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TECNICHE DI RADIOLOGIA MEDICA, PER IMMAGINI E RADIOTERAPIA

CORSO INTEGRATO
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TECNICHE DI IMAGING TC E ANGIOGRAFICO
RMX055 - 25 ore MED/50 CFU 2

dic. ’24

2° anno I semestre

Fondazione Policlinico Universitario Agostino Gemelli IRCCS
Università Cattolica del Sacro Cuore

Formazione per l'eccellenza

Insegnamento:
TECNICHE DI IMAGING TC E ANGIOGRAFICO
RMX055 - 25 ore MED/50 CFU 2

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ACR Catalog

Image Wisely Radiation Safety Case - Child-sizing CT Dose: Optimizing Patient Care Through Quality Improvement — Pediatric and Adult Imaging

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Child-sizing CT Dose: Optimizing Patient Care Through Quality Improvement – *Pediatric and Adult Imaging*

Get Started!

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This educational program was developed by Image Gently® and the ACR Dose Index Registry.

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Goals and Objectives

Target Audience

The goal of ***Child-sizing CT Dose: Optimizing Patient Care through Quality Improvement – Pediatric and Adult Imaging***, is to provide practical explanations of some of the newer technologies and terminology in CT scans in children. This module, reviews quality improvement as it relates to the performance of pediatric CT scans, discusses radiation risk and the reasons for increased concern, and the relationships of image quality to patient dose. Many of the important concepts presented in this module also apply to imaging adult patients.

Target Audience

Learner Objectives

The module is targeted to radiologists, radiologic technologists and medical physicists involved with CT imaging of both children and adults. Members of the imaging team who are enrolled in, or are interested in enrolling in the American College of Radiology (ACR) Dose Index Registry (DIR) are particularly encouraged to take advantage of this valuable educational opportunity.

The authors of this program hope you will find this module helpful in your daily practice and a valuable adjunct to your Registry participation.

Learner Objectives

Credit Information

After completing this educational activity, you should be better able to:

- Optimize the radiation dose in order to produce the best image quality with the least radiation exposure in pediatric and adult patients
- Apply the current techniques of dose estimating and utilize these "best practices" to achieve radiation dose reduction during pediatric and adult CT scans
- Advocate for quality improvement in your organization and share your expertise to educate health care teams on the positive societal outcomes from lifelong learning and practice improvement

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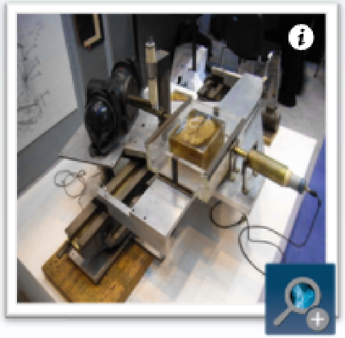
Introduction

Table of Contents

CT Scans

Computed tomography (CT) or CT scans are regarded as one of the greatest discoveries in medicine in the last millennium.



There is no question that CT scans save lives and impact patient care in a positive way, such that routine exploratory surgery after trauma and surgical staging of lymphomas and other cancer are no longer necessary. In children, CT scans have been shown to provide faster patient disposition from the emergency department and more accurate staging of cancer.

With these advances comes increased use. In the past 25 years there has been a six-fold increase in the number of CT scans in the US, which poses a potential health risk for excess cancer from medical radiation. Because of this serious safety concern, CT technology is best used safely and effectively only when understood by the professionals who perform (radiologic technologists), interpret (radiologists) or optimize (medical imaging physicists) the scans.

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Continue to Section 1

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Section 1: *Quality Improvement as it Relates to the Performance of Pediatric CT Scans*

Quality Improvement: Why do we care?

In 1999, the Institute of Medicine, a scientific advisory group, issued a report called To Err is Human: Building a Safe Health System.

It stated that medical error was a significant cause of morbidity and mortality in the United States.

Medical error is a more common cause of death in the United States than breast cancer or motor vehicle accidents!

It is estimated that up to 98,000 US citizens die each year from medical error.

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Section 1: *Quality Improvement as it Relates to the Performance of Pediatric CT Scans*

Table of Contents

At the American College of Radiology (ACR), quality is defined as:

"*the right procedure done in the right way, at the right time with the correct interpretation to maximize the desired health outcomes and to satisfy the patient*".

The United Kingdom Health Foundation stresses the following key principles of quality:


The dimensions of quality

Safe Avoiding harm to patients from care that is intended to help them.	Effective Providing services based on scientific knowledge and which produce a clear benefit.
Person-centred Providing care that is respectful or responsive to individuals' needs and values.	Timely Reducing waits and sometimes harmful delays.
Efficient Avoiding waste.	Equitable Providing care that does not vary in quality because of a person's characteristics.

The medical imaging community is committed to improving radiation protection for children. Proactive methods to improve patient safety include the ACR Dose Index Registry® and continuing education.

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Section 1: *Quality Improvement as it Relates to the Performance of Pediatric CT Scans*

Table of Contents

Practice Quality Improvement (PQI)

PQI has been identified as an *"ongoing, organization-wide framework to monitor all aspects of an organization's activities for the purpose of continuous improvement."*

Goals of PQI

- Improve quality of care for patients
- Reduce error
- Minimize medical legal risk
- Save money

Important components of PQI

- Focus on the patient
- Break down the process into steps
- Understand variation that may lead to error
- Test on a small scale before implementing
- Teamwork

Knowledge Check #1

What are the goals of PQI?

The expert:

- Improve quality of care
- Reduce errors
- Minimize medical legal risk
- Save money

Implementing PQI: PDSA Cycle

Plan, do, study, and act (PDSA) is an improvement method that includes 4 steps:

1. Plan a test
2. Do the test
3. Study the outcomes of the test
4. Act on knowledge gained from the test

The American College of Radiology summarizes PQI as "*a path to establish best practices, determine variations in practice, and standardize these practices to minimize error.*"

Applications of the PDSA cycle

- Analyze estimated radiation dose from hospital or facility enrolled in the ACR DIR
- Compare your pediatric doses to those from similar facilities
  - For patients of the same body size
  - For the same clinical scan indication

Quality can be difficult to assess in a complex medical system

Break the process into parts or simple steps or *metrics*

A metric is

- A standard of measurement
- A reference point against which other things can be measured

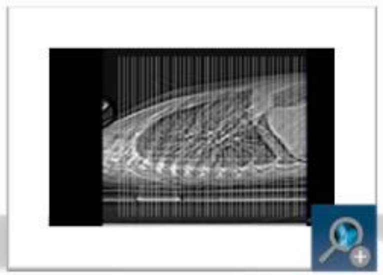
A good example of a simple PQI project is to evaluate the consistency of scan lengths in pediatric chest CT

- Is the scan length correct for the size of the patient and the exam?
- For a chest CT, the scan length should include the lung apex to 2 cm below the diaphragm
- The actual length will vary depending on patient size

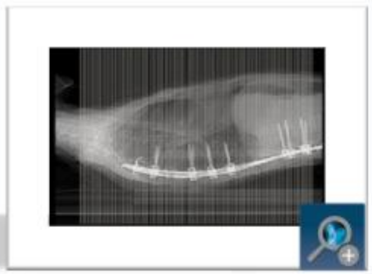
Plan the test

Example:

- Identify a problem: radiologists noted that scan lengths were longer than necessary
- Verify problem exists based on data from previous scans
- Create a corrective plan of action
- Establish a goal of 95% compliance



Good



Bad

Do the test

- Educate CT technologists as to best practice
- CT technologists adjust scan length (metric) to adhere to best practice

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Section 1: *Quality Improvement as it Relates to the Performance of Pediatric CT Scans*

Table of Contents

Study the test

- Manager reviews scan lengths for adherence to best practice

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Section 1: *Quality Improvement as it Relates to the Performance of Pediatric CT Scans*

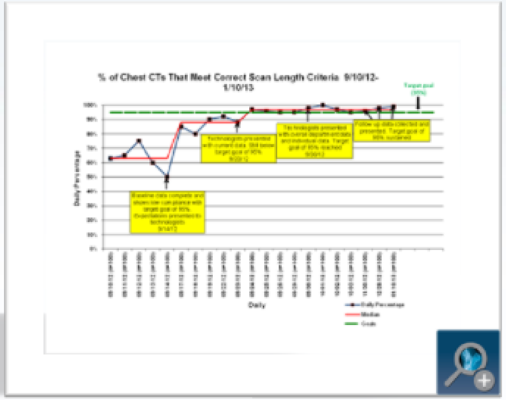
Act on the results

- Manager provides feedback to individual technologists concerning compliance with best practice
- Evaluate variation among technologists
- Data collection and feedback continue until 95% compliance achieved

Reducing variation

A goal of PQI in pediatric CT is to reduce the variation for CT scans of the same body part for patients of the same body size.

Although a facility has protocols for patients of the same age, weight, or size (the preferred method), what process is in place to ensure that this happens? Monitoring variation through the use of a chart may be helpful.



Run chart - a quality improvement tool

This is a sample "run chart" that was used to improve performance for the PQI project discussed

Knowledge Check #2 - Drag and Drop

Match each of the 4 steps of a PQI cycle in order.

Step 1	**Plan** the test
Step 2	**Do** the test
Step 3	**Study** the outcomes of the test
Step 4	**Act** on the knowledge gained from the test

Correct!

You matched all steps of the PQI cycle.

Measurement of patient dose is complex. Radiation dose can only be *estimated.*

Radiation Quantities & Units

Air Kerma

Formerly called "exposure," air kerma specifies the amount of radiation existing at a position in space (e.g., output of the CT scanner).

- Units: Gray (Gy) or milliGray (mGy)
- Air Kerma is the quantity typically measured by an imaging physicist

Absorbed Dose

This occurs when energy carried by an x-ray is transferred to kinetic energy of charged particles in the tissue as the x-rays pass through the tissue.

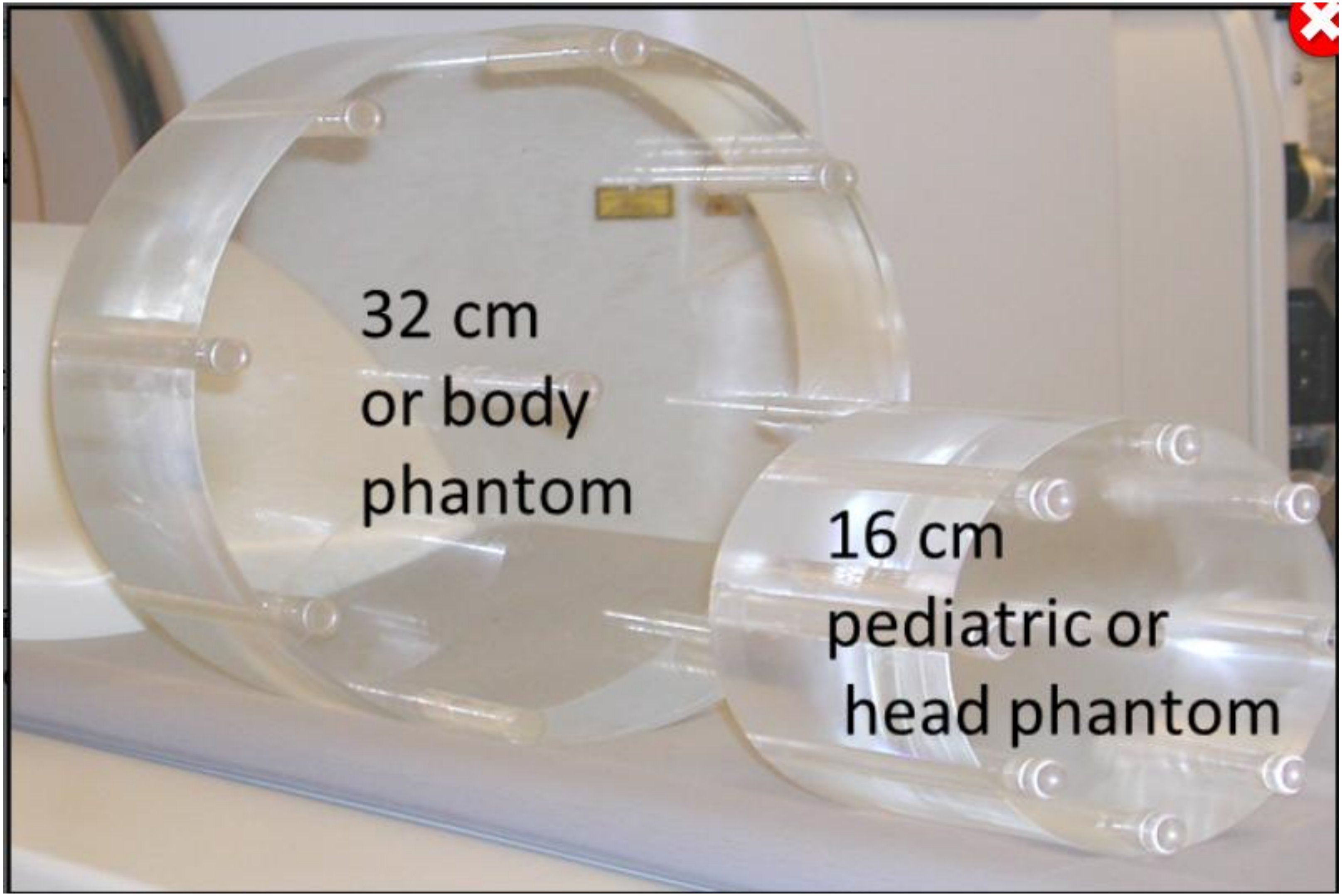
- Transferred energy may cause biological damage
- Units: Gray (Gy) or milliGray (mGy)
- Absorbed dose is typically not directly measured. It is calculated from air kerma measurements

Radiation Quantities & Units

$CTDI_{vol}$

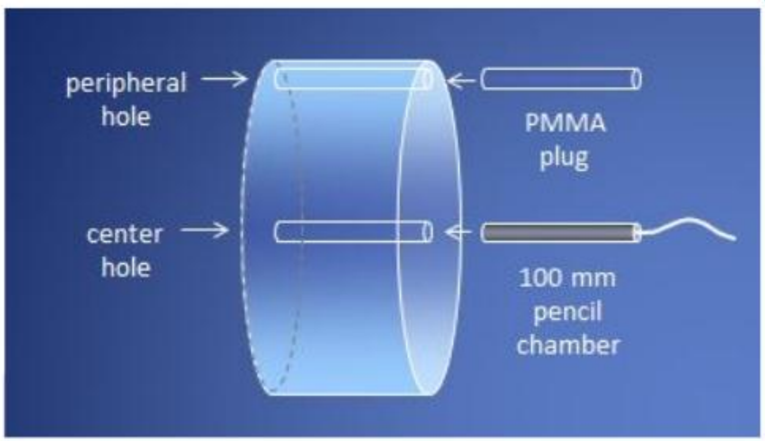
This is the absorbed dose given to 1of 2 standard-sized plastic cylindrical phantoms by a CT scanner.

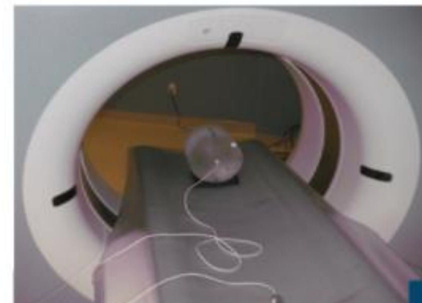
- Units: Gray (Gy) or milliGray (mGy)
- Imaging physicists use 1of the 2 phantoms shown to make the measurements needed to calculate $CTDI_{vol}$

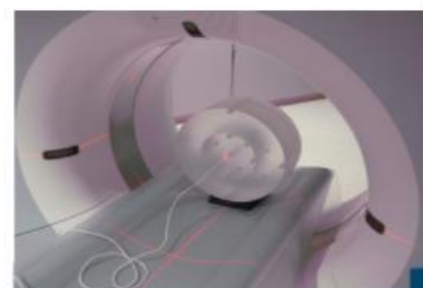

32 cm
or body
phantom
16 cm
pediatric or
head phantom

CT Dosimetry Measurements

$CTDI_{vol}$ is commonly measured for CT scanners and is reported on the CT console for set techniques.



