



*AAPM Computed Tomography Radiation
Dose Education Slides
Hitachi Version*

Many of the terms used in these slides can be
found in the CT Terminology Lexicon

[http://www.aapm.org/pubs/CTProtocols/docu
ments/CTTerminologyLexicon.pdf](http://www.aapm.org/pubs/CTProtocols/documents/CTTerminologyLexicon.pdf)

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Disclaimer

- Screen captures are **examples** of a common (or latest) software version only and all software versions are not represented
- The information contained herein is current as of the date shown on the title slide
- The master version of these slides is located at:
 - <http://www.aapm.org/pubs/CTProtocols/documents/EducationSlides.pptx>
- Modification of the content of these slides is **not allowed**.



Vendor Specific Slide Details

- The presence of a vendor name in the title of the slide indicates that the slide is vendor specific slide
- White text is used throughout to indicate vendor specific language
- An example of a vendor specific slide follows



Vendor: *Generic Parameter/Topic Name*

Vendor Specific Name

Vendor screen
capture of how the
acquisition
parameter is set
or how
information on the
topic is displayed

Text describing acquisition
parameter or topic



Motivation

- These slides are provided to aid in understanding the factors that affect radiation dose in CT studies
- Image patients **wisely** and **gently**
 - A CT study should use as little radiation as possible, while still meeting the image quality needs of the exam
 - A CT study that is non-diagnostic because the radiation dose is too low may require rescanning the patient – increasing the total patient dose



imagegently.org

imagewisely.org





Outline

- What is Dose?
- Acquisition Parameter Settings
- Dose Modulation and Reduction
- Dose Display



What Is Dose?

- Volume Computed Tomography Dose Index ($CTDI_{vol}$) is a standardized parameter to measure **Scanner Radiation Output**
 - $CTDI_{vol}$ is NOT patient dose
 - $CTDI_{vol}$ is reported in units of mGy for either a 16-cm (for head exams) or 32-cm (for body exams) diameter acrylic phantom
 - For the same technique settings, the $CTDI_{vol}$ reported for the 16-cm phantom is about twice that of the 32-cm phantom
 - The reported $CTDI_{vol}$ is based on measurements made by the manufacturer in a factory setting
- In these slides, the term "patient dose" is used to describe the absorbed dose to a patient, while the generic term "dose" refers to $CTDI_{vol}$

1. Bauhs, J. A., Vrieze, T. J., Primak, A. N., Bruesewitz, M. R., & McCollough, C. H. (2008). CT Dosimetry: Comparison of Measurement Techniques and Devices1. *Radiographics*, 28(1), 245-253. doi:10.1148/rg.281075024
2. McCollough, C. H., Primak, A. N., Braun, N., Kofler, J., Yu, L., & Christner, J. (2009). Strategies for reducing radiation dose in CT. *Radiologic clinics of North America*, 47(1), 27-40.
3. International Electrotechnical Commission. *Medical Electrical Equipment. Part 2–44: Particular requirements for the safety of x-ray equipment for computed tomography*. 2.1. International Electrotechnical Commission (IEC) Central Office; Geneva, Switzerland: 2002. IEC publication No. 60601–2–44.



How is $CTDI_{vol}$ related to patient dose?

- $CTDI_{vol}$ is not patient dose
- The relationship between the two depends on many factors, including patient size and composition
- [AAPM Report 204](#) introduces a parameter known as the Size Specific Dose Estimate (SSDE) to allow estimation of patient dose based on $CTDI_{vol}$ and patient size
- For the same $CTDI_{vol}$, a smaller patient will tend to have a higher patient dose than a larger patient

What is Dose?

http://www.aapm.org/pubs/reports/RPT_204.pdf



How is $CTDI_{vol}$ related to patient dose?

120 kVp at 200 mAs



32 cm
Phantom

$CTDI_{vol} = 20 \text{ mGy}$

120 kVp at 200 mAs



32 cm
Phantom

$CTDI_{vol} = 20 \text{ mGy}$

Both patients scanned with the same $CTDI_{vol}$
Patient dose will be higher for the smaller patient

What is Dose?



How is $CTDI_{vol}$ related to patient dose?

120 kVp at 100 mAs



32 cm
Phantom

$CTDI_{vol} = 10$ mGy

120 kVp at 200 mAs



32 cm
Phantom

$CTDI_{vol} = 20$ mGy

**Smaller patient scanned with a lower $CTDI_{vol}$
Patient doses will be approximately equal**

What is Dose?



Size Specific Dose Estimate (SSDE)

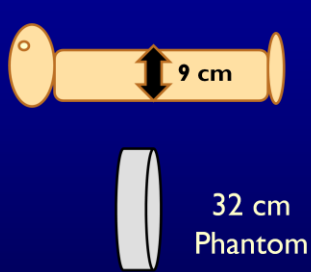
- AAPM report 204 describes a method to calculate SSDE using $CTDI_{vol}$
- Conversion factors based on patient size (e.g., AP or lateral width, effective diameter) are provided to **estimate** patient dose for a patient of that size
- However, SSDE is still not the exact patient dose, as factors such as scan length and patient composition may differ from the assumptions used to calculate SSDE
- SSDE is not dose to any specific organ, but rather the mean dose in the center of the scanned volume

What is Dose?



