gmail.com)

[tim.wood@hey.nhs.uk](mailto:tim.wood@hey.nhs.uk)

