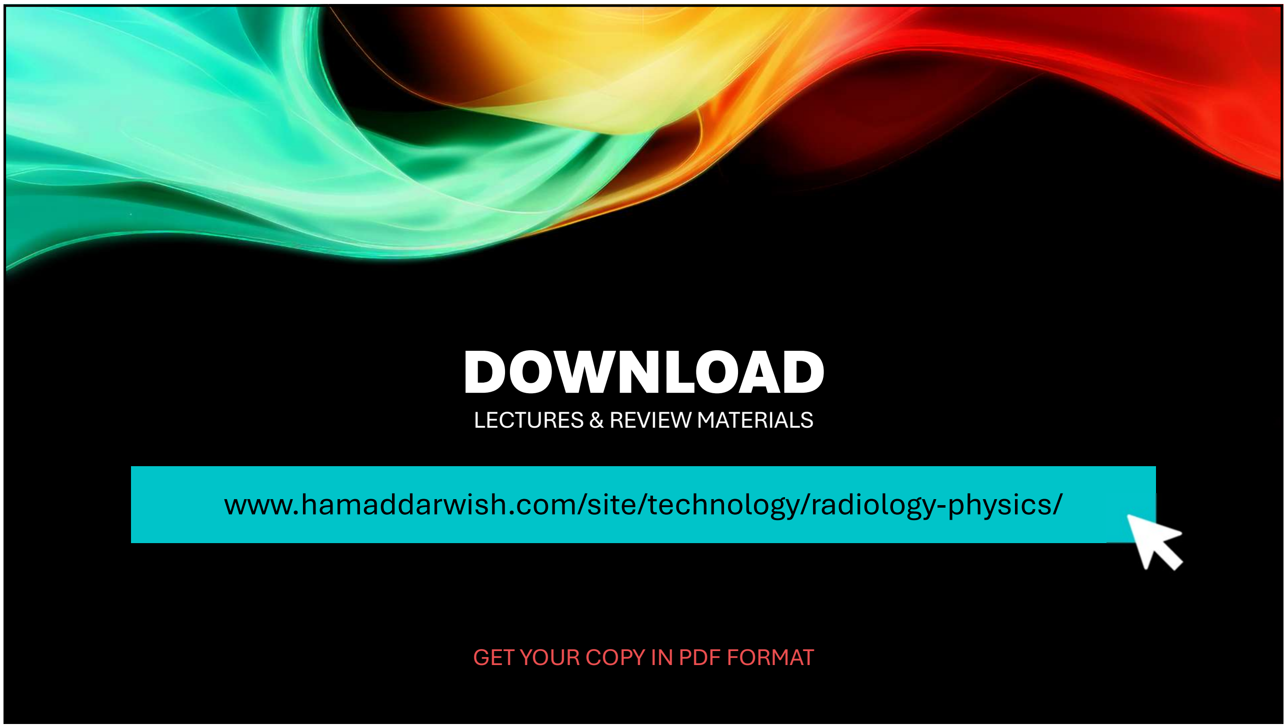
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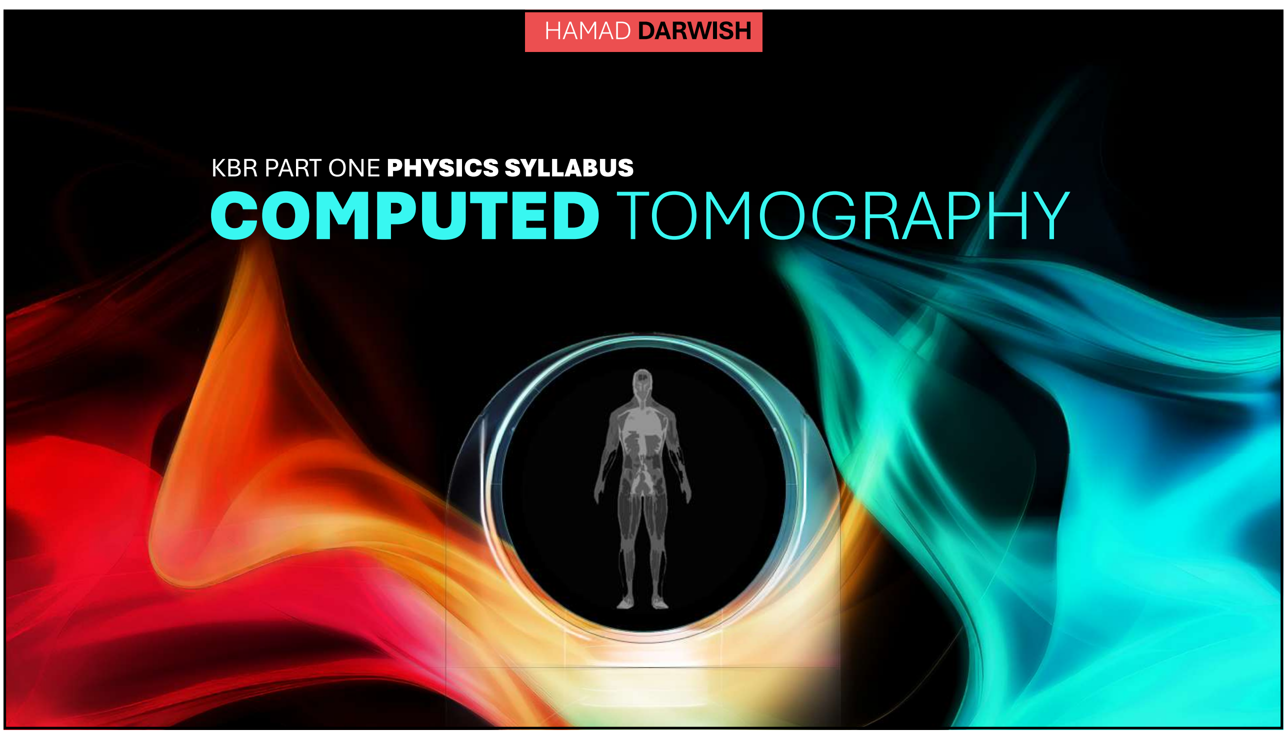
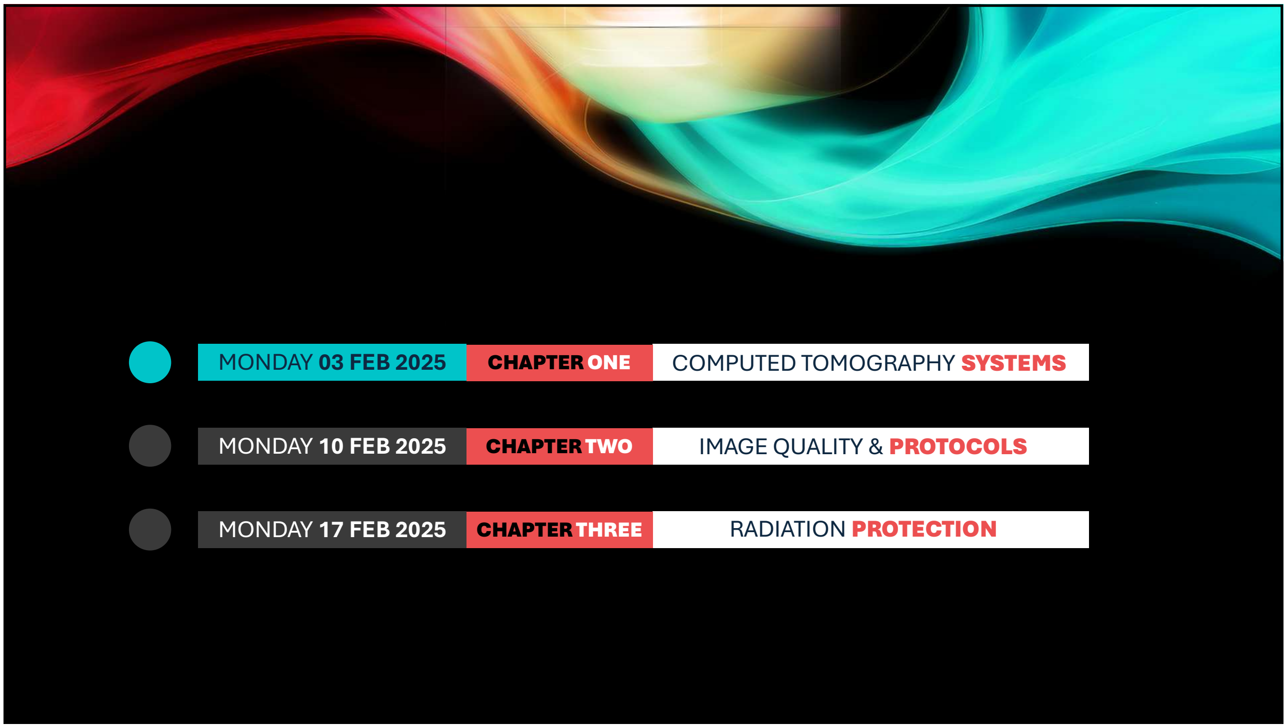
LECTURES & REVIEW MATERIALS
www.hamaddarwish.com/site/technology/radiology-physics/
GET YOUR COPY IN PDF FORMAT

140


HAMAD DARWISH
KBR PART ONE PHYSICS SYLLABUS
COMPUTED TOMOGRAPHY

141


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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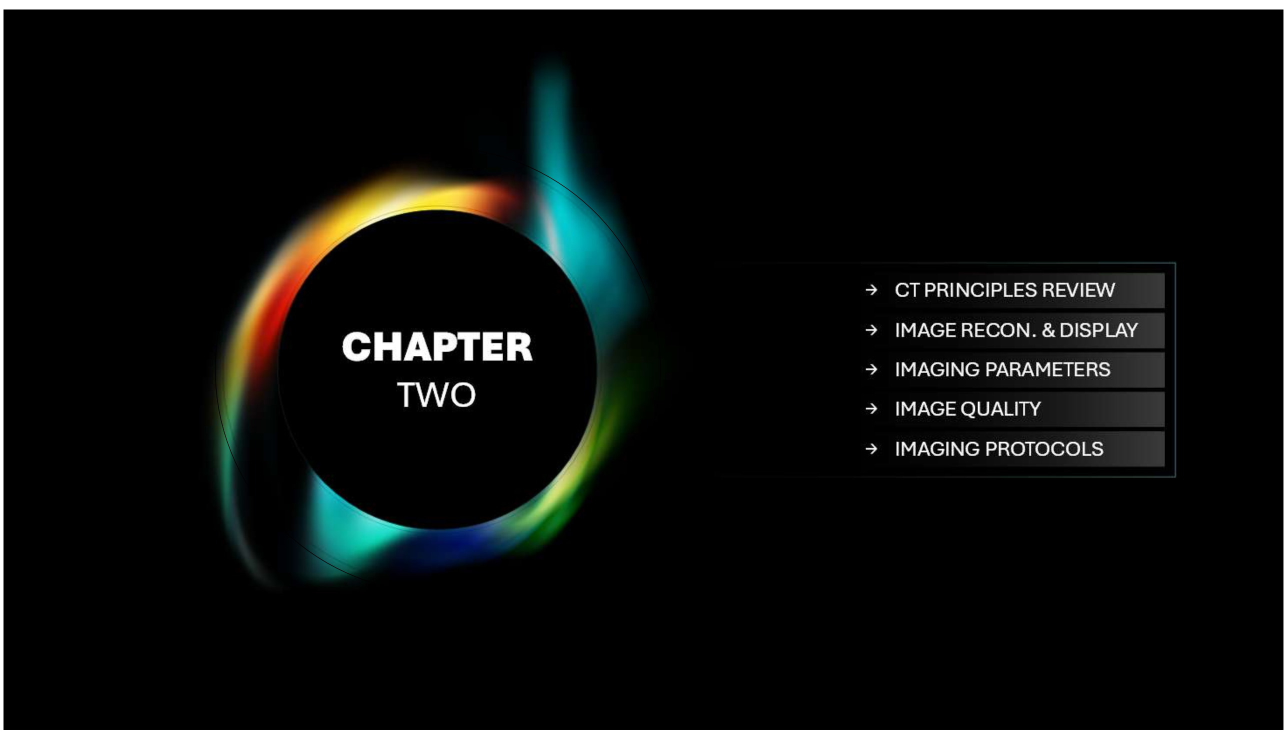
CHAPTER
TWO
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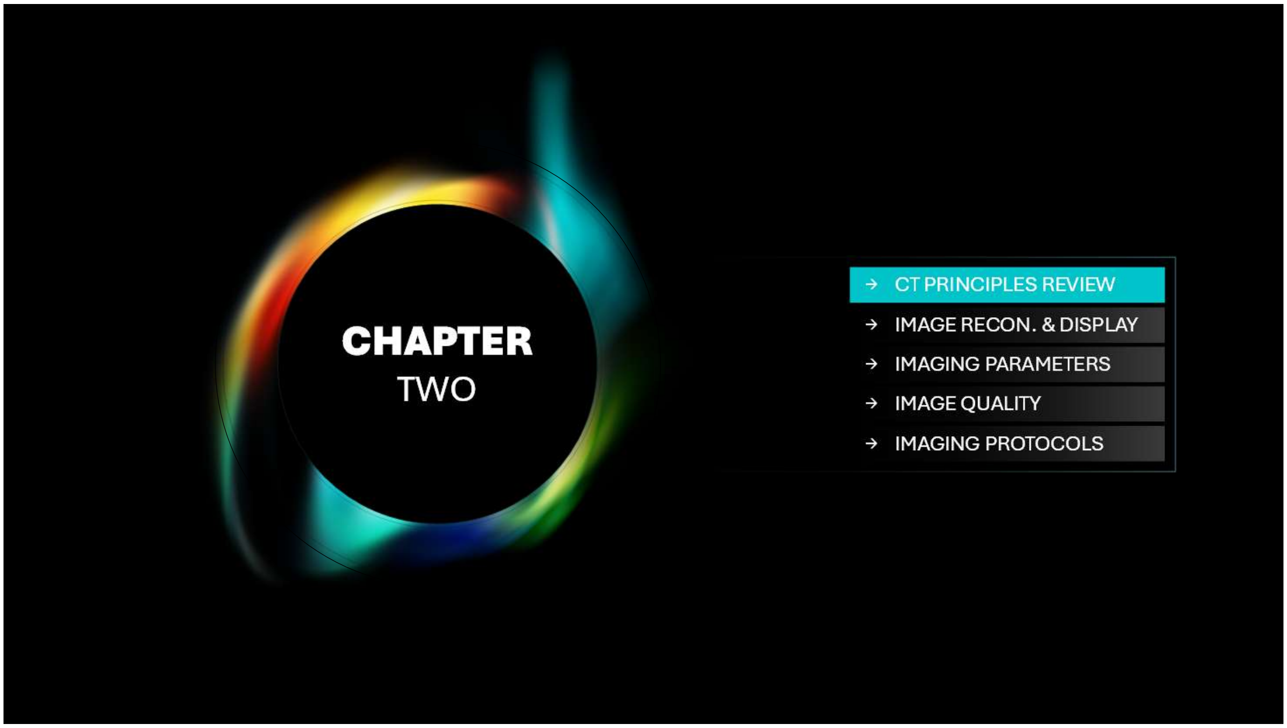
IMAGE RECON. & DISPLAY
IMAGING PARAMETERS
IMAGE QUALITY
IMAGING PROTOCOLS

