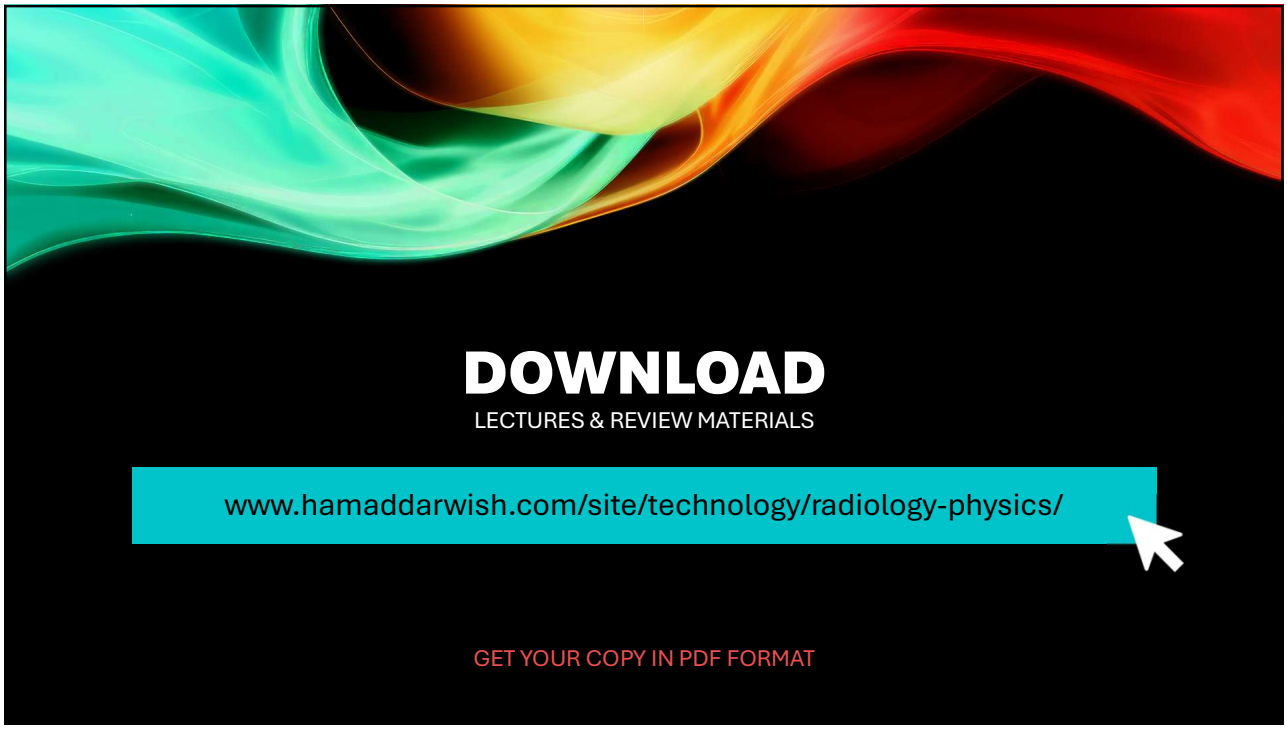
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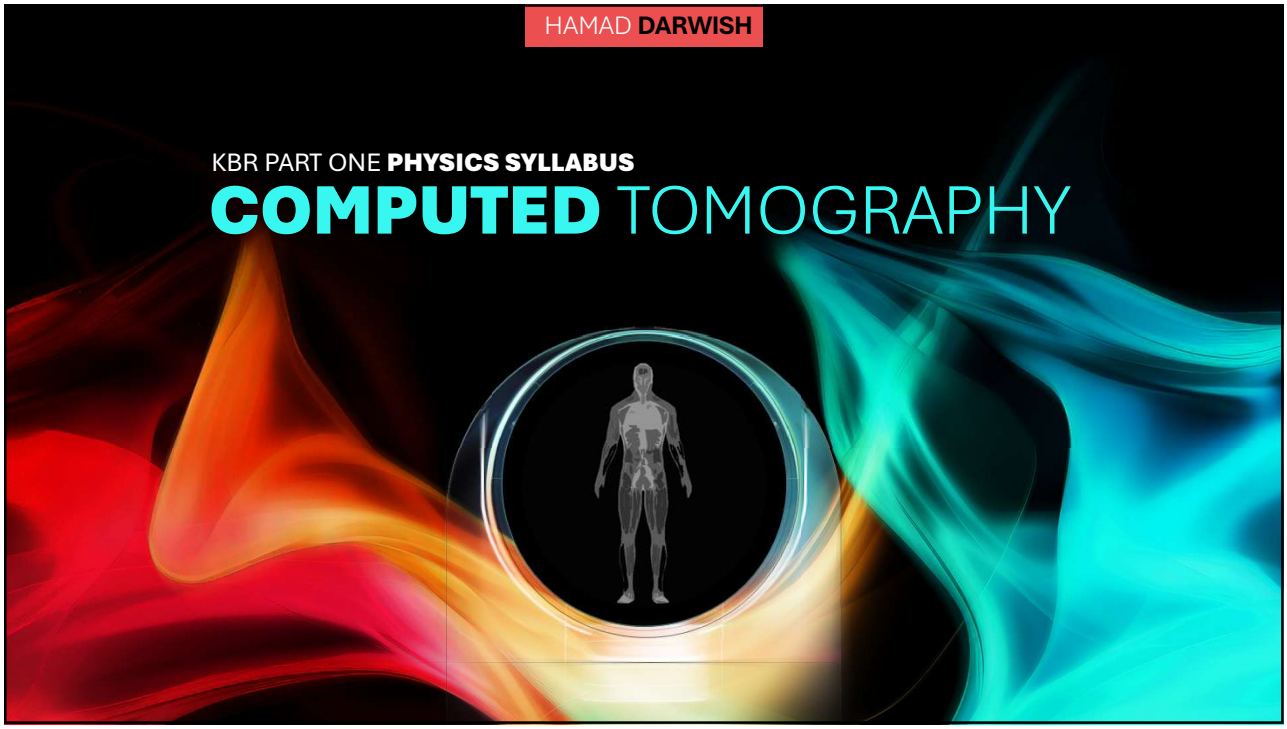
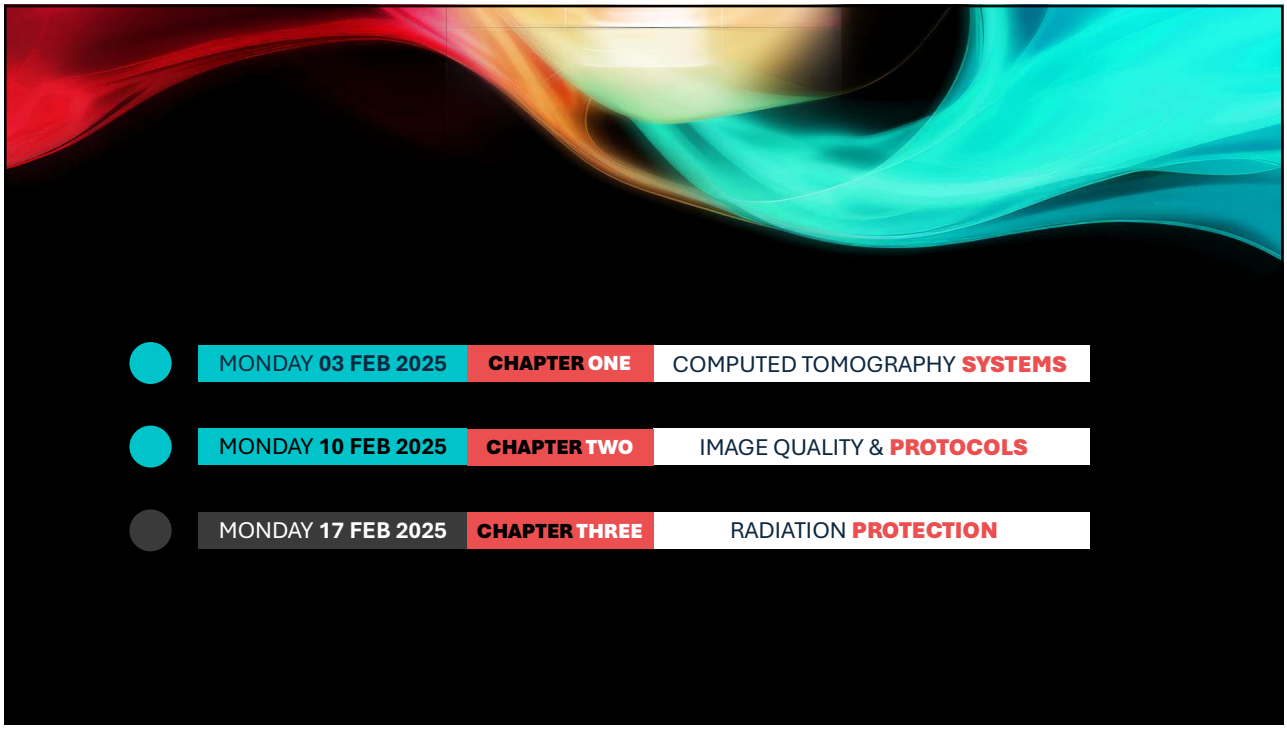

HAMAD DARWISH
KBR PART ONE PHYSICS SYLLABUS
COMPUTED TOMOGRAPHY

258


MONDAY 03 FEB 2025
CHAPTER ONE
COMPUTED TOMOGRAPHY SYSTEMS
MONDAY 10 FEB 2025
CHAPTER TWO
IMAGE QUALITY & PROTOCOLS
MONDAY 17 FEB 2025
CHAPTER THREE
RADIATION PROTECTION