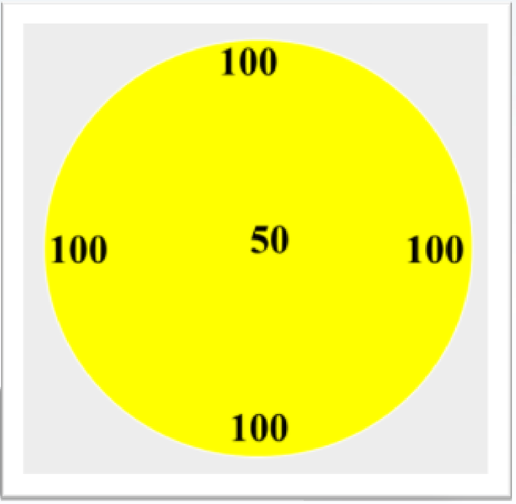




Radiation Quantities & Units

$CTDI_{vol}$

- Is **NOT** an estimate of **patient** dose
- Is the dose to one of the CTDI phantoms. It allows comparison of the radiation output between CT scanners
- Is the **average** dose in the transverse plane (CT slice) of the CTDI phantom. In this example, the surface dose is 2 times greater than the central dose in the 32 cm phantom



For this example, $CTDI_{vol}$ = 84 mGy

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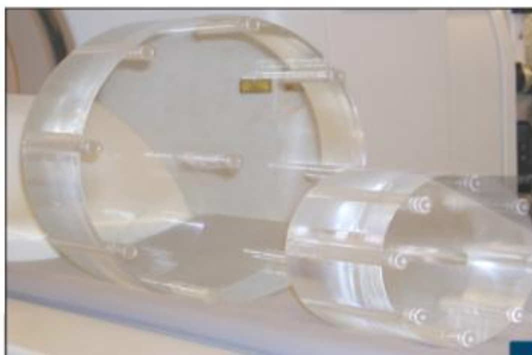
Section 2: *Estimates of Radiation Dose*

CT dose index or estimate ($CTDI_{vol}$) may underestimate a neonatal dose by over 200%!

It does not take into account patient size, patient shape, or the varying tissue attenuating factors of the human body.



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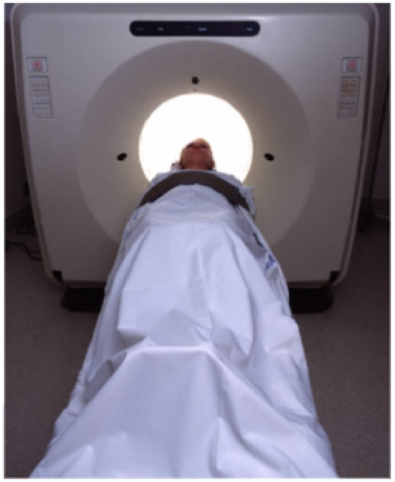
A Challenge:

CT manufacturers do not use the same CTDI to display $CTDI_{vol}$ as patient size changes.

You need to know which CTDI phantom (16 or 32 cm) is being used by the scanner.

The dose estimates will be incorrect by a factor of 2 if you assume the wrong phantom.

Example:
A 20 mGy estimated dose based on a 16 cm phantom = 10 mGy based on a 32 cm phantom.



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Section 2: *Estimates of Radiation Dose*

Table of Contents

Knowledge Check #3 - True/False

$CTDI_{vol}$ measures the radiation dose to the patient:

- True
- False

Correct!

The answer is False. $CTDI_{vol}$ measures the radiation dose to one of the CTDI phantoms.

It is NOT an estimate of patient dose because it does not take into account patient size, patient shape, or the varying tissue attenuating factors of the human body and, therefore, it may significantly underestimate dose.

Radiation Quantities & Units

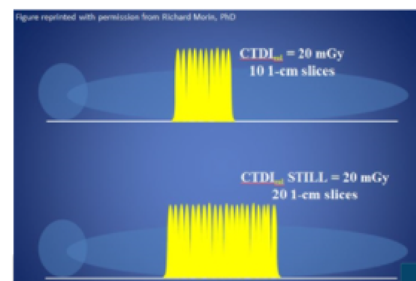
What is the dose from an abdominal CT scan?

Intuitively, we understand that the biologic risk from 20 CT slices should be greater than from 10 CT slices.

If the average dose is 20 mGy for 10 slices, what is the dose for 20 slices?

In the image to the right, ten 1 cm slices were delivered in the top example, while twenty 1 cm slices were delivered in the bottom. However, the $CTDI_{vol}$ of each slice was 20mGy in both examples.

So how do we represent the possible greater biologic risk?



Radiation Quantities & Units

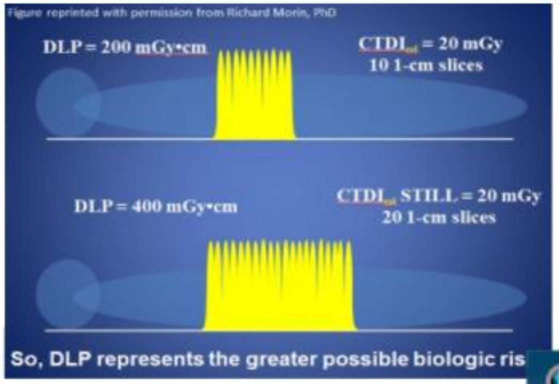
This dilemma led to the development of an additional radiation quantity:

Dose Length Product (DLP): is the dose index that represents the "summed" dose along the total scan length: calculated by

DLP = $CTDI_{vol}$ (mGy) • scan length (cm)

where
total scan length = # slices • slice width

The $CTDI_{vol}$ is the same in both of these examples. However, the DLP in the second example (400 mGy-cm) is double the DLP in the first example (200 mGy-cm) because of the longer scan length.



Another Challenge:

While DLP provides more information about the possible risk than $CTDI_{vol}$, DLP like $CTDI_{vol}$ is not an indicator of patient dose.

Neither $CTDI_{vol}$ nor DLP account for changes in patient size since both use the dose delivered to 1 of the 2 standard CTDI phantoms.

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Section 2: *Estimates of Radiation Dose*

Table of Contents

Knowledge Check #4 - Multiple Choice

What additional radiation dose factor does the DLP account for?

- ○ Patient weight
- ○ Patient thickness
- ◉ Scan length

Correct!

The DLP represents the "summed" dose along the entire scan length, so DLP = $CTDI_{vol}$ x scan length (cm). It reflects the greater radiation dose associated with a greater number of slices. Because it is based on $CTDI_{vol}$, it is NOT a measure of patient dose.

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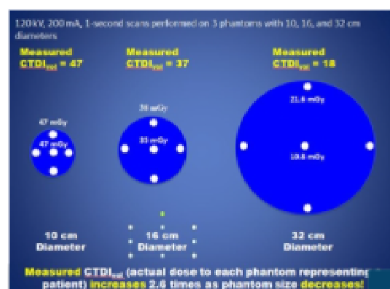
Section 2: *Estimates of Radiation Dose*

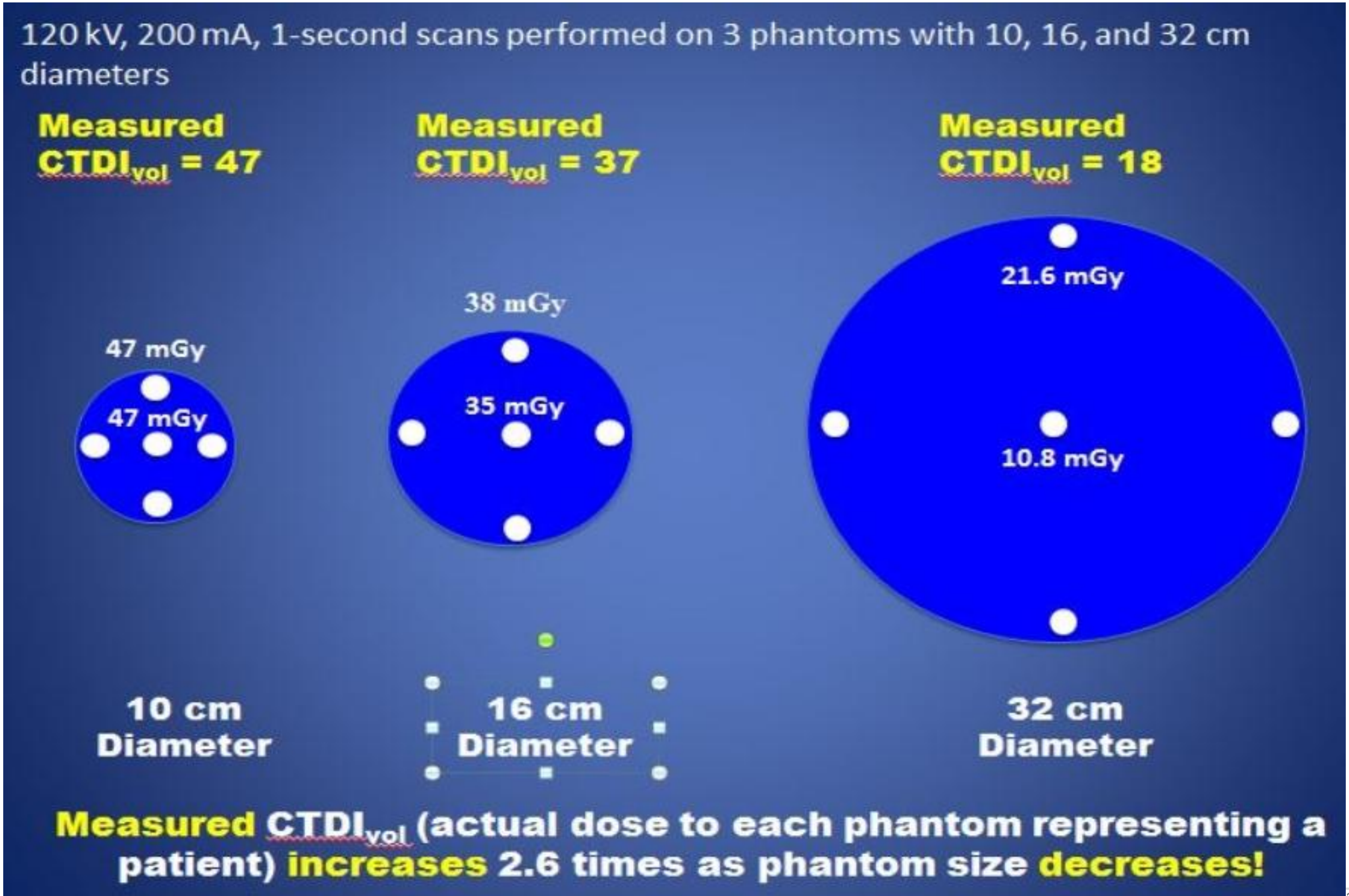
Table of Contents

Since the **displayed CTDI$_{vol}$** is, by definition, the dose to either the 16 or 32 cm CTDI phantom:

- When the patient size changes and all the scan parameters remain identical
- **The displayed CTDI$_{vol}$ does not change, in spite of the different body sizes!**

Let's demonstrate this important point.




120 kV, 200 mA, 1-second scans performed on 3 phantoms with 10, 16, and 32 cm diameters
Measured CTDI$_{vol}$ = 47
Measured CTDI$_{vol}$ = 37
Measured CTDI$_{vol}$ = 18
47 mGy
47 mGy
38 mGy
35 mGy
21.6 mGy
10.8 mGy
10 cm Diameter
16 cm Diameter
32 cm Diameter
Measured CTDI$_{vol}$ (actual dose to each phantom representing a patient) increases 2.6 times as phantom size decreases!

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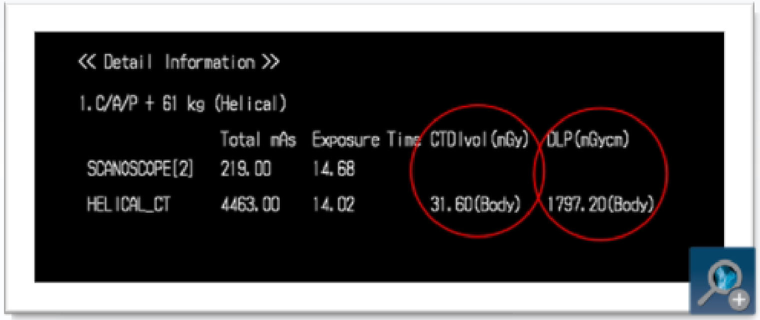
Despite the fact that $CTDI_{vol}$ and DLP are not patient doses, these are the values currently provided by the CT scanner:

- Dose Report (shown here) or
- DICOM Structured Report (DICOM header)

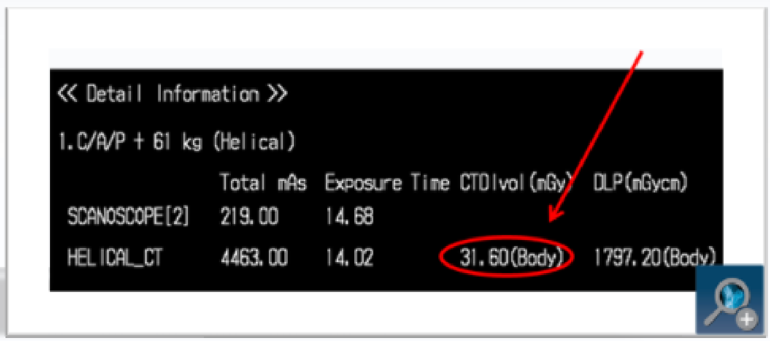


The '(Body)' tells us the 32 cm body CTDI phantom was used to calculate $CTDI_{vol}$.

Another Challenge:

One must know which phantom was referenced in order to understand the estimated dose ($CTDI_{vol}$) on the display. The conversion factor (2) to correct from one CTDI phantom to the other is given by the equation below.

RADIATION OUTPUT,
NOT PATIENT DOSE !



$$31.6 \text{ mGy } CTDI_{vol}\ 32 \times 2 = 63.2 \text{ mGy } CTDI_{vol}\ 16$$

$$CTDI_{vol}\ 32 \times 2 = CTDI_{vol}\ 16$$

DICOM Structured Report

DICOM: Digital Imaging and Communications in Medicine

The DICOM Radiation Dose Structured Report (RDSR) includes all imaging parameters utilized in a scan in addition to the dose report. This report can be exported into a spreadsheet, making data collection much easier. This report may not be available on older equipment. **DICOM SR provides more information than the Dose Report**.

Scan Len (mm)	CTDIvol (mGy)	DLP (mGy*cm)	Phantom Type	KVP (kV)	MA Mean (mA)	MA Max (mA)	Expo Time (Sec)	Expo Time / Rot(Sec)	Pitch Factor
2				120		20	2.4		
2				120		20	2.4		
210	49.4	922.3	IEC Head Dosimetry Phantom	100		340	10.78	0.75	0.84

This illustration is an example of the RDSR showing only a small portion of the entire report.