145


CHAPTER
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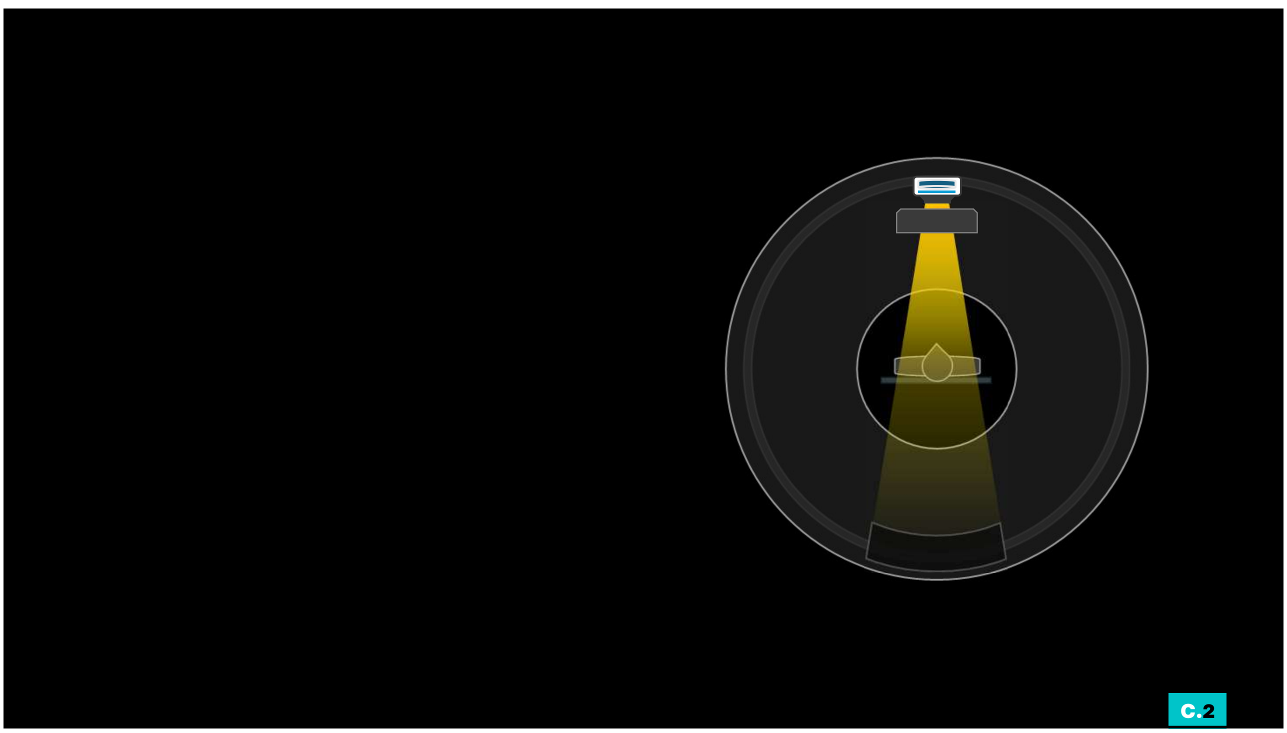
146

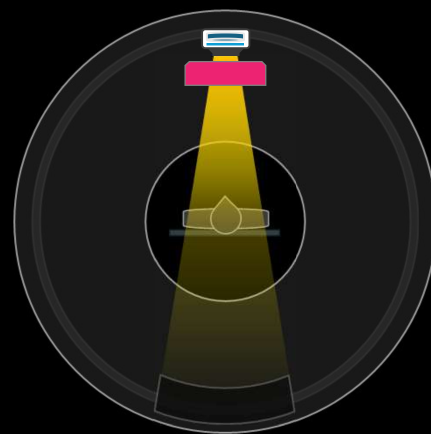

C.2

147

COLLIMATORS

Beam limiting device responsible for adjusting the width of the beam. Adjusting the width in:

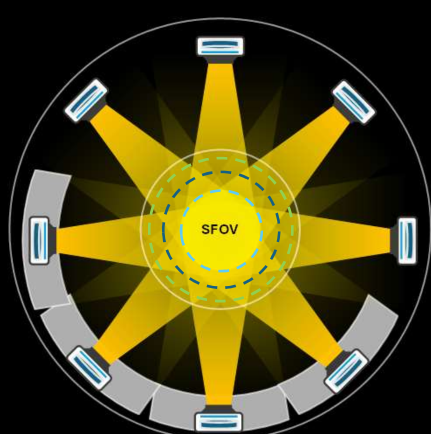
- **X-Y-Axis:** affects the scan field of view (SFOV)
- **Z-axis:** affects the patient coverage per rotation

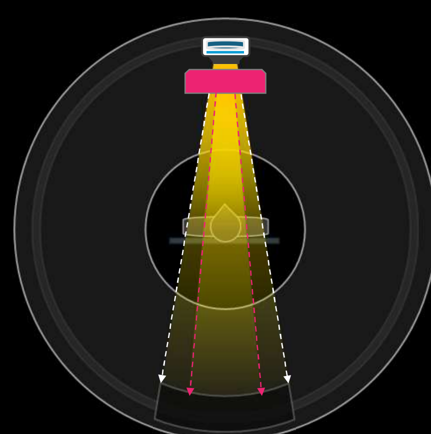


C.2

148

COLLIMATION: X-Y-AXIS





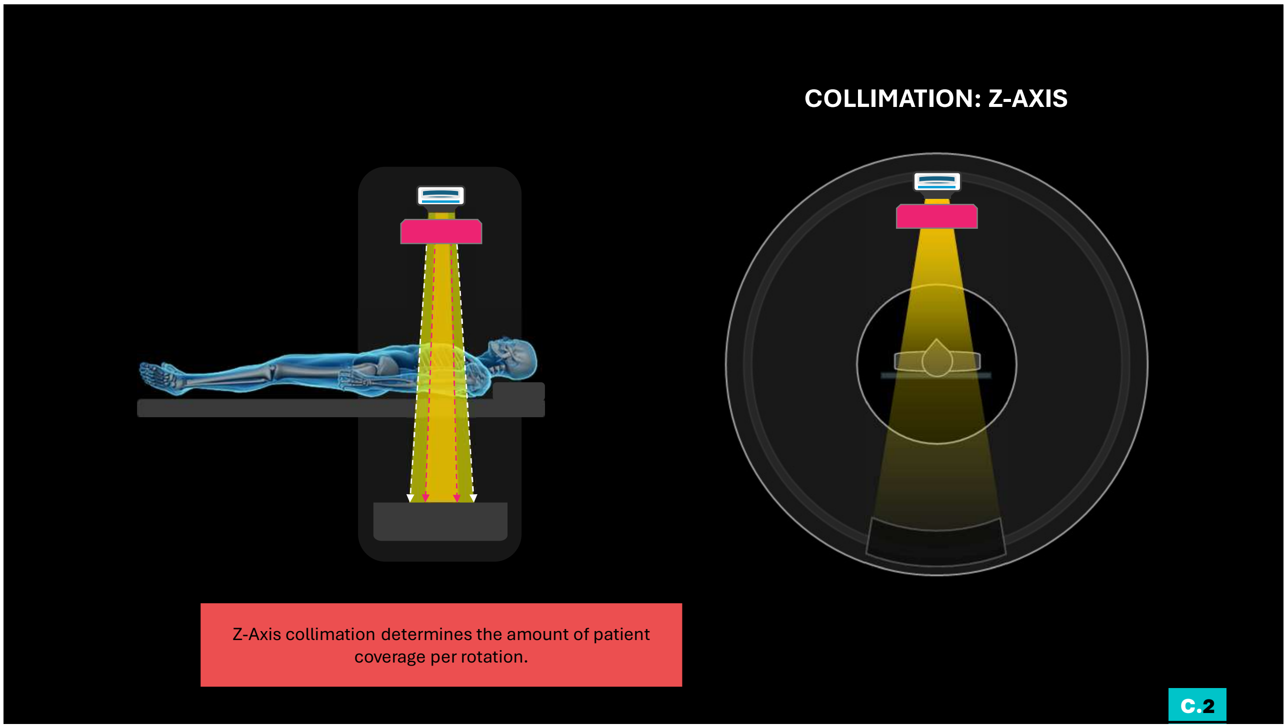
SFOV SIZES

SMALL | MEDIUM | LARGE

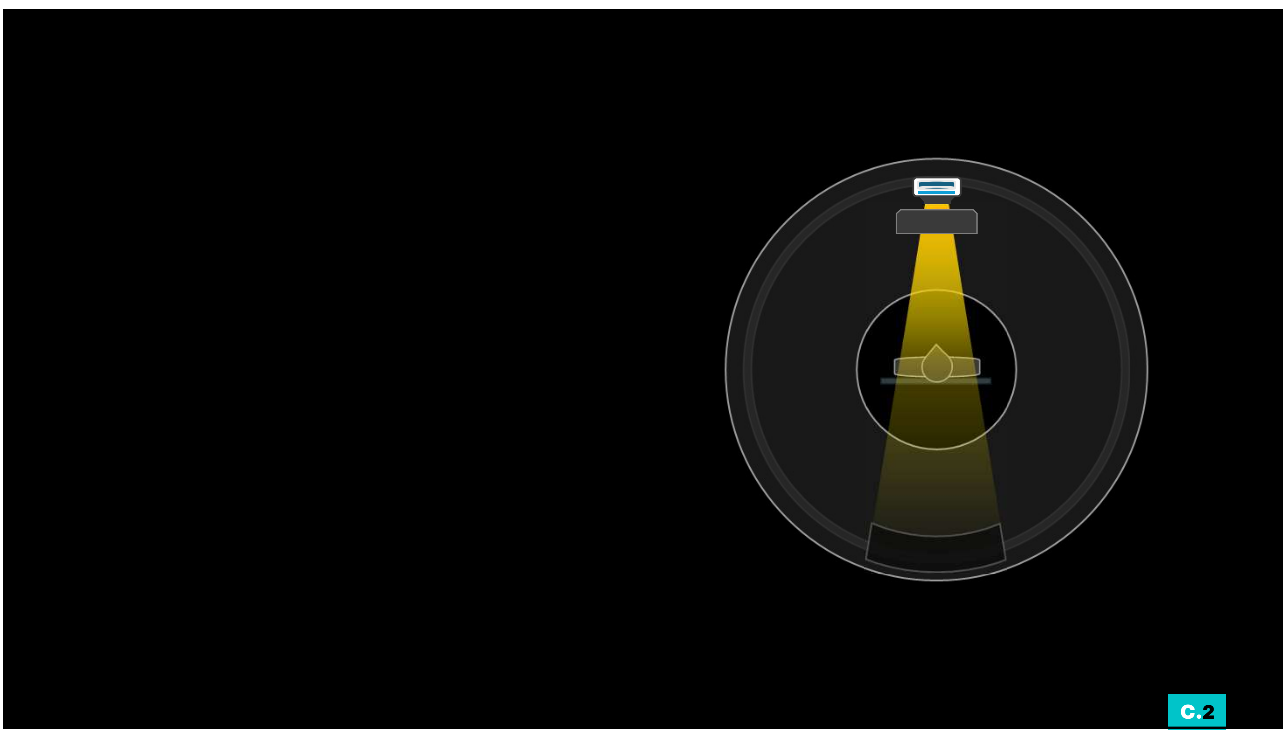
The largest possible SFOV is limited by the gantry opening size and length of the detector

