Wide beam CT dosimetry

Elly Castellano
Outline

• revision: CT dose indices
• wide-beam CT: the end of the road for CTDI?
• the IEC rescue plan for CTDI_{100}
• the american way
  – AAPM report 111
• better estimates of patient dose
  – AAPM report 204
• effective dose calculations
  – options for wide beam CT
Revision: CT dose indices
Multiple Scan Average Dose

- axial scanning
  - beam rotation + translation
- beam width $T = \text{increment}$
  - $NT$ for MSCT
- MSAD = average dose in centre of irradiated volume
  - tends towards equilibrium value $\text{MSAD}_\infty$

Shope et al 1981
CT Dose Index

- MSAD can be measured instead on one axial scan
- CTDI = CT dose index

\[
CTDI = \frac{1}{T} \int_{-\infty}^{\infty} D(z) \, dz
\]

or \( NT \) for MSCT

- CTDI = MSAD for equivalent scan range

Shope et al 1981

Linköping PhD dosimetry course: April 2014
CTDI in practice

- measured parallel to axis of scanner using pencil ionisation chamber
  - 100 mm integration length
    - CTDI$_{100}$
  - free-in-air, or in dose phantoms
  - in terms of air kerma
CTDI in practice

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CTDI\textsubscript{100} in dose phantoms

- Cylindrical PMMA phantoms with holes for pencil chamber
  - 32 cm body phantom
  - 16 cm head phantom
  - 14 cm depth

- CTDI\textsubscript{100} measured at centre and 1 cm below surface
CTDI$_{100}$ in dose phantoms

- cylindrical PMMA phantoms with holes for pencil chamber
  - 32 cm body phantom
  - 16 cm head phantom
  - 14 cm depth
- CTDI$_{100}$ measured at centre and 1 cm below surface
CT dose descriptors

• based on CTDI$_{100}$
• combined with actual scan parameters to indicate dose to patient
• CTDI$_w$ – weighted value of central & peripheral values in PMMA phantom

\[
CTDI_w = \frac{1}{3} CTDI_{100,c} + \frac{2}{3} CTDI_{100,p}
\]

– linear increase in dose along radius assumed
CT dose descriptors

- $CTDI_{vol}$ – takes account of helical pitch or axial scan increment

$$CTDI_{vol} = \frac{CTDI_w}{p}$$

- DLP – takes into account scan range

$$DLP = CTDI_{vol} \cdot R$$

- $CTDI_{vol}$ and DLP displayed on scanner console
Limitations of CTDI$_{100}$

- underestimates MSAD
  - for scan ranges > 100 mm
    - typical scan range 300 – 700 mm
- overestimates MSAD
  - for scan ranges < 100 mm
- defined for axial scanning only
  - overestimates MSAD for stationary scans
  - extension to helical scanning “presumptuous”
Limitations of CT dose descriptors

- $\text{CTDI}_w$ defined empirically
- $\text{CTDI}_\text{vol}$ inaccurate under AEC
  - DLP good indicator of integral dose
  - Dixon and Boone 2013
- they are not patient dose
  - phantoms not representative of human body
  - 100 mm unrepresentative of clinical scan ranges
Wide beam CT: the end of the road for CTDI?
Wide-beam CT

• **MSCT**
  – 40 mm (Siemens)
  – 80 mm (Philips, GE)
  – 160 mm (Toshiba)

• **CBCT**
  – interventional units
  – linac on-board imaging
  – NM localisation imaging
D(z) and increasing beam width

- free-in-air

Mori et al 2005
D(z) and increasing beam width

- centre of 900 mm long body phantom

Mori et al 2005
D(z) and increasing beam width

- periphery of 900 mm long body phantom

Mori et al 2005
D(z) and increasing beam width

- free-in-air
  - dose profile widens with collimation
  - heel effect becomes evident

- in phantom
  - dose profile widens with collimation
  - $D(0)$ increases with collimation
    - tends to equilibrium value
  - analogous to train of contiguous narrow beam profiles
CTDI$_{100}$ and increasing beam width

- free-in-air
  - well-defined <100 mm
  - definition breaks down for NT $\geq$ 100 mm
CTDI\textsubscript{100} and increasing beam width

• in long phantom
  – stable ≤ 40 mm
  – decreases for 40-80 mm
  – definition breaks down for ≥ 80 mm
• diverging primary beam wider than 100 mm

\[
\text{CTDI\textsubscript{100} efficiency} = \frac{\text{CTDI}_{100}}{\text{CTDI}_{\infty}}
\]