Scan Len (mm)	CTDIvol (mGy)	DLP (mGy*cm)	Phantom Type	KVP (kV)	MA Mean (mA)	MA Max (mA)	Expo Time (Sec)	Expo Time / Rot(Sec)	Pitch Factor
2				120		20	2.4		
2				120		20	2.4		
210	49.4	922.3	IEC Head Dosimetry Phantom	100		340	10.78	0.75	0.844

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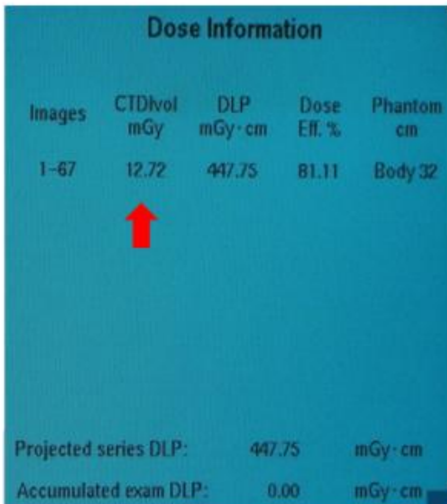
Section 2: *Estimates of Radiation Dose*

Table of Contents

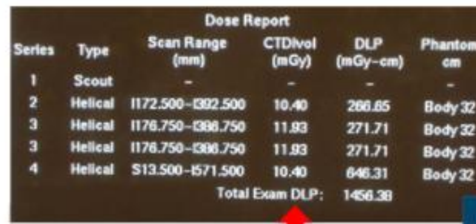
Current CT dose displays vary by manufacturer



Dose Information

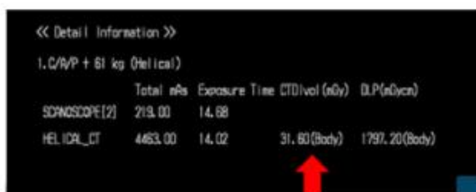
Images	CTDIvol mGy	DLP mGy·cm	Dose Eff. %	Phantom cm
1-67	12.72	447.75	81.11	Body 32

Projected series DLP:	447.75	mGy·cm
Accumulated exam DLP:	0.00	mGy·cm



Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
2	Helical	I1172.500-I1392.500	10.40	266.65	Body 32
3	Helical	I1176.750-I1386.750	11.93	271.71	Body 32
3	Helical	I1176.750-I1386.750	11.93	271.71	Body 32
4	Helical	S13.500-I1571.500	10.40	646.31	Body 32
			Total Exam DLP:	1456.38	



<< Detail Information >>

1.C/A/P + 61 kg (Helical)

	Total mAs	Exposure Time	CTDIvol(mGy)	DLP(mGycm)
SCANOSCOPE[2]	219.00	14.68		
HELICAL_CT	4463.00	14.02	31.60(Body)	1797.20(Body)

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Knowledge Check #5

What two measures of radiation dose are provided on the CT dose report and the DICOM structured report?

The expert:

$CTDI_{vol}$ and DLP

Remember, these are NOT patient doses. Also, depending on the size of the phantom, a conversion factor (2) may need to be used to correct from one CTDI phantom to the other.

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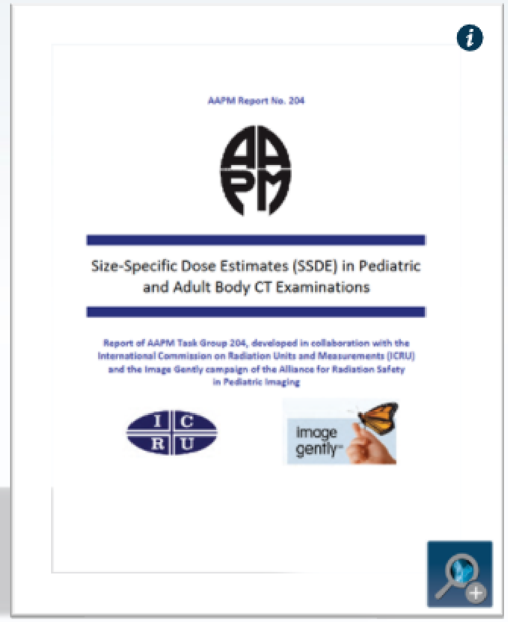
Section 2: *Estimates of Radiation Dose*

Table of Contents

The AAPM developed a new patient dose estimate called Size Specific Dose Estimate, or SSDE, which takes into account the effect of the patient's size on their radiation dose. SSDE is currently the best estimate of patient dose.


AAPM Report No. 204

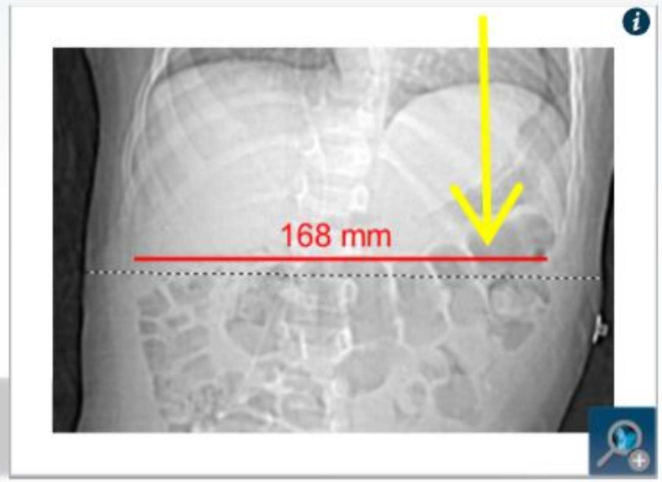
Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations

Report of AAPM Task Group 204, developed in collaboration with the International Commission on Radiation Units and Measurements (ICRU) and the Image Gently campaign of the Alliance for Radiation Safety in Pediatric Imaging

Size Specific Dose Estimate (SSDE)

- Better estimate of patient dose
- Based on patient body size (e.g., 16.8 cm lateral dimension)
- Accurate to within 10-20%
- A conversion factor is applied to $CTDI_{vol}$

16.8 cm lateral dimension



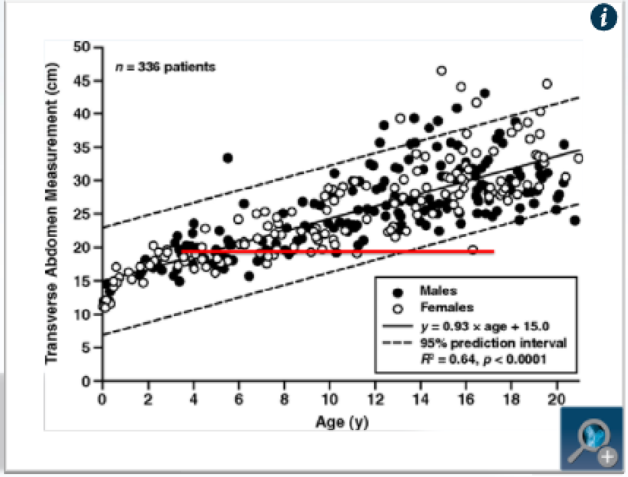
Four things needed to calculate SSDE

1. Patient size
2. CTDI phantom used (16 or 32 cm) to display $CTDI_{vol}$
3. Conversion factor in lookup table in TG204
4. Displayed $CTDI_{vol}$ from clinical scan

Estimating body size

The most accurate method to estimate body size is patient thickness.

- The largest 4-year-old patients are the same size as the smallest 18-year-old patients



Avoid using:

1. Age
2. Weight

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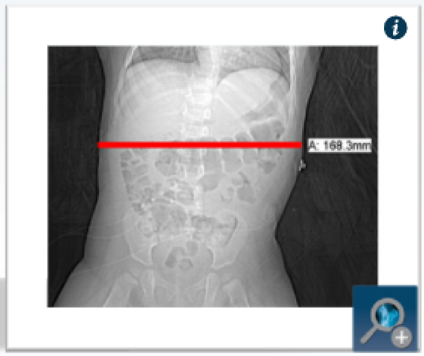
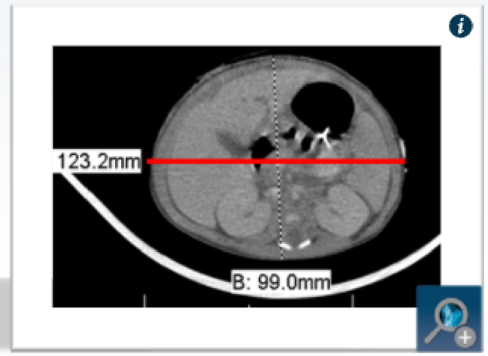
Patient size can be calculated from the projection scan **BEFORE** the scan or from the axial image **AFTER** the scan.



The red line demonstrates the lateral width as measured with electronic calipers.



The red line demonstrates the lateral width, and the dotted vertical line demonstrates the anteroposterior (AP) dimension.

SSDE can be calculated from

- AP dimension
- Transverse or lateral dimension
- AP + lateral dimensions or
- Effective diameter

For the Dose Index Registry, the SSDE is automatically calculated from the de-identified projection scan. Possibly in the future, SSDE will become part of the Dose Report captured by PACS or in the DICOM structured report.

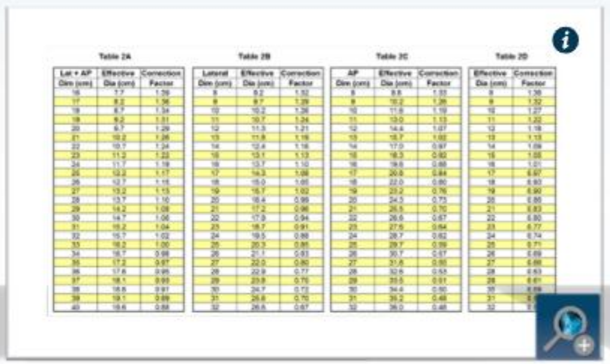
These lookup tables in the TG204 report provide the conversion factors for a patient scanned using the 16 cm phantom to the displayed $CTDI_{vol}$. Tables for the 32 cm phantom are also provided.

IMAGE WISELY
Radiation Safety Case

Section 2: *Estimates of Radiation Dose*

Table of Contents

These lookup tables in the TG204 report provide the conversion factors for a patient scanned using the 16 cm phantom to the displayed $CTDI_{vol}$. Tables for the 32 cm phantom are also provided.



For reference when the 16 cm diameter PMMA phantom was used to compute $CTDI_{vol}$

IMAGE WISELY

Table 2A

Lat + AP Dim (cm)	Effective Dia (cm)	Correction Factor
16	7.7	1.39
17	8.2	1.36
18	8.7	1.34
19	9.2	1.31
20	9.7	1.29
21	10.2	1.26
22	10.7	1.24
23	11.2	1.22
24	11.7	1.19
25	12.2	1.17
26	12.7	1.15
27	13.2	1.13
28	13.7	1.10
29	14.2	1.08
30	14.7	1.06
31	15.2	1.04
32	15.7	1.02
33	16.2	1.00
34	16.7	0.98
35	17.2	0.97
36	17.6	0.95
37	18.1	0.93
38	18.6	0.91
39	19.1	0.89
40	19.6	0.88

Table 2B

Lateral Dim (cm)	Effective Dia (cm)	Correction Factor
8	9.2	1.32
9	9.7	1.29
10	10.2	1.26
11	10.7	1.24
12	11.3	1.21
13	11.8	1.19
14	12.4	1.16
15	13.1	1.13
16	13.7	1.10
17	14.3	1.08
18	15.0	1.05
19	15.7	1.02
20	16.4	0.99
21	17.2	0.96
22	17.9	0.94
23	18.7	0.91
24	19.5	0.88
25	20.3	0.85
26	21.1	0.83
27	22.0	0.80
28	22.9	0.77
29	23.8	0.75
30	24.7	0.72
31	25.6	0.70
32	26.6	0.67

Table 2C

AP Dim (cm)	Effective Dia (cm)	Correction Factor
8	8.8	1.33
9	10.2	1.26
10	11.6	1.19
11	13.0	1.13
12	14.4	1.07
13	15.7	1.02
14	17.0	0.97
15	18.3	0.92
16	19.6	0.88
17	20.8	0.84
18	22.0	0.80
19	23.2	0.76
20	24.3	0.73
21	25.5	0.70
22	26.6	0.67
23	27.6	0.64
24	28.7	0.62
25	29.7	0.59
26	30.7	0.57
27	31.6	0.55
28	32.6	0.53
29	33.5	0.51
30	34.4	0.50
31	35.2	0.48
32	36.0	0.46

Table 2D

Effective Dia (cm)	Correction Factor
8	1.38
9	1.32
10	1.27
11	1.22
12	1.18
13	1.13
14	1.09
15	1.05
16	1.01
17	0.97
18	0.93
19	0.90
20	0.86
21	0.83
22	0.80
23	0.77
24	0.74
25	0.71
26	0.69
27	0.66
28	0.63
29	0.61
30	0.59
31	0.56
32	0.54

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Radiation Safety Case

Section 2: *Estimates of Radiation Dose*

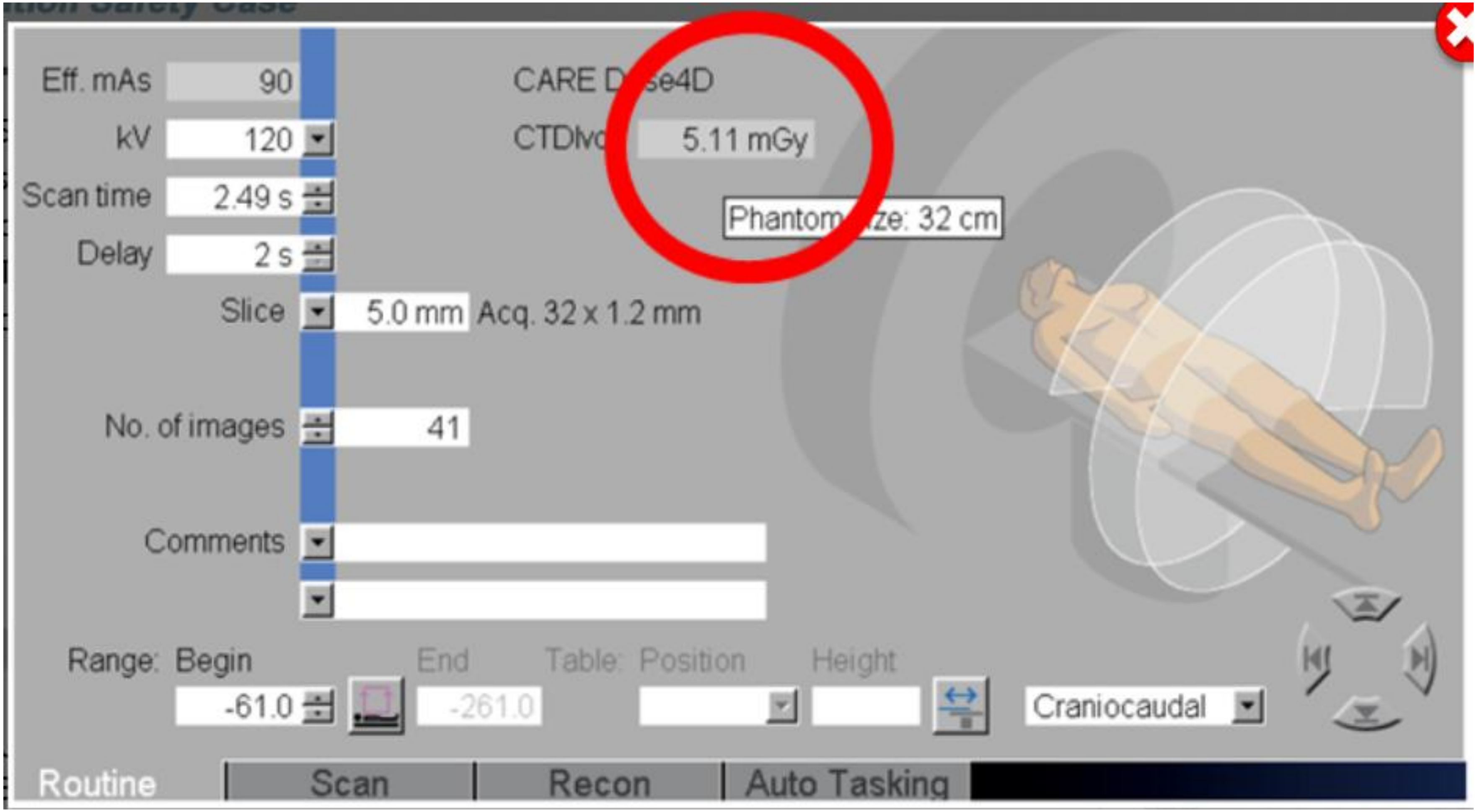
Table of Contents

SSDE can be calculated **before** the scan by measuring the patient size from the projection scan. On the console display, note the CTDI (red circle) after the radiographic technique has been selected. Note that the CTDI was based on the 32cm phantom. Find the correct table in TG204 document: 32cm - lateral dimension (red box) to find the conversion factor to calculate SSDE.