C.2

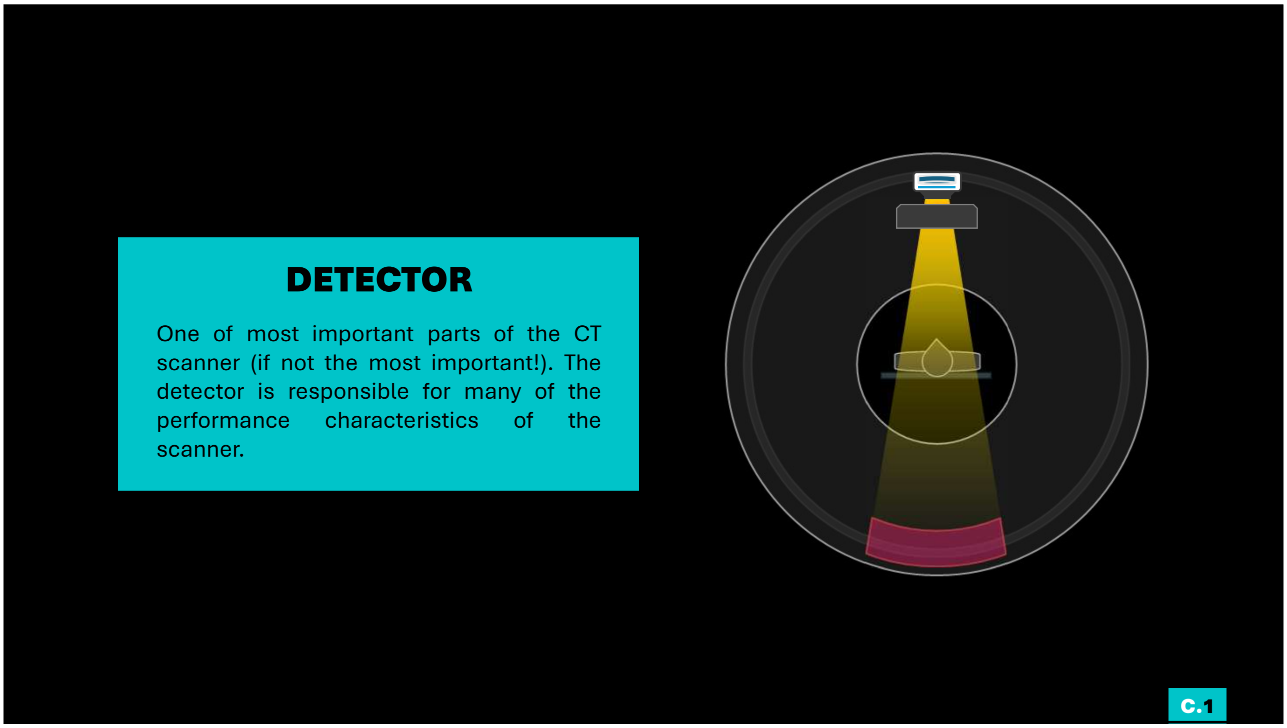
149


COLLIMATION: Z-AXIS
Z-Axis collimation determines the amount of patient coverage per rotation.
C.2

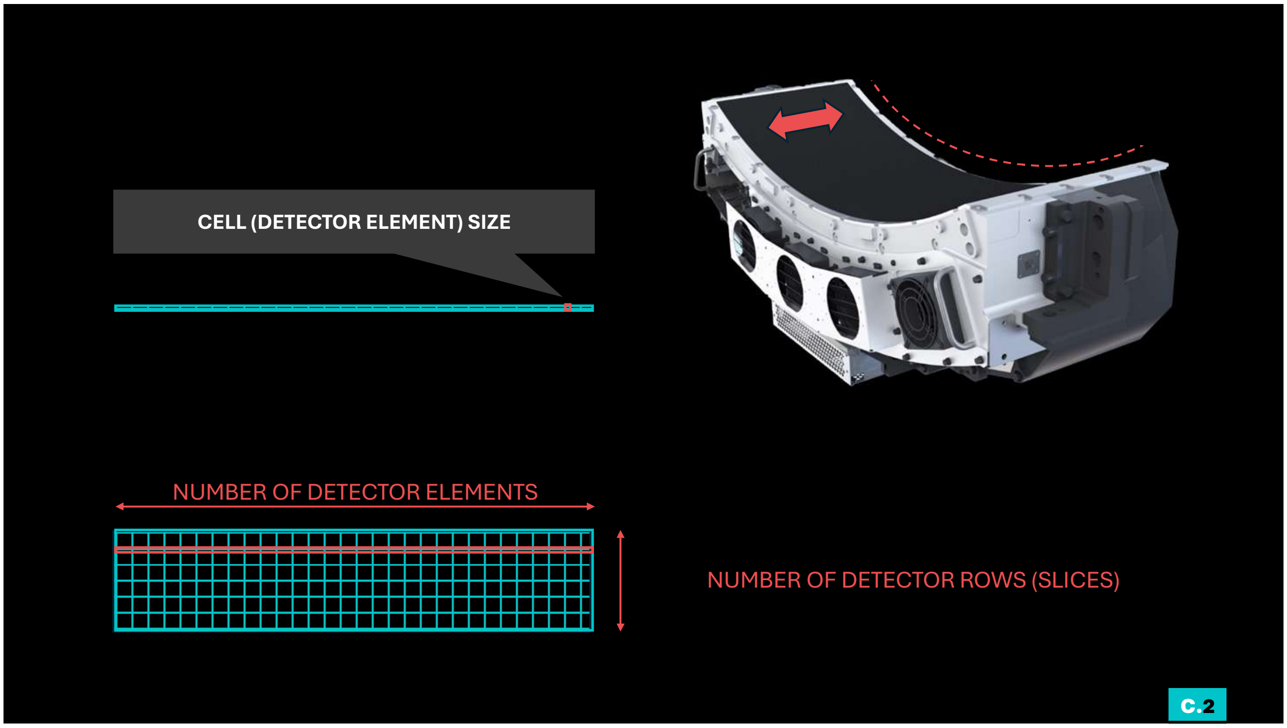
150


C.2

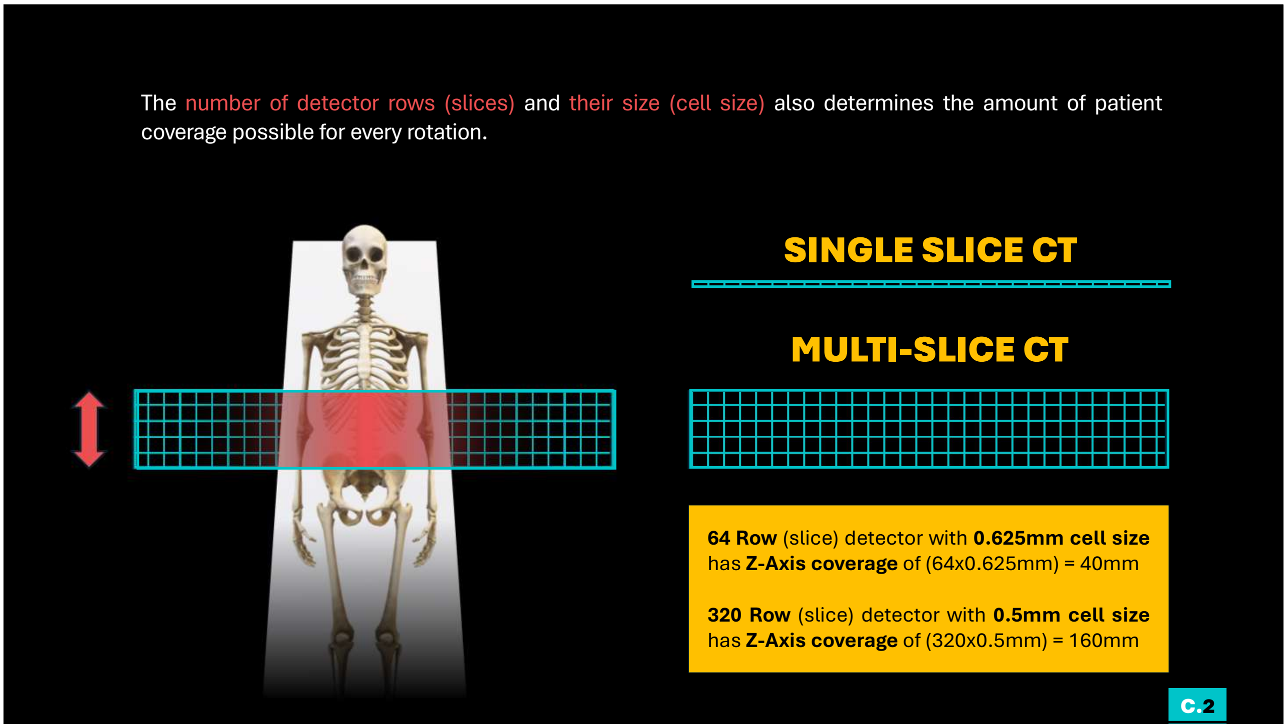
151


DETECTOR
One of most important parts of the CT scanner (if not the most important!). The detector is responsible for many of the performance characteristics of the scanner.
C.1

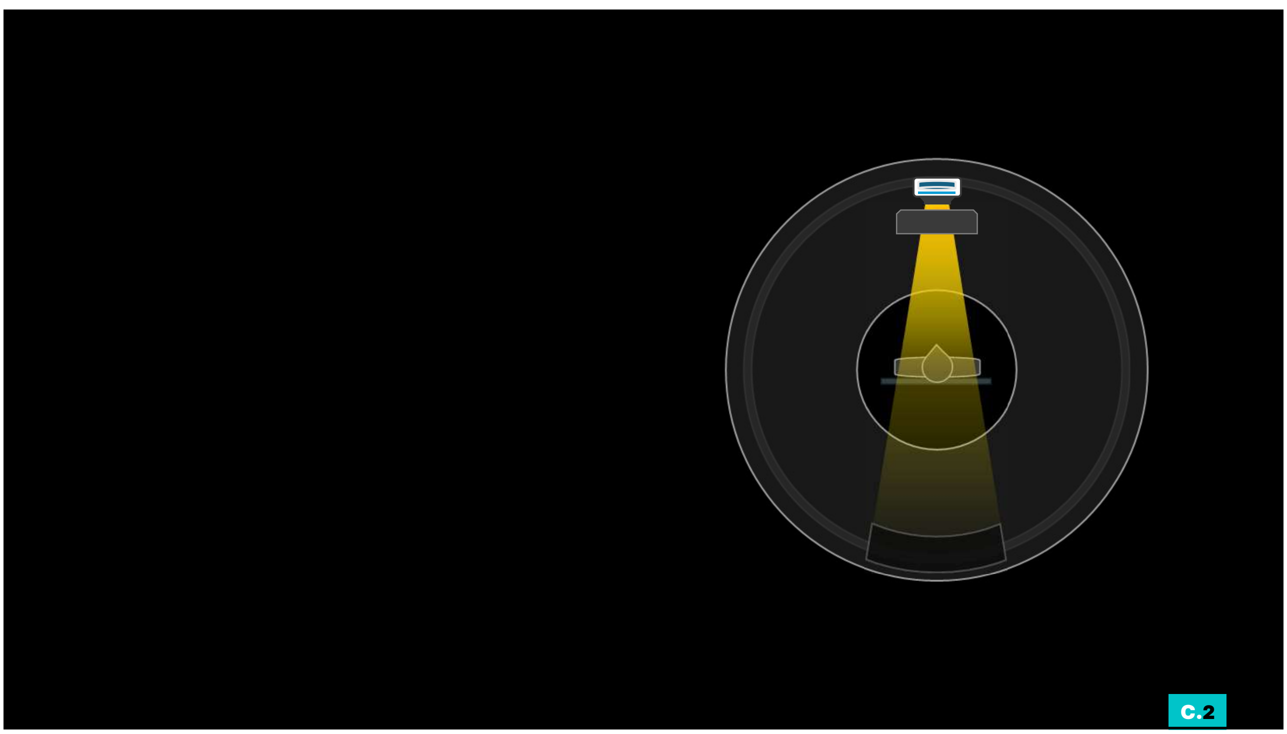
152


CELL (DETECTOR ELEMENT) SIZE
NUMBER OF DETECTOR ELEMENTS
NUMBER OF DETECTOR ROWS (SLICES)
C.2

153


The number of detector rows (slices) and their size (cell size) also determines the amount of patient coverage possible for every rotation.
SINGLE SLICE CT
MULTI-SLICE CT
64 Row (slice) detector with 0.625mm cell size has Z-Axis coverage of (64x0.625mm) = 40mm
320 Row (slice) detector with 0.5mm cell size has Z-Axis coverage of (320x0.5mm) = 160mm
C.2

154


C.2

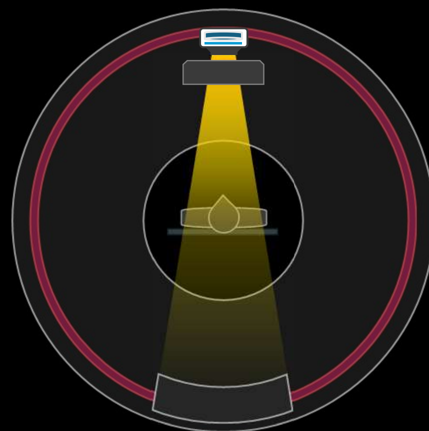
155

ROTATION SYS.