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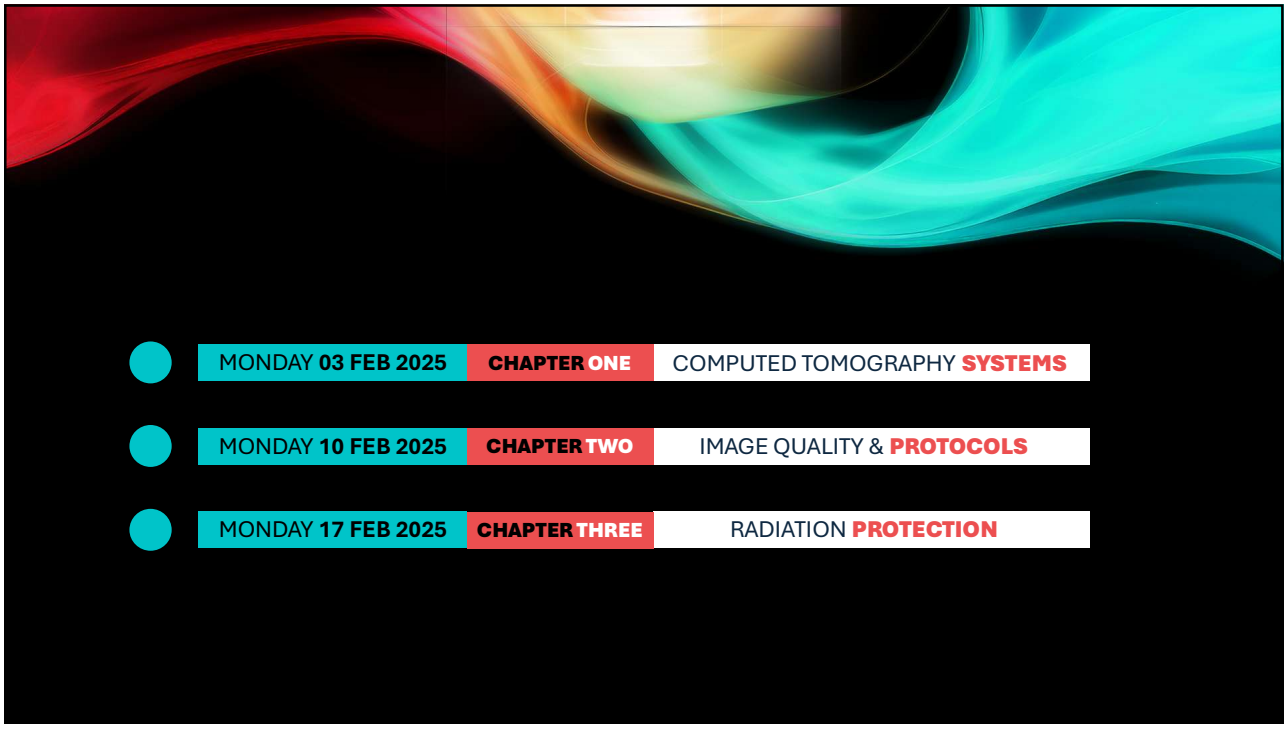
MONDAY 03 FEB 2025
CHAPTER ONE
COMPUTED TOMOGRAPHY SYSTEMS
MONDAY 10 FEB 2025
CHAPTER TWO
IMAGE QUALITY & PROTOCOLS
MONDAY 17 FEB 2025
CHAPTER THREE
RADIATION PROTECTION

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CHAPTER
THREE
CT DOSE METRICS
CT DOSE REPORTS
FACTORS AFFECTING DOSE
REDUCING RISKS
SAFETY ALLIANCES

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CHAPTER
THREE
CT DOSE METRICS
CT DOSE REPORTS
FACTORS AFFECTING DOSE
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SAFETY ALLIANCES

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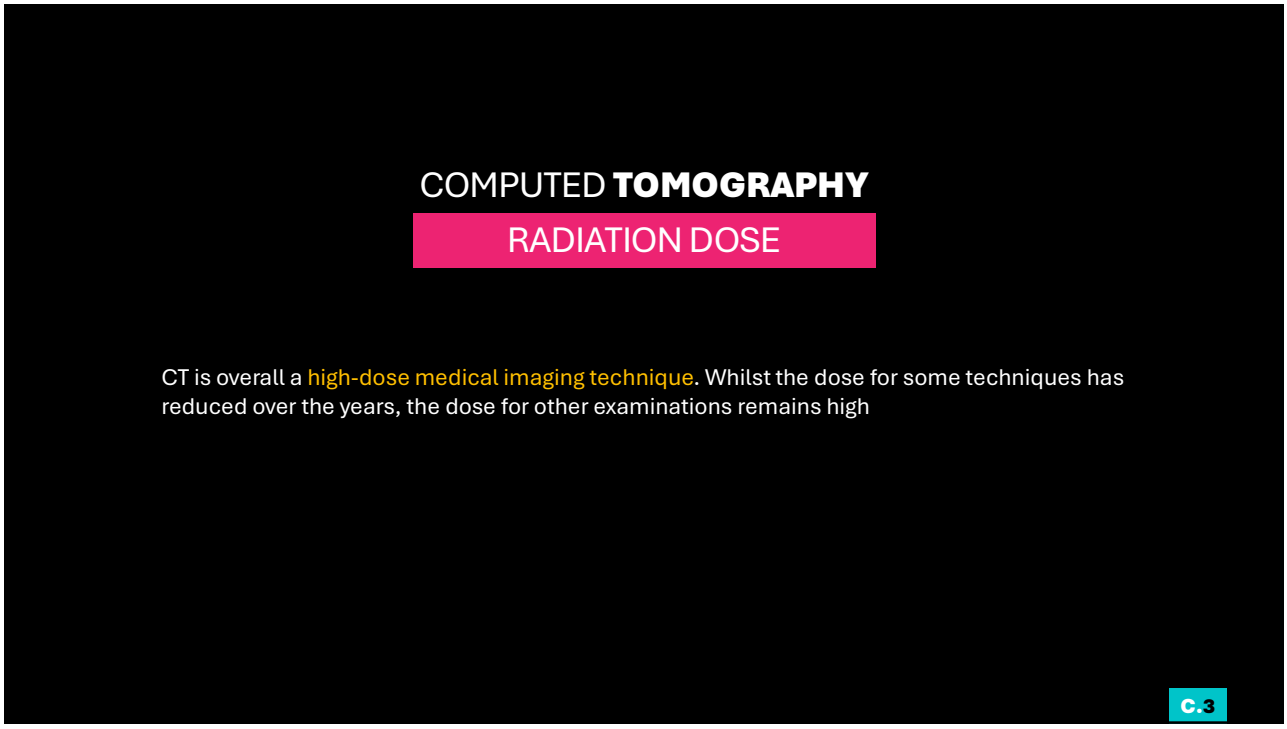
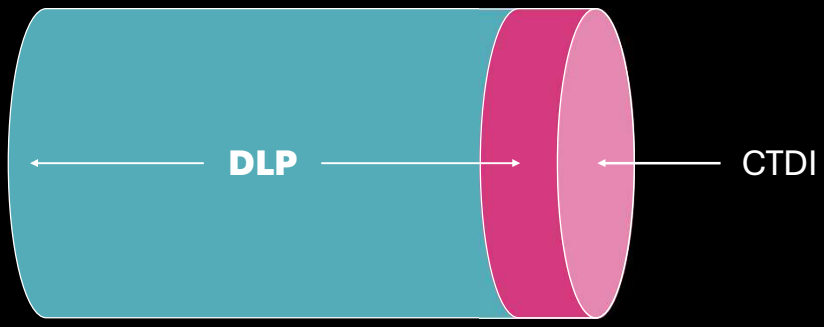

COMPUTED TOMOGRAPHY
RADIATION DOSE
CT is overall a high-dose medical imaging technique. Whilst the dose for some techniques has reduced over the years, the dose for other examinations remains high
C.3

264

DOSE **METRICS**

CTDI: Computed Tomography Dose Index is a measure of radiation dose delivered per slice (one rotation) in a CT scan. It is expressed in (mGy).



DLP: Dose Length Product is a measure of the total radiation dose delivered to the patient during the entire scan. It is calculated by multiplying the CTDI by the scan length. DLP is expressed in (mGy.cm).

C.3

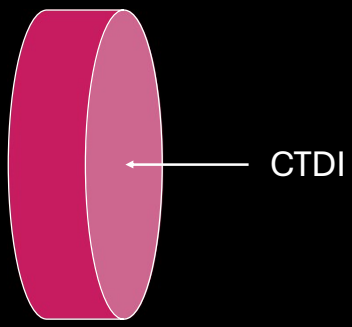
265

DOSE **METRICS**: CTDI

CTDI: is a measurement of the radiation dose delivered to the patient in one rotation.

Units: mGy

The CTDI is a measurement **done in a lab** (at the manufacturer) **using phantoms** of what the dose is for different exposure and scan combinations.



C.3

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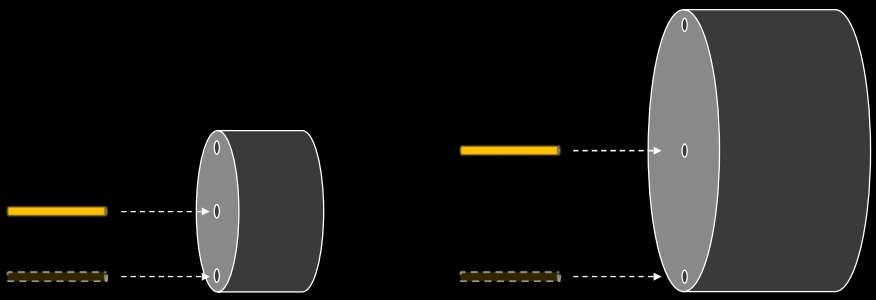
DOSE **METRICS**: CTDI

- Two phantom sizes are used to simulate patients.
- An ionization chapter is inserted in the center of the phantom and again on the periphery of the phantom.
- All possible exposure combinations are taken, and the dose readings are recorded for each phantom size.