Lateral Dim (cm)	Effective Dia (cm)	Correction Factor
8	9.2	2.65
9	9.7	2.60
10	10.2	2.55
11	10.7	2.50
12	11.3	2.45
13	11.8	2.40
14	12.4	2.35
15	13.1	2.29
16	13.7	2.24
17	14.3	2.19

Use lateral dimension from the CT projection scan
32 cm phantom

5.1mGy ($CTDI_{vol}$) x 2.29(conversion factor) = 11.6 mg (SSDE)


Eff. mAs 90
kV 120
Scan time 2.49 s
Delay 2 s
Slice 5.0 mm Acq. 32 x 1.2 mm
No. of images 41
Comments
CARE Dose4D
CTDIvol 5.11 mGy
Phantom size: 32 cm
Range: Begin -61.0 End -261.0 Table: Position Height
Craniocaudal
Routine Scan Recon Auto Tasking

Lateral Dim (cm)	Effective Dia (cm)	Correction Factor
8	9.2	2.65
9	9.7	2.60
10	10.2	2.55
11	10.7	2.50
12	11.3	2.45
13	11.8	2.40
14	12.4	2.35
15	13.1	2.29
16	13.7	2.24
17	14.3	2.19

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SSDE can be calculated **after** the scan from the axial image.

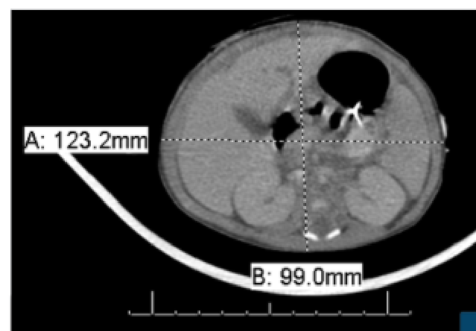
The dose report showed a $CTDI_{vol}$ **32** of **5.40 mGy**.
In this case, the radiographers chose to add the lateral and AP dimension.

12 cm (lat) + 10 cm (ap) = **22 cm (lat +ap)**

Lat + AP Dim (cm)	Effective Dia (cm)	Correction Factor
15	7.2	2.84
16	7.7	2.79
17	8.2	2.74
18	8.7	2.69
19	9.2	2.64
20	9.7	[illegible]
21	10.2	[illegible]
22	10.7	2.50
23	11.2	2.46
24	11.7	2.41
25	12.2	2.37
26	12.7	2.32
27	13.2	2.28
28	13.7	2.24
29	14.2	2.20
30	14.7	2.16

SSDE = 5.4 mGy × 2.5

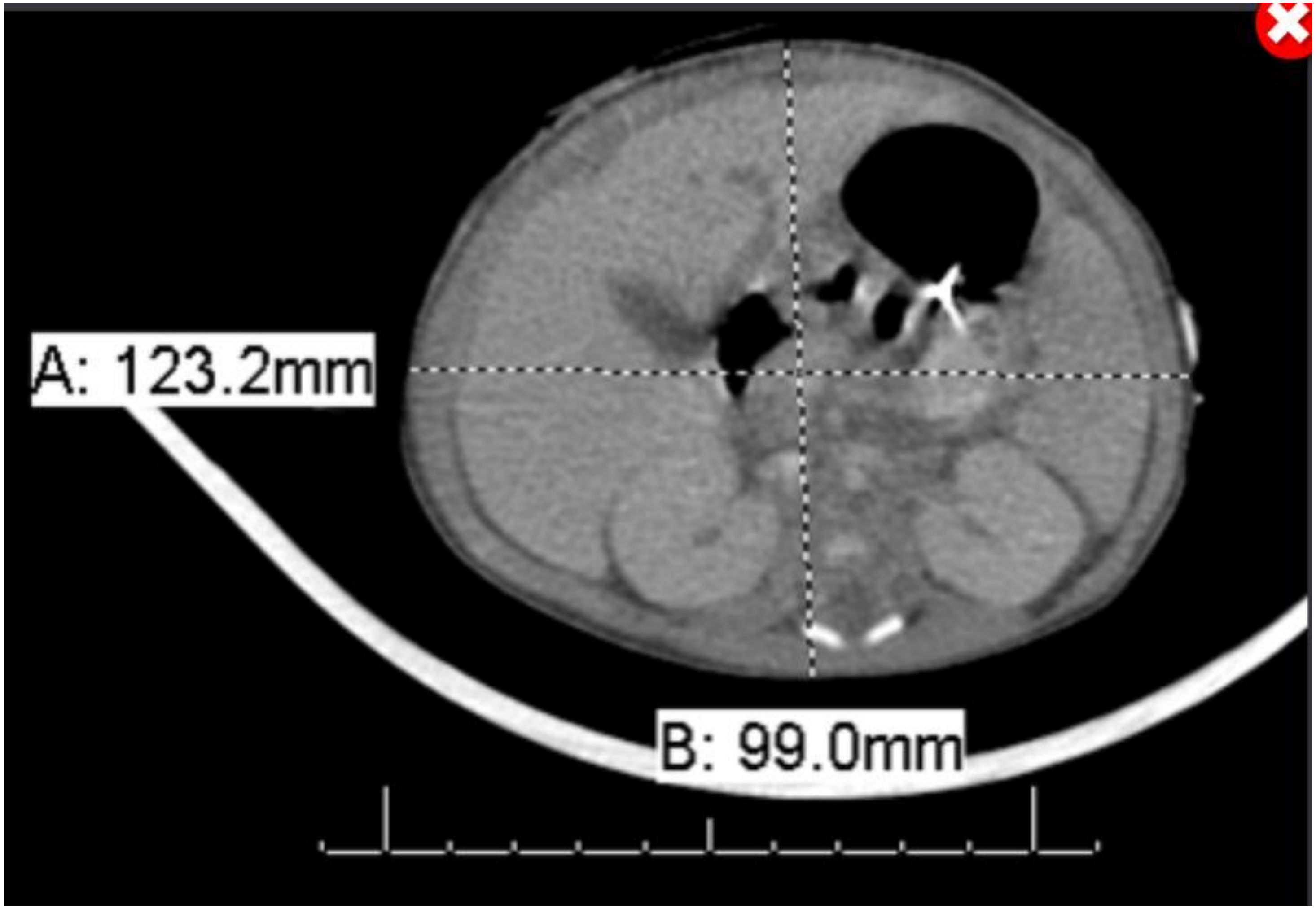
SSDE = 14 mGy



Lat + AP Dim (cm)	Effective Dia (cm)	Correction Factor
15	7.2	2.84
16	7.7	2.79
17	8.2	2.74
18	8.7	2.69
19	9.2	2.64
20	9.7	[illegible]
21	10.2	[illegible]
22	10.7	2.50
23	11.2	2.46
24	11.7	2.41
25	12.2	2.37
26	12.7	2.32
27	13.2	2.28
28	13.7	2.24
29	14.2	2.20
30	14.7	2.16

SSDE = 5.4 mGy × 2.5

SSDE = 14 mGy


A: 123.2mm
B: 99.0mm

Knowledge Check #6 - Check All That Apply

What i[...]

- [x] Dis
- [x] CT
- [x] Pa
- [ ] Dis

Correct!

You selected the correct response.

You have completed **Section 2**. Click the **Continue** button to proceed to **Section 3**.

To return to the table of contents, click **Table of Contents** button.

Continue to Section 3

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Section 3: *Relationship of Image Quality to Dose*

Table of Contents

Ensure that pediatric patients receive no more radiation than needed to answer the clinical question. One factor that influences radiation dose is image quality. Image noise is one component of assessing image quality.

1/5

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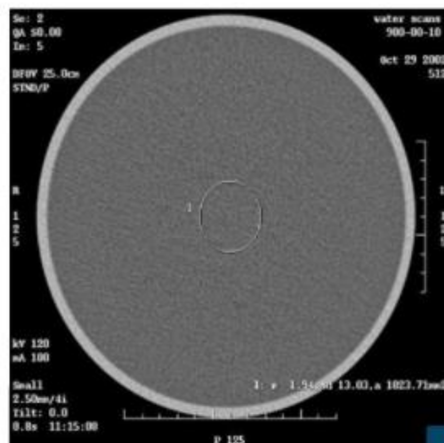
Section 3: *Relationship of Image Quality to Dose*

Image Noise

Image noise appears as the speckled gray background of a uniform phantom. It is measured as the standard deviation of the voxel values in a homogenous (typically water) phantom.



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Section 3: *Relationship of Image Quality to Dose*

Table of Contents

Image quality plays an important role in radiation protection for children. Take a look at the example below.

Image A

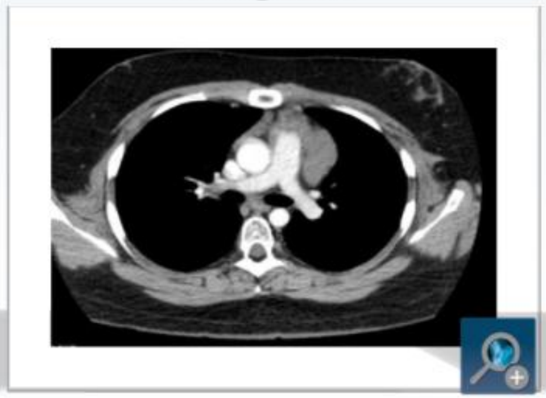

Image B

These are two CT images of a teenage boy who had two scans three months apart. Note that **Image B** has a more "mottled" or grainy appearance than **Image A**.

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3/5

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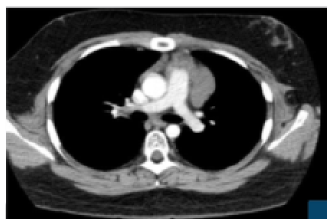
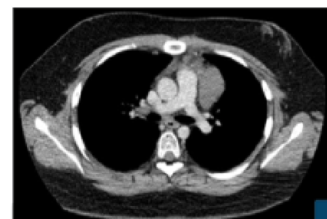
Estimated patient dose (**DLP**) demonstrates that **Image A** is more than twice the dose of **Image B**. If the clinical diagnosis can be made at a lower patient dose, most radiologists will "accept" the grainier image.

A. Higher dose



DLP.e(mGycm) (Head) : - (Body) : 1284.50

B. Lower dose



DLP(mGycm) (Head) : - (Body) : 559.50

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Section 3: *Relationship of Image Quality to Dose*

There is a point or threshold below which a CT scan dose is so low that no diagnosis can be made.

Lowering protocols must be done with caution and with consensus from the local medical imaging team, particularly the radiologists. If no diagnosis is possible from a low dose image, the radiation to the patient, although reduced, was wasted.

Why is the balance of radiation dose and image quality particularly important for children?

Since children are much more sensitive to radiation, a balance between achieving an acceptable image that can be interpreted and the dose delivered to the patient must be found.

Knowledge Check #7 - True/False

Higher radiation doses are generally associated with better image quality:

- (●) True
- ( ) False

Correct!

Because children are more sensitive to radiation, it is important to find the balance between achieving an acceptable image that can be interpreted and the minimizing the radiation dose delivered to the patient.

Although a higher dose scan generally produces better image quality, if a diagnosis can be made with a lower dose scan (with more image noise), there is no reason to perform a higher dose scan.

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Section 4: *Diagnostic Reference Levels*

Table of Contents

It is important for medical imaging professionals to be aware of target levels for CT radiation dose for different exams and to work to stay below the target level.

One method of assessing target levels is the development of Diagnostic Reference Levels.

DRLs are dose levels for typical examinations for groups of standard-sized patients or standard phantoms for different types of equipment.

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1/4

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Diagnostic Reference Levels (DRLs)

- Are derived from surveys or registries of many patients that track a facility's CT data
- Are a tool to compare doses at different sites
- Apply to populations of patients, NOT individual exams
- Are a supplement to professional judgment
- Are NOT a dividing line between good or bad medicine
- Are inappropriate to use for regulatory or commercial purposes
- Are voluntary
- Will change over time with changes in practice

If a site's CT dose estimates are > 75th percentile compared to peers (DRL, typically), local action should be triggered.

Knowledge Check #8 – Select the Correct Choice

DRLs are dose levels for typical examinations for groups of patients that are derived from practice surveys or registries. Which of the following statements regarding DRLs is correct?

- ○ They show whether an institution is practicing good medicine.
- ◉ They are used to compare doses at different sites.

Correct!

DRLs are used for quality improvement; they are NOT used to determine "good" or "bad" medical practice.

American College of Radiology CT Accreditation Standards

The new upper limit for pass/fail for an abdominal CT for a 5 year old is 20 mGy using the 16 cm CTDI phantom as a reference.

ACR CT Accreditation Dose Pass/Fail Criteria and Reference Levels

Examination	Pass/Fail Criteria $CTDI_{vol}$ (mGy)	Reference Levels $CTDI_{vol}$ (mGy)
Adult Head	80	75
Adult Abdomen	30	25
Pediatric Head (1 year old)	40	35
Pediatric Abdomen (40-50 lb.)	20	15

***20 mGy based 16 cm phantom= 10 mGy based on a 32 cm phantom

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Section 4: *Diagnostic Reference Levels*

Diagnostic Reference Levels (mGy) for pediatric abdomen/pelvis CT

Patient Body Width

	SSDE (mGy)					
Width (cm)	N	Mean	Std Error	Lower DRR (25th Percentile)	Median (50th Percentile)	Upper DRR (75th Percentile)
<15	21	8.6	0.9	5.8	8.0	12.0
15-19	153	10.0	0.5	7.3	8.7	12.2
20-24	286	11.4	0.7	7.6	9.8	13.4
25-29	326	13.5	0.3	9.8	13.0	16.4
30+	168	16.5	0.4	13.1	15.6	19.0

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4/4

Continue to Section 5

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	SSDE (mGy)					
	N	Mean	Std Error	Lower DRR (25th Percentile)	Median (50th Percentile)	Upper DRR (75th Percentile)
Width (cm)						
<15	21	8.6	0.9	5.8	8.0	12.0
15-19	153	10.0	0.5	7.3	8.7	12.2
20-24	286	11.4	0.7	7.6	9.8	13.4
25-29	326	13.5	0.3	9.8	13.0	16.4
30+	168	16.5	0.4	13.1	15.6	19.0

What is a registry?

A registry is a systematic method for collection of observational data on patient health and demographics in a uniform manner to evaluate specified metrics for a population defined by a particular condition or procedure.

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Section 5: *The Dose Index Registry and Interpreting DIR Reports*

Table of Contents

The American College of Radiology's Dose Index Registry

In May 2011, the American College of Radiology (ACR) launched its Dose Index Registry (DIR) as part of the National Radiology Data Registry (NRDR). NRDR is a warehouse of ACR quality registry databases that houses several registries including DIR. This fee-based registry allows facilities to automatically upload dose data from their CT scans to compare their facilities' radiation dose indices to other similar facilities for similar types of exams. This registry can be used to monitor and improve quality.

There is also a pediatric CT research registry within the DIR called Quality Improvement Registry in CT scans in Children (QuIRCC) that is working toward establishing target levels or DRLs for pediatric CT.

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2/14

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NRDR
NATIONAL RADIOLOGY
DATA REGISTRY

- ACR NRDR Homepage
- Information For Facilities
- New Facility Registration
- Participation Agreement
- Registries
  - CTC
  - DIR
  - GRID
  - ICE
  - NMD
  - NOPR
  - QuIRCC
- FAQ
- IRB Exemption
- NRDR User Guide

User Type: Facility User Facility ID: User name: Password: Log In

Forgot password?

NRDR

The National Radiology Data Registry is a data warehouse for the registries listed below. The primary purpose of NRDR is to aid facilities with their quality improvement programs and efforts to improve patient care by comparing facility data to that of their region and the nation. A practice or facility may choose to participate in any or all registries as appropriate for their practice. When a facility joins more than one registry, the warehouse allows information to be shared across registries within the facility.

CTC

The CT Colonography Registry collects measures critical to evaluating CT colonography procedures. Data collected in this registry will contribute to the evaluation of colonography as an alternative to colonoscopy.