The rotation mechanism is responsible for how fast the CT scanner can complete an acquisition. It is generally referred to as "Rotation Speed". It describes the **time it takes the X-Ray tube & Detector to complete one full rotation around the patient**.

Responsible for the scanner's

"TEMPORAL RESOLUTION"

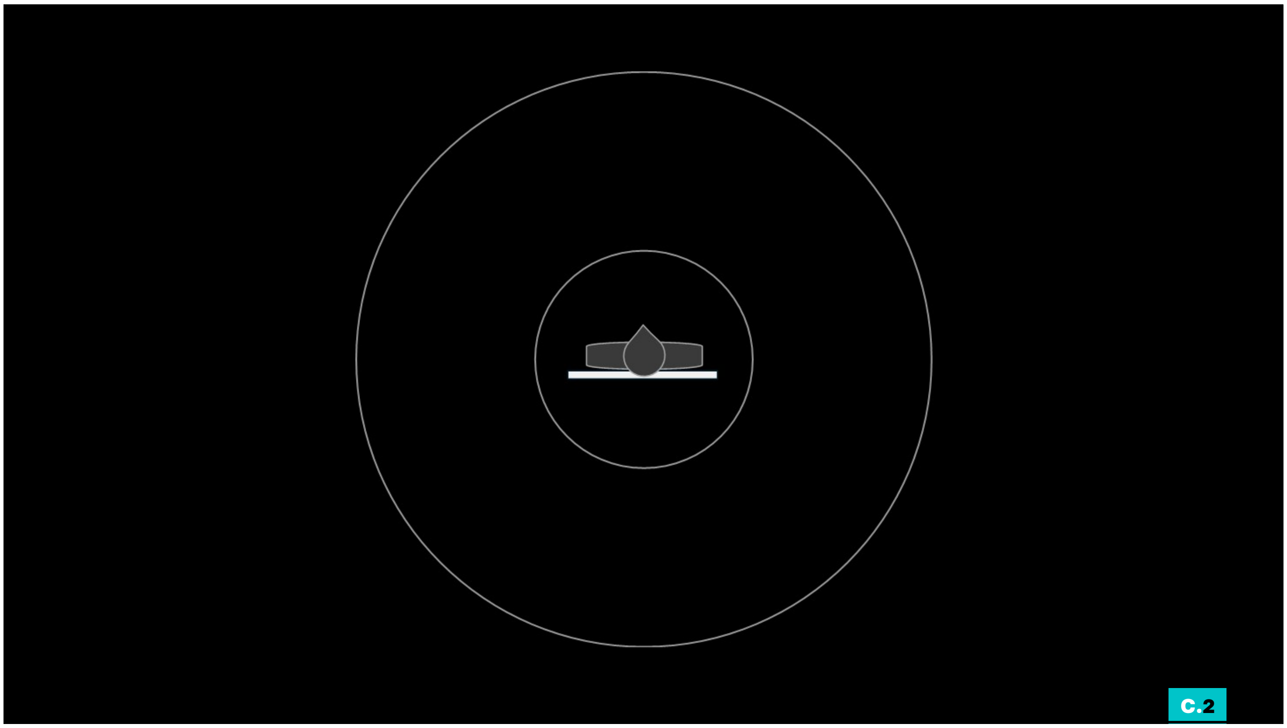


C.2

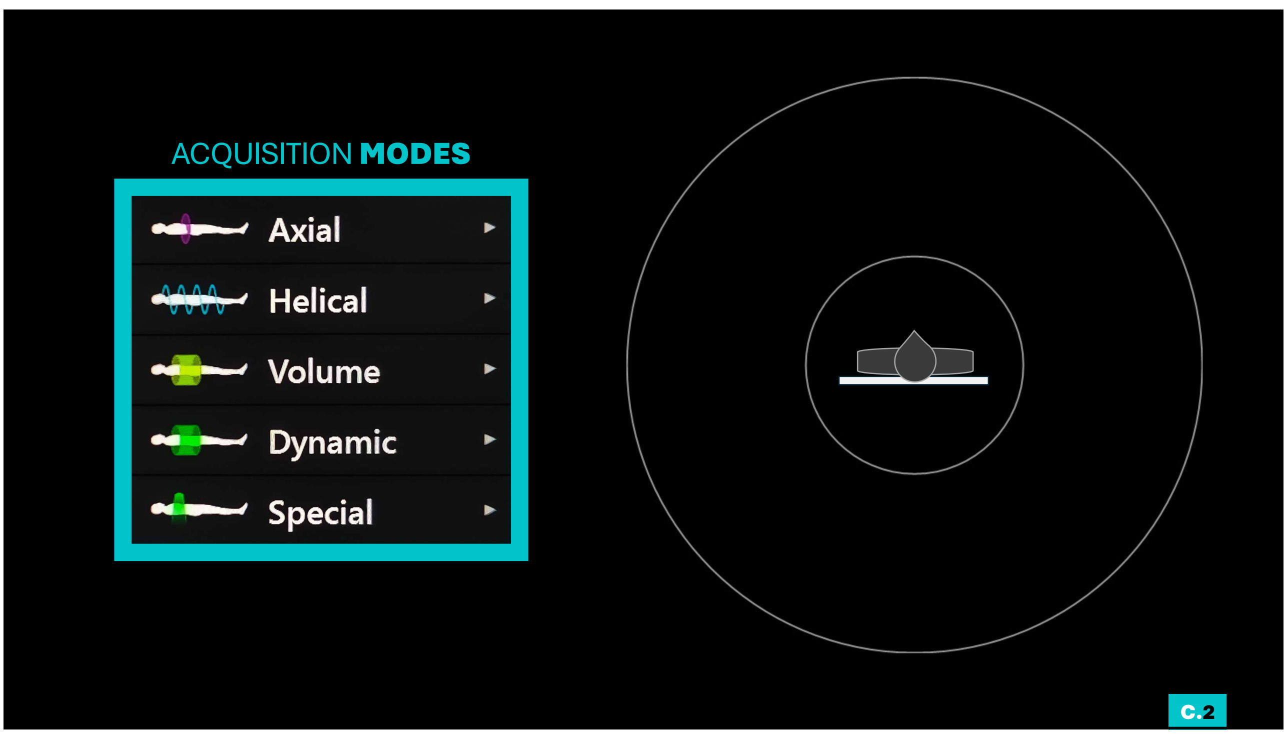
156

C.2

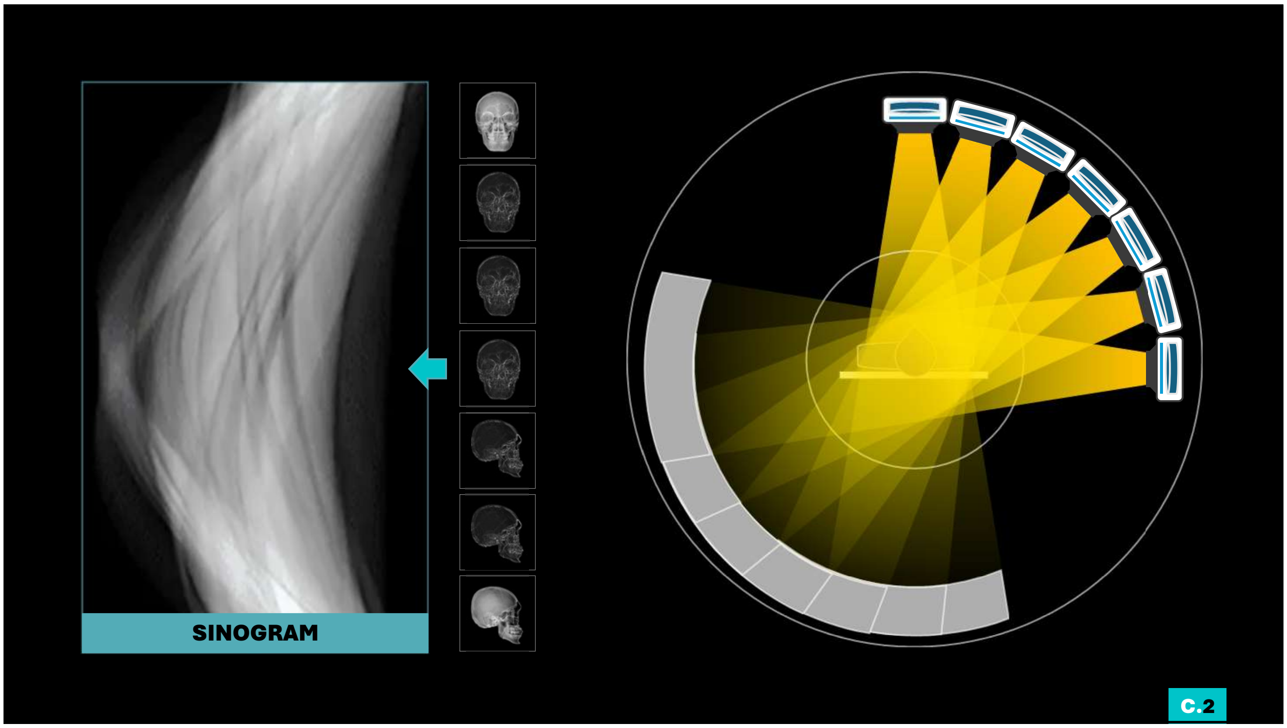
157


C.2

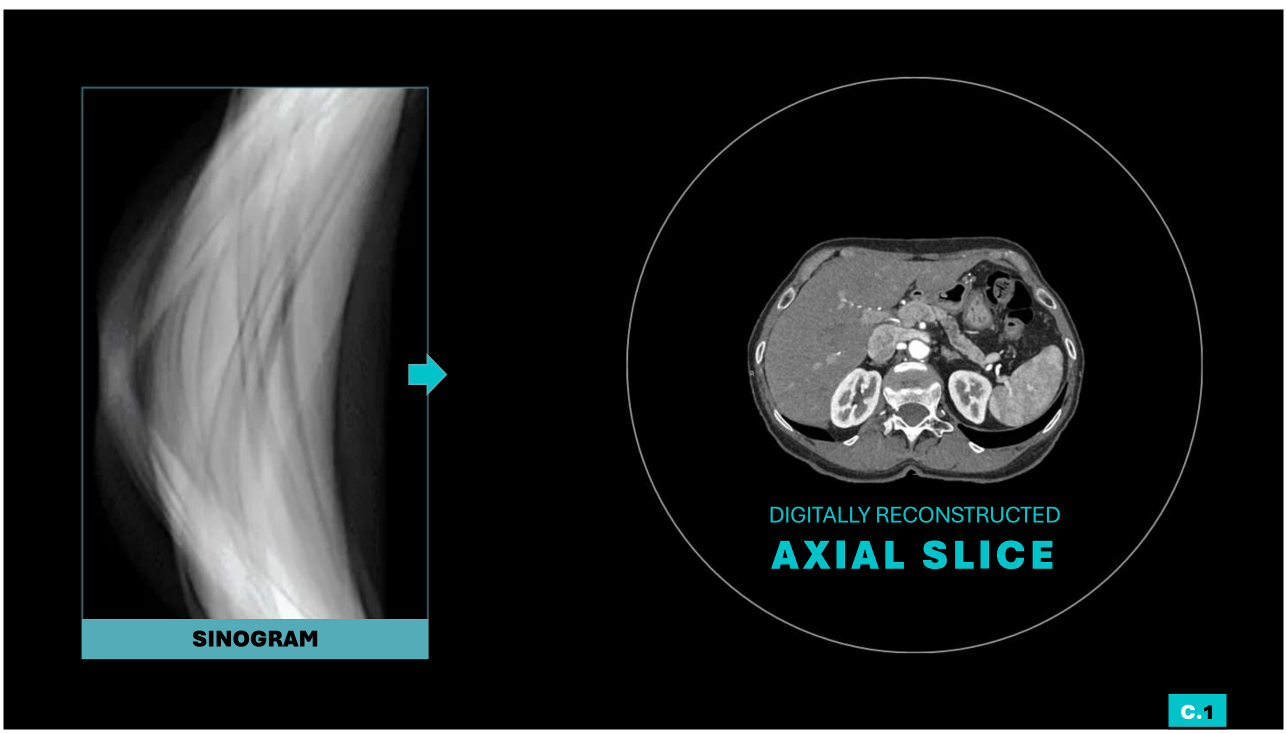
158


ACQUISITION MODES
Axial
Helical
Volume
Dynamic
Special
C.2

159


SINOGRAM
C.2

160


SINOGRAM
DIGITALLY RECONSTRUCTED
AXIAL SLICE
C.1

161

FILTERED BACK-PROJECTION

How it Works:

1. **Projection Data**
2. **Back Projection**
3. **Filtering**

PROS

- Fast and computationally efficient
- well-established (industry standard)

CONS

- Susceptible to noise and artifacts
- FBP does not explicitly account for the physics of x-ray interactions, which can lead to inaccuracies in the reconstructed image.