Boone 2007
The IEC rescue plan for $\text{CTDI}_{100}$
IEC 60601-2-44 Edition 3

\[
CTDI_{100} = \frac{1}{\min\{N \times T, 100mm\}} \int_{-50mm}^{+50mm} D(z) \, dz
\]

- two definitions of CTDI_{100}:
  - choice of denominator
    - NT for \( NT < 100 \) mm
    - 100 mm for \( NT > 100 \) mm
IEC 60601-2-44 Edition 3

- for beams < 100 mm
  - no change
- for beams > 100mm
  - measure average dose over 100 mm
  - ≈ CTDI$_{300}$ for 160 mm beam (Geleijns et al 2009)
  - but different CTDI efficiency
IEC 60601-2-44 Edition 3
Amendment 1

• for $NT \leq 40$ mm

\[ CTDI_{100,N \times T} = \frac{1}{N \times T} \int_{-50\text{mm}}^{+50\text{mm}} D(z) dz \]

• for $NT > 40$ mm

\[ CTDI_{100,N \times T} = \frac{1}{(N \times T)_{\text{ref}}} \times \left( \int_{-50\text{mm}}^{+50\text{mm}} D_{\text{ref}}(z) dz \right) \times \left( \frac{CTDI_{\text{free-in-air},N \times T}}{CTDI_{\text{free-in-air,ref}}} \right) \]

• $NT_{\text{ref}} \approx 20$ mm

• integration length for $CTDI_{\text{free-in-air}}$ – max\{$NT+40$ mm, 100 mm\}

Linköping PhD dosimetry course: April 2014
IEC 60601-2-44 Edition 3 Amendment 1

- no change for beams ≤ 40 mm
- for beams > 40mm same CTDI efficiency

Linköping PhD dosimetry course: April 2014
Why so much effort to hang on to CTDI$_{100}$?

• test equipment available
  – 100 mm pencil chambers
  – 140 mm head and body phantoms
• practicalities
  – transporting ≥ 300 mm PMMA phantoms
• no consensus on new phantom length
## IEC 60601-2-44 Edition 3 Amendment 1: in practice

<table>
<thead>
<tr>
<th>Modality</th>
<th>Availability of $N_{T_{\text{ref}}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSCT</td>
<td>Range of collimations available in axial mode</td>
</tr>
<tr>
<td>CBCT - DR</td>
<td>Collimation set manually</td>
</tr>
<tr>
<td>CBCT - RT</td>
<td>Varian – user choice&lt;br&gt;Elekta – 20 mm collimator</td>
</tr>
<tr>
<td>CBCT - NM</td>
<td>Narrow collimation available in service mode</td>
</tr>
</tbody>
</table>
IEC 60601-2-44 Edition 3 Amendment 1: in practice

- $\text{CTDI}_{\text{free-in-air}}$
  - CT chamber centred well beyond table
    - to reduce scatter
  - use 100 mm table feed to step chamber through beam

160 mm beam
IAEA HHR #5

Linköping PhD dosimetry course: April 2014
The american way: AAPM report 111
Rationale for report 111

- CTDI has been outgrown
  - defined for axial scanning only
  - helical and CBCT geometries now ubiquitous
- $\text{CTDI}_{100}$ breaks down for wide beams
Rationale for report 111

• new CT metrics for
  – acceptance testing and QC
  – axial, helical and stationary scanning
  – all beam widths and scan lengths
  – uniform phantoms of sufficient length

• new CT dose descriptors
  – for patient dose estimates
Glossary

- $f(z)$ single-scan dose profile
- $nT$ nominal beam width
- $a$ collimation width
  - FW @ half $f(0)$
- $b$ table increment per rotation
  - $b = v \tau$ helically
- $L$ scan range along $z$-axis
  - $L = Nb$ axially
  - $L = v t$ helically

AAPM report 111

Dose Profile Free-in-Air
GE LS=16, Body Filter, Small Focal Spot
$nT = 4 \times 2.5 \text{ mm} = 10 \text{ mm}$

$a = 11.4 \text{ mm}$
$nT = 10 \text{ mm}$
Cumulative dose in phantoms for scans with table translation
Cumulative dose