16cm Phantom 32cm Phantom

C.3

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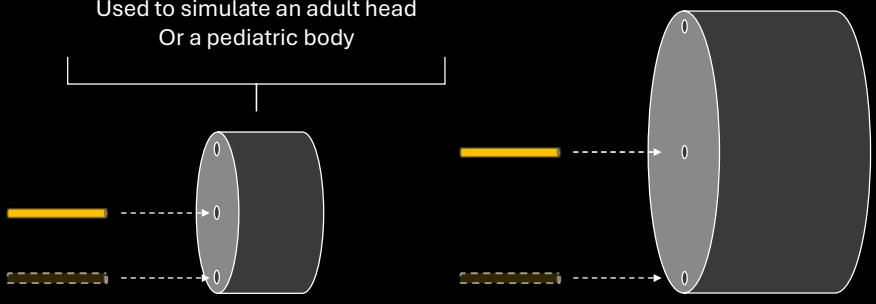
DOSE **METRICS**: CTDI

Used to simulate an adult body

Used to simulate an adult head
Or a pediatric body



16cm Phantom 32cm Phantom

C.3

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DOSE **METRICS**: CTDI

Weighted **CTDI**: $CTDI_w$

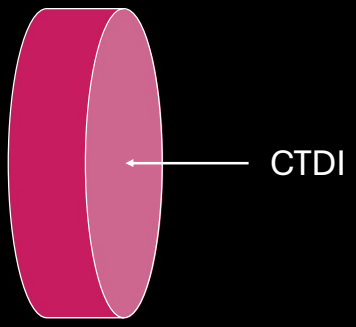
Takes into account that dose is not equal across the scan plane.

- **How is it calculated**: $CTDI_w = (1/3\ CTDI_{center}) + (2/3\ CTDI_{periphery})$
- **When do we use it:** Axial (Step & Shoot) or Volume scanning.

Volume **CTDI**: $CTDI_{vol}$

Takes into account the pitch during continuous scanning (helical).

- **How is it calculated**: $(CTDI_w) / (Pitch)$
- **When do we use it:** Helical scanning.



C.3

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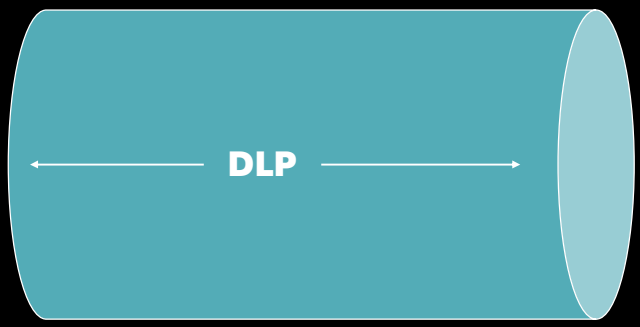
DOSE **METRICS**: DLP



Takes into account the from a single rotation and the entire length of the scan along the Z-axis.

Units: mGy.cm

- **How is it calculated**: (CTDI) x (Length)
- **When do we use it:** When describing the amount of radiation dose given to the patient during an acquisition.

Every scan phase is a separate DLP. The **total exam DLP is the sum of all DLPs** from all scan phases.

C.3

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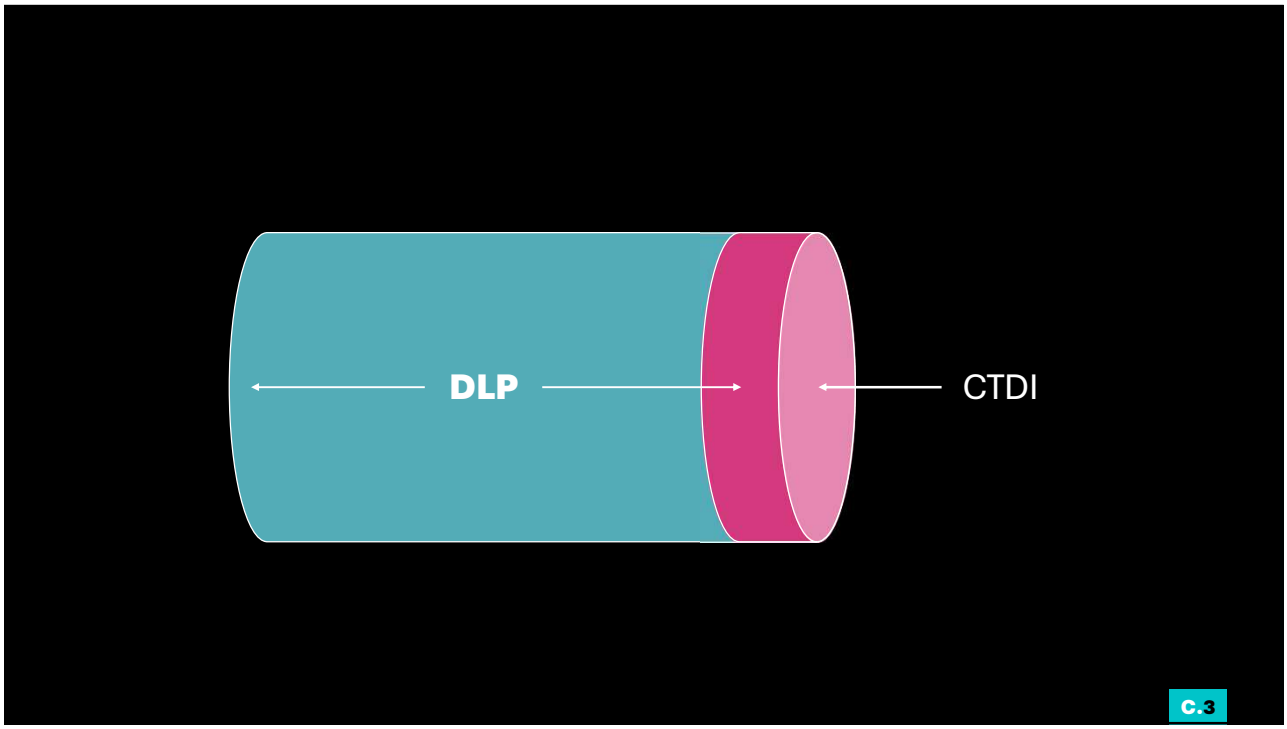


271

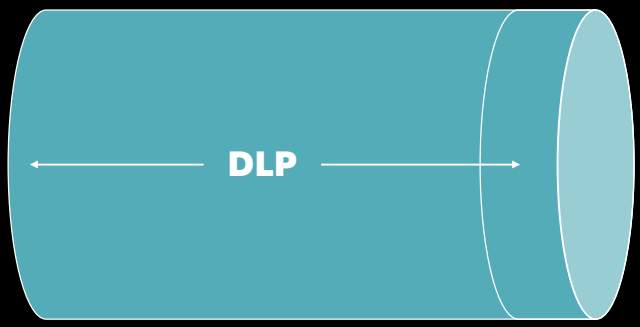
DOSE **METRICS**: EFFECTIVE DOSE

Takes into account that not all organs are equal in their sensitivity to radiation.

Units: mSv

- **How is it calculated:** DLP x (Sensitivity Factor)
- **When do we use it:** As an estimation of biological risk.

Although widely used, effective dose is **an estimation of risk not a measure of radiation dose**. It is also meant for used to describe a population not an individual. It should not be used to compare scanners or optimize protocols.



272

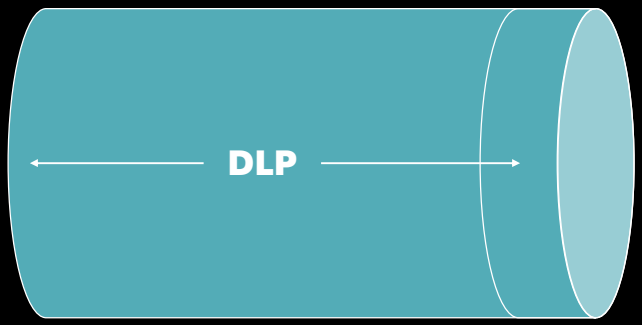
DOSE **METRICS**: EFFECTIVE DOSE

The International commission on Radiological Protection (ICRP) issues the weighting factors and revises them.

Tissue type	Weighting Factor
Bone Marrow	0.12
Colon	0.12
Lung	0.12
Breast	0.12
Gonads	0.08
Bladder	0.04
Brain	0.04
Skin	0.01

*Examples

EFFECTIVE DOSE: DLP **x** Weighting Factor



C.3

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DOSE **METRICS**: SSDE

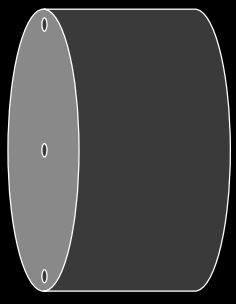
SSDE: Size-specific dose estimate is an important refinement of CT dose reporting that takes into account the patient's size to provide a more accurate estimate of the radiation dose received.

Using standard CTDI phantoms (16 cm and 32 cm diameter) to estimate patient dose **can lead to inaccuracies** due to differences in size between the phantom and the actual patient.

SMALLER **PATIENT**:

Dose Over-estimation: smaller patients attenuate less radiation and produce less scatter.

Can lead to unnecessary concerns or reluctancy to perform a procedure



32cm Phantom

LARGER **PATIENT**:

Dose Under-estimation: larger patients attenuate more radiation and produce more scatter.

Can lead to inaccurate assessment of risk and potential to exceed safety limits.