DIR

The Dose Index Registry (DIR) allows facilities to compare their CT dose indices to regional and national values. Institutions receive periodic feedback reports comparing their results by body part and exam type to aggregate results. This data will be used to establish national benchmarks for CT dose indices.

GRID

The General Radiology Improvement Database (GRID) collects information about imaging facilities which is then aggregated to establish benchmarks for quality improvement. It allows facilities and physicians to compare turnaround times, patient wait times, patient satisfaction and many other process and outcome measures with other facilities and practices of similar size and type. For physicians participating in CMS's Physician Quality Reporting Initiative, GRID provides a means of comparing results of the various imaging measures included in the initiative.

ICE

Intravenous iodinated contrast injection for computerized tomography is a commonly used diagnostic tool in nearly every radiology practice. IV contrast extravasation is a known complication of this method and is estimated to occur in up to 0.9% of exams. Although often without serious consequences, these extravasations can produce significant signs and symptoms, and occasionally long-term sequelae.

The Society of Abdominal Radiology (SAR) has developed a reporting template identifying many of the known risk factors for IV contrast extravasation, common treatments, and a reporting tool for initial and long-term outcomes.

NMD

The National Mammography Database (NMD) leverages data that radiology practices are already collecting under federal mandate by providing them with comparative information for national and regional benchmarking. Participants receive semi-annual feedback reports that include important benchmark data such as true positive rates, positive predictive value rates and recall rates.

NOPR - National Oncologic PET Registry

The National Oncology PET Registry (NOPR) is a collaboration of the American College of Radiology Imaging Network (ACRIN), the American College of Radiology (ACR), and the Academy of Molecular Imaging (AMI). Participation in this registry facilitates Medicare reimbursement for certain types of positron emission tomography (PET) scans.

What is the purpose of the CT DIR?

- To collect dose data ($CTDI_{vol}$ and SSDE) from children from multiple sites undergoing CT scans of the same body part
- An opportunity for an individual practice to monitor CT radiation dose estimates compared to target levels and compare their estimates with other facilities

What type of data does the CT DIR collect?

- Parameters such as scanner type and vendor, all technical factors involved in the scan protocol, and age are automatically uploaded to the ACR DIR when your facility signs up for the DIR

Sites must sign a participation agreement with the ACR, pay a fee, and install software that enables a connection.

All sites automatically send the de-identified projection view (scout), so that more accurate data based on patient size (not age) can be obtained.

Knowledge Check #9 - Match the Expert

The information automatically uploaded to the DIR includes parameters such as scanner type and vendor, all technical factors involved in the scan protocol, age, and a de-identified projection view (scout). What is the purpose of uploading the scout view?

The expert:

The scout view is uploaded so that the SSDE can be calculated. This provides a more accurate estimate of patient dose than estimates based on patient age.

DIR table data

- The 25th percentile, median, and 75th percentile of $CTDI_{vol}$ or SSDE are displayed for the DIR as a whole and for an individual site
- Data is divided by:
  - Type of exam (e.g., CT head without IV contrast)
  - Age level

Type of exam	Age (years)	DIR ($CTDI_{vol}$) 25%ile/med/75%ile	Site ($CTDI_{vol}$) 25%ile/med/75%ile
CT HEAD BRN WO IVCON	0-2	(22/33/41)	
	3-6	(27/41/45)	
	7-10	(33/47/54)	
	11-14	(40/49/58)	(67/67/67)
	15-18	(46/54/66)	(25/25/25)

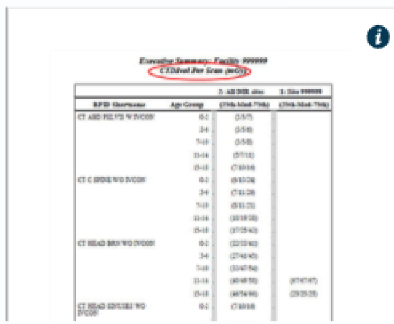
Type of exam	Age (years)	DIR ($CTDI_{vol}$)25%ile	site ($CTDI_{vol}$) 25%ile/med/75%ile
CT HEAD BRN WO IVCON	0-2	(22/33/41)	
	3-6	(27/41/45)	
	7-10	(33/47/54)	
	11-14	(40/49/58)	(67/67/67)
	15-18	(46/54/66)	(25/25/25)

DIR Reports

The DIR reports are presented in two ways:

1. Tables
2. Graphs

In this example, the $CTDI_{vol}$ is used as the dose estimate, as noted in the title of the table (red circle).



This table provides average $CTDI_{vol}$ based on patient age for 4 exams.

Executive Summary: Facility 999999
CTDIvol Per Scan (mGy)

RPID Shortname	Age Group	2: All DIR sites (25th-Med-75th)	1: Site 999999 (25th-Med-75th)
CT ABD PELVIS W IVCON	0-2	(3/5/7)	
	3-6	(3/5/6)	
	7-10	(3/5/8)	
	11-14	(5/7/11)	
	15-18	(7/10/16)	
CT C SPINE WO IVCON	0-2	(6/13/24)	
	3-6	(7/11/26)	
	7-10	(8/11/21)	
	11-14	(10/19/38)	
	15-18	(17/25/43)	
CT HEAD BRN WO IVCON	0-2	(22/33/41)	
	3-6	(27/41/45)	
	7-10	(33/47/54)	
	11-14	(40/49/58)	(67/67/67)
	15-18	(46/54/66)	(25/25/25)
CT HEAD SINUSES WO IVCON	0-2	(7/10/16)	
	3-6	(7/10/17)	
	7-10	(8/14/23)	
	11-14	(12/20/33)	
	15-18	(13/21/39)	(3/3/3)

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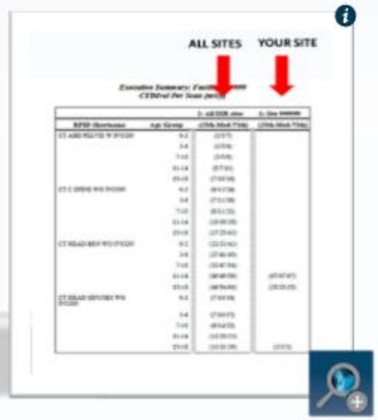
Section 5: *The Dose Index Registry and Interpreting DIR Reports*

Note: The CT And-Pelvis and CT C-Spine are based on the 32 cm CTDI phantom. The CT head and sinus are based on the 16 cm CTDI phantom.

This same table provides the lower (25th percentile) and upper (75th percentile) limits of the target range for all DIR sites and for your site for comparison.



Formazione per l'eccellenza

ALL SITES

YOUR SITE

Executive Summary: Facility 999999
CTDIvol Per Scan (mGy)

RPID Shortname	Age Group	2: All DIR sites (25th-Med-75th)	1: Site 999999 (25th-Med-75th)
CT ABD PELVIS W IVCON	0-2	(3/5/7)	
	3-6	(3/5/6)	
	7-10	(3/5/8)	
	11-14	(5/7/11)	
	15-18	(7/10/16)	
CT C SPINE WO IVCON	0-2	(6/13/24)	
	3-6	(7/11/26)	
	7-10	(8/11/21)	
	11-14	(10/19/38)	
	15-18	(17/25/43)	
CT HEAD BRN WO IVCON	0-2	(22/33/41)	
	3-6	(27/41/45)	
	7-10	(33/47/54)	
	11-14	(40/49/58)	(67/67/67)
	15-18	(46/54/66)	(25/25/25)
CT HEAD SINUSES WO IVCON	0-2	(7/10/16)	
	3-6	(7/10/17)	
	7-10	(8/14/23)	
	11-14	(12/20/33)	
	15-18	(13/21/39)	(3/3/3)

Gemelli

WORLD'S BEST HOSPITALS 2021 Newsweek statista
L'OSPEDALE IN ITALIA
POLICLINICO UNIVERSITARIO A. GEMELLI IRCCS

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Section 5: *The Dose Index Registry and Interpreting DIR Reports*

Table of Contents

The table below demonstrates a more accurate estimate of patient dose based on size, SSDE. The 75th percentile could be considered the upper target or DRL for this exam at this time. Note how the SSDE target levels increase for patients as their age increases.

Executive Summary: Facility 999999
SSDE Per Scan (mGy)

RPID Shortname	Age Group	2: All DIR sites (25th-Med-75th)
CT ABD PELVIS W IVCON	0-2	(4/5/14)
	3-6	(5/7/12)
	7-10	(6/9/13)
	11-14	(9/13/19)
	15-18	(11/16/24)

Executive Summary: Facility 999999

SSDE Per Scan (mGy)

		2: All DIR sites
RPID Shortname	Age Group	(25th-Med-75th)
CT ABD PELVIS W IVCON	0-2	(4/5/14)
	3-6	(5/7/12)
	7-10	(6/9/13)
	11-14	(9/13/19)
	15-18	(11/16/24)

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Section 5: *The Dose Index Registry and Interpreting DIR Reports*

For this facility, for patients aged 11 to 14 years, there was only one patient included in the report.

This patient's $CTDI_{vol}$ was higher than the 75th percentile of all facilities in the DIR at 67 mGy versus 58 mGy (all sites). This site can work with their medical physicist to decrease their target dose for this age group.

16 cm reference phantom	Age in yr	25th/med/75th	25th/med/75th
CT HEAD BRN WO IVCON	0-2	(22/33/41)	
	3-6	(27/41/45)	
	7-10	(33/47/54)	
	11-14	(40/49/58)	(67/67/67)
	15-18	(46/54/66)	(25/25/25)

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Section 5: *The Dose Index Registry and Interpreting DIR Reports*

Because PQI is a continuous process, the DRL for CT of the abdomen/pelvis in children (as well as other DRLs) will likely decrease over time as sites around the country work toward optimizing patient dose.

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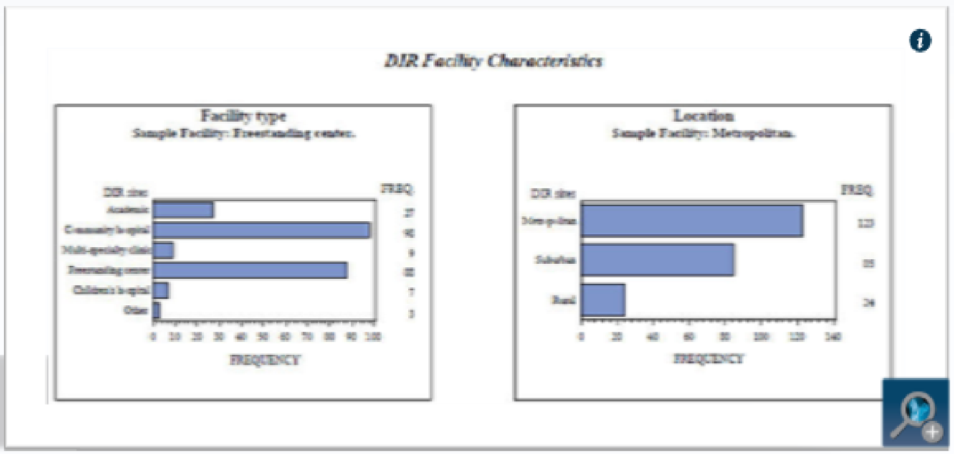
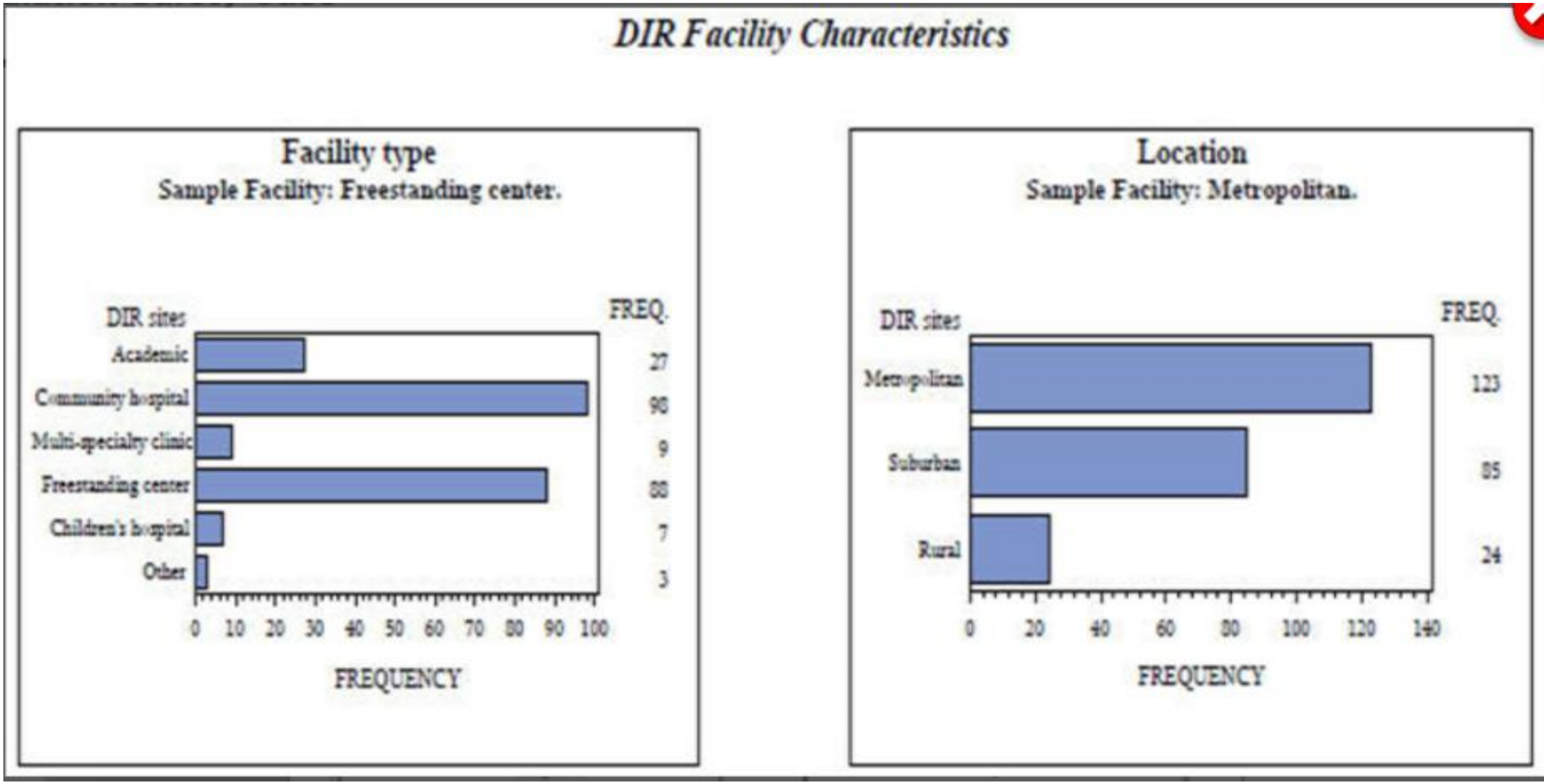
Section 5: *The Dose Index Registry and Interpreting DIR Reports*

Facility Information

This table provides information related to the types of facilities that are sending information to the DIR. At this time, "adult-focused" and free-standing sites make up most of the DIR facilities. These facilities are then further categorized as to location (rural, metropolitan, etc).