• cumulative dose profile $D_L(z)$
  – smoothed for general applicability

Shope et al 1981

AAPM report 111
Cumulative dose: axial scanning

\[ D_L(z) = \frac{1}{b} f(z) \otimes \Pi(z/L) = \frac{1}{b} \int_{-L/2}^{L/2} f(z - z') \, dz' \]

- oscillatory with period \( b \)
- smoothed by averaging over \( z \pm b/2 \) at each value of \( z \)
  - convolution with rectangular function \( \Pi(z/L) \)
Cumulative dose: helical scanning

• no smoothing required along central axis
  – non-oscillatory function for right cylindrical phantoms

• smoothed by angular averaging over $2\pi$ at each value of $z$
  – equivalent to smoothing along $z$ axis
Cumulative dose: helical scanning
Cumulative dose at the scan midpoint

• general expression:

\[ D_L(z) = \frac{1}{b} \int_{-L/2}^{L/2} f(z - z') \, dz' \]

• at scan midpoint:

\[ D_L(z = 0) = \frac{1}{b} \int_{-L/2}^{L/2} f(z') \, dz' \]

• at midpoint for \( L = \infty \)

\[ D_{eq} = \frac{1}{b} \int_{-\infty}^{\infty} f(z') \, dz' \]
CT metric # 1: equilibrium dose

• $D_{eq}$
• equilibrium reached at $L_{eq}$
  – ~ 400 mm for this example
  – measurements practical
• $D_{eq} \propto \alpha / \beta$
• dose distribution broadens for $L > L_{eq}$
  – no scatter reaches $z=0$
CT metric # 2: equilibrium dose-pitch product

\[ \hat{D}_{eq} \equiv p \cdot D_{eq}(a, p) \propto \frac{a}{nT} \]

where \( p = \text{pitch} = \frac{b}{nT} \)

- independent of \( p, b \)
  - can be measured at any convenient \( p \)
- equal to CTDI\(_\infty\)
CT metric # 3: equilibrium dose constant

- independent of $a, b$
- equilibrium dose when increment = beam width
- complete specification of the midpoint dose
  - $D_{eq}$ and $\hat{D}_{eq}$ can be calculated for any other beam widths
  - note $nT/a$ is 1/geometric efficiency (tabulated)
Cumulative dose in phantoms for stationary scans
Cumulative dose

- for $N$ rotations:
  \[ D_N(z) = Nf(z) \]

- at scan midpoint:
  \[ D_N(0) = Nf(0) \]

- analogous measurement to $D_L(0)$
  - unlikely to reach $D_{eq}$
    - beam widths too narrow
Dose free-in-air
Dose free-in-air

• expressed in terms of equilibrium dose-pitch product:

\[ \hat{D}_{eq,\text{air}} = \frac{1}{nT} \int_{-\infty}^{\infty} f_{\text{air}}(z') \, dz' \approx \frac{a}{nT} f_{\text{air}}(z = 0) \]

• \( f_{\text{air}}(z) \) dose profile free-in-air for single axial rotation

• equal to CTDI_\infty
CT dose descriptors
Integral dose

- total energy absorbed in phantom

\[
E_{\text{tot}} = N \rho \int_{-\infty}^{\infty} \int_{0}^{R} f(r, z) 2\pi r dr dz
\]

where

- \( f(r, z) \) axial dose profile at radius \( r \) from central axis
- \( R \) phantom radius
- \( \rho \) phantom density
Planar average equilibrium dose

- denoted by $D_{eq}$

- related to $E_{tot}$ by

$$E_{tot} = \rho \pi R^2 L \left\{ \frac{1}{\pi R^2} \int_{0}^{R} D_{eq}(r) 2\pi r dr \right\} = \rho \pi R^2 L \overline{D}_{eq}$$

- valid for any scanning length $L$
Comments on CT dose descriptors

• $E_{tot}$ is not the energy deposited in the scanned volume

• $\bar{D}_{eq}$ is not the average dose over the scanned volume
AAPM report 111 in practice
Test equipment

- phantoms
  - uniform
  - sufficiently long > 450 mm
  - shape, size and composition not yet specified

30 cm water phantom, 50 cm long
32 cm PMMA phantom, 45 cm long
Test equipment

• detectors
  – thimble chamber
    • 20-35 mm active length
    • volume > 0.6 cm$^3$
  – other point dosimeters
    • TLDs
    • solid state detector