C.3

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FACTORS AFFECTING DOSE
REDUCING RISKS
SAFETY ALLIANCES

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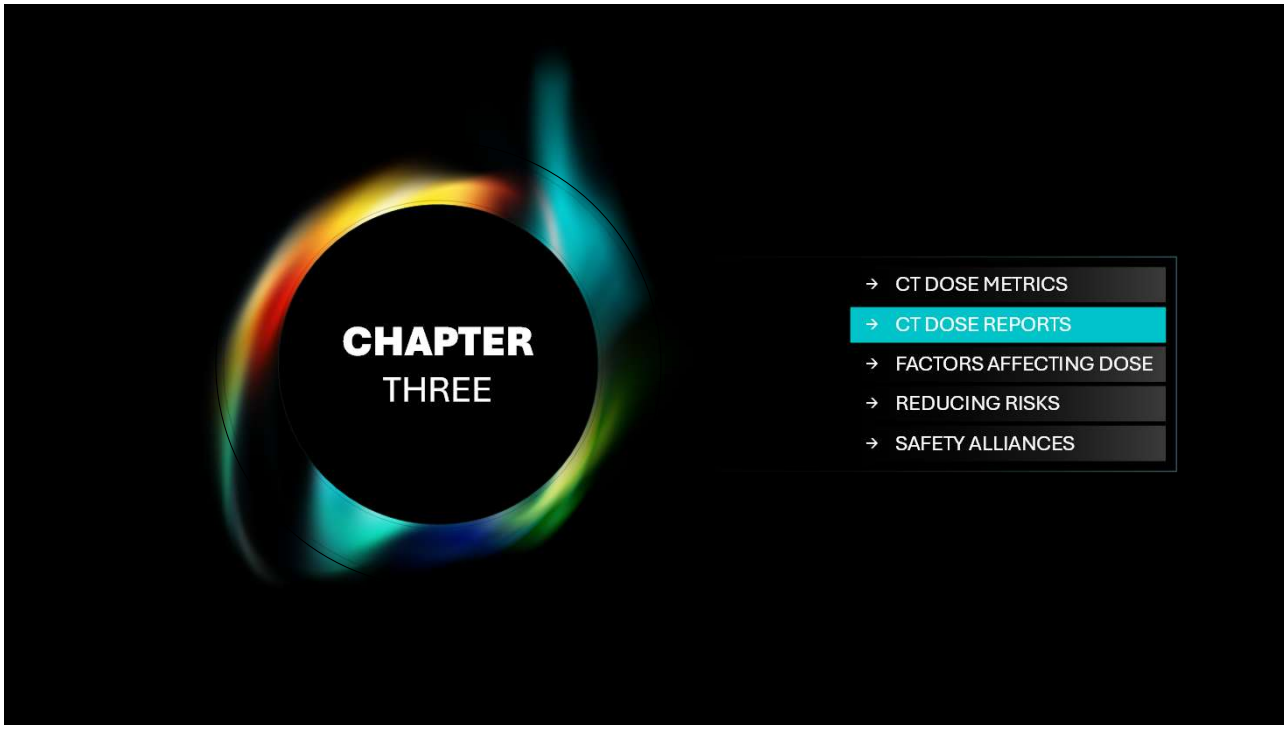
CHAPTER
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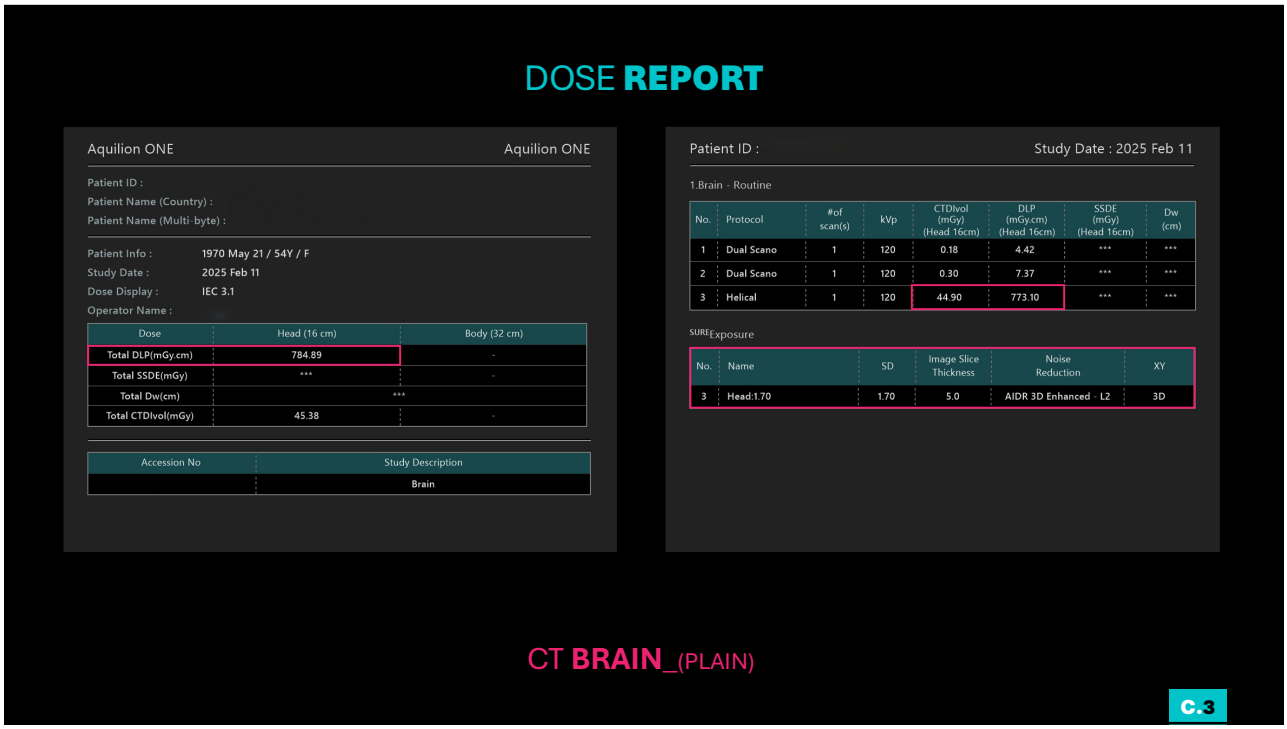
DOSE REPORT
Aquilion ONE
Aquilion ONE
Patient ID :
Patient Name (Country) :
Patient Name (Multi-byte) :
Patient Info : 1970 May 21 / 54Y / F
Study Date : 2025 Feb 11
Dose Display : IEC 3.1
Operator Name :
Dose | Head (16 cm) | Body (32 cm)
Total DLP(mGy.cm) | 784.89 | -
Total SSDE(mGy) | *** | -
Total Dw(cm) | *** |
Total CTDIvol(mGy) | 45.38 | -
Accession No | Study Description
Brain
Patient ID :
Study Date : 2025 Feb 11
1.Brain - Routine
No. | Protocol | #of scan(s) | kVp | CTDIvol (mGy) (Head 16cm) | DLP (mGy.cm) (Head 16cm) | SSDE (mGy) (Head 16cm) | Dw (cm)
1 | Dual Scano | 1 | 120 | 0.18 | 4.42 | *** | ***
2 | Dual Scano | 1 | 120 | 0.30 | 7.37 | *** | ***
3 | Helical | 1 | 120 | 44.90 | 773.10 | *** | ***
SUREExposure
No. | Name | SD | Image Slice Thickness | Noise Reduction | XY
3 | Head:1.70 | 1.70 | 5.0 | AIDR 3D Enhanced - L2 | 3D
CT BRAIN_(PLAIN)
C.3

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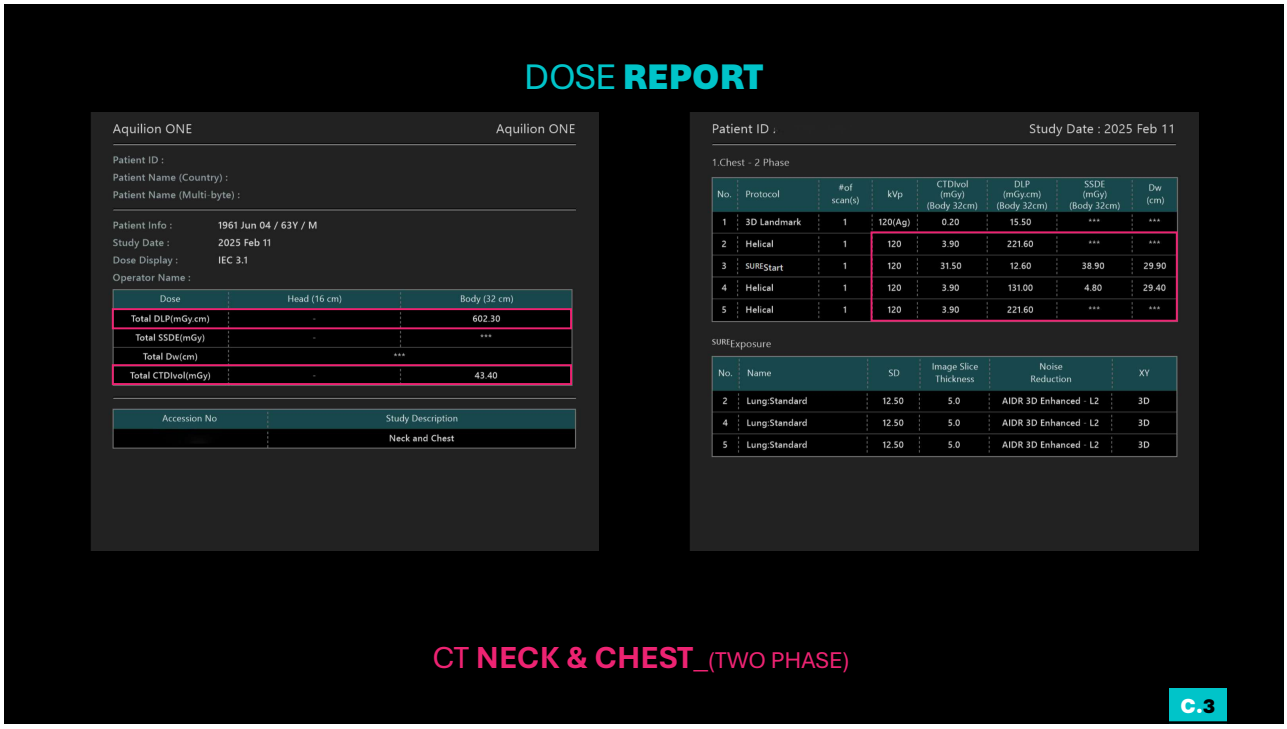
DOSE REPORT
Aquilion ONE
Aquilion ONE
Patient ID :
Patient Name (Country) :
Patient Name (Multi-byte) :
Patient Info : 1961 Jun 04 / 63Y / M
Study Date : 2025 Feb 11
Dose Display : IEC 3.1
Operator Name :
Dose | Head (16 cm) | Body (32 cm)
Total DLP(mGy.cm) | - | 602.30
Total SSDE(mGy) | - | ***
Total Dw(cm) | *** |
Total CTDIvol(mGy) | - | 43.40
Accession No | Study Description
Neck and Chest
Patient ID :
Study Date : 2025 Feb 11
1.Chest - 2 Phase
No. | Protocol | #of scan(s) | kVp | CTDIvol (mGy) (Body 32cm) | DLP (mGy.cm) (Body 32cm) | SSDE (mGy) (Body 32cm) | Dw (cm)
1 | 3D Landmark | 1 | 120(Ag) | 0.20 | 15.50 | *** | ***
2 | Helical | 1 | 120 | 3.90 | 221.60 | *** | ***
3 | SUREStart | 1 | 120 | 31.50 | 12.60 | 38.90 | 29.90
4 | Helical | 1 | 120 | 3.90 | 131.00 | 4.80 | 29.40
5 | Helical | 1 | 120 | 3.90 | 221.60 | *** | ***
SUREExposure
No. | Name | SD | Image Slice Thickness | Noise Reduction | XY
2 | Lung:Standard | 12.50 | 5.0 | AIDR 3D Enhanced - L2 | 3D
4 | Lung:Standard | 12.50 | 5.0 | AIDR 3D Enhanced - L2 | 3D
5 | Lung:Standard | 12.50 | 5.0 | AIDR 3D Enhanced - L2 | 3D
CT NECK & CHEST_(TWO PHASE)
C.3