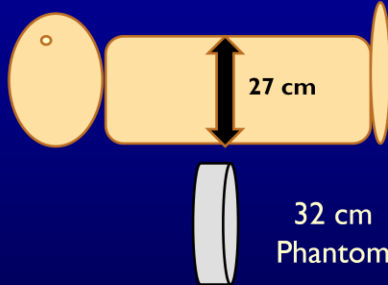
How is $CTDI_{vol}$ related to patient dose?

120 kVp at 100 mAs



$CTDI_{vol} = 10 \text{ mGy}$
 $SSDE = 13.2 \text{ mGy}$

120 kVp at 200 mAs



$CTDI_{vol} = 20 \text{ mGy}$
 $SSDE = 13.2 \text{ mGy}$

Patients have equivalent SSDE

What is Dose?



Why Use $CTDI_{vol}$?

- $CTDI_{vol}$ provides information about the amount of radiation used to perform the study
- $CTDI_{vol}$ is a useful index to track across patients and protocols for quality assurance purposes
- $CTDI_{vol}$ can be used as a metric to compare protocols across different practices and scanners when related variables, such as resultant image quality, are also taken in account
- The ACR Dose Index Registry (DIR) allows comparison across institutions of $CTDI_{vol}$ for similar exam types (e.g., routine head exam)

What is Dose?

1. McCollough, C. H., Leng, S., Yu, L., Cody, D. D., Boone, J. M., & McNitt-Gray, M. F. (2011). CT Dose Index and Patient Dose: They are Not the Same Thing, EDITORIAL, *Radiology* 259(2), 311-316.



Dose Length Product

- The Dose Length Product (DLP) is also calculated by the scanner
- DLP is the product of the length of the irradiated scan volume and the average $CTDI_{vol}$ over that distance
- DLP has units of $mGy \cdot cm$

What is Dose?



Useful Concepts/Terms

- The relationships between acquisition parameters and $CTDI_{vol}$ described in the following slides assume all other parameters are held constant
- The relationship between a parameter and $CTDI_{vol}$ is often described as **proportional** in some way
 - The symbol \propto is used to indicate “proportional to”
- Directly proportional means that a change in the parameter results in the same change in $CTDI_{vol}$
 - Example: Doubling the rotation time from 0.5 to 1.0 seconds will double the $CTDI_{vol}$
- Inversely proportional means that a change in a parameter has the opposite effect on $CTDI_{vol}$
 - Example: Doubling the pitch from 1 to 2 will reduce the $CTDI_{vol}$ by half



Acquisition Parameter Settings

- Acquisition Parameters define the technique that will be used and how the scan will proceed
- Acquisition Parameters are set in the user interface where scans are prescribed
- Changing a single Acquisition Parameter while holding everything else constant will typically affect the $CTDI_{vol}$ for that scan
- The following slides describe what that affect is for each parameter



Scan Mode

- CT Scanners offer a variety of **Scan Modes** which describe how the table moves during an exam
- **Scan Modes** include
 - Axial
 - Helical or Spiral
 - Dynamic

The Acquisition Parameters that affect CTDIvol may change amongst different Scan Modes

Acquisition Parameter Settings



Dynamic Scan Mode Notes

- In the Dynamic Scan Mode multiple acquisitions covering the same body region are acquired. Examples of these study types include:
 - Perfusion Studies
 - Bolus Tracking Studies
 - Test Bolus Studies
- Dynamic Scans often have large $CTDI_{vol}$ values because the scanner reports the sum of the $CTDI_{vol}$ values from each rotation
- The reported $CTDI_{vol}$ is NOT skin dose or organ dose

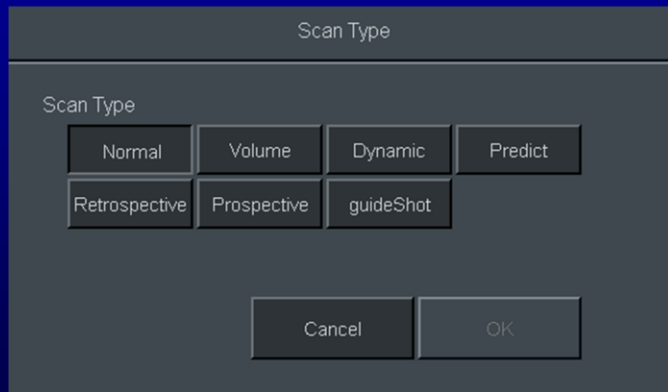
Acquisition Parameter Settings

1. Bauhs, J. A., Vrieze, T. J., Primak, A. N., Bruesewitz, M. R., & McCollough, C. H. (2008). CT Dosimetry : Comparison of Measurement Techniques and Devices. *Radiographics*, 28(1), 245-254.
2. Zhang, D., Cagnon, C. H., Villablanca, J. P., McCollough, C. H., Cody, D. D., Stevens, D. M., Zankl, M., et al. (2012). Peak Skin and Eye Lens Radiation Dose From Brain Perfusion CT Based on Monte Carlo Simulation. *American Journal of Roentgenology*, 198(2), 412-417.



Hitachi: *Scan Mode*

Scan Type



Acquisition Parameter Settings

Hitachi

For Hitachi users:

Normal = Axial scanning

Volume = Helical/Spiral scanning

Predict = Bolus tracking

guideShot = snap shot needle localization



Table Feed/Increment

- Is the movement of the table through the bore of the scanner over a full 360 degree rotation
- Units: millimeters/rotation or millimeters/second
- The parameter is known both as **Table Feed** (helical/spiral acquisition) & **Table Increment** (axial acquisition)

Table Feed may affect $CTDI_{vol}$ through its inclusion in Pitch (discussed later)

Acquisition Parameter Settings

Hitachi calls this feature TABLE INDEX.