C.2

162

ITERATIVE RECONSTRUCTION

How it Works:

1. **Initial Image Estimate**
2. **Forward Projection**
3. **Comparison**
4. **Image Update**
5. **Iteration**

PROS

- Excellent noise reduction and Image quality
- Has potential to reduce the radiation dose
- Less susceptible to artifacts and can be used to reduce artifacts.

CONS

- Slow and computationally demanding
- Images may look "Plastic-y"

C.2

163

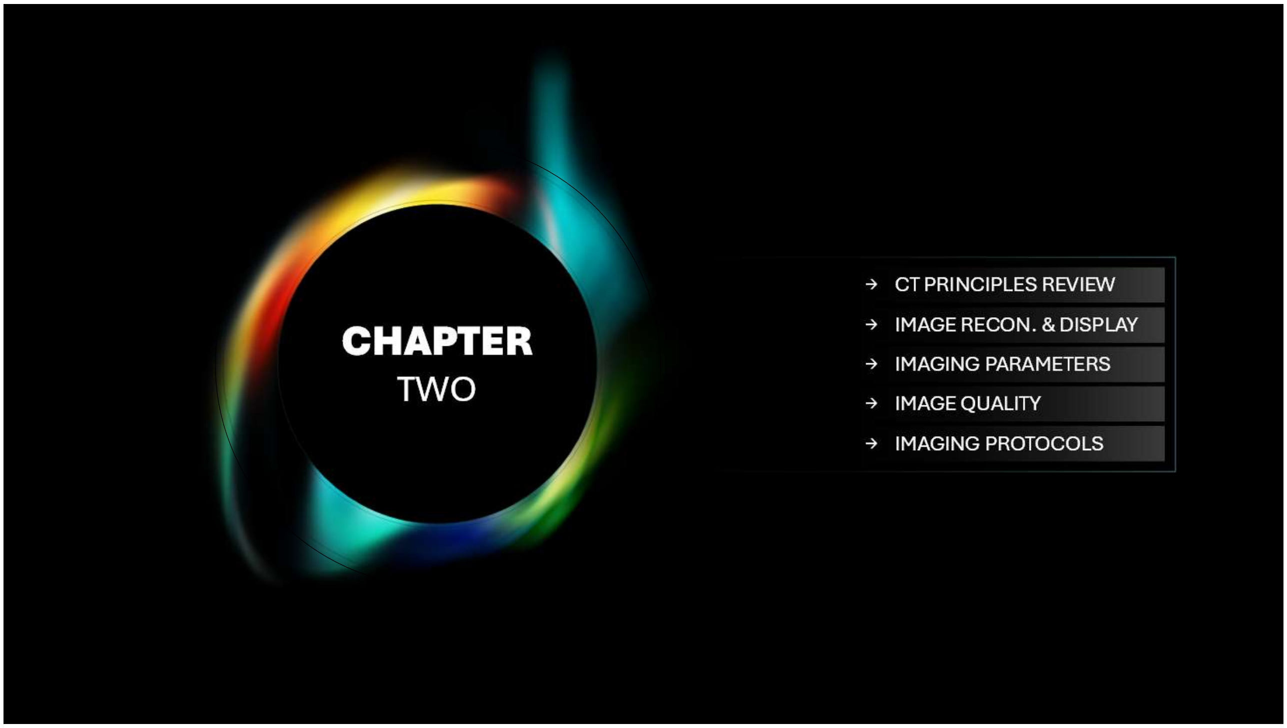

CHAPTER
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IMAGE RECON. & DISPLAY
IMAGING PARAMETERS
IMAGE QUALITY
IMAGING PROTOCOLS

164

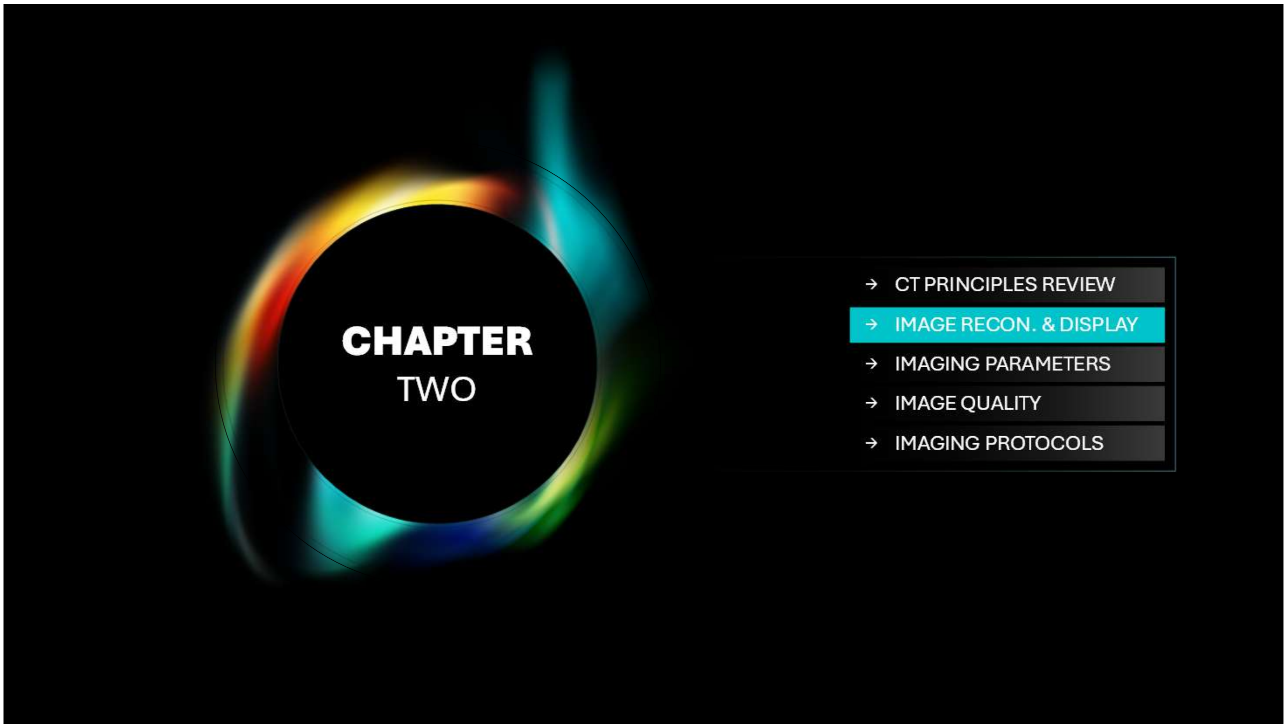
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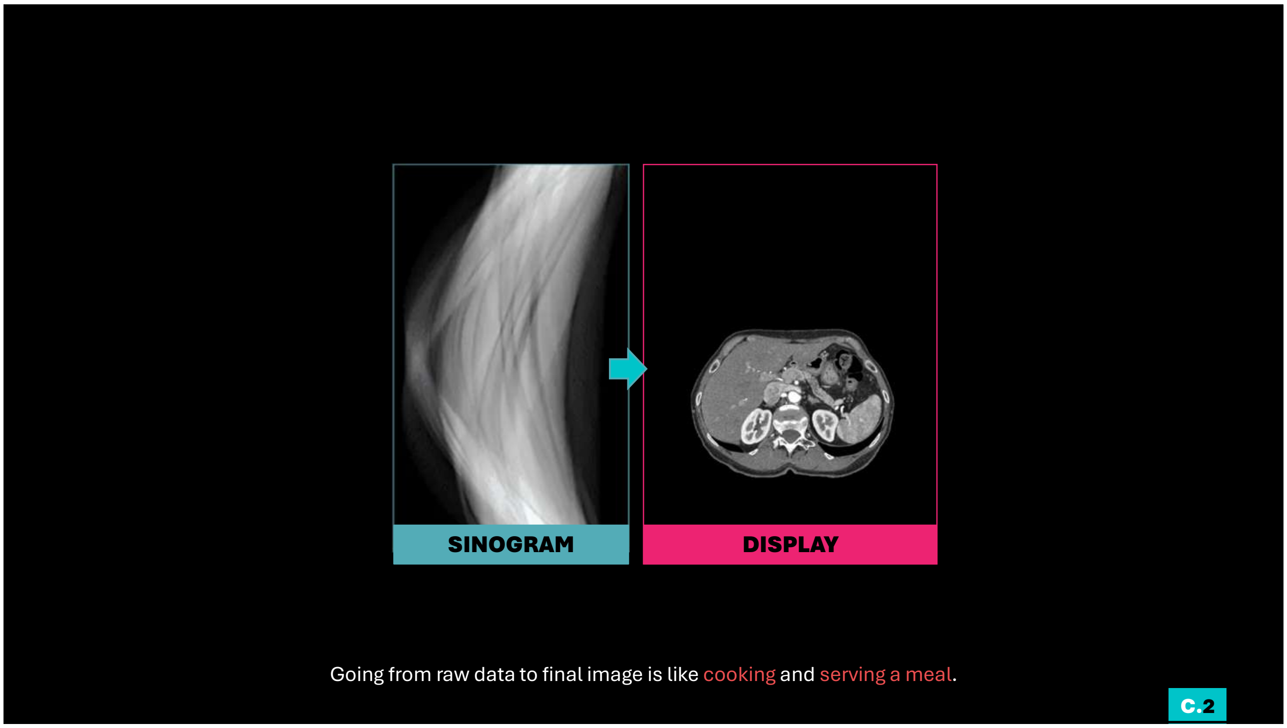
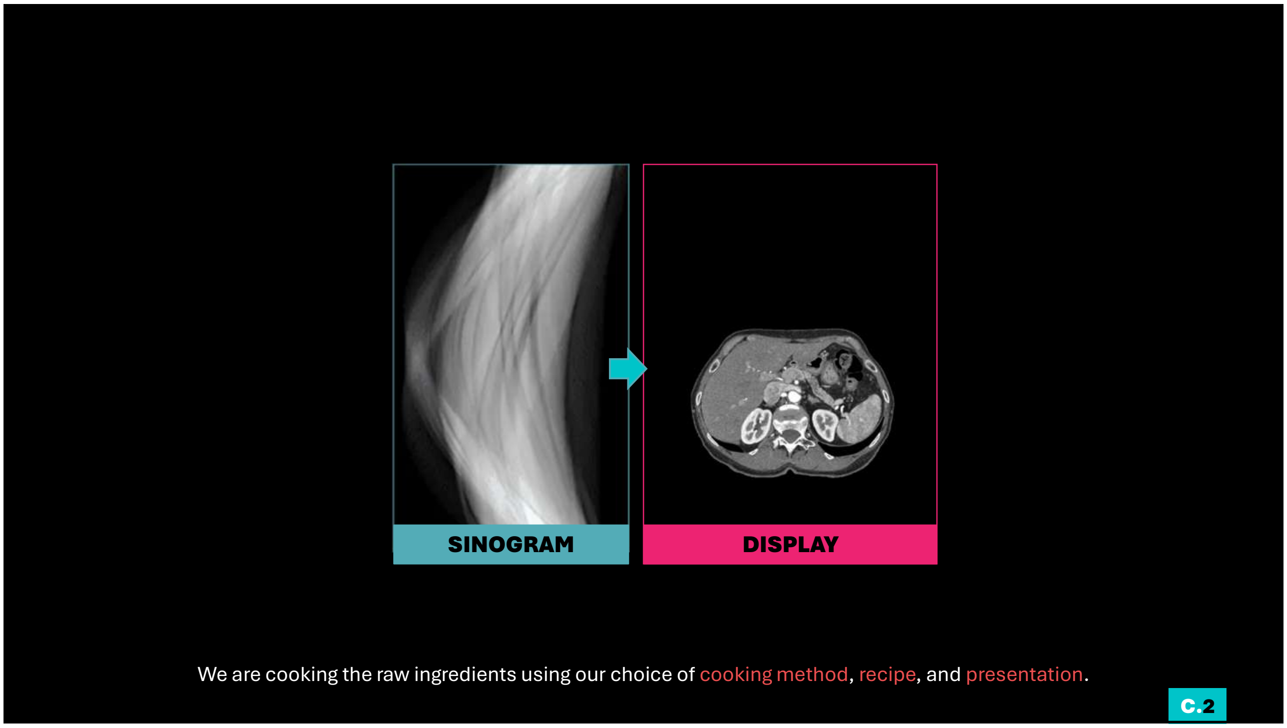
IMAGE QUALITY
IMAGING PROTOCOLS