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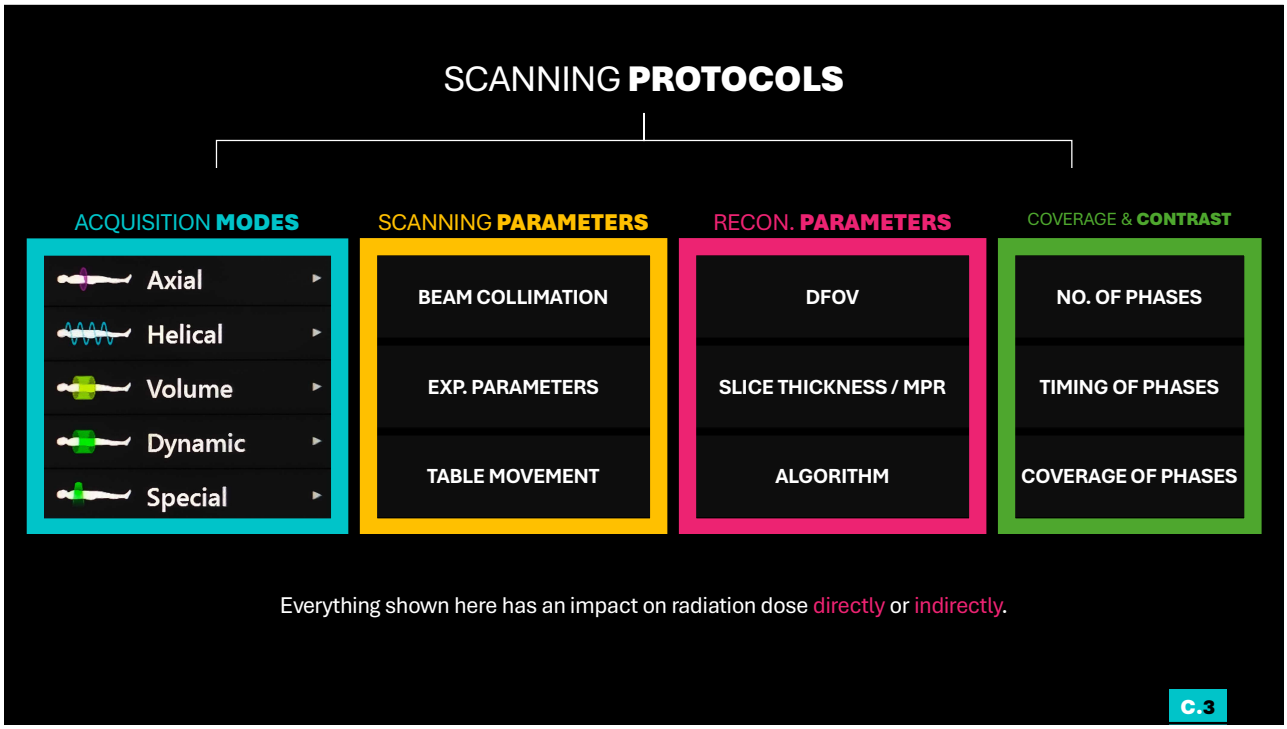
SCANNING PROTOCOLS
ACQUISITION MODES
Axial
Helical
Volume
Dynamic
Special
SCANNING PARAMETERS
BEAM COLLIMATION
EXP. PARAMETERS
TABLE MOVEMENT
RECON. PARAMETERS
DFOV
SLICE THICKNESS / MPR
ALGORITHM
COVERAGE & CONTRAST
NO. OF PHASES
TIMING OF PHASES
COVERAGE OF PHASES
Everything shown here has an impact on radiation dose directly or indirectly.
C.3

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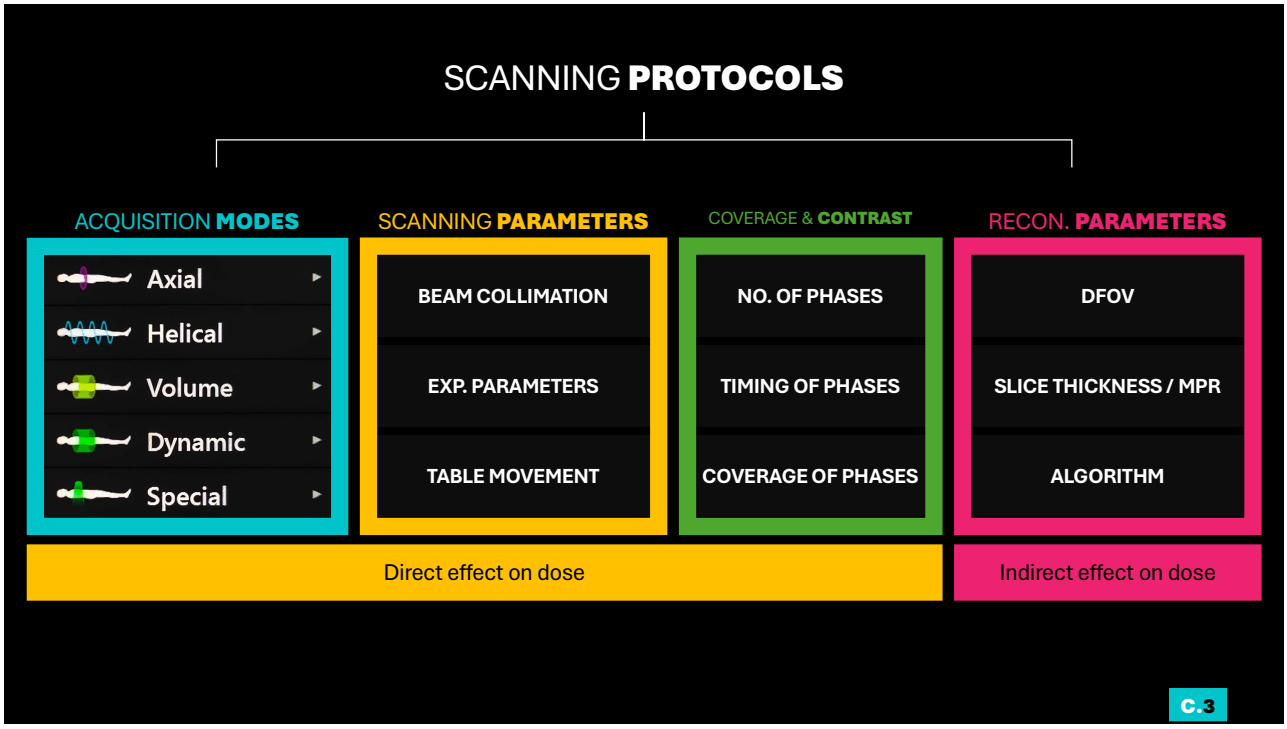
SCANNING PROTOCOLS
ACQUISITION MODES
Axial
Helical
Volume
Dynamic
Special
SCANNING PARAMETERS
BEAM COLLIMATION
EXP. PARAMETERS
TABLE MOVEMENT
COVERAGE & CONTRAST
NO. OF PHASES
TIMING OF PHASES
COVERAGE OF PHASES
RECON. PARAMETERS
DFOV
SLICE THICKNESS / MPR
ALGORITHM
Direct effect on dose
Indirect effect on dose
C.3

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DOSE **MANAGEMENT**

FACTORS AFFECTING DOSE IN CT:

Directly:

- **Tube Current (mA):** determines the number of photons produced by the tube.
- **Rotation Speed (time):** determines the length of time for a single acquisition.
- **kVp:** determines beam penetration and scatter production.
- **Beam Collimation:** determines the width (Z-Axis) / Size (XY-Axis) of the exposed area
- **Helical Pitch:** determines the amount of exposure gapping or overlapping (also total exposure time).
- **Number of Scan Phases:** determines how many acquisitions or exposures performed.
- **Acquisition Mode:** Volume scanning can potentially be less radiation to the patient.