DIR Facility Characteristics
Facility type
Sample Facility: Freestanding center.
DIR sites
FREQ.
Academic
Community hospital
Multi-specialty clinic
Freestanding center
Children's hospital
Other
27
98
9
88
7
3
0 10 20 30 40 50 60 70 80 90 100
FREQUENCY
Location
Sample Facility: Metropolitan.
DIR sites
FREQ.
Metropolitan
Suburban
Rural
123
85
24
0 20 40 60 80 100 120 140
FREQUENCY

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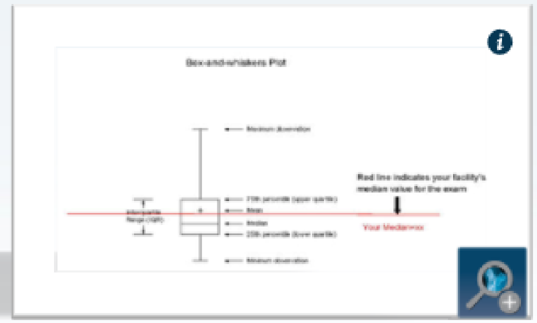
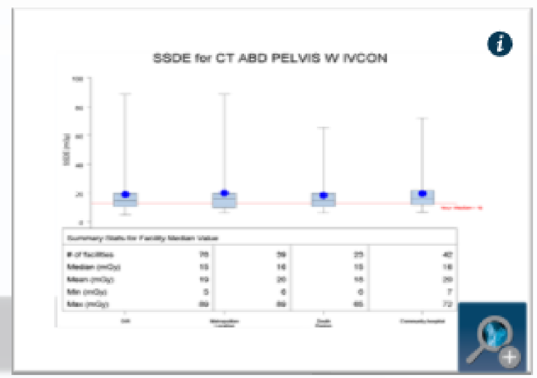
Section 5: *The Dose Index Registry and Interpreting DIR Reports*

Table of Contents

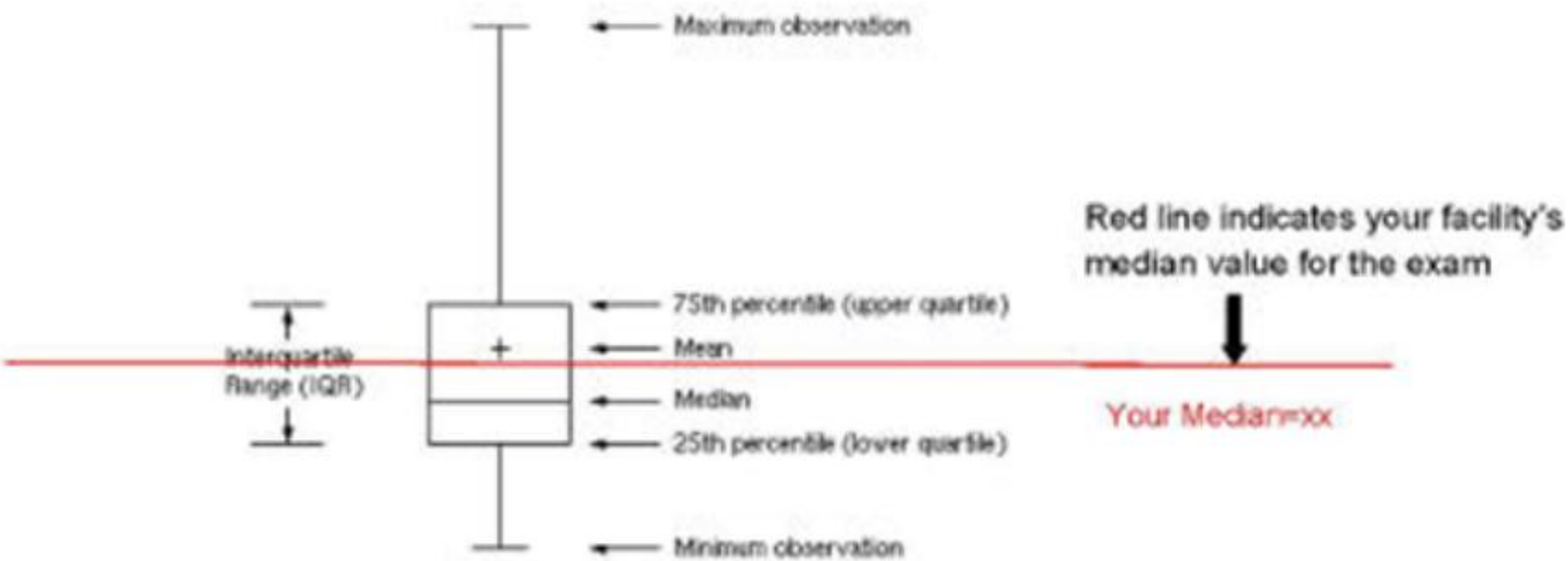
Use this guide to interpret the next "box-and-whiskers" plot.



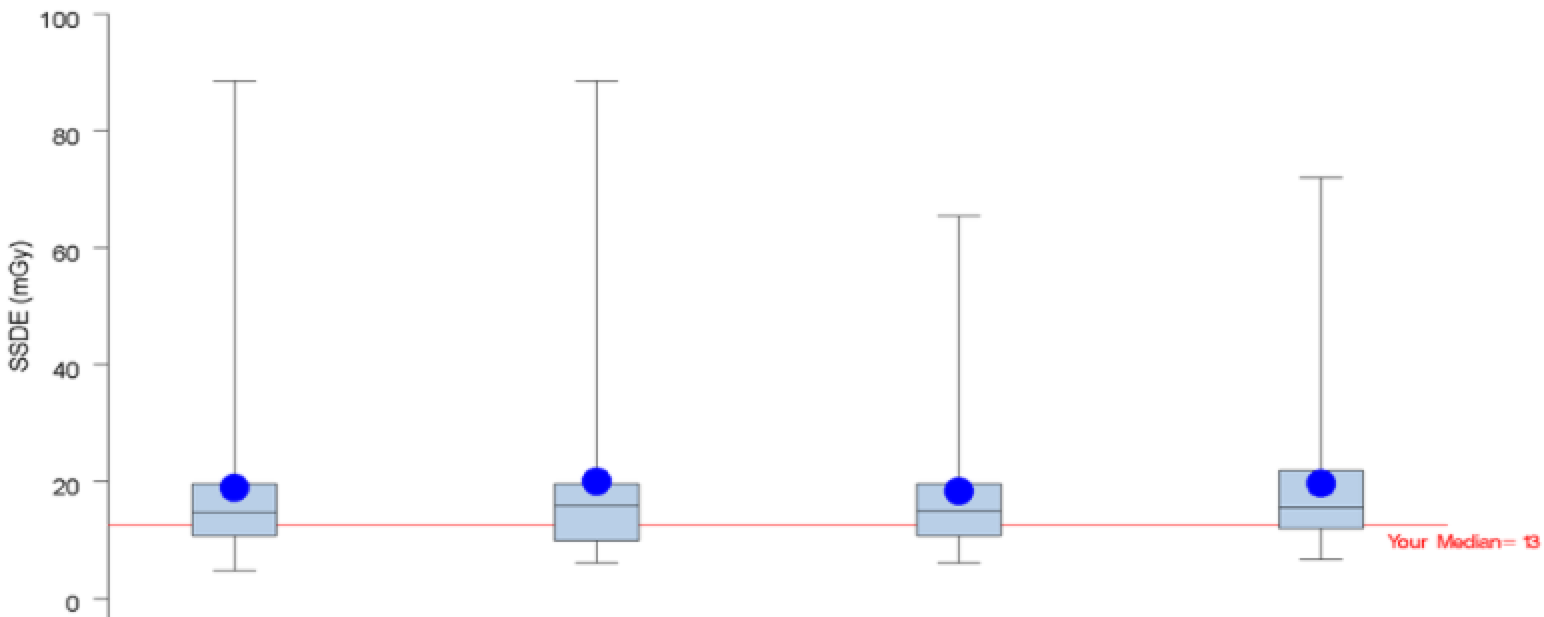
The blue dot shows the median value for all facilities within the DIR. The red line shows the median value for an individual facility. This suggests that the individual facility's CT dose estimates (SSDE) are lower than the national median.



Box-and-whiskers Plot



SSDE for CT ABD PELVIS W IVCON



Summary Stats for Facility Median Value

# of facilities	78	39	23	42
Median (mGy)	15	16	15	16
Mean (mGy)	19	20	18	20
Min (mGy)	5	6	6	7
Max (mGy)	89	89	65	72

DIR | Metropolitan Location | South Region | Community hospital

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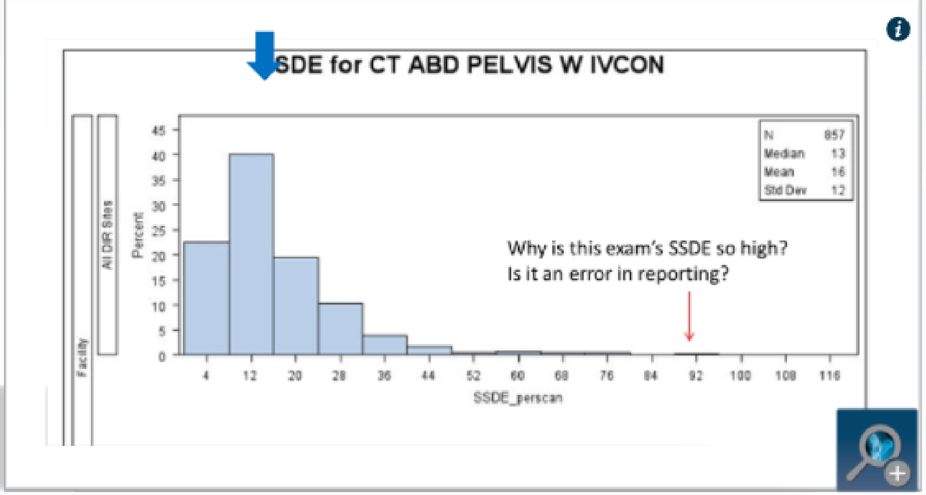
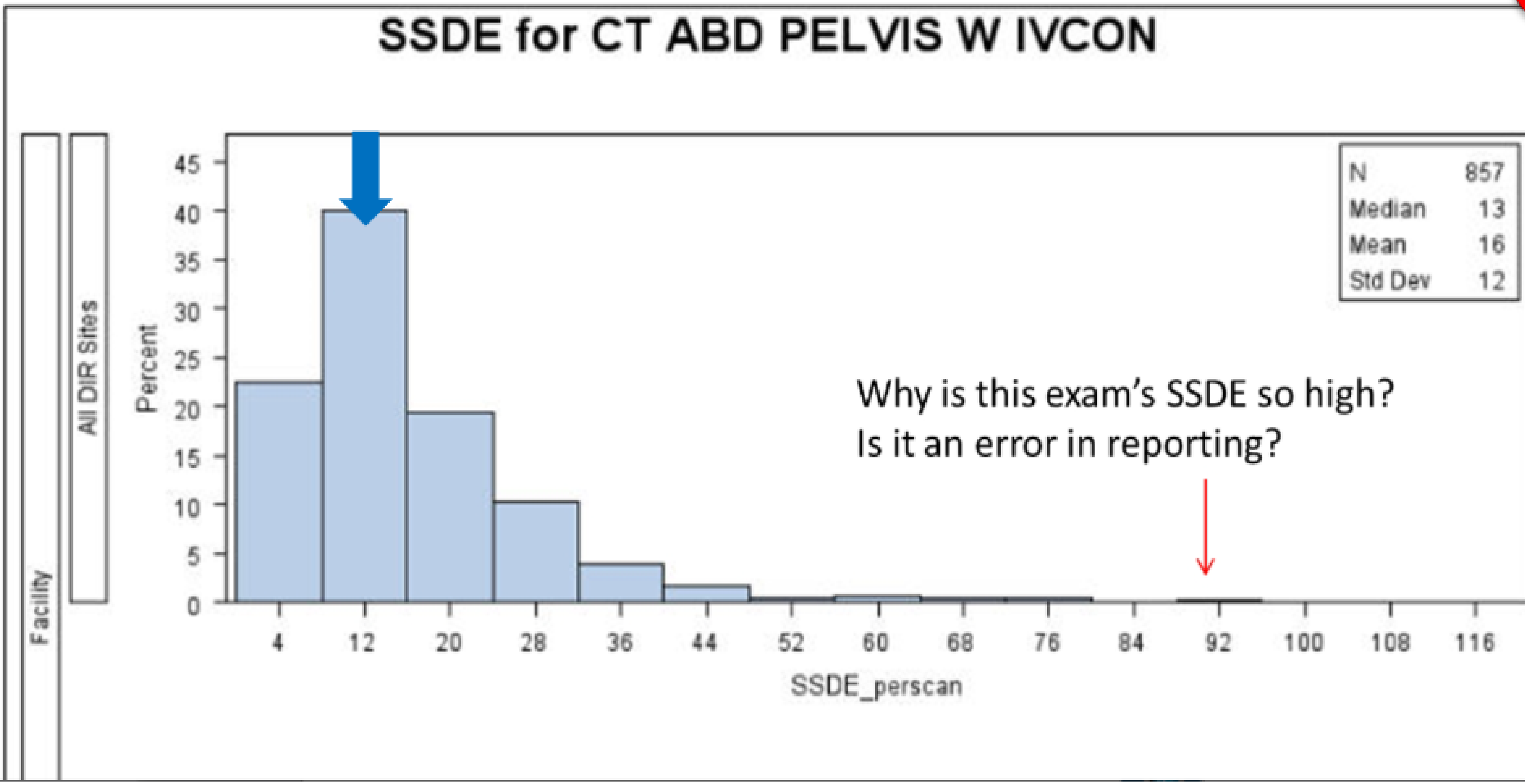
Section 5: *The Dose Index Registry and Interpreting DIR Reports*

This table provides the distribution of dose estimates using SSDE for all DIR sites.

It allows facilities to investigate outliers within their own institution and to compare to other sites nationally. (In this example, the SSDE per scan at one facility was almost 92 mGy).





SSDE for CT ABD PELVIS W IVCON
Facility
All DIR Sites
Percent
45
40
35
30
25
20
15
10
5
0
4
12
20
28
36
44
52
60
68
76
84
92
100
108
116
SSDE_perscan
N 857
Median 13
Mean 16
Std Dev 12
Why is this exam's SSDE so high?
Is it an error in reporting?

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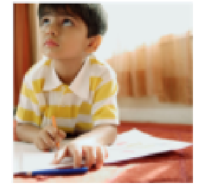
Section 5: *The Dose Index Registry and Interpreting DIR Reports*

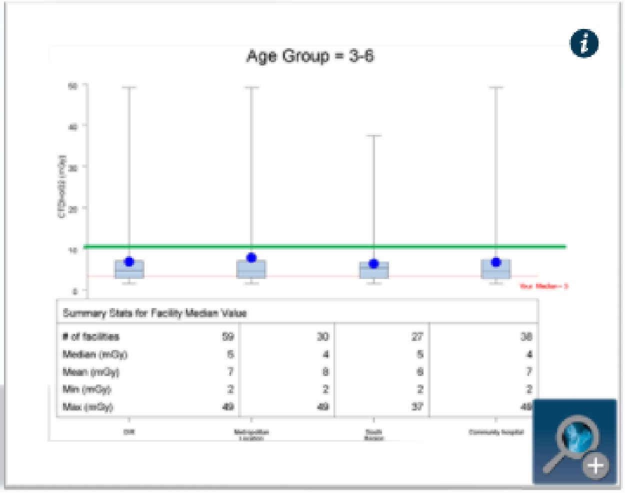
Table of Contents

These reports provide a basis for investigating radiation dose estimates that are higher (or lower) than would be expected and can be used as a quality improvement tool.