Hitachi: Table Feed/Increment

Table Index

Axial /Normal Scanning

No.	Scan Type	Geo. Effic. Scan Period	CTDIvol DLP	Start Mode	Contrast	Focus Size	Joint Mode	Series Link	mAs Tube Voltage	No. of Scans No. of Images	FOV	Thickness Collimation	Direction Table Index	Recon. Index Scan Interv
1	N	83.0% 22s	52.1mGy 834.2mGy·cm					U n	300mAs 120kV	8 32img	S220 0.0	5.0 4i 0.63X32	OUT 20.00mm	Accord: Of 2.0s

Helical/Volume Scanning

No.	Scan Type	Geo. Effic. Scan Period	CTDIvol DLP	Start Mode	Contrast	Focus Size	Joint Mode	Series Link	mAs Tube Voltage	No. of Scans No. of Images	FOV	Thickness Collimation	Direction Table Index	Recon. Index Scan Interv
2	V	89.8% 5s	8.0mGy 382.8mGy·cm					U n	S117.5mAs 120kV	9 86img	354 16.0	5.0 P1.3 0.63X64	OUT 53.13mm	0.00mm -

Acquisition Parameter Settings

Hitachi

Examples of how Table Index is displayed for an Axial and a Volume scan



Detector Configuration

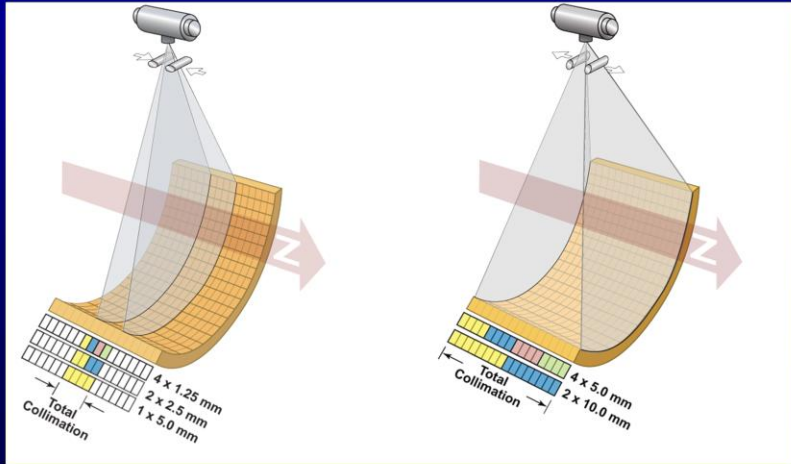
- Is the combination of the number of data channels and the width of the detector associated with each data channel
- The **Detector Configuration** determines the Beam Width or Beam Collimation (nT), which is the number of channels (n) times the detector width associated with each data channel (T)
- For a selected detector width per data channel, a smaller total Beam Collimation usually has a higher $CTDI_{vol}$ than a larger Beam Collimation
 - Example: On a 16 slice scanner with a detector width per channel of 1.25 mm, a collimation of $4 \times 1.25\text{mm}$ is generally less dose efficient than a collimation of $16 \times 1.25\text{mm}$

Users should monitor $CTDI_{vol}$ values when changing detector configuration

Acquisition Parameter Settings



Detector Configuration



Acquisition Parameter Settings



Hitachi: *Detector Configuration*

Collimation

Thickness

Thickness (mm)

0.625	1.25	2.5	3.75
5.0	7.5	10.0	

Image Mode

1i	2i	4i	8i	16i
32i	64i			

Collimation: 0.625x64

Cancel OK

Normal (axial) mode

Thickness

Thickness (mm)

0.625	1.0	1.25	2.5
3.75	5.0	7.5	10.0

Collimation

0.625x32	0.625x64
----------	----------

Table Pitch

0.5781	0.8281	1.0781	1.3281
1.5781			

Cancel OK

Volume (helical) mode

Acquisition Parameter Settings

Hitachi



Pitch

- Is the Table Feed per gantry rotation divided by the beam width/collimation
- *Pitch* is the ratio of two distances and therefore has no units
- Users should monitor other parameters when changing *Pitch*. The scanner may or may not automatically compensate for changes in *Pitch* (for example, by changing the tube current) to maintain the planned $CTDI_{vol}$.

$CTDI_{vol} \propto 1/Pitch$:

Hitachi, Toshiba (no AEC)

$CTDI_{vol}$ independent of Pitch:

GE, Siemens, Philips, Neusoft, Toshiba (AEC)