C.3

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DOSE **MANAGEMENT**

FACTORS AFFECTING DOSE IN CT:

Indirectly:

- **Patient Centering:** Can affect the size of the patient on the scout image, which can potentially cause under/over estimation of tube current by the Auto mA setting.
- **Reconstruction Method / DeNoisers:** IR or DLR can produce excellent images with less radiation
- **Slice Thickness:** Can potentially cause under/over estimation of tube current by the Auto mA setting.
- **DFOV:** Can influence the SFOV which determines the size of the area exposed by radiation (X-Y-Axis)

C.3

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REDUCING RISKS
ALARA: AS LOW AS REASONABLEY ACHIEVABLE
JUSTIFICATION
OPTIMIZATION
LIMITATION
C.3

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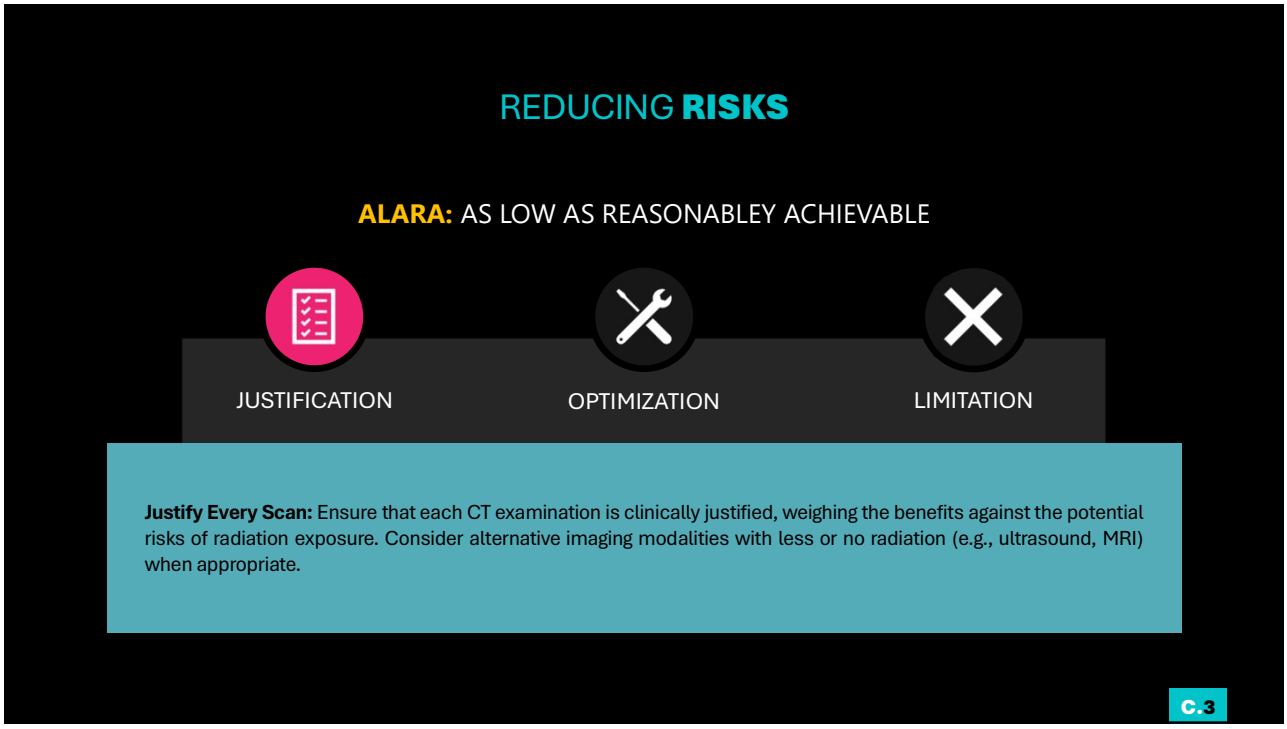
REDUCING RISKS
ALARA: AS LOW AS REASONABLEY ACHIEVABLE
JUSTIFICATION
OPTIMIZATION
LIMITATION
Justify Every Scan: Ensure that each CT examination is clinically justified, weighing the benefits against the potential risks of radiation exposure. Consider alternative imaging modalities with less or no radiation (e.g., ultrasound, MRI) when appropriate.
C.3

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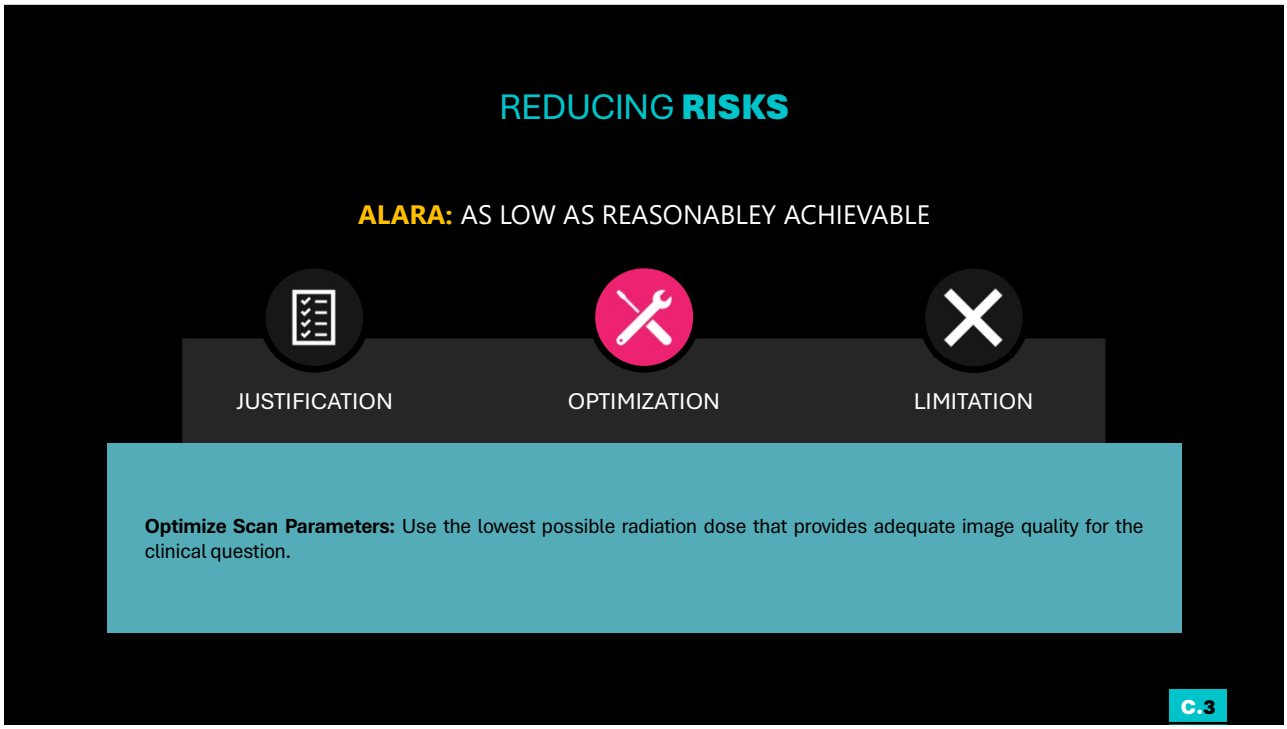
REDUCING RISKS
ALARA: AS LOW AS REASONABLEY ACHIEVABLE
JUSTIFICATION
OPTIMIZATION
LIMITATION
Optimize Scan Parameters: Use the lowest possible radiation dose that provides adequate image quality for the clinical question.
C.3

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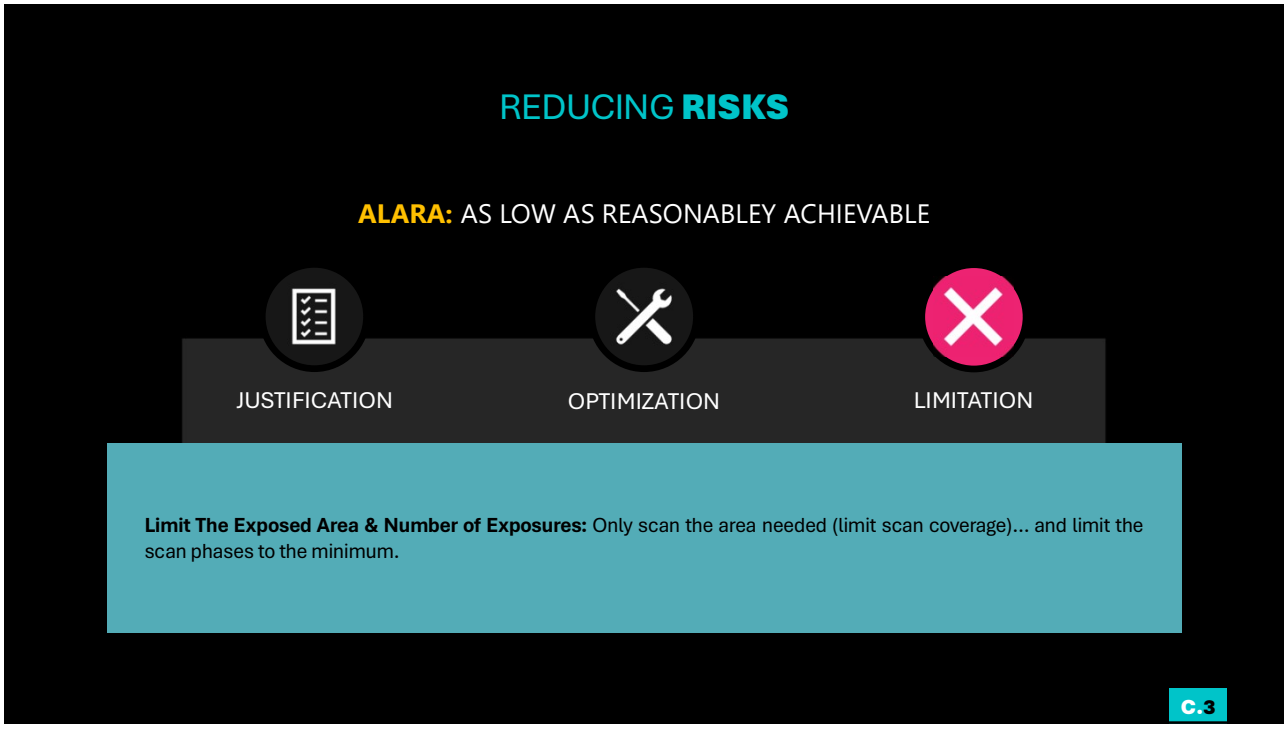
REDUCING RISKS
ALARA: AS LOW AS REASONABLEY ACHIEVABLE
JUSTIFICATION
OPTIMIZATION
LIMITATION
Limit The Exposed Area & Number of Exposures: Only scan the area needed (limit scan coverage)... and limit the scan phases to the minimum.
C.3