RadCal 0.6 cm$^3$ chamber
Measurement technique with translation

• chamber in midpoint along chosen axis
  – centre, 1 cm below surface typical

• select reference scan protocol
  – kVp, mAs, focus
  – beam-shaping filter
  – beam width

  – table increment / pitch
    • < ½ chamber length
      – average out oscillations
Measurement technique with translation

- $L_{eq}$ is unknown...
- so measure *approach-to-equilibrium* function $h(L)$

\[ D_L(z = 0) = h(L)D_{eq} \]

- for selection of scan ranges $L$
  - beware of helical overranging!
Measurement technique with translation

- fit function of form*

\[ 1 - \alpha \exp\left(-\frac{4L}{L_{eq}}\right) \]

- evaluate \( D_{eq} \) and \( L_{eq} \)

- calculate equilibrium dose-pitch product

- calculate equilibrium dose constant
  - if \( a \) is known

* for 32 cm PPM phantom, Dixon and Ballard 2007
Measurement technique with translation

- equilibrium dose-pitch product for other collimations
  - can be calculated if $a / nT$ is known
  - or measured at $L \geq L_{eq}$

\[
\hat{D}_{eq}(a) = \left( \frac{a}{n_a T_a} \right) \cdot \left( \frac{b_{ref}}{a_{ref}} \right) \cdot D_{eq,ref}(a_{ref})
\]

- repeat all measurements for other kVps, beam-shaping filters
- repeat along other axes
- repeat with other phantoms
Measurement technique without translation

• chamber in midpoint along chosen axis
  – centre, 1 cm below surface typical
• select reference scan protocol
  – kVp, mAs, focus
  – beam-shaping filter
  – beam width
• measure $f(0)$ directly
  – reference scan protocol
  – other permutations
Measurement technique free-in-air

• chamber centred free-in-air, clear of table
• select reference scan protocol
• measure dose integral
  – translate chamber through beam
• calculate equilibrium dose-pitch product
• if $a/nT$ is known, calculate for other collimations, otherwise measure
• measure for other permutations
Why are we not embracing AAPM report 111?

• equipment not available
• too heavy to carry
• fillable water phantoms pose an electrical hazard
• extensive measurements required
  – more suited to type testing than QC?
• no closer to patient dose than CTDI_{100}
Better estimates of patient dose: AAPM report 204
Rationale for AAPM report 204

• patient dose depends on
  – scanner radiation output
  – patient size

• $\text{CTDI}_{\text{vol}}$ provides information only on scanner output
  – adopting $\text{CTDI}_{\text{vol}}$ as patient dose can result in large underestimates
    • e.g. factor 2-3 for paediatric scans using 32 cm dose phantom
Objectives

• conversion factors to estimate patient dose
  – applied to displayed $\text{CTD}_{\text{vol}}$
• for subjects of all sizes
• user-friendly
  – radiologists, technologists, physicists
General approach

• estimate patient dose from
  – patient size
  – size-specific conversion factor
  – radiation output metric

• normalisation of conversion factors by \( CTDI_{vol} \) eliminates variations due to different beam qualities
  – kVp, scanner filtration, geometry etc

• Turner et al 2010
General approach

• patient size described by
  – AP dimension
  – LAT dimension
  – AP+LAT
  – effective diameter
    • \( \sqrt{(AP \times LAT)} \)

• patient size determined using
  – electronic calliper on SPR or CT scan
  – physical calliper on patient
AAPM report 204: deriving conversion factors
Review of research studies

• data from 4 research groups combined
• different materials and methods
  – 2 phantom-based studies
  – 2 Monte Carlo-based studies
Group 1: Mc group

- anthropomorphic torso phantoms
  - 11 sizes: 9 to 39 cm LAT dimension
  - additional scattering material superior and inferior
- 4 CT scanner models
- abdominal protocol
  - helical, axial, cine
  - clinical scan ranges
- measured $D_L(0)$ at centre and periphery
- calculated area mean $D_L(0) \ (1/3 \ C + 2/3 \ P)$
- normalised by displayed CTDI$_{vol}$
Group 2: TS group

- uniform PMMA phantoms
  - 3 sizes: 10, 16, 32 cm diameter, 15 cm long
  - water-equivalent diameter (WED) calculated for each
- all CT vendors, 18 models, range of kVps
- measured CTDI$_{vol}$ and normalised as function of WED
  - 100 mm scan range implicit
- established WEDs and LAT sizes of head, chest and body of children from SPRs and CT scans
- produced tables of CTDI$_{vol}$ factors v. LAT size
Group 3: MG group