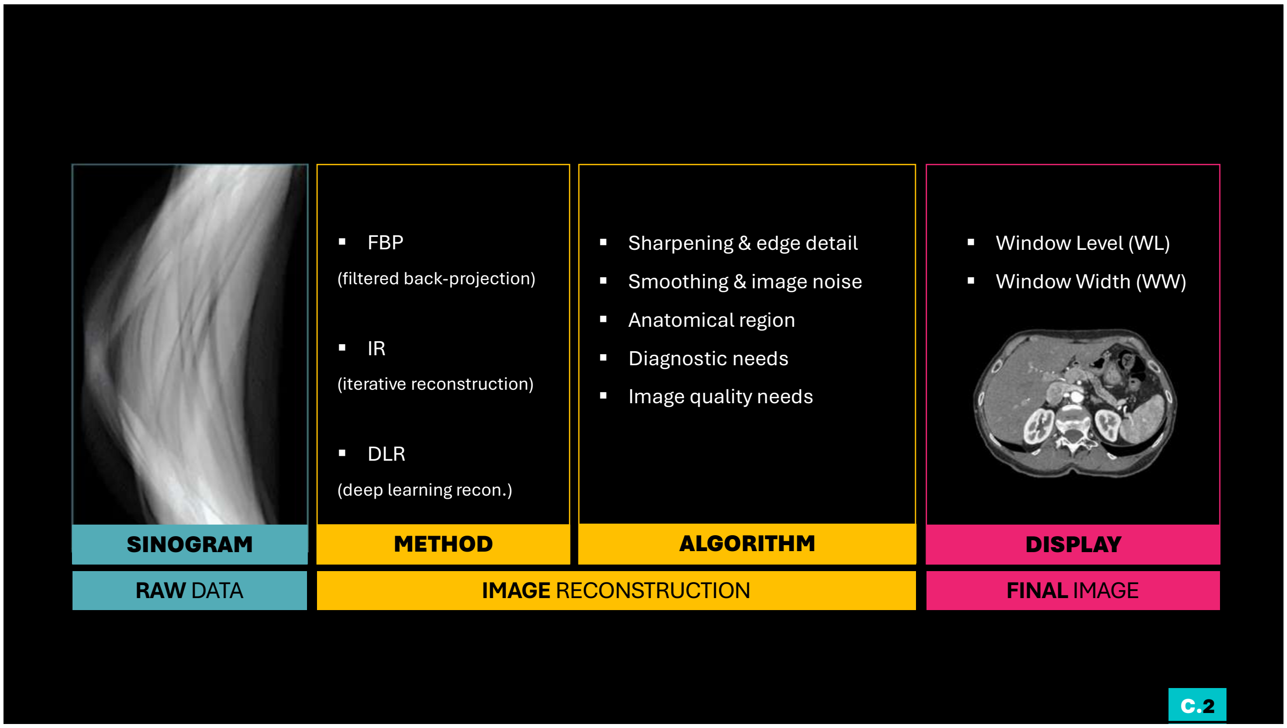
165


SINOGRAM
DISPLAY
Going from raw data to final image is like cooking and serving a meal.
C.2

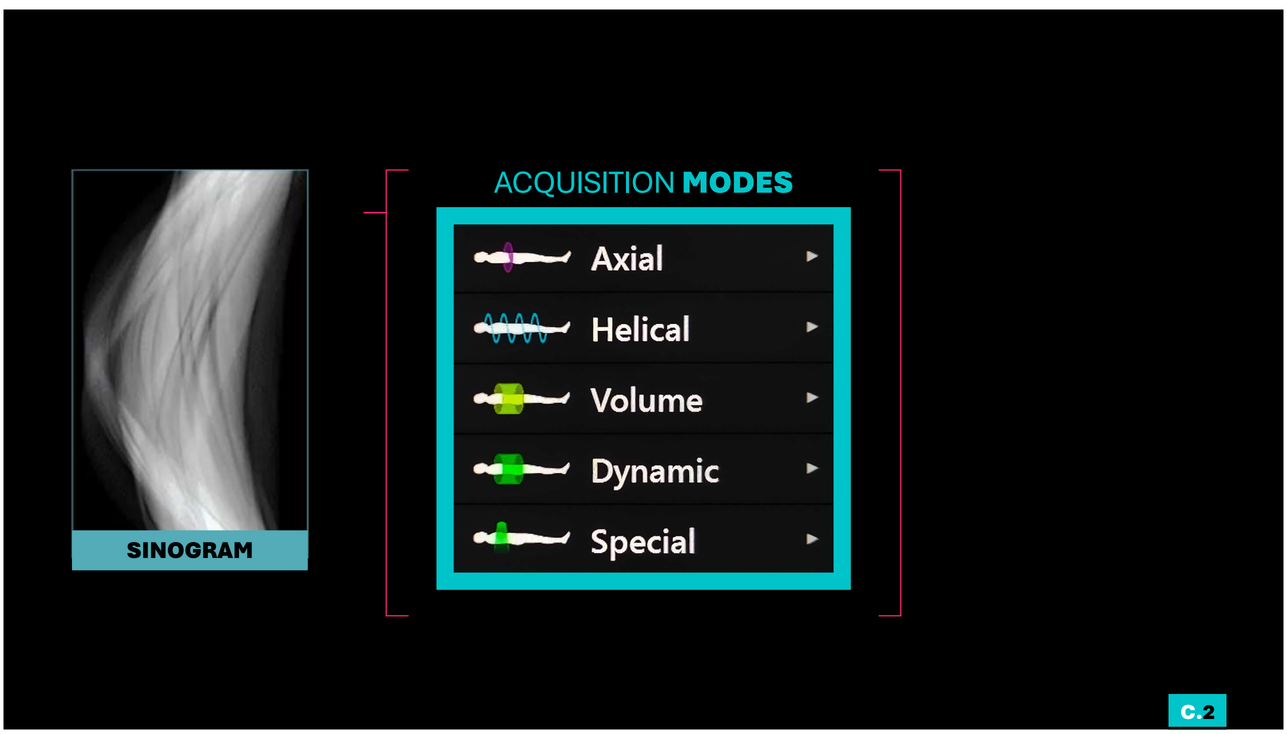
166


SINOGRAM
DISPLAY
We are cooking the raw ingredients using our choice of cooking method, recipe, and presentation.
C.2

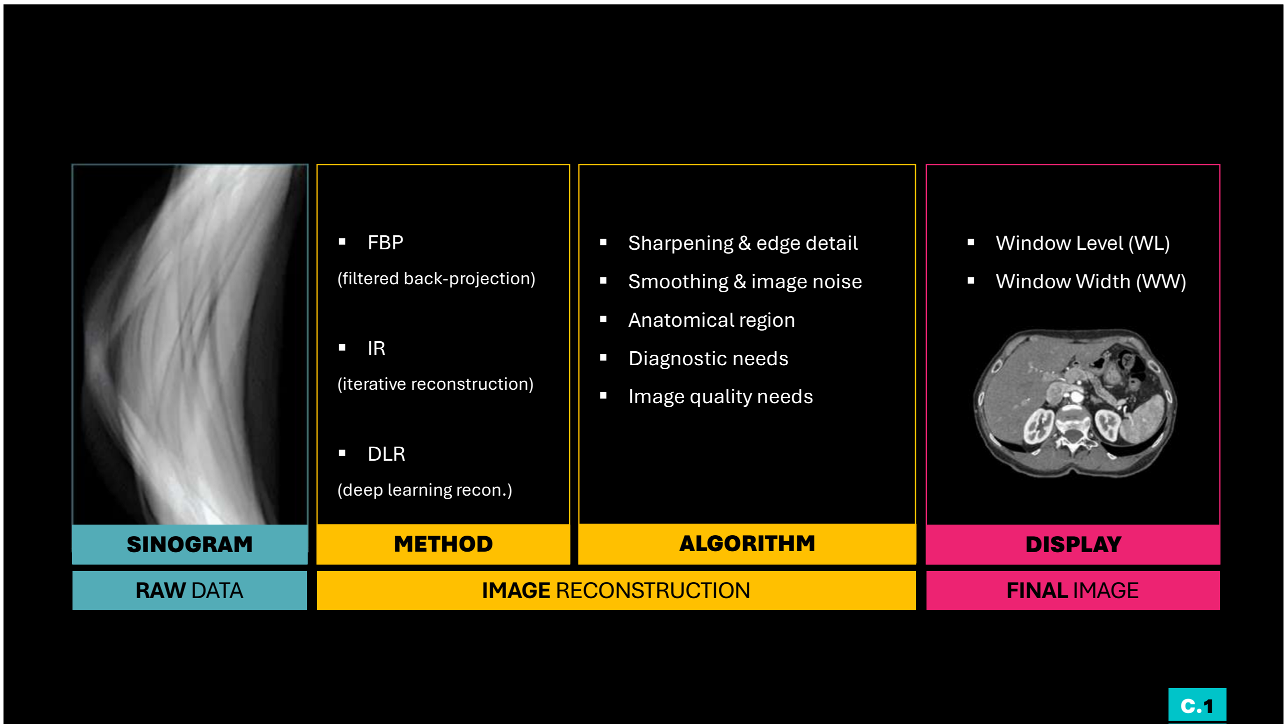
167


FBP
(filtered back-projection)
IR
(iterative reconstruction)
DLR
(deep learning recon.)
Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
Window Level (WL)
Window Width (WW)
SINOGRAM
METHOD
ALGORITHM
DISPLAY
RAW DATA
IMAGE RECONSTRUCTION
FINAL IMAGE
C.2