Acquisition Parameter Settings

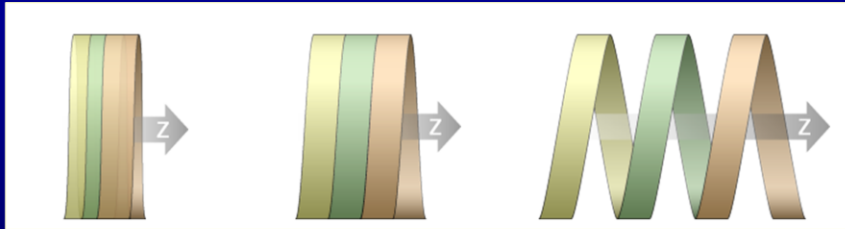


Pitch

- $CTDI_{vol}$ may not change in the expected manner if the scanner automatically adjust other parameters when the pitch is changed
- The relationships between $CTDI_{vol}$ and pitch for the different vendors are described below
 - $CTDI_{vol}$ inversely proportional to change in pitch: Hitachi, NeuroLogica
 - $CTDI_{vol}$ constant when pitch is changed due to changes to other parameters: GE, Neusoft, Philips and Siemens
 - The relationship between $CTDI_{vol}$ and pitch depends on scan mode or Software version: Toshiba



Pitch



Pitch < 1
Beam Width has some overlap at each view angle from rotation to rotation

Pitch = 1
No overlap of Beam Width at each view angle and no view angles not covered at certain table positions

Pitch > 1
Some view angles are not covered by the beam width at certain table positions

Acquisition Parameter Settings

AAPM Working Group on Standardization of CT Nomenclature and Protocols

Hitachi: Pitch

Table Pitch

. of Scans of Images	FOV	Thickness Collimation	Direction Table Index
9	354	5.0 P1.3	0 JT
86img	16.0	0.63X64	53 13mm

Thickness

Thickness (mm)

0.625	1.0	1.25	2.5
3.75	5.0	7.5	10.0

Collimation

0.625X32	0.625X64
----------	----------

Table Pitch

0.5781	0.8281	1.0781	1.3281
1.5781			

Hitachi

Acquisition Parameter Settings

Pitch is indicated on the Thickness/Collimation parameter indicated with a "P" (i.e. P1.3)

In order to change the pitch, click on the Thickness/Collimation parameter and the Thickness window will open to give the user the ability to change the Table Pitch parameter.



Exposure Time per Rotation

- Is the length of time, in seconds, that the X-ray beam is “on” during a gantry rotation
 - It takes into account the gantry rotation time and angular acquisition range
- Units: seconds
- Users should monitor other parameters when changing Exposure Time per Rotation. The scanner may or may not automatically compensate for changes in Exposure Time per Rotation (for example, by changing the tube current)

$CTDI_{vol} \propto$ Exposure Time per Rotation

Hitachi, NeuroLogica, Toshiba (no AEC)

$CTDI_{vol}$ independent of Exposure Time per Rotation:

GE, Siemens, Philips, Neusoft, Toshiba (AEC)

Acquisition Parameter Settings



Exposure Time per Rotation

- $CTDI_{vol}$ may not change in the expected manner if the scanner automatically adjust other parameters when the exposure time per rotation is changed
- The relationships between $CTDI_{vol}$ and exposure time per rotation for the different vendors are described below
 - $CTDI_{vol}$ proportional to change in parameter: Hitachi and NeuroLogica
 - $CTDI_{vol}$ constant when the parameter is changed due to changes to other parameters: GE, Neusoft, Philips and Siemens
 - The relationship between $CTDI_{vol}$ and the parameter depends on scan mode or Software version: Toshiba



Hitachi: Exposure Time per Rotation

Scan Time (s)

Series Link	mAs Tube Voltage	No. of Scans No. of Images	FOV	Thickni Collimai
U	300mAs 120kV	8 32img	S220 0.0	5.0 4 0.63X3

mAs, Tube Voltage

Tube Current (mA) 10 600

440

Scan Time (s)

0.35 0.4 0.5 0.75

1.0

Tube Voltage (kV)

80 100 120 140

IntelliEC mode

SD

Cancel OK

Acquisition Parameter Settings

Hitachi

Scan Time (s) is located under the mAs/Tube Voltage parameter
 In order to change the scan time, click on the mAs/Tube Voltage parameter and the mAs,Tube Voltage window will open to give the user the ability to change the Scan Time (s) parameter.



Tube Current

- Determines the number of electrons accelerated across the x-ray tube per unit time
- Units: milliAmperes (mA)
- $CTDI_{vol}$ is directly proportional to **Tube Current**

$$CTDI_{vol} \propto \text{Tube Current}$$

Acquisition Parameter Settings



Hitachi: Tube Current

Tube Current (mA)

Series	mAs	No. of Scans	FOV	Thickness
Link	Tube Voltage	No. of Images		Collimator
U...	300mAs	8	S220	5.0 4
n...	120kV	32img	0,0	0.63X3

The image shows a control window titled "mAs, Tube Voltage". It features a "Tube Current (mA)" slider set to 440, with a range from 10 to 600. Below the slider are buttons for "Scan Time (s)" with options 0.35, 0.4, 0.5 (selected), 0.75, and 1.0. There are also buttons for "Tube Voltage (kV)" with options 80, 100, 120 (selected), and 140. An "IntelliEC mode" button is set to "SD". At the bottom are "Cancel" and "OK" buttons.

Acquisition Parameter Settings

Hitachi

Tube Current (mA) is located under the mAs/Tube Voltage parameter
In order to change the Tube Current (mA), click on the mAs/Tube Voltage parameter and the mAs,Tube Voltage window will open to give the user the ability to change the Tube Current (mA) parameter.