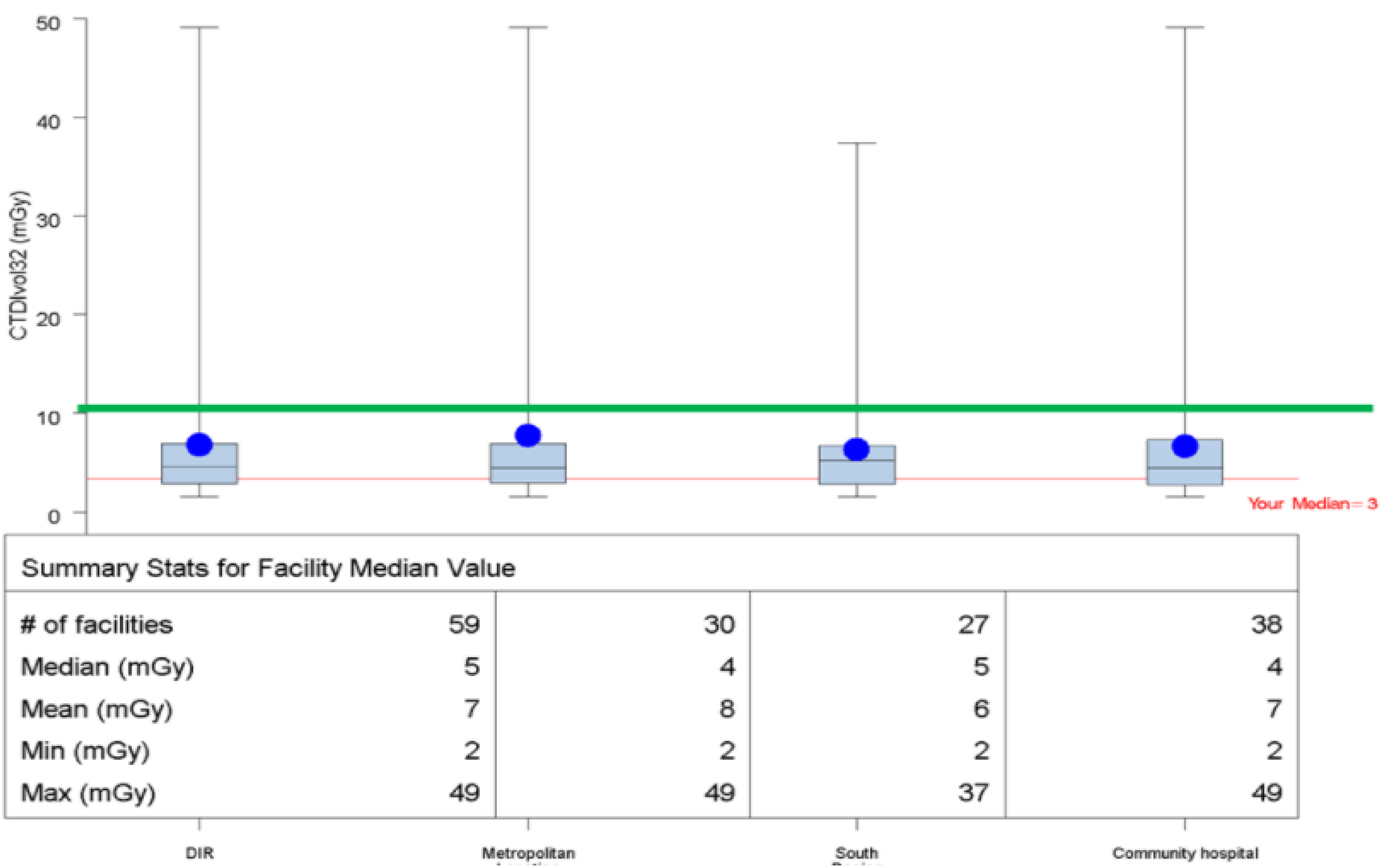
Compare an individual site with the ACR CT accreditation data (green line).

The green line indicates that using $CTDI_{vol}$32 most sites fall below the target range. The median of one particular facility (represented by the red line) is lower than the median of the hospital groups.





Age Group = 3-6



Summary Stats for Facility Median Value				
# of facilities	59	30	27	38
Median (mGy)	5	4	5	4
Mean (mGy)	7	8	6	7
Min (mGy)	2	2	2	2
Max (mGy)	49	49	37	49

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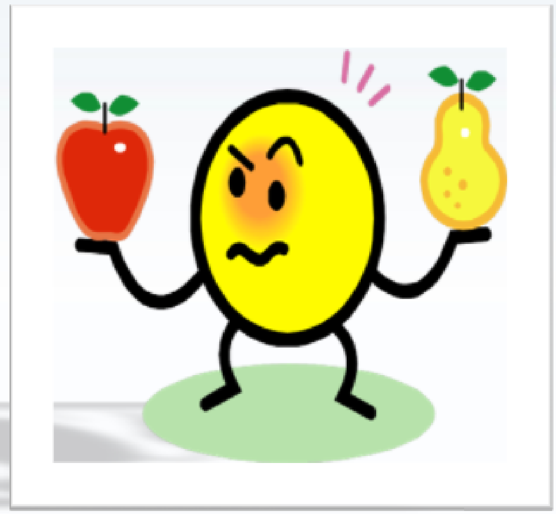
Section 5: *The Dose Index Registry and Interpreting DIR Reports*

How do these dose reports relate to my practice?

The dose reports can be used to compare consistency of exams at one site as well as compare doses between sites.



Knowledge Check #10 - Check All That Apply

The DIR graphs can be used:

- [ ] As a quality improvement tool to track changes in a practice over time.
- [ ] To visually compare data between an individual site and the DIR as a whole.
- [ ] To identify practices with high radiation dose estimates so that they can be investigated by the ACR.
- [ ] To compare an individual site to ACR CT accreditation data.

Knowledge Check #10 - Check All That Apply

The DIR graphs can be used:

- [x] As a quality improvement tool to track changes in a practice over time.
- [x] To visually compare data between an individual site and the DIR as a whole.
- [ ] To identify practices with high radiation dose estimates so that they can be investigated by the ACR.
- [x] To compare an individual site to ACR CT accreditation data.

Correct!

That's right! You selected the correct responses.

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Section 5: *The Dose Index Registry and Interpreting DIR Reports*

The ACR DIR is valuable. Data from QuIRCC, the pediatric research registry, shows that radiation dose estimates from the United States are 43% lower than the ACR CT accreditation data from 2006.

This shows that radiation doses are decreasing in the United States.

This is good news!

- Normalized to 32 cm phantom
- 5 year old abdomen

	QuIRCC 3rd quartile	ACR 3rd quartile
5 yr old (20-24 cm)	5.7 mGy ↓ 43 %	10 mGy

Practical Measures to Optimize Radiation Dose for Pediatric CT

Things you can do:

- Consult with your medical imaging physicist for methods
- Adopt the recommendations and protocols outlined in this module
- "Child-size" CT protocols based on patient body size

CT Protocols

- CT protocols are specific by vendor, number of detectors, software version on the scanner, filtration, and other unique design characteristics of the CT scanner
- Unless your site has a unit identical to another, protocols will **NOT** be transferable
- That is why universal protocols may be a better approach to managing technique

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Section 6: *Practical Steps to Optimize Radiation Dose for Pediatric Patients*

Use "Universal Protocols"

Universal protocols allow any site with any machine to adapt their protocols and compare their results to best practice as suggested by an appropriate DRL.

Use the Image Gently® Universal Protocols

Obtain ACR CT accreditation and follow the directions:

- Go to www.imagegently.org
- Select the tab for CT protocols
- The universal protocols serve as a start to lower dose
- A medical imaging physicist can help adapt to design characteristics of your CT scanner

Other methods to reduce CT dose to pediatric patients

- Appropriate centering
- Optimize projection scans
- Limit scan length
- Eliminate multiphase scans (non-contrast, contrast, delayed CT scans)
- Organ shielding (gonads, thyroid, lens of eye)
- Automatic tube current modulation (ATCM)
- Iterative reconstruction

Appropriate centering

Because the entrance dose to the skin of the patient is, in part, a function of the distance of the skin from the focal spot of the CT scanner (inverse-square law), positioning the patient's body in the middle of the CT gantry reduces the radiation dose to the patient.

Reduce doses during projection views

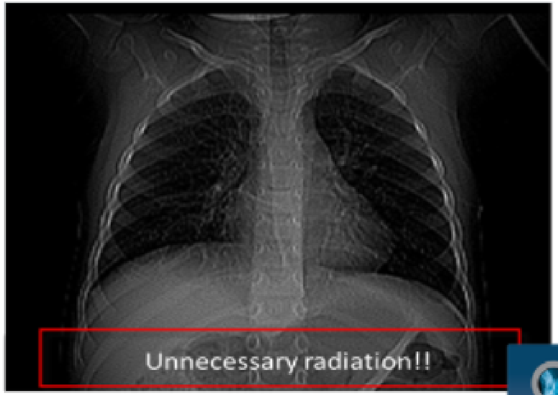
- Switch from an AP scout image to a posteroanterior projection scout image to reduce dose to radiosensitive organs (male gonads, breast, thyroid, lens of the eye)
- Proper adjustment of the high voltage and/or tube current significantly reduces radiation dose to the patient

Limit scan length

Limiting the scan length on both the scout and clinical images is an easy way to reduce the volume of tissues directly irradiated.

Eliminate multiphases

- A multiphase exam may **double** the dose to a pediatric patient!
- Multiphase exams are **rarely** needed in pediatric patients
- Multiphase exams should be done less than 1% of the time



Organ shielding

Shields made of thin sheets of flexible latex impregnated with bismuth and shaped to cover the lens of the eye, thyroid, or breasts can be used during brain, cervical spine, or chest CT exams, respectively.

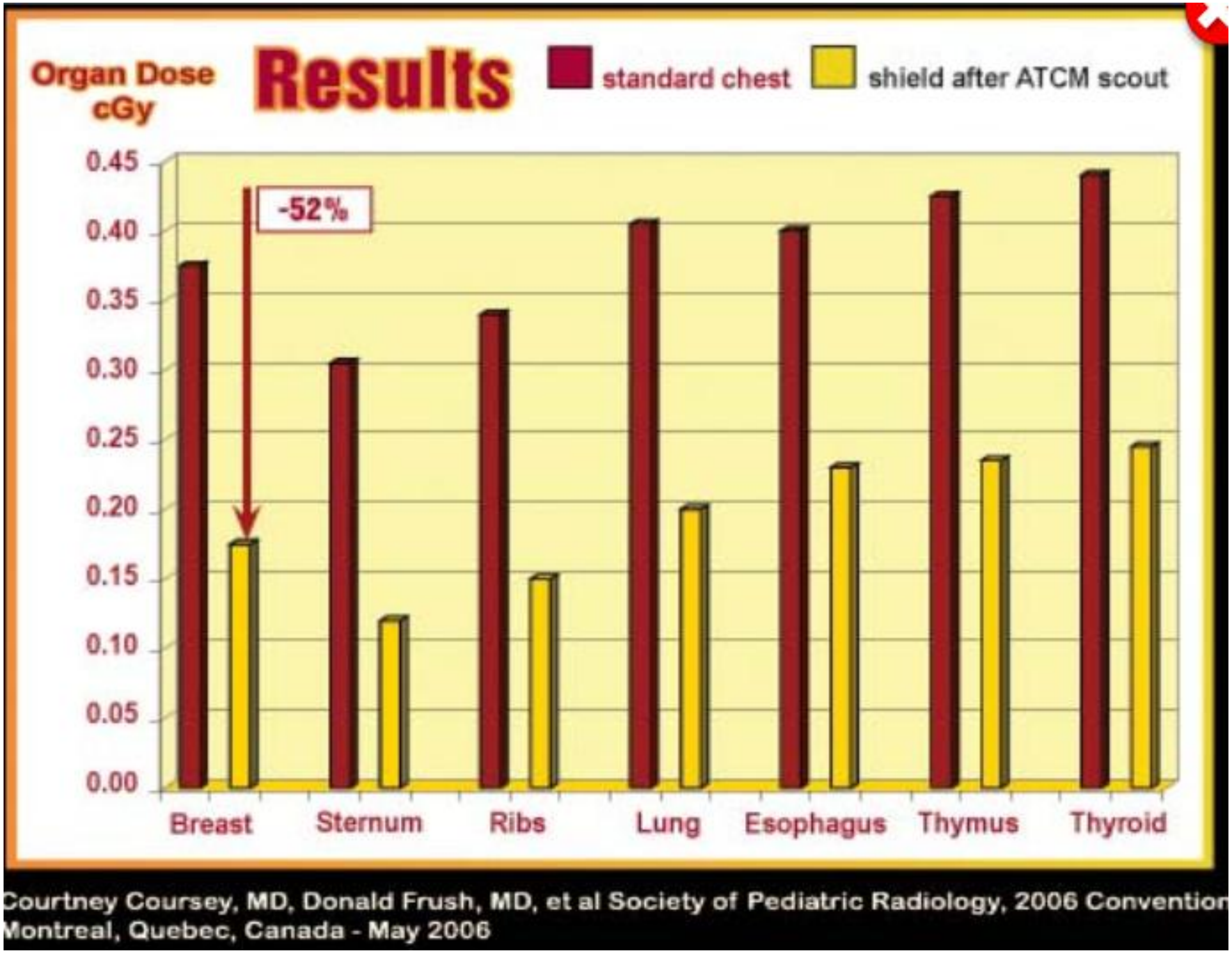
Graph demonstrates potential dose reduction with bismuth shielding of various body parts

Shielding has potential disadvantages

The American Association of Physicists in Medicine issued this statement in February, 2012.

AAPM Position Statement on the Use of Bismuth Shielding for the Purpose of Dose Reduction in CT scanning

Policy Text: Bismuth shields are easy to use and have been shown to reduce dose to anterior organs in CT scanning. However, there are several disadvantages associated with the use of bismuth shields, especially when used with automatic exposure control or tube current modulation. Other techniques exist that can provide the same level of anterior dose reduction at equivalent or superior image quality that do not have these disadvantages. The AAPM recommends that these alternatives to bismuth shielding be carefully considered, and implemented when possible.


Organ Dose cGy
Results
standard chest
shield after ATCM scout
-52%
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Breast
Sternum
Ribs
Lung
Esophagus
Thymus
Thyroid
Courtney Coursey, MD, Donald Frush, MD, et al Society of Pediatric Radiology, 2006 Convention
Montreal, Quebec, Canada - May 2006

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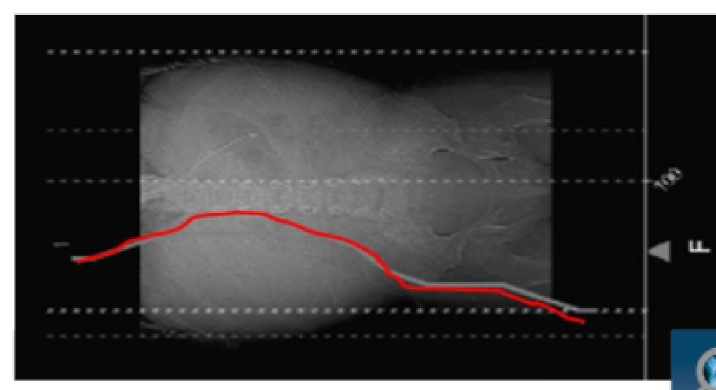
Automated tube current modulation (ATCM)

In automated tube current modulation (ATCM-red line), the scanner automatically adjusts mA according to the projection scans. This can lower dose significantly.



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Section 6: *Practical Steps to Optimize Radiation Dose for Pediatric Patients*

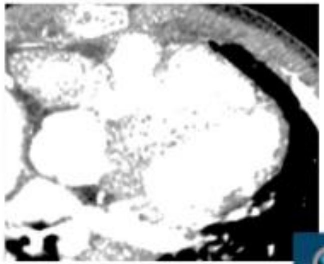
Iterative reconstruction

Iterative reconstruction techniques have demonstrated the potential for improving image quality and reducing radiation dose in CT relative to the currently used filtered back projection techniques.

The most noticeable benefit of iterative reconstruction is that it is able to incorporate into the reconstruction process a physical model of the CT system that can accurately characterize the data acquisition process.

This allows for dramatic improvements in image quality, especially in the case of low-dose CT scans.

Acquired Image



Post-iterative Reconstruction

Knowledge Check #11 - Match the Expert

How can you reduce CT radiation dose in pediatric patients?

The expert:

- Child-sizing CT protocols
- Centering appropriately
- Limiting scan length
- Using appropriate FOV
- Eliminating multi-phase scans (non-contrast, contrast, delayed CT scans)
- Shielding
- Using Automatic Tube Current Modulation (ATCM)
- Using Iterative Reconstruction

Media reports raise the question of potential cancer risk from ionizing radiation.

CT scans in children linked to cancer later

Children's CT scans linked to cancers

These media reports raise parents' concern and cause them to ask….

"What is the radiation dose my child received from the CT scan?"