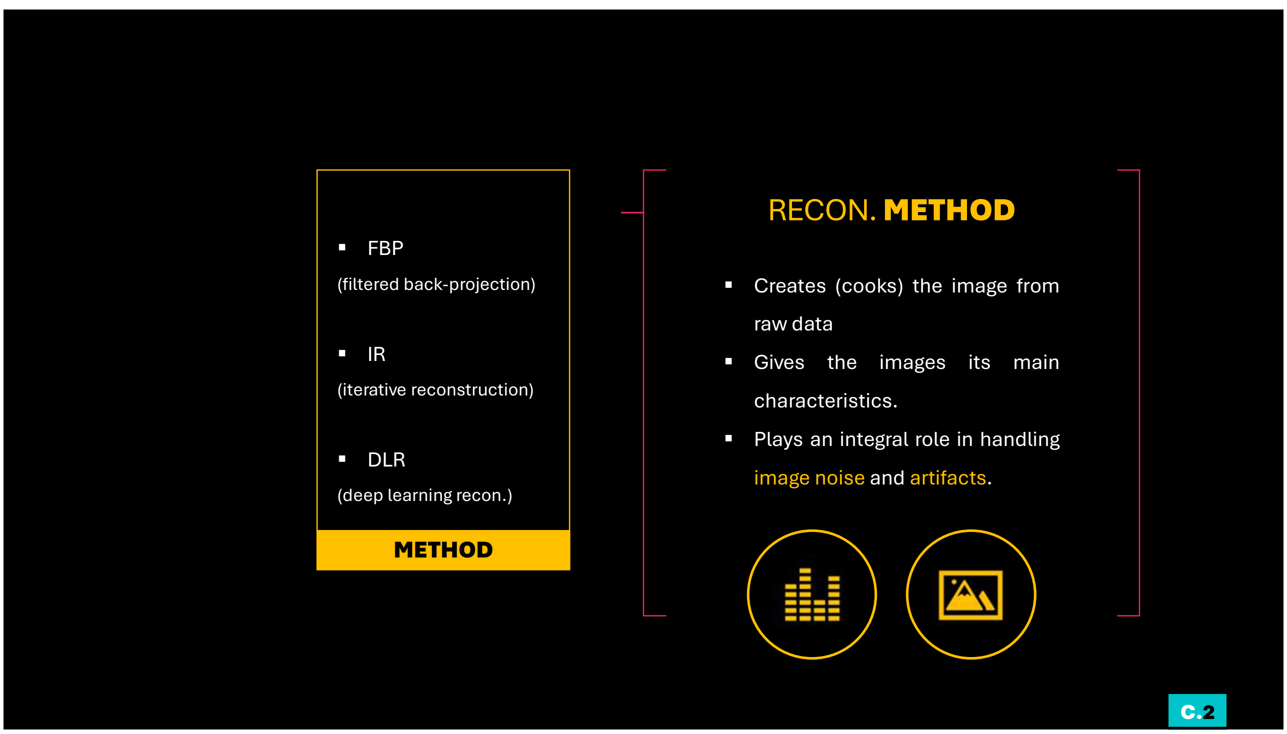
168


SINOGRAM
ACQUISITION MODES
Axial
Helical
Volume
Dynamic
Special
C.2

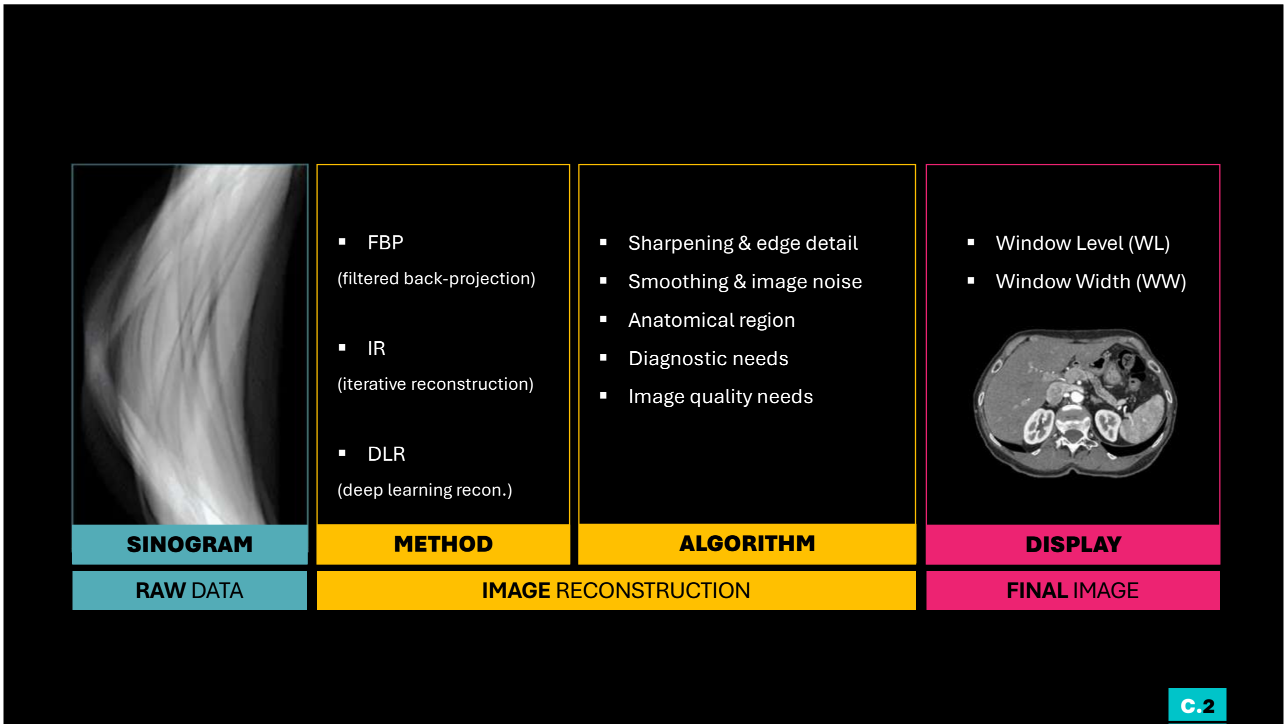
169


SINOGRAM
RAW DATA
FBP
(filtered back-projection)
IR
(iterative reconstruction)
DLR
(deep learning recon.)
METHOD
Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
ALGORITHM
IMAGE RECONSTRUCTION
Window Level (WL)
Window Width (WW)
DISPLAY
FINAL IMAGE
C.1

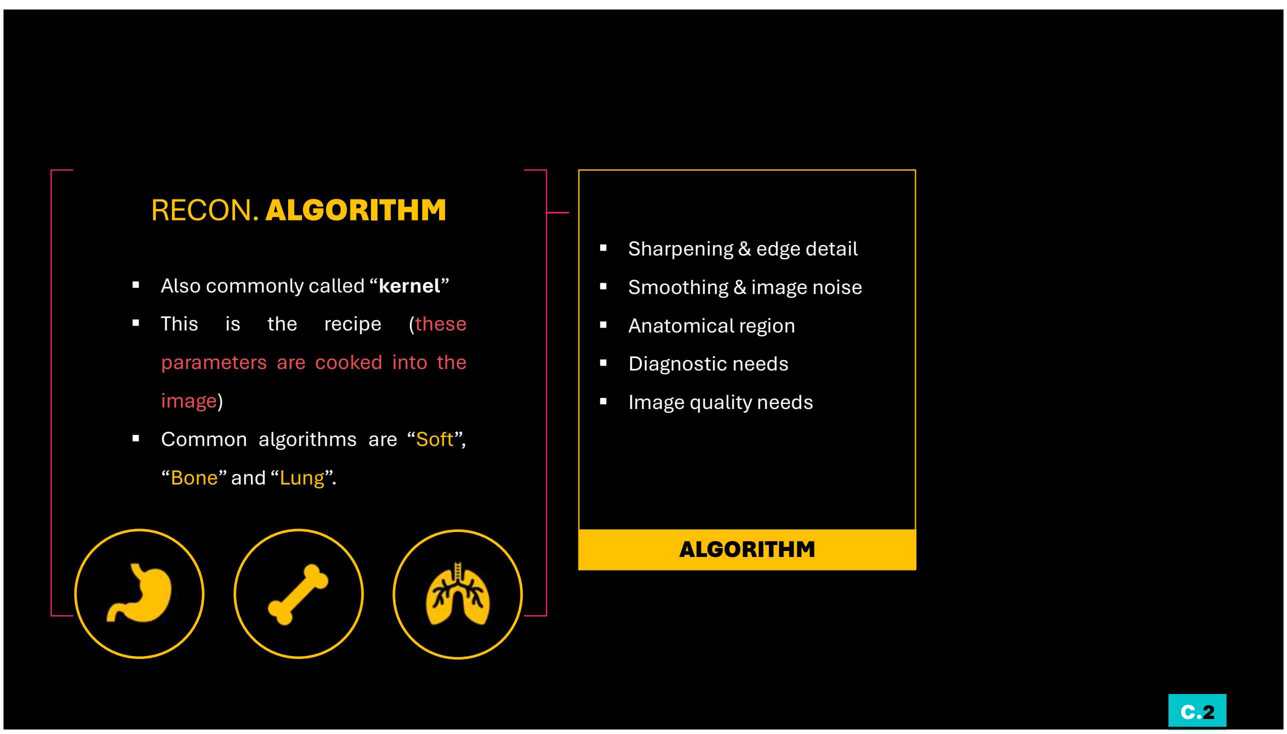
170


FBP
(filtered back-projection)
IR
(iterative reconstruction)
DLR
(deep learning recon.)
METHOD
RECON. METHOD
Creates (cooks) the image from raw data
Gives the images its main characteristics.
Plays an integral role in handling image noise and artifacts.
C.2

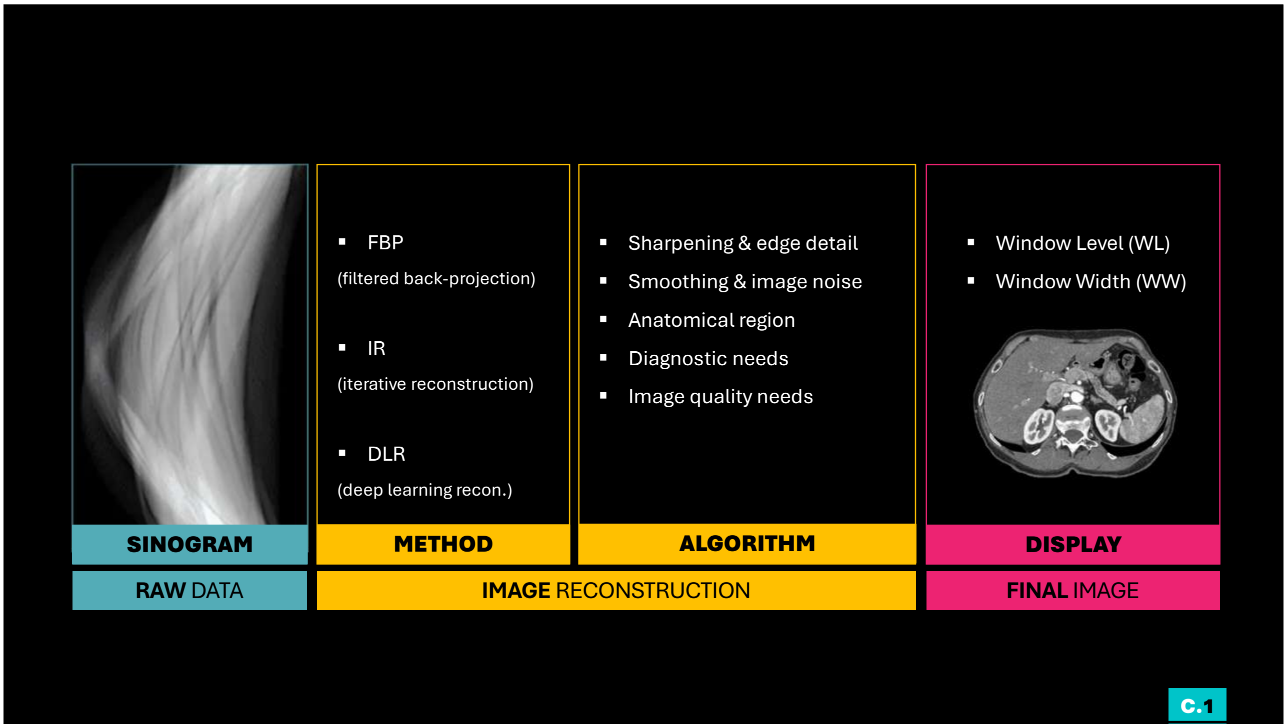
171


FBP
(filtered back-projection)
IR
(iterative reconstruction)
DLR
(deep learning recon.)
Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
Window Level (WL)
Window Width (WW)
SINOGRAM
METHOD
ALGORITHM
DISPLAY
RAW DATA
IMAGE RECONSTRUCTION
FINAL IMAGE
C.2

172


RECON. ALGORITHM
Also commonly called "kernel"
This is the recipe (these parameters are cooked into the image)
Common algorithms are "Soft", "Bone" and "Lung".
Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
ALGORITHM
C.2

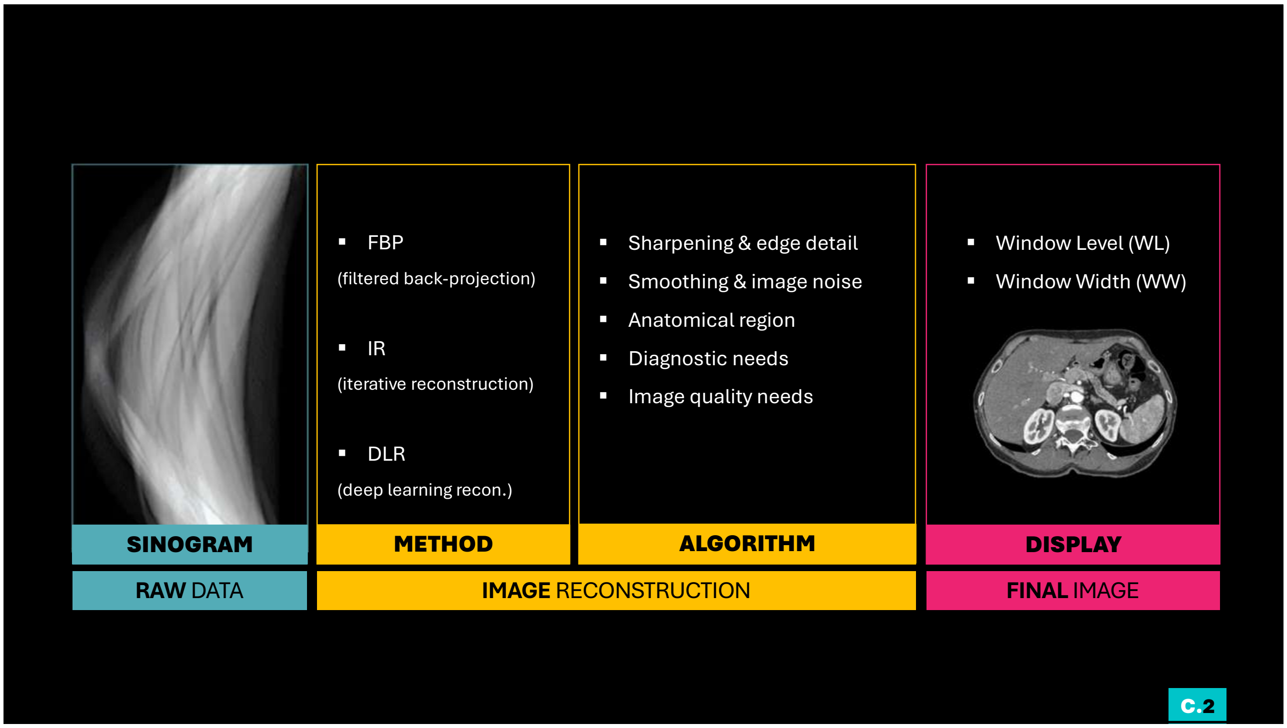
173


FBP
(filtered back-projection)
IR
(iterative reconstruction)
DLR
(deep learning recon.)
Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
Window Level (WL)
Window Width (WW)
SINOGRAM
METHOD
ALGORITHM
DISPLAY
RAW DATA
IMAGE RECONSTRUCTION
FINAL IMAGE
C.1