- mathematical voxel phantoms
  - 8 sizes: newborn to large adult
- MCNPX code
- 4 CT scanner models
- abdominal protocol
  - 150 to 330 mm scan range
- calculated organ doses within irradiated volume
- normalised by calculated CTDI$_{vol}$ and averaged over all scanners
- plotted against patient perimeter at central slice
Group 4: ZB group

- mathematical uniform cylindrical phantoms
  - many sizes: 1 to 50 cm, infinitely long
  - water, PMMA
- SIERRA code
- 1 CT scanner model, range of kVps
- 10, 100 mm and $\infty$ scan range
  - interpolate to estimate 200 to 300 mm scan range
- calculated dose to water at centre and periphery
- calculated mean $(1/3 \ C + 2/3 \ P)$
- normalised by calculated $\text{CTDI}_{\text{vol}}$
Comparison of data

- 120 kVp coefficients normalised to 32 cm phantom
- good agreement except @ 10 cm
  - spectral differences?
- good agreement with Huda 2000
  - thoracic study
- similar result for 16 cm phantom
Comparison of data

- coefficients for range of kVps normalised to 32 cm phantom
- data from 2 groups
- $R^2 = 0.973$ for single best fit
- within 5.1% of 120 kVp data
Outcomes

• 120 kVp coefficients adopted
  – considered most robust data

• look-up tables generated
  – conversion factor v. AP, LAT, AP+LAT, effective diameter

32 cm dose phantom
AAPM report 204 in practice
User-friendly dose estimate

\[ \text{size specific dose estimate} = SSDE = f_{size}^{32X} \times CTDI_{vol}^{32} \]

• estimate of mean dose at the central slice of a clinically realistic scan range
• \( f \) defined for patient size indicator \( X \), 32 cm phantom
  – \( X = A \) for AP, \( L \) for LAT, \( D \) for effective diameter
• equivalent expression for 16 cm phantom
User-friendly dose estimate

• obtain CTDI\textsubscript{vol} for scan series
  – confirm reference dose phantom

• determine patient dimension
  – LAT from SPR
    • beware of miscentering
  – AP and LAT from CT scan
    • beware of FOV
  – LAT from direct measurement
  – effective diameter from age

• select \( f^{32X}_{\text{size}} \) and calculate SSDE
Will SSDE catch on?

• IEC exploring mandatory implementation
  – patient size measured automatically
  – SSDE displayed with CTDI$_{vol}$ and DLP

• risk of drifting towards constant dose scan protocols
  – lower doses required to image smaller patients

<table>
<thead>
<tr>
<th>weight kg</th>
<th>SSDE for equal noise mGy</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>18</td>
</tr>
<tr>
<td>70</td>
<td>29</td>
</tr>
<tr>
<td>90</td>
<td>37</td>
</tr>
</tbody>
</table>
Effective dose calculations: options for wide beam CT
## Available CT dose calculators

<table>
<thead>
<tr>
<th>Monte Carlo source data</th>
<th>phantoms</th>
<th>normalisation</th>
<th>measurable quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRPB R-248 to R-250 + ImPACT dose calculator</td>
<td>adult male MIRD, fixed weight</td>
<td>CTDI\textsubscript{ICRU}\text{muscle} free-in-air, CTDI\textsubscript{air} free-in-air</td>
<td>CTDI\textsubscript{air} free-in-air</td>
</tr>
<tr>
<td>GSF CT conversion factors + CT-Expo</td>
<td>adult male and female MIRD, Child and Baby, fixed weight</td>
<td>CTDI\textsubscript{air} free-in-air, CTDI\textsubscript{w}</td>
<td>CTDI\textsubscript{w}</td>
</tr>
</tbody>
</table>
## ImPACT CT Patient Dosimetry Calculator

**Version 0.99u, 12/12/2003**

### Acquisition Parameters:

- **mA**: 250 mA
- **Rotation time**: 1 s
- **mAs / Rotation**: 250 mAs
- **Collimation**: 20 mm
- **Slice Width**: 7.5 mm
- **Pitch**: 1.375
- **Rel. CTDI**: Look up 0.86 at selected collimation
- **CTDI (air)**: Look up 25.1 mGy/100 mAs
- **CTDI (soft tissue)**: 26.9 mGy/100 mAs
- **CTDIn**: 9.9 mGy/100 mAs