Tube Potential

- Is the electrical potential applied across the x-ray tube to accelerate electrons toward the target material
- Units: kiloVolts (kV or kVp)
- CTDI_{vol} is **approximately** proportional to the square of the percentage change in **Tube Potential**

$$\text{CTDI}_{\text{vol}} \propto \left(\frac{kV_{\text{new}}}{kV_{\text{old}}} \right)^n \quad n \approx 2 \text{ to } 3$$

Acquisition Parameter Settings



Hitachi: Tube Potential

Tube Voltage (kV)

Series Link	mAs Tube Voltage	No. of Scans No. of Images	FOV	Thickn Collima
U C	300mAs 120kV	8 32img	S220 0,0	5.0 4 0.63X

The image shows a screenshot of the Hitachi CT console's parameter settings window titled "mAs, Tube Voltage". The window contains several adjustable parameters:

- Tube Current (mA):** A slider control ranging from 10 to 600 mA, currently set at 440 mA.
- Scan Time (s):** A set of buttons for 0.35, 0.4, 0.5, 0.75, and 1.0 seconds, with 0.5 seconds selected.
- Tube Voltage (kV):** A set of buttons for 80, 100, 120, and 140 kV, with 120 kV selected. This section is circled in yellow.
- IntelliEC mode:** A button labeled "SD".
- Navigation:** "Cancel" and "OK" buttons at the bottom.

Acquisition Parameter Settings

Hitachi

Tube Voltage (kV) is located under the mAs/Tube Voltage parameter. In order to change the Tube Voltage (kV), click on the mAs/Tube Voltage parameter and the mAs,Tube Voltage window will open to give the user the ability to change the Tube Voltage (kV) parameter.



Tube Current Time Product

- Is the product of Tube Current and the Exposure Time per Rotation
- Units: milliAmpere-seconds (mAs)
- $CTDI_{vol}$ is directly proportional to Tube Current Time Product

$$CTDI_{vol} \propto \text{Tube Current Time Product}$$

Acquisition Parameter Settings



Hitachi: Tube Current Time Product

mAs

No.	Scan Type	Geo. Effic. Scan Period	CTDIvol DLP	Start Mode	Contrast	Focus Size	Joint Mode	Series Link	mAs Tube Voltage	No. of Scans No. of Images	FOV
1	N	83.0% 22s	52.1mGy 834.2mGy·cm					U _n	300mAs 120kV	8 32img	S220 0.0

Acquisition Parameter Settings

Hitachi



Field Of Measurement

- Is the diameter of the primary beam in the axial plane at the gantry iso-center
- Units: millimeters (mm)
- $CTDI_{vol}$ may decrease with a decrease in the Field of Measurement
 - The relationship is vendor specific

Users should monitor the $CTDI_{vol}$ values when changing the Field of Measurement

Acquisition Parameter Settings



Hitachi: Field of Measurement

FOV (Field of View)

Series	mAs	No. of Scans	FOV	Thickness
ink	Tube Voltage	No. of Images		Collimator
U	300mAs	8	S220	5.0 4
n	120kV	32img	0,0	0.63X



FOV

FOV (mm) 20 500
350

FOV-X (mm) -250 250
0

FOV-Y (mm) -250 250
0

Bow Tie
Small Normal Auto Switch ON

Apply to All Apply After Cancel OK

Acquisition Parameter Settings

Hitachi



Beam Shaping Filter

- Is the scanner component that modifies the energy spectrum and spatial distribution of the primary beam
- **Beam Shaping** may include a bow tie filter and/or flat filters
- $CTDI_{vol}$ is affected by a change in **Beam Shaping Filters**
 - The relationship is vendor and filter specific

Users should monitor $CTDI_{vol}$ values when changing the Beam Shaping Filter

Acquisition Parameter Settings



Hitachi: Beam Shaping Filter

Bow Tie

mAs	No. of Scans	FOV	Thickness Collimation
S25mAs	12	S210	5.0 8i
120kV	96img	0.0	0.63X64

The interface shows three sliders: FOV (mm) with a value of 350, FOV-X (mm) with a value of 0, and FOV-Y (mm) with a value of 0. Below the sliders are buttons for 'Bow Tie' (Small, Normal) and 'Auto Switch ON'. The 'Normal' button and 'Auto Switch ON' button are highlighted with a yellow oval.

Acquisition Parameter Settings

Hitachi

The "S" in front of the FOV value indicates the Small Bow Tie filter is in use. The Small Bow Tie filter can be used when the FOV is below 240mm.

The Small Bow Tie filter can be automatically turned on when the Auto Switch button is depressed in Scan Protocol Settings and saved permanently within the protocol.



Acquisition Parameter Settings Summary

Parameter	Relationship to $CTDI_{vol}$
Scan Mode	Changes in the Scan Mode may affect $CTDI_{vol}$
Table Feed/Increment	Table Feed affects $CTDI_{vol}$ through its inclusion in Pitch
Detector Configuration	Decreasing the Beam Collimation typically, but not always, increases the $CTDI_{vol}$
Pitch	$CTDI_{vol}$ relationship to pitch is vendor dependent
Exposure Time Per Rotation	$CTDI_{vol}$ relationship to exposure time per rotation is vendor dependent
Tube Current	$CTDI_{vol} \propto$ Tube Current
Tube Potential	$CTDI_{vol} \propto (kVp_1/kVp_2)^n$ $n \sim 2$ to 3
Tube Current Time Product	$CTDI_{vol} \propto$ Tube Current Time Product
Effective Tube Current Time Product	$CTDI_{vol} \propto$ Effective Tube Current Time Product
Field of Measurement	Changes in the Field of Measurement may affect $CTDI_{vol}$
Beam Shaping Filter	Changes in the Beam Shaping Filter may affect $CTDI_{vol}$