174

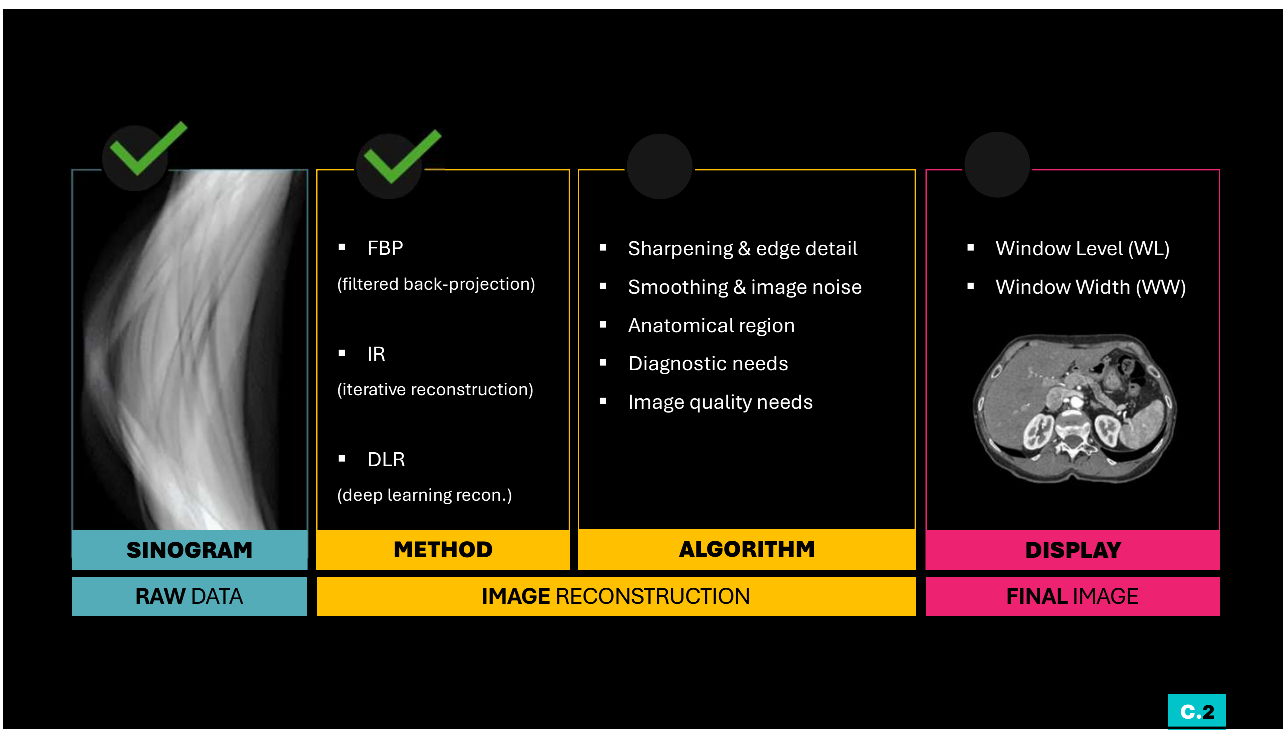

IMAGE DISPLAY
These parameters are not cooked into the image.
they can be adjusted during display.
They include WL, WW, flip, rotate, ...
W/L
W/W
Window Level (WL)
Window Width (WW)
DISPLAY
C.2

175



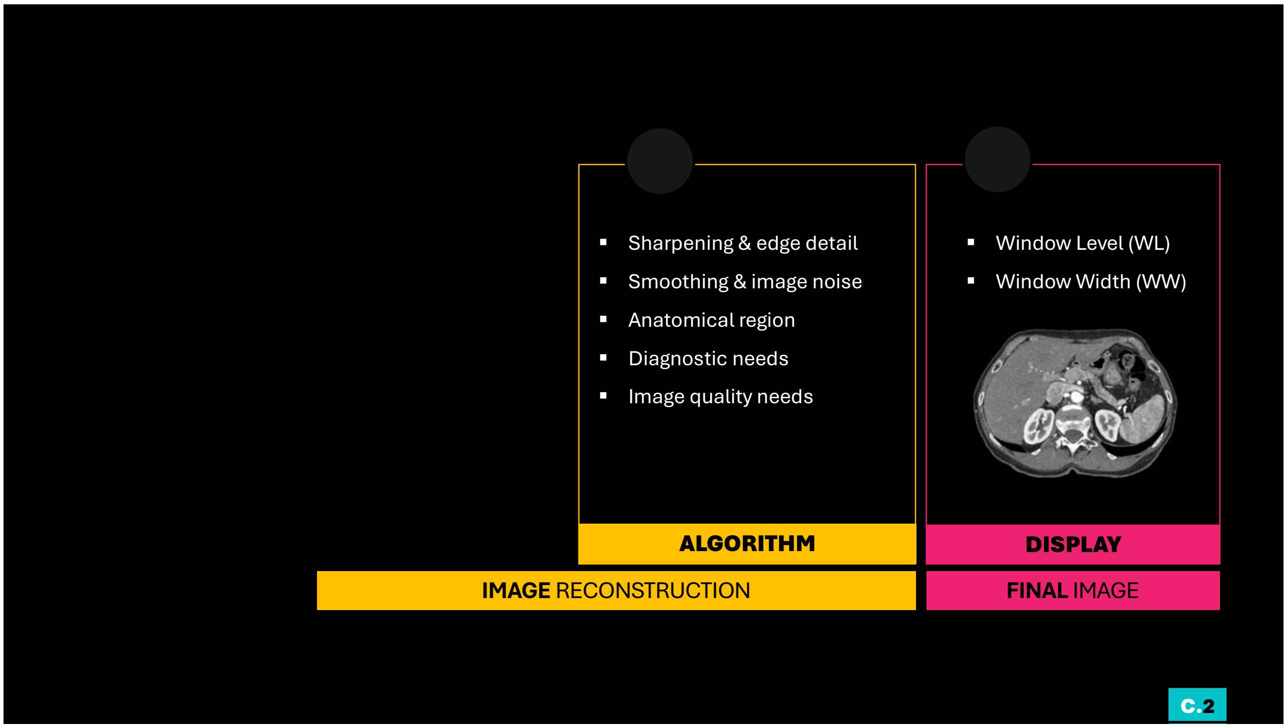
FBP
(filtered back-projection)
IR
(iterative reconstruction)
DLR
(deep learning recon.)
Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
Window Level (WL)
Window Width (WW)
SINOGRAM
METHOD
ALGORITHM
DISPLAY
RAW DATA
IMAGE RECONSTRUCTION
FINAL IMAGE
C.2

176

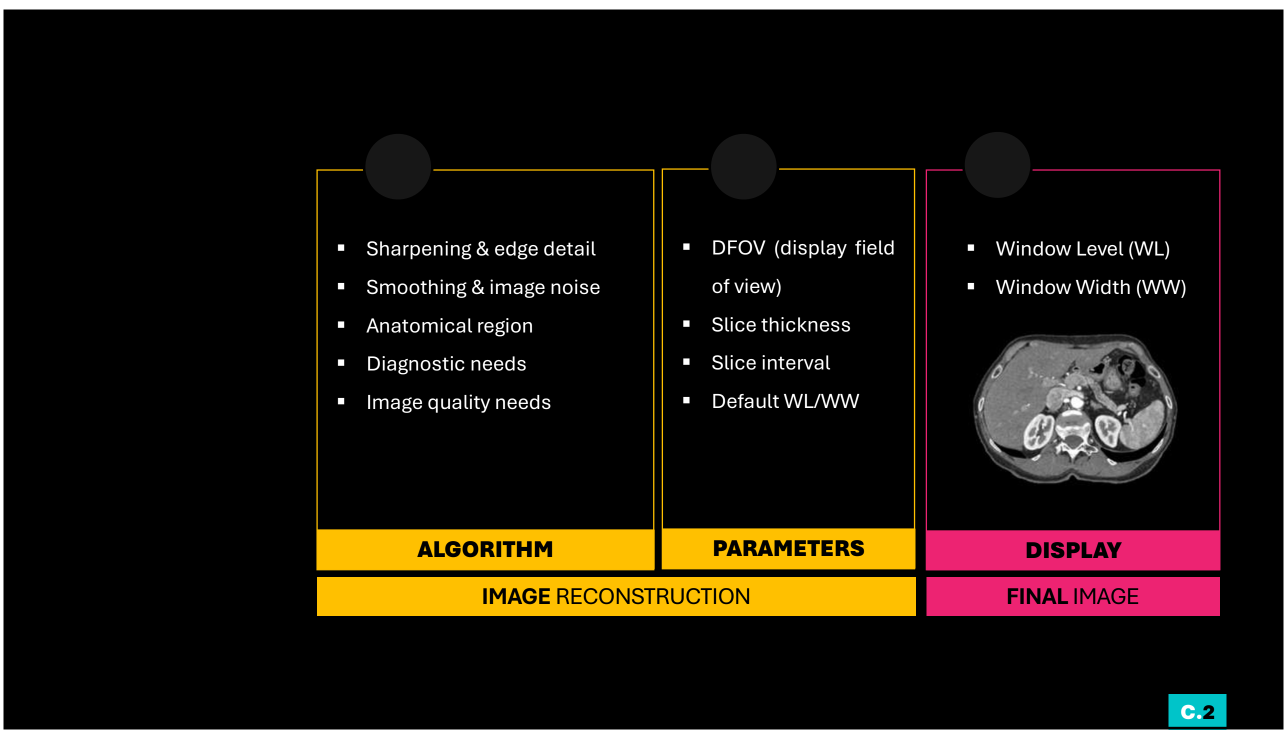


FBP
(filtered back-projection)
IR
(iterative reconstruction)
DLR
(deep learning recon.)
Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
Window Level (WL)
Window Width (WW)
SINOGRAM
METHOD
ALGORITHM
DISPLAY
RAW DATA
IMAGE RECONSTRUCTION
FINAL IMAGE
C.2

177


Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
ALGORITHM
Window Level (WL)
Window Width (WW)
DISPLAY
IMAGE RECONSTRUCTION
FINAL IMAGE
C.2

178


Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
ALGORITHM
DFOV (display field of view)
Slice thickness
Slice interval
Default WL/WW
PARAMETERS
Window Level (WL)
Window Width (WW)
DISPLAY
IMAGE RECONSTRUCTION
FINAL IMAGE
C.2

179

- Sharpening & edge detail
- Smoothing & image noise
- Anatomical region
- Diagnostic needs
- Image quality needs

ALGORITHM

- DFOV (display field of view)
- Slice thickness
- Slice interval
- Default WL/WW

PARAMETERS

- Window Level (WL)
- Window Width (WW)

DISPLAY

IMAGE RECONSTRUCTION

FINAL IMAGE

We will discuss them in reverse

C.2

180

The Hounsfield scale, named after Sir Godfrey Hounsfield, is a quantitative scale used in CT imaging to represent the radiodensity of tissues. It assigns a numerical value, called a CT number or Hounsfield unit (HU), to each pixel in the CT image, reflecting the relative attenuation of x-rays by the corresponding tissue.

In the Hounsfield scale we use **water as the reference point**. Water is given the value of **zero** (0 HU).

C.2

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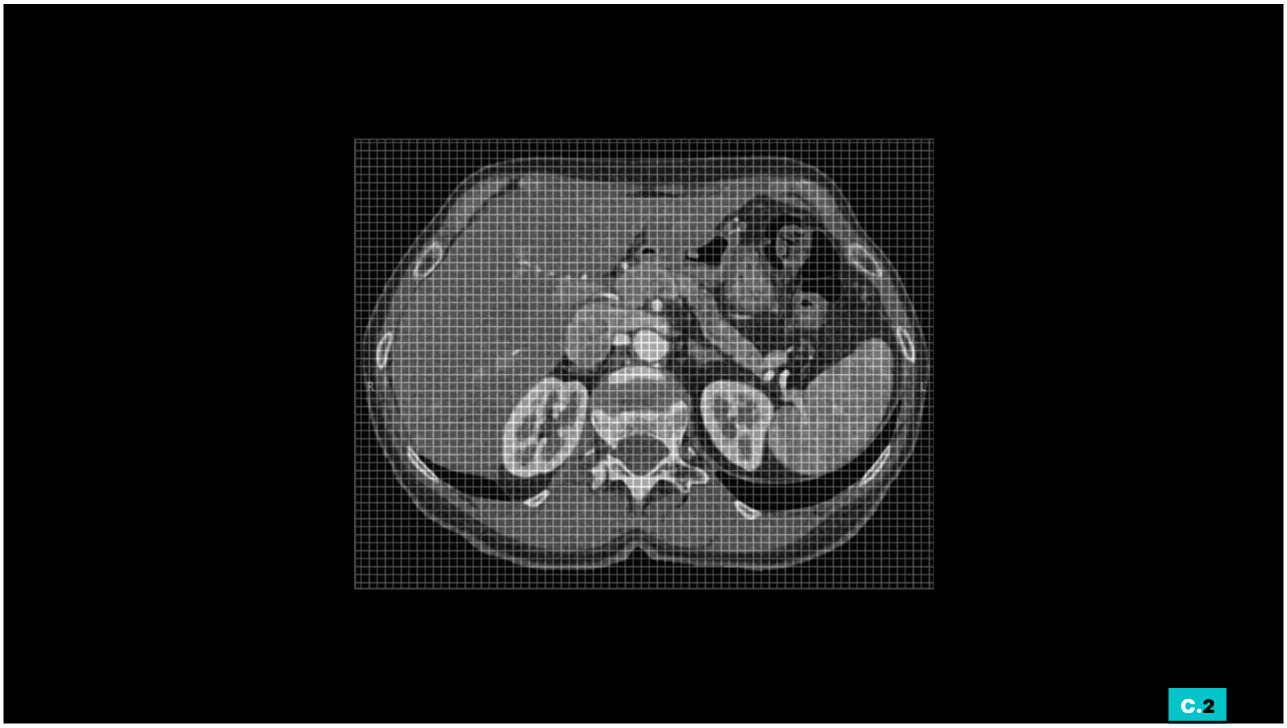