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DIAGNOSTIC **REFERENCE LEVELS**

DRLs: Diagnostic Reference Levels are reference radiation dose values for typical examinations. They are indicators for the typical acceptable and safe practice in a country or a region.

DOSE **LIMITS**	DIAGNOSTIC **REFERENCE LEVELS**
Use: Apply to occupational and public exposure to radiation	**Use:** Apply to medical exposures
A value that is not to be exceeded	**A value that can be exceeded in clinical needs demand.**
Purpose: radiation safety	**Purpose:** Optimization of procedures

C.3

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KUWAIT **ADULT DRLs**

	$CTDI_{vol}$ (mGy)	DLP (mGy.cm)
Head	52	750
Chest	13	480
Abdomen	15	970

NOTE: typical working range is ±30% of the given DRL for standard adult patient.

C.3

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KUWAIT **ADULT DRLs**

	$CTDI_{vol}$ (mGy)	DLP (mGy.cm)
Head	52	750
Chest	13	480
Abdomen	15	970

In reality,
- **Brain** = 950 DLP
- **Chest** = 200 DLP
- **Abd.Pelvis** = 500 DLP

NOTE: typical working range is ±30% of the given DRL for standard adult patient.

C.3

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KUWAIT **PEDIATRIC DRLs**

	Weight (Kg)	Age (Years)	$CTDI_{vol}$	DLP
Head	-	0	25	300
	-	1	25	370
	-	5	38	505
	-	10	53	700
	-	15	60	900
Thorax	<10	-	2.7	45
	10<15	-	3.3	80
	15<30	-	5.6	115
	30<60	-	5.7	180
	>60	-	6.9	200
Abdomen	<10	-		90
	10<15	-	5.7	160
	15<30	-	5.7	170
	30<60	-	7.0	290
	>60	-	14	580

C.3

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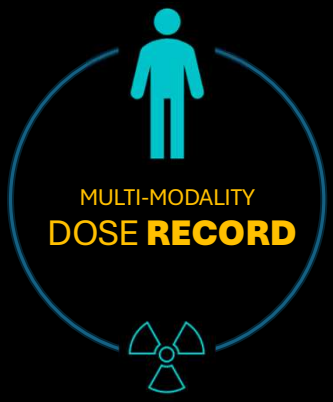
DOSE **MANAGEMENT**

Computer software to automatically collect and analyze data about patient exposure to radiation from medical sources. It's like PACS, but for Radiation Dose + Analytics.

Comprehensive Tracking:
keeps track of a patient's total radiation exposure over time, across different types of imaging procedures and equipment.



Automated Data Collection:
It automatically gathers data from various imaging devices, regardless of the manufacturer.

Data-Driven Insights:
The reports generated provide valuable insights into radiation exposure trends and patterns, helping to identify areas for improvement.

Improved Patient Safety:
By monitoring radiation exposure, dose records help to ensure that patients are not receiving excessive doses of radiation.

C.3

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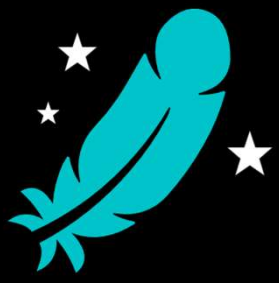
Generally, improving **image quality** is not free; comes at the cost of increased **radiation dose** to the patient.



Our responsibility is to be sensible with our decisions and to "**image gently**"

C.3

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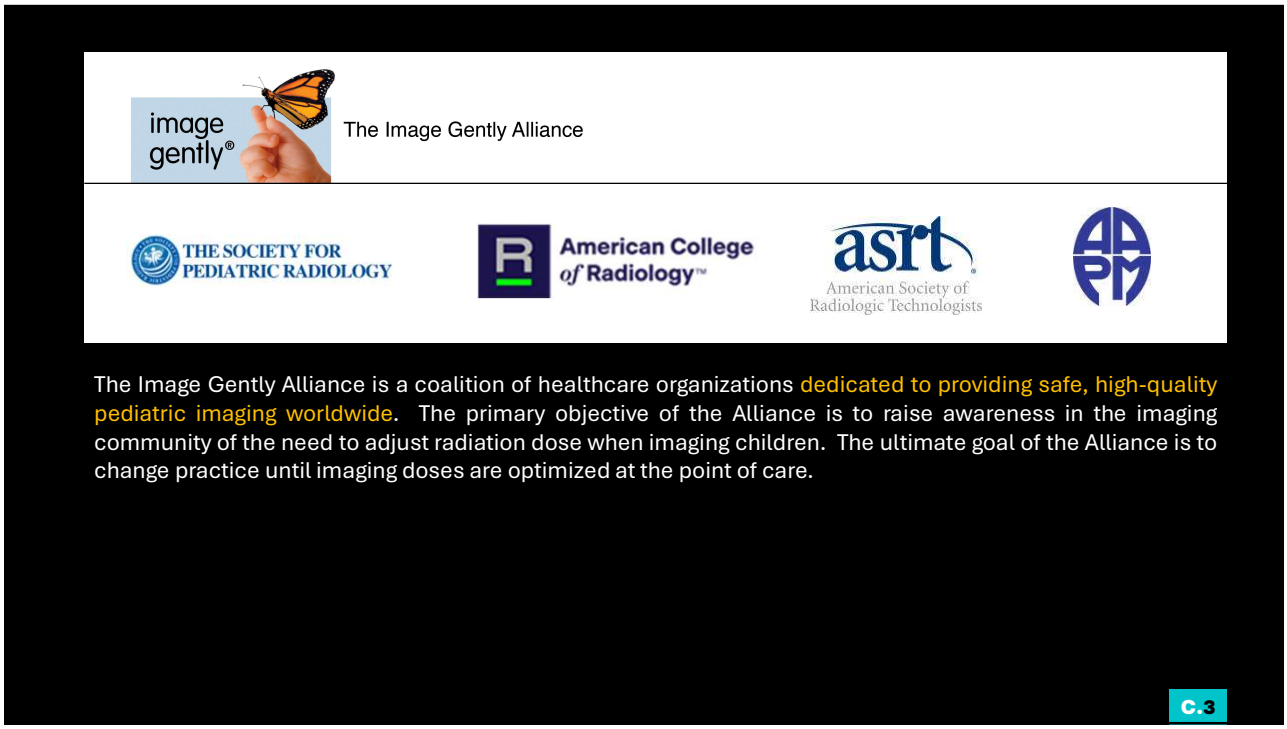
image gently®
The Image Gently Alliance
THE SOCIETY FOR PEDIATRIC RADIOLOGY
American College of Radiology™
asrt
American Society of Radiologic Technologists
The Image Gently Alliance is a coalition of healthcare organizations dedicated to providing safe, high-quality pediatric imaging worldwide. The primary objective of the Alliance is to raise awareness in the imaging community of the need to adjust radiation dose when imaging children. The ultimate goal of the Alliance is to change practice until imaging doses are optimized at the point of care.
C.3