Dose Modulation and Reduction

- Many CT scanners automatically adjust the technique parameters (and as a result the $CTDI_{vol}$) to achieve a desired level of image quality and/or to reduce dose
- Dose Modulation and Reduction techniques vary by scanner manufacturer, model and software version



Automatic Exposure Control (AEC)

- Automatically adapts the Tube Current or Tube Potential according to patient attenuation to achieve a specified image quality
 - Automatic adjustment of Tube Current may not occur when Tube Potential is changed
 - **Centering the patient in the gantry is VITAL for most AEC systems**
- AEC aims to deliver a specified image quality across a range of patient sizes. It tends to increase $CTDI_{vol}$ for large patients and decrease it for small patients relative to a reference patient size

The use of Automatic Exposure Control may decrease or increase $CTDI_{vol}$ depending on the patient size and body area imaged and image quality requested

Dose Modulation and Reduction



Hitachi: Automatic Exposure Control (AEC)

IntelliEC



IntelliEC control panel showing settings for Target SD, Lower Limit mA, and Upper Limit mA. The Target SD is set to 12.0, Lower Limit mA is set to 50, and Upper Limit mA is set to 600. The panel also includes buttons for IntelliEC Mode (OFF, SD, CNR), Cancel, and OK.

Parameter	Value
IntelliEC Mode	SD
Target SD	12.0
Lower Limit mA	50
Upper Limit mA	600

Dose Modulation and Reduction

Hitachi

For the Hitachi Scenaria scanner, IntelliEC is based on one PA scanogram



Image Quality Reference Parameter

- Is the AEC parameter that is set by the user to define the desired level of image quality
- Changing the Image Quality Reference Parameter will affect the $CTDI_{vol}$

The effect on $CTDI_{vol}$ when changing the Image Quality Reference Parameter is vendor dependent

Dose Modulation and Reduction



Hitachi: Image Quality Reference Parameter

SD (standard deviation)

Cont-ist	Focus Size	Joint Mode	Series Link	mAs Tube Voltage	No. of Scans No. of Images	FOV
				S25mAs 120kV	10 97img	350 0,0

IntelliEC

IntelliEC Mode

OFF SD CNR

Target SD 1.0 200.0

12.0

Lower Limit mA 10 600

50

Upper Limit mA 10 600

600

Cancel OK

Hitachi

Dose Modulation and Reduction

Inversely proportional

Increasing SD will decrease the dose but increase the noise

Decreasing the SD will increase the dose but decrease the noise

The user will be able to determine SD is turned "ON" by the indication of the "S" in front of the mAs value.



Image Quality Reference Parameter

- A change in the Image Quality Reference Parameter will affect the $CTDI_{vol}$
- Setting the parameter for “increased” image quality (e.g., lower noise) will result in more dose
 - Decreasing the SD# (standard deviation) will result in an increase in the $CTDI_{vol}$
- Setting the parameter for “decreased” image quality (e.g., more noise) will result in less dose
 - Increasing the SD# (standard deviation) will result in a decrease in the $CTDI_{vol}$

Dose Modulation and Reduction



Angular and Longitudinal Tube Current Modulation

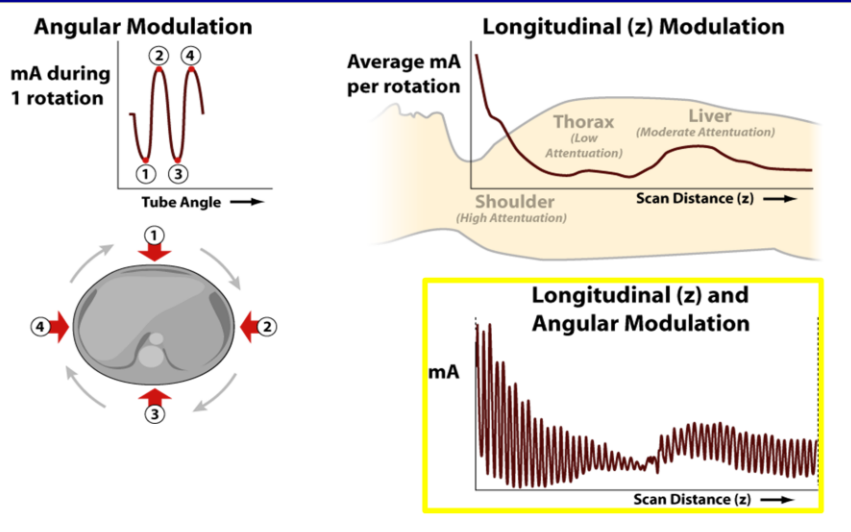
- Is an AEC feature that incorporates the properties of both **Angular and Longitudinal Tube Current Modulation** to
 - Adjust the Tube Current based on the patient's overall attenuation
 - Modulate the Tube Current in the angular (X-Y) and longitudinal (Z) dimensions to adapt to the patient's shape

The use of Angular and Longitudinal Tube Current Modulation may decrease or increase $CTDI_{vol}$ depending on the patient size and body area imaged and image quality requested