### Patient Data:

- **Start Position**: 40 cm
- **End Position**: 70.5 cm
- **Data Set**: MCSET12
- **Scan Region**: Body
- **Scanner Model**: GE LightSpeed 16
- **Manufacturer**: GE
- **KV**: 120
- **Scan range**: 40 cm
- **Patient Sex**:

### Organ Dose:

<table>
<thead>
<tr>
<th>Organ</th>
<th>Wt</th>
<th>Ht</th>
<th>Wt.Ht</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonads</td>
<td>0.2</td>
<td>0.034</td>
<td>0.0067</td>
</tr>
<tr>
<td>Bone Marrow (red)</td>
<td>0.12</td>
<td>7.9</td>
<td>0.95</td>
</tr>
<tr>
<td>Colon</td>
<td>0.12</td>
<td>0.069</td>
<td>0.0063</td>
</tr>
<tr>
<td>Lung</td>
<td>0.12</td>
<td>27</td>
<td>3.2</td>
</tr>
<tr>
<td>Stomach</td>
<td>0.12</td>
<td>5.4</td>
<td>0.65</td>
</tr>
<tr>
<td>Bladder</td>
<td>0.05</td>
<td>0.02</td>
<td>0.00098</td>
</tr>
<tr>
<td>Breast</td>
<td>0.05</td>
<td>22</td>
<td>1.1</td>
</tr>
<tr>
<td>Liver</td>
<td>0.05</td>
<td>8.8</td>
<td>0.44</td>
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<tr>
<td>Oesophagus (Thymus)</td>
<td>0.05</td>
<td>31</td>
<td>1.5</td>
</tr>
<tr>
<td>Thyroid</td>
<td>0.05</td>
<td>8.1</td>
<td>0.41</td>
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<tr>
<td>Skin</td>
<td>0.01</td>
<td>5.8</td>
<td>0.058</td>
</tr>
<tr>
<td>Bone Surface</td>
<td>0.01</td>
<td>15</td>
<td>0.15</td>
</tr>
<tr>
<td>Remainder 1</td>
<td>0.025</td>
<td>31</td>
<td>0.77</td>
</tr>
<tr>
<td>Remainder 2</td>
<td>0.025</td>
<td>5.5</td>
<td>0.14</td>
</tr>
</tbody>
</table>

**Total Effective Dose (mSv)**: 9.4 mSv

### Remainder Organs:

<table>
<thead>
<tr>
<th>Organ</th>
<th>Ht</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrenals</td>
<td>1.2</td>
</tr>
<tr>
<td>Brain</td>
<td>0.32</td>
</tr>
<tr>
<td>Upper Large Intestine</td>
<td>0.4</td>
</tr>
<tr>
<td>Small Intestine</td>
<td>0.3</td>
</tr>
<tr>
<td>Kidney</td>
<td>1.9</td>
</tr>
<tr>
<td>Pancreas</td>
<td>6.5</td>
</tr>
<tr>
<td>Spleen</td>
<td>6.5</td>
</tr>
<tr>
<td>Thymus</td>
<td>31</td>
</tr>
<tr>
<td>Uterus</td>
<td>0.077</td>
</tr>
<tr>
<td>Muscle</td>
<td>6</td>
</tr>
</tbody>
</table>

**CTDIn (mGy)**: 24.8 mGy

**CTDIn (mGy)**: 18.0 mGy

**DLP (mGy.cm)**: 550

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**courtesy: ImPACT**

**Linköping PhD dosimetry course: April 2014**
CT-Expo

courtesy: Stamm
Effective dose estimates for wide beam CT

• ImPACT dose calculator can be used for
  – full rotation scans
  – partial rotation scans with random start

• adopt IEC 60601-2-44 edition 3 amendment 1 experimental methods
  – reference collimation to match scanner to available MC data set
  – new integration limits to measure CTDI-in-air
Effective dose estimates for wide beam CT

- PCXMC20Rotation could be used for
  - full rotation scans
  - partial rotation scans with random or fixed start
- x-ray beam modelled by adding beams of varying sizes
- x-ray beam quality parameters required
- air kerma at isocentre, rather than CTDI, to calculate organ doses
PCXMC20 Rotation

Linköping PhD dosimetry course: April 2014
courtesy: Stamm
Primary references

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