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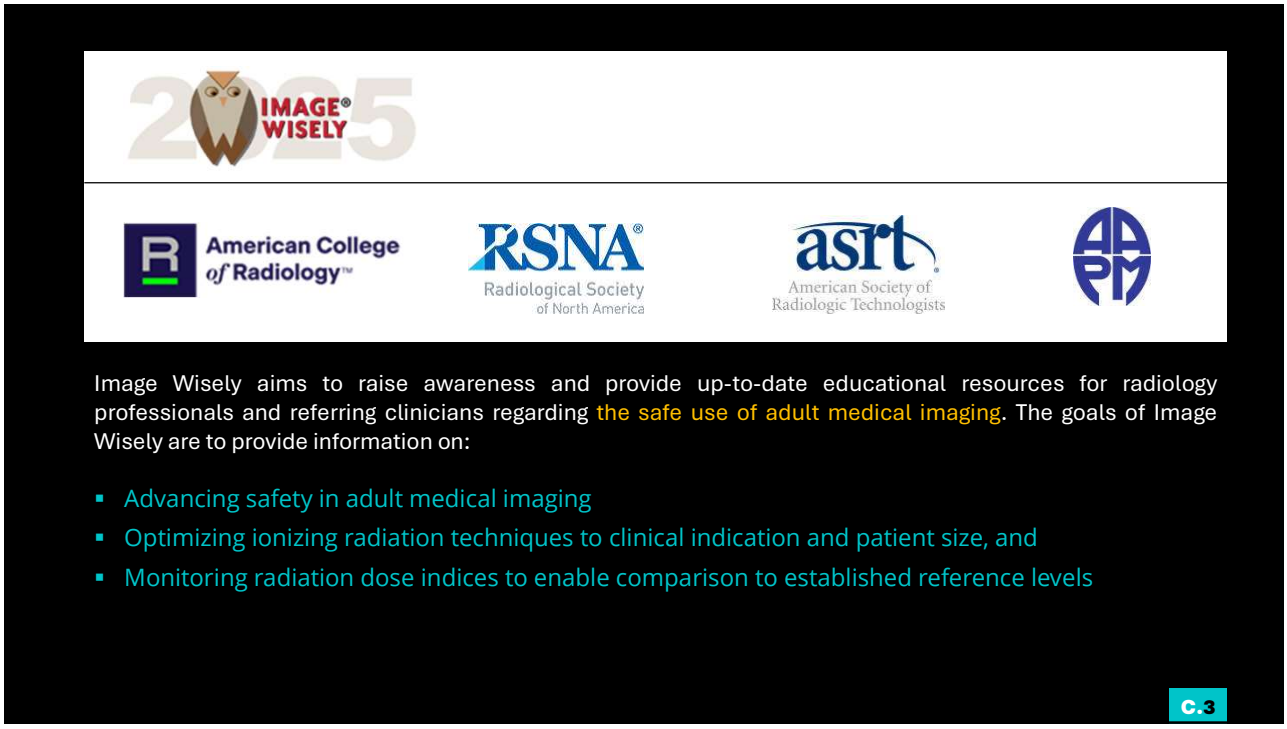
2025
IMAGE® WISELY
American College of Radiology™
RSNA®
Radiological Society of North America
asrt
American Society of Radiologic Technologists
Image Wisely aims to raise awareness and provide up-to-date educational resources for radiology professionals and referring clinicians regarding the safe use of adult medical imaging. The goals of Image Wisely are to provide information on:
Advancing safety in adult medical imaging
Optimizing ionizing radiation techniques to clinical indication and patient size, and
Monitoring radiation dose indices to enable comparison to established reference levels
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AAPM **PROTOCOLS**

http://www.aapm.org/pubs/CTProtocols/?tab=5#CTabbedPanels

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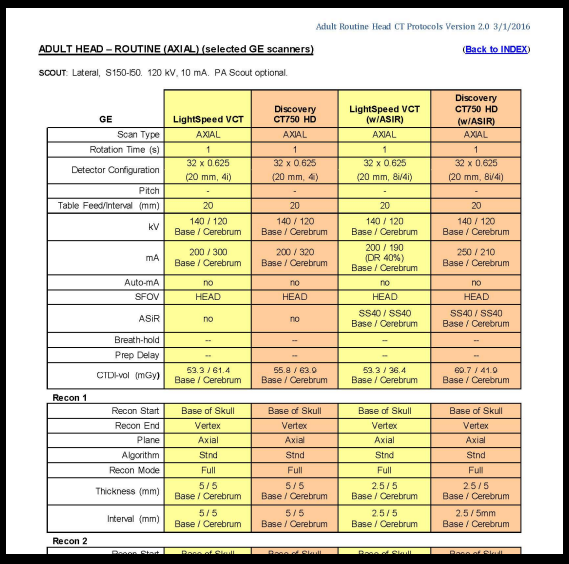
ADULT vs PEDIATRIC **PROTOCOLS**

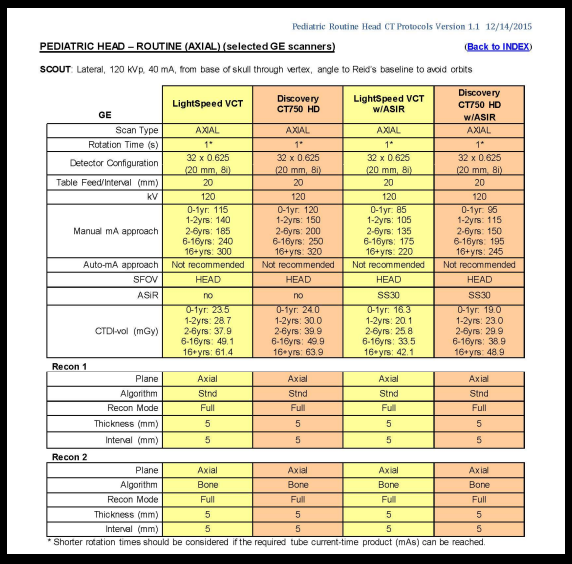


Adult Routine Head CT Protocols Version 2.0 3/1/2016

ADULT HEAD – ROUTINE (AXIAL) (selected GE scanners) (Back to INDEX)

SCOUT: Lateral, S150-I50. 120 kV, 10 mA. PA Scout optional.

GE	LightSpeed VCT	Discovery CT750 HD	LightSpeed VCT (w/ASIR)	Discovery CT750 HD (w/ASIR)
Scan Type	AXIAL	AXIAL	AXIAL	AXIAL
Rotation Time (s)	1	1	1	1
Detector Configuration	32 x 0.625 (20 mm, 4i)	32 x 0.625 (20 mm, 4i)	32 x 0.625 (20 mm, 8i/4i)	32 x 0.625 (20 mm, 8i/4i)
Pitch	-	-	-	-
Table Feed/Interval (mm)	20	20	20	20
kV	140 / 120 Base / Cerebrum	140 / 120 Base / Cerebrum	140 / 120 Base / Cerebrum	140 / 120 Base / Cerebrum
mA	200 / 300 Base / Cerebrum	200 / 320 Base / Cerebrum	200 / 190 (DR 40%) Base / Cerebrum	250 / 210 Base / Cerebrum
Auto-mA	no	no	no	no
SFOV	HEAD	HEAD	HEAD	HEAD
ASiR	no	no	SS40 / SS40 Base / Cerebrum	SS40 / SS40 Base / Cerebrum
Breath-hold	--	--	--	--
Prep Delay	--	--	--	--
CTDI-vol (mGy)	53.3 / 61.4 Base / Cerebrum	55.8 / 63.9 Base / Cerebrum	53.3 / 36.4 Base / Cerebrum	69.7 / 41.9 Base / Cerebrum
Recon 1				
Recon Start	Base of Skull	Base of Skull	Base of Skull	Base of Skull
Recon End	Vertex	Vertex	Vertex	Vertex
Plane	Axial	Axial	Axial	Axial
Algorithm	Stnd	Stnd	Stnd	Stnd
Recon Mode	Full	Full	Full	Full
Thickness (mm)	5 / 5 Base / Cerebrum	5 / 5 Base / Cerebrum	2.5 / 5 Base / Cerebrum	2.5 / 5 Base / Cerebrum
Interval (mm)	5 / 5 Base / Cerebrum	5 / 5 Base / Cerebrum	2.5 / 5 Base / Cerebrum	2.5 / 5mm Base / Cerebrum
Recon 2				



Pediatric Routine Head CT Protocols Version 1.1 12/14/2015

PEDIATRIC HEAD – ROUTINE (AXIAL) (selected GE scanners) (Back to INDEX)

SCOUT: Lateral, 120 kVp, 40 mA, from base of skull through vertex, angle to Reid's baseline to avoid orbits

GE	LightSpeed VCT	Discovery CT750 HD	LightSpeed VCT w/ASIR	Discovery CT750 HD w/ASIR
Scan Type	AXIAL	AXIAL	AXIAL	AXIAL
Rotation Time (s)	1*	1*	1*	1*
Detector Configuration	32 x 0.625 (20 mm, 8i)	32 x 0.625 (20 mm, 8i)	32 x 0.625 (20 mm, 8i)	32 x 0.625 (20 mm, 8i)
Table Feed/Interval (mm)	20	20	20	20
kV	120	120	120	120
Manual mA approach	0-1yr: 115 1-2yrs: 140 2-6yrs: 185 6-16yrs: 240 16+yrs: 300	0-1yr: 120 1-2yrs: 150 2-6yrs: 200 6-16yrs: 250 16+yrs: 320	0-1yr: 85 1-2yrs: 105 2-6yrs: 135 6-16yrs: 175 16+yrs: 220	0-1yr: 95 1-2yrs: 115 2-6yrs: 150 6-16yrs: 195 16+yrs: 245
Auto-mA approach	Not recommended	Not recommended	Not recommended	Not recommended
SFOV	HEAD	HEAD	HEAD	HEAD
ASiR	no	no	SS30	SS30
CTDI-vol (mGy)	0-1yr: 23.5 1-2yrs: 28.7 2-6yrs: 37.9 6-16yrs: 49.1 16+yrs: 61.4	0-1yr: 24.0 1-2yrs: 30.0 2-6yrs: 39.9 6-16yrs: 49.9 16+yrs: 63.9	0-1yr: 16.3 1-2yrs: 20.1 2-6yrs: 25.8 6-16yrs: 33.5 16+yrs: 42.1	0-1yr: 19.0 1-2yrs: 23.0 2-6yrs: 29.9 6-16yrs: 38.9 16+yrs: 48.9
Recon 1				
Plane	Axial	Axial	Axial	Axial
Algorithm	Stnd	Stnd	Stnd	Stnd
Recon Mode	Full	Full	Full	Full
Thickness (mm)	5	5	5	5
Interval (mm)	5	5	5	5
Recon 2				
Plane	Axial	Axial	Axial	Axial
Algorithm	Bone	Bone	Bone	Bone
Recon Mode	Full	Full	Full	Full
Thickness (mm)	5	5	5	5
Interval (mm)	5	5	5	5

* Shorter rotation times should be considered if the required tube current-time product (mAs) can be reached.

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CHAPTER
CONCLUDED
CT DOSE METRICS
CT DOSE REPORTS
FACTORS AFFECTING DOSE
REDUCING RISKS
SAFETY ALLIANCES

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