Best Practices Guidelines for CT-guided Interventional Procedures

A. Kyle Jones, PhD, FAAPM, Robert (Bob) Dixon, M.D., Jeremy Collins, MD, Eric Walser, MD, Boris Nikolic, MD

on behalf of the Society of Interventional Radiology Health and Safety Committee
Disclosure

• A. Kyle Jones, Ph.D. is President of FluoroSafety, a company that produces CME on quality and safety in medical imaging

• Neither FluoroSafety nor its products will be discussed in this talk
SIR Health and Safety Committee

• Now the “Safety and Professional Development Workgroup”

• Greatest hits include:


Best Practices Guidelines

• Consensus document authored by content experts, including representatives from the parent SIR committee

• Reviewed by the parent committee, and goes through the standard review process at the *Journal of Vascular and Interventional Radiology*
CTBPG authors

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SIR support

• Debbie Katsarellis
Accessing the CTBPG

• The document was too long to be included in full in JVIR

• Instead, a brief executive summary was published with a link to the full CTBPG

• Open Access at JVIR

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Major content areas

• CT dose indices
• Documentation of CT guided procedures
• Minimum equipment requirements
• Phases of CT-guided procedures
• Determinants of image quality in CT
• Strategies for optimizing technical factors
Major content areas

• Ultrasound as an alternative/adjunct

• Radiation management

• Radiation protection

• Quality improvement

• Staffing levels for CT-guided procedures
Documentation of CT-guided procedures

• Minimum requirements outlined in *ACR-SIR-SPR Practice Parameter for the Reporting and Archiving of Interventional Radiology Procedures*

• Considering that the marginal cost for storing additional images is essentially 0, may consider archiving all images

• Configuration options provided by manufacturers may be inflexible
Equipment

• Multidetector CT capable of covering an axial extent of at least 10 mm in a single rotation

• Can produce at least 3 images/rotation

• Basic dose reporting capabilities
  • Prospective display of CTDI$_{vol}$ and DLP
  • Itemization of scan parameters for each acquisition
  • Reporting of total CTDI$_{vol}$ and DLP for the procedure
  • Capable of permanently archiving total procedural dose indices
Phases of CT-guided procedures

- Scout
- Pre-procedure planning scan (PPS)
- Intervention phase
- Post-procedure scan
Scout

- Very minor impact on patient dose

- Should include sufficient extent to identify necessary landmarks

- Center the patient to the extent possible

- Often good practice to perform 2 scouts (AP and lateral) to ensure appropriate operation of tube current modulation (TCM)
Effects of Vertical Off-Center on CTDIvol vs. Topogram

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Pre-procedure planning scan (PPS)

• Typically helical

• Extent should be limited (e.g., 75 mm) – lesion location is known from prior imaging and landmarks are included in the scout

• Techniques should be adapted to indication and patient size

• Should contribute no more than 50% of total procedural dose-length product (DLP)
Technical factor selection

• Technical factors should be adapted to indication and patient size, as they are for diagnostic CT

• Different implementations of interventional CT present different challenges

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<td>Solid organ ablation</td>
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Intervention phase

• May be done using axial, helical, or CT fluoroscopy
  • If helical, scan range should be limited to that used for the PPS or less

• Techniques should again be adapted to patient size
  • Automatically (may not be possible, depending on manufacturer and mode)
  • Manually (can also match to TCM-selected techniques from PPS)

• Dose accumulation can be monitored by observing total CTDI$_{vol}$
Post-procedure scan

• Not always acquired, used to verify therapeutic endpoint or to identify complications
  • May use iodine contrast, timing considerations

• Should be performed similarly to PPS, although a longer scan range may be necessary
Monitoring and managing radiation dose (intra-procedure)

• Relies primarily on scanner-reported dose indices
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• Some rudimentary tools are provided by manufacturers
Monitoring and managing radiation dose (intra-procedure)

• Relies primarily on scanner-reported dose indices

• Some rudimentary tools are provided by manufacturers

• Model for estimating skin dose from $\text{CTDI}_{\text{vol}}$

\[
\text{CTDI}_{\text{vol}} = \frac{\text{CTDI}_{\text{w}}}{\text{pitch}}
\]

\[
\text{CTDI}_{\text{w}} = \frac{1}{3} \text{CTDI}_{\text{center}} + \frac{2}{3} \text{CTDI}_{\text{peripheral}}
\]

\[
\begin{align*}
\text{skin dose} &= \begin{cases} 
\frac{1}{3} \text{CTDI}_{\text{peripheral}} & \text{helical mode} \\
0.5 \times \text{CTDI}_{\text{peripheral}} & \text{intermittent mode}
\end{cases} \\
\text{skin dose} &= \begin{cases} 
1.2 \times \text{CTDI}_{\text{vol}} & \text{helical mode} \\
0.6 \times \text{CTDI}_{\text{vol}} & \text{intermittent mode}
\end{cases}
\]

Bland-Altman (Model)

% Difference

Average (mGy)

Bland-Altman (CTDI_{vol})

% Difference

Average (mGy)

p < 0.0001

p = 0.29

MO-GH-221AB       A. Kyle Jones,
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CT dose indices

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<th>CT dose metric</th>
<th>Describes</th>
<th>Fluoro analog</th>
<th>Use</th>
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<td>CTDI$_{vol}$</td>
<td>Scanner output</td>
<td>$K_{a,r}$</td>
<td>Notification levels</td>
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<td>DLP</td>
<td>Total energy imparted</td>
<td>$P_{KA}$</td>
<td>Total radiation burden to patient, proportional to scatter (i.e., operator dose)</td>
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Monitoring and managing radiation dose (across procedures)

- Different problem than diagnostic CT
- Procedures are not as “standard”, although there is some standardization

Table 2: Procedure-specific Dose Metric Distributions

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<th>Category</th>
<th>No. of Procedures</th>
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<th>50th Percentile</th>
<th>75th Percentile</th>
<th>CTDIw (mGy)</th>
<th>25th Percentile</th>
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Note.—Category definitions are provided in Table 1. CTDIw = scan-length-weighted CT dose index, DLP = dose-length product, SSDE = size-specific dose estimate.
Operator dose

• Proportional to procedural DLP

• Can be really close to zero depending on how you practice
  • Although you may be surprised if you evaluate the scatter distribution in the room – each situation is rather unique

• NVLAP-accredited daily-read dosimeters are now on the market