However, the question that parents are really asking is "What is the risk to my child?"

Medical professionals should be able to answer parents' questions regarding risk.

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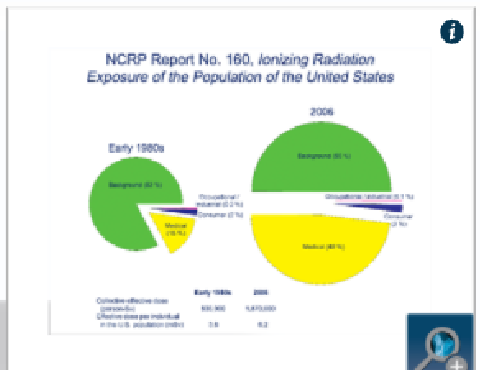
Section 7: *Clinical Benefits Versus Radiation Risk Estimates*

Part of the concern is that the collective radiation dose from medical imaging has dramatically increased to the US population because CT scans are performed more frequently today.

In 1980, medical imaging made up only 15% of radiation that humans received. In 2006, medical radiation increased to almost 50% of radiation that the U.S. population receives. This tells us that medical radiation is increasing dramatically for both adults and children.

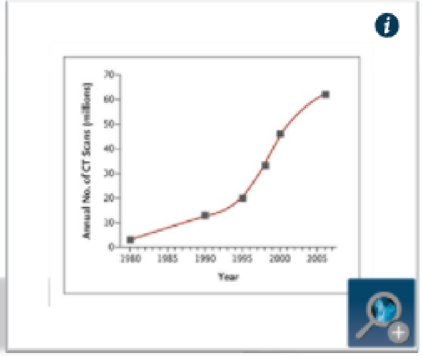


Since 1980, the number of CT scans has increased dramatically.

While CT scans in the U.S. continue to increase, CT scans in children are decreasing.

It is estimated that between 1 and 7-10 persons in the US will have a CT scan in any one year.

Estimated Number of CT Scans Performed Annually in the United States (adults and children up to 2006)



Increasing use of CT scans in the United States

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Section 7: *Clinical Benefits Versus Radiation Risk Estimates*

To answer parents' questions, medical professionals need to understand the two types of radiation effects

High dose → tissue effects (acute)

Tissue effects are the acute effects like skin ulcers, hair loss, and facial burns seen within hours or days from a high dose of radiation. There *is* a threshold associated with tissue effects.

Lower dose → stochastic effects

Potential for cancer
Potential for genetic effects

Tissue effects: Dose dependent with threshold → predictable

This is an example of deterministic effects (skin burns) from this child being scanned over 100 X for a neck CT

Oct 30, 2008 9:19 pm US/Pacific

CBS13 Investigates: Radiation Overexposure

Radiation Overexposure Involving A 2-Year-Old Child

Reporting Sam Shane

ARCATA (CBS13) — Inside the tiny frame of two-year-old Jacoby Roth no one really knows for sure what's going on.

"I just want him to be ok," says Carrie Roth, Jacoby's mother.

But Jacoby's mother Carrie, and his father Padre and Jacoby himself may very well live the rest of their lives not knowing.

"Do you really, as a mom, know how much damage has been done here?" asks CBS13 reporter Sam Shane.

"No," cries Carrie.

Back in January Jacoby hurt his neck. His parents brought him to the Mad River Community Hospital for a C-T scan. But instead of making him better, his parents say the technician who administered that C-T scan made the situation much worse.

"She did it wrong and she exposed him to a significant amount of radiation," explains Carrie.

‹ 1 of 1 › Click to enlarge

Formazione per l'eccellenza

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"She did it wrong and she exposed him to a significant amount of radiation," explains Carrie.

Potential Stochastic Effects in Children: why do we care?

- Stochastic effects refer to the *potential* for cancer and the *potential* for genetic effects. The *risk* of the event occurring depends on the dose. There is assumed to be no threshold
- Children's cells are rapidly dividing, making them more vulnerable than adults for most cancers
- Children live longer after exposure than adults and may manifest adverse effects such as increased incidence of cancer

Knowledge Check # 12

What type of radiation injury has the potential to cause an increase in cancer risk over time?

The expert:

- Stochastic radiation injury

Stochastic radiation injury may cause an increase in cancer risk. Because children's cells are rapidly dividing and they live longer after exposure than adults, they are more vulnerable to the stochastic effects of radiation than adults.

Children with chromosomal deletions are at increased risk of developing radiation induced cancer

Examinations involving radiation in these children should be performed with discretion.

- Ataxia telangiectasia
- Fanconi anemia
- Hereditary retinoblastoma
- Down syndrome
- Gardner syndrome
- Nijmegen breakage syndrome
- Usher syndrome
- Basal cell nevus
- Bloom syndrome
- Cockayne syndrome

Cancer occurs in patients who have not been exposed to medical ionizing radiation

- Four of every 10 US citizens will get cancer
- About one-half of those will die from the disease
- There is no way to tell if a cancer occurred from effects from radiation or from all other causes

Background Radiation

- Background radiation occurs naturally from the sun and soil
- Background radiation is 3 mSv/year

Source	Estimated effective dose (mSv)
Natural background radiation	3 mSv/yr
Airline passenger (cross country)	0.04 mSv
Chest X-ray (single view)	up to 0.01 mSv
Chest X-ray (2 view)	up to .1 mSv
Head CT	up to 2 mSv
Chest CT	up to 3 mSv
Abdominal CT	up to 5 mSv

The radiation used in X-rays and CT scans has been compared to background radiation we are exposed to daily. This also is misleading as this refers to whole body dose which is not truly comparable to studies that image only a portion of the body. However, this comparison may be helpful in understanding relative radiation doses to the patient.

Radiation source	Days background radiation
Background	1 day
Chest X-ray (single)	1 day
Head CT	up to 8 months
Abdominal CT	up to 20 months

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Section 7: *Clinical Benefits Versus Radiation Risk Estimates*

Table of Contents

Relative Dose

- A single Gray is a large dose of radiation
- This amount of radiation may be used in radiotherapy to treat cancer
- Most medical doses are in milliGray (mGy), which is a thousand times less than a Gray
- For x-ray, a mGy = mSv

Relative Radiation Dose

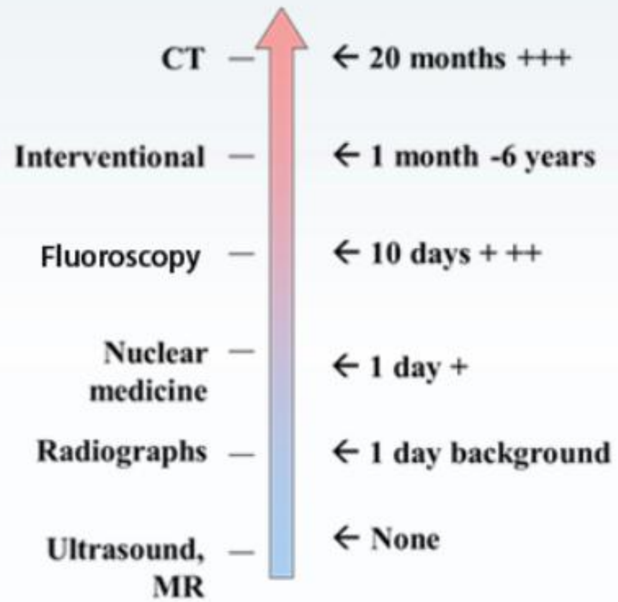

IMAGE WISELY

11/17

image gently

Do CT scans cause cancer?

There *is not* much controversy that radiation at very high doses causes cancer (atomic bomb survivors).

There *is* controversy as to what lower doses of radiation from medical imaging may do. Some believe there is no effect at lower doses.

There has been much controversy as to what the risk is and how to prevent this risk.

This article demonstrates that there is controversy regarding CT dose and radiation risk.

Radiology

Radiation Exposure in CT:
What Is the Professionally Responsible Approach?[1]

Stephen J. Golding, FRCR

B exposure of the population resulting from computed tomography (CT) in Western medicine is currently a controversy. On one hand, some radiologists and medical physicists believe that rising use of CT has resulted in exposure levels that must result in radiation-induced disease and that, given the latency period with which such disease develops, this is creating a medical time bomb, the effects of which we will have to face (1–9). The opposing lobby argues that this is alarmist, that there is a threshold effect for radiation-induced disease, and that there is no evidence of actual harm to patients from diagnostic imaging but that, instead, there is potential harm from avoiding imaging where it is indicated (10–19). It is not the purpose of this editorial to deliberate between these opposing views, but to ask what an appropriate and professional response to the debate should be.

Does medical radiation cause cancer?

We don't know.

We should act cautiously

as if there may be a risk.

image gently®

www.imagegently.org

"Justification"

Every CT scan, particularly in children, should be *justified*. This means that the information gained from the CT will help the referring doctor in the care of the patient and that the small risk is outweighed by the benefit of the scan.

Justification may eliminate the delivery of ionizing radiation to the patient. In other words, if a scan will not answer the clinical question, it should be canceled.

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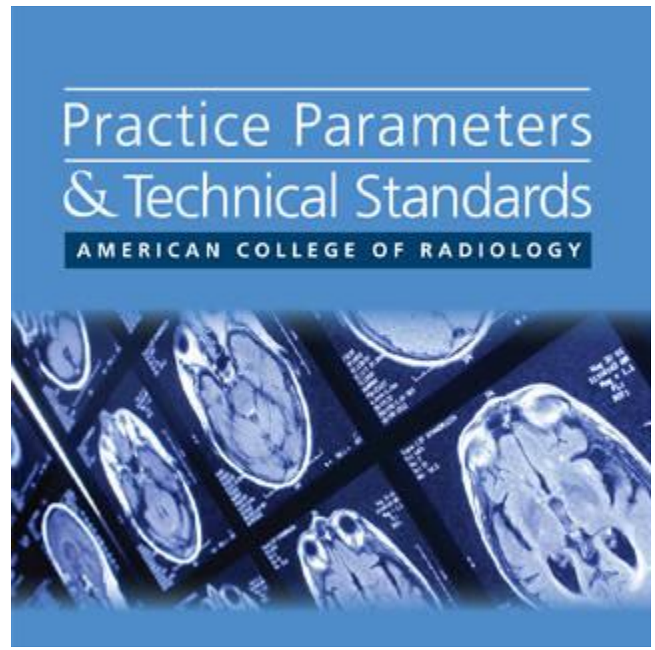
Section 7: *Clinical Benefits Versus Radiation Risk Estimates*

There are few studies that address specific use of CT in children.

The ACR Appropriateness Criteria® and Guidelines and Technical Standards promote the safe and effective use of diagnostic radiology, guide appropriate clinical decision-making, and provide justification of requested exams.

www.acr.org/Quality-Safety/Appropriateness-Criteria

www.acr.org/Quality-Safety/Standards-Guidelines https://www.acr.org/Clinical-Resources/ACR-Appropriateness-Criteria



https://www.acr.org/Clinical-Resources/Practice-Parameters-and-Technical-Standards

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Section 7: *Clinical Benefits Versus Radiation Risk Estimates*

These practical approaches can go a long way in managing pediatric CT dose

- Work together as a team toward this goal
- Your patients and their parents will

THANK YOU!

Continue to Claim Credit

Image Wisely Case 10 - Posttest

1. The United Kingdom Health Foundation stresses six key principles when defining the dimensions of quality. Of the six principles below, which one is NOT included?

A) Safe

B) Effective

C) **Hospital-centered**

D) Timely

E) Efficient

F) Equitable

Answer 1 is C.

Domanda 2 di 10

2. A widely accepted and highly effective 4-step method that can be used to improve healthcare processes

A) PSDA

B) PASD

C) DASP

D) PDSA

Image Wisely Case 10 - Posttest

Domanda 2 di 10

2. A widely accepted and highly effective 4-step method that can be used to improve healthcare processes

A) PSDA

B) PASD

C) DASP

D) **PDSA**

Answer 2 is D.

Formazione per l'eccellenza

Domanda 3 di 10

3. Which of the following statements with regard to CTDIvol, is true?

A) CTDIvol is a dose metric that measures the absorbed dose given to a standard phantom during a CT scan

B) CTDIvol is an estimate of patient dose

C) CTDIvol dose estimates for 16cm and 32cm phantoms are equivalent

D) When measuring CTDIvol, the 16cm phantom is commonly utilized as the adult abdominal phantom

Domanda 3 di 10

3. Which of the following statements with regard to CTDIvol, is true?

A) **CTDIvol is a dose metric that measures the absorbed dose given to a standard phantom during a CT scan**

B) CTDIvol is an estimate of patient dose

C) CTDIvol dose estimates for 16cm and 32cm phantoms are equivalent

D) When measuring CTDIvol, the 16cm phantom is commonly utilized as the adult abdominal phantom

Answer 3 is A.

Image Wisely Case 10 - Posttest

Domanda 4 di 10

4. All of the following statements are true about SSDE (Size Specific Dose Estimate) except:

A) Based on patient's body size

B) Accurate to within 20%

C) A better estimate of patient dose than CTDIvol

D) A dose estimate that applies only to the surface of the patient

Domanda 4 di 10

4. All of the following statements are true about SSDE (Size Specific Dose Estimate) except:

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B) Accurate to within 20%

C) A better estimate of patient dose than CTDIvol

D) **A dose estimate that applies only to the surface of the patient**

Answer 4 is D.

Domanda 5 di 10

5. What is image noise in CT?

A) The sound that the machine makes during an exposure

B) The amount of contrast in an image

C) The standard deviation of the voxel values in a homogenous (typically water) phantom

D) The end result of patient motion during imaging

Formazione per l'eccellenza

Domanda 5 di 10

5. What is image noise in CT?

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B) The amount of contrast in an image

C) **The standard deviation of the voxel values in a homogenous (typically water) phantom**

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Answer 5 is C.

Domanda 6 di 10

6. Diagnostic Reference Levels (DRLs) are all of the following except:

A) A supplement to professional judgment

B) Appropriate for use for a regulatory purposes

C) Voluntary

D) Ever changing

Formazione per l'eccellenza

Domanda 6 di 10

6. Diagnostic Reference Levels (DRLs) are all of the following except:

A) A supplement to professional judgment

B) **Appropriate for use for a regulatory purposes**

C) Voluntary

D) Ever changing

Answer 6 is B.

Image Wisely Case 10 - Posttest

Domanda 7 di 10

7. What is the purpose of a Dose Index Registry (DIR)?

A) To collect dose indices on patients from multiple sites undergoing CT scans of the same body part for comparison to peer facilities and national values

B) To give the ACR a database to audit accredited sites

C) To regulate doses in accordance with state mandates

D) To track individual patient doses

Domanda 7 di 10

7. What is the purpose of a Dose Index Registry (DIR)?

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B) To give the ACR a database to audit accredited sites

C) To regulate doses in accordance with state mandates

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Answer 7 is A.

Domanda 8 di 10

8. The following are all easy, practical measures a site can take to optimize radiation dose for pediatric CT except:

A) "Childsize" CT protocols based on patient age

B) Use of Automated Tube Current Modulation (ATCM)

C) Eliminate multiphase scans (noncontrast, contrast, delayed CT scans)

D) Appropriate centering

Image Wisely Case 10 - Posttest

Domanda 8 di 10

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A) **"Childsize" CT protocols based on patient age**

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D) Appropriate centering

Answer 8 is A.

Image Wisely Case 10 - Posttest

Domanda 9 di 10

9. In 1980, radiation to the U.S. population from medical imaging made up 15% of the total annual dose received. In 2006, this number was close to:

A) 5%

B) 25%

C) 50%

D) 75%

Answer 9 is C.

Domanda 10 di 10

10. For which type of radiation effects are children at greater risk than adults?

A) Deterministic

B) Longitudinal

C) Stochastic

D) Gamma

Formazione per l'eccellenza

Domanda 10 di 10

10. For which type of radiation effects are children at greater risk than adults?

A) Deterministic

B) Longitudinal

C) **Stochastic**

D) Gamma

Answer 10 is C.

Image Wisely Case 10 - Posttest

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