Dose Modulation and Reduction



Angular and Longitudinal Tube Current Modulation

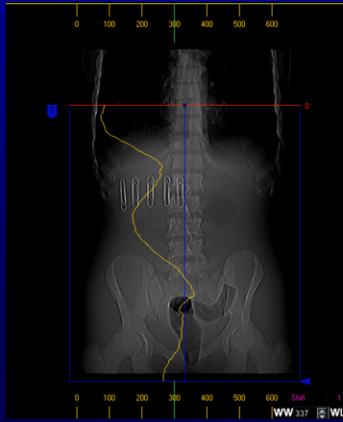


Dose Modulation and Reduction



Hitachi: Angular and Longitudinal Tube Current Modulation

IntelliEC



Dose Modulation and Reduction

Hitachi

For the Hitachi Scenaria scanner, IntelliEC is based on one PA scanogram



Iterative Reconstruction

- Is a feature that uses the information acquired during the scan and repeated reconstruction steps to produce an image with less “noise” or better image quality (e.g., higher spatial resolution or decreased artifacts) than is achievable using standard reconstruction techniques

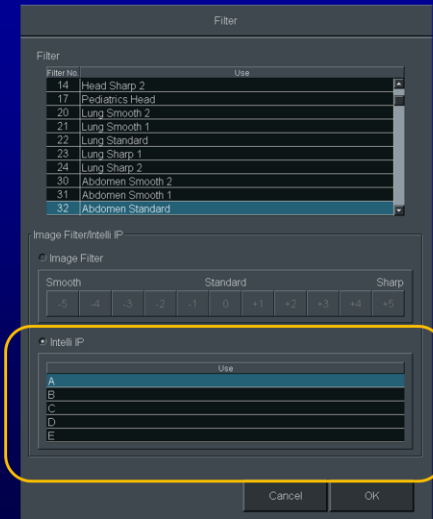
The use of Iterative Reconstruction by itself may not decrease $CTDI_{vol}$; with use of Iterative Reconstruction, image quality will change and this may allow a reduction in the $CTDI_{vol}$ by adjusting the acquisition parameters used for the exam

Dose Modulation and Reduction



Hitachi: *Iterative Reconstruction*

Intelli IP



Dose Modulation and Reduction

Hitachi



Iterative Reconstruction

- Iterative Reconstruction using Intelli IP is completed using Image and Projection Data
- Changing the Letter of Intelli IP will affect the resultant image quality; it **WILL NOT** affect the $CTDI_{vol}$ of the scan
- In consultation, the radiologists and medical physicists may adjust the acquisition parameters for studies reconstructed using Intelli IP based on the imaging task and patient population, dose concerns, and the needs of the interpreting radiologist(s)

Dose Modulation and Reduction



Dose Display

- Information about the $CTDI_{vol}$ planned for each scan is typically displayed before the exam on the user console
- Information about the $CTDI_{vol}$ delivered by each scan is typically reported in a data page or DICOM structured dose report
- Dose information provided after the exam typically also includes the DLP and the CTDI phantom size. These may also be included in information displayed before the scan.



Display of Planned $CTDI_{vol}$

- $CTDI_{vol}$ is displayed before a study is performed based on the selected technique parameters
- It is important to check $CTDI_{vol}$ before a study is performed to ensure that the output of the scanner is appropriate for the specific patient and diagnostic task

$CTDI_{vol}$ is displayed for each planned acquisition

Dose Display



Hitachi: Display of Planned $CTDI_{vol}$

$CTDI_{vol}$

No.	Scan Type	Geo. Effic. Scan Period	$CTDI_{vol}$ DLP	Start Mode	Contrast	Focus Size	Joint Mode	Series Link	mAs Tube Voltage	No. of Scans No. of Images	FOV	Thickness Collimation
1	N	83.0% 22s	52.1mGy 834.2mGy-cm					U n	300mAs 120kV	8 32img	S220 0,0	5,04 0,63X

Dose Display

Hitachi



Post Study Data Page

- Following the completion of a study, a **Post Study Data Page** is created that includes information on the delivered $CTDI_{vol}$ and DLP and the phantom size used to calculate these values
- Information is displayed for each series

Dose Display



Hitachi: Post Study Data Page

Dose History

Dose History							
Patient ID	Patient Name	Exam Date	Region	Total CTDIvol[mGy]	DI[mGy·cm]	Alert Value(CTDIvol)[mGy]	Operator Name
20120927-2	NONE	09/27/2012	Head	1842.0	3684.0	1000.0	GS
swsaxaq	SSSS	09/24/2012	Chest-Abdomen	42.6	1444.3	1000.0	
swsaxaq	SSSS	09/24/2012	Chest	300.7	786.2	1000.0	
teswt fat	TEAST FAT	09/21/2012	Abdomen-Pelvis	41.6	1215.3	1000.0	
test don	TEST DON	09/18/2012	Abdomen-Pelvis	57.8	128.9	1000.0	
QA	QA	09/17/2012	Head	104.3	1251.4	1000.0	
QA TEST	QA TEST	09/17/2012	Head	156.4	1355.6	1000.0	
0000667	TEST	09/17/2012	Head	56.5	790.8	1000.0	
00909	TEST	09/17/2012	Abdomen-Pelvis	22.3	412.2	1000.0	
090876	FED ABD	09/17/2012	Abdomen-Pelvis	28.1	520.7	1000.0	
67	P BR	09/17/2012	Head	47.2	565.9	1000.0	
qa cms	QA CMSA	09/17/2012	Head	104.3	1664.2	1000.0	
qaafdf	DFSF	09/17/2012	Head	174.7	1061.2	1000.0	
restest	RETEST	09/17/2012	Head	190.9	1167.9	1000.0	
ddfdfff	FFAEFD	09/17/2012	Head	252.6	1267.4	1000.0	
ddfdfff	FFHGHGFGHF	09/17/2012	Head	397.0	1594.3	1000.0	
dfstfstdsfj	HJHGF	09/17/2012	Head	431.5	1093.7	1000.0	

Total CTDIvol[mGy]: 0.0

Buttons: Extract, Detail Information, Highlight Setting, ChangeDisplayTerm, Modify, Delete, AutoDeleteSetting, Exit

Dose Display

Hitachi



Post Study Data Page - $CTDI_{vol}$

- $CTDI_{vol}$ is displayed for each series after a study is performed and is calculated based on the technique factors used to acquire the data
- It is useful to check $CTDI_{vol}$ after a study is performed to ensure that the output of the scanner was as expected

$CTDI_{vol}$ is displayed for each completed acquisition

Dose Display



Post Study Data Page - DLP

- DLP is displayed for each series after a study is performed and is calculated based on the technique factors and scan length used

DLP is displayed for each completed acquisition and is typically summed for all of the acquisitions

Dose Display



Hitachi: Post Study Data Page

Detail Information

Detail Information

Detail Information per Sequence

Region	CTDIvol(mGy)	DLP(mGy#cm)	Tube Current(mA)	Tube Voltage(kV)	IntelliEC ON/OFF	Scan Time(s)	Scan Count	Exposure Time(s)	Dose Validation Phantom
Head	52.1	1147.1	300	120	OFF	1.00	11	11.00	Head Phantom
Head	138.8	20.8	300	120	OFF	1.00	1	1.00	Head Phantom

OK

Dose Display

Hitachi



Post Study Data Page – CTDI Phantom

- The CTDI Phantom used for each acquisition in the study is typically displayed
- Different phantoms may be used to calculate the $CTDI_{vol}$ for different acquisitions in the same study (and may vary by vendor)
 - Head and C-Spine Example
 - Body Phantom used to report $CTDI_{vol}$ for C-Spine portion of exam
 - Head Phantom used to report $CTDI_{vol}$ for Head portion of exam

Dose Display



Hitachi: Post Study Data Page – CTDI Phantom

Detail Information

Detail Information per Sequence									
Region	CTDIvol[mAs]	DLP[mGyWcm]	Tube Current[mA]	Tube Voltage[kV]	IntelliEC ON/OFF	Scan Time[s]	Scan Count	Exposure Time[s]	Dose Validation Phantom
Head	62.1	1147.1	300	120	OFF	1.00	11	11.00	Head Phantom
Head	138.8	20.8	300	120	OFF	1.00	1	1.00	Head Phantom

OK

Detail Information

Detail Information per Sequence									
Region	CTDIvol[mAs]	DLP[mGyWcm]	Tube Current[mA]	Tube Voltage[kV]	IntelliEC ON/OFF	Scan Time[s]	Scan Count	Exposure Time[s]	Dose Validation Phantom
Abdomen-Pelvis	17.0	314.6	145	120	OFF	0.75	8	6.00	Body Phantom
Abdomen-Pelvis	11.1	206.1	95	120	OFF	0.75	8	6.00	Body Phantom

OK

Dose Display



Summing Dose Report Values

- $CTDI_{vol}$ values for separate series are NOT to be summed to give a “total” $CTDI_{vol}$ for a study
 - This is especially true if the series cover different anatomic regions
- DLP is typically summed over all series in the Post Study Data Page to provide an estimate of the total patient exposure
 - Extreme care should be taken when considering summed DLPs because different phantoms may have been used to calculate the $CTDI_{vol}$ values used to determine DLP
- A medical physicist should be contacted if patient specific dose estimates are required

Dose Display



Dose Alert Levels

- **Dose Alert Levels** require specific action by the operator to continue scanning
- **Dose Alert Levels** are typically much higher than Notification Levels and take into account all series within the exam
- Triggering a **Dose Alert** requires that the operator confirm the protocol and settings are correct by entering in his or her name. Optionally, sites may require that the operator provide a brief explanation in the provided field

Dose Display



Hitachi: Dose Alert Levels

Dose Alert

Dose Alert

Seq.No	CTDlvl[mGy]	DLP[mGy·cm]	Notification Value[DLP][mGy·cm]
7	88.5	1327.1	150.0

Sum DLP[mGy·cm] : 1769.4
Alert Value[DLP][mGy·cm] : 1000.0

A Dose Alert Value will be exceeded.
Please input a password and click the "Confirm" button to scan.

Password

The Dose Alert feature complies with the NEMA XR-25 standard. Hitachi

Dose Display



Radiation Dose Structured Reports

- Radiation Dose Structured Reports (RDSRs) are provided in newer software versions in a defined DICOM format
- They provide the most complete set of information regarding the irradiating events
- The reports are very detailed and require an RDSR viewer for easy visualization of relevant information

Dose Display



Questions

- Please contact the medical physicist providing support for your CT practice, your lead technologist, supervising radiologist or manufacturer's application specialist with questions regarding these important topics and concepts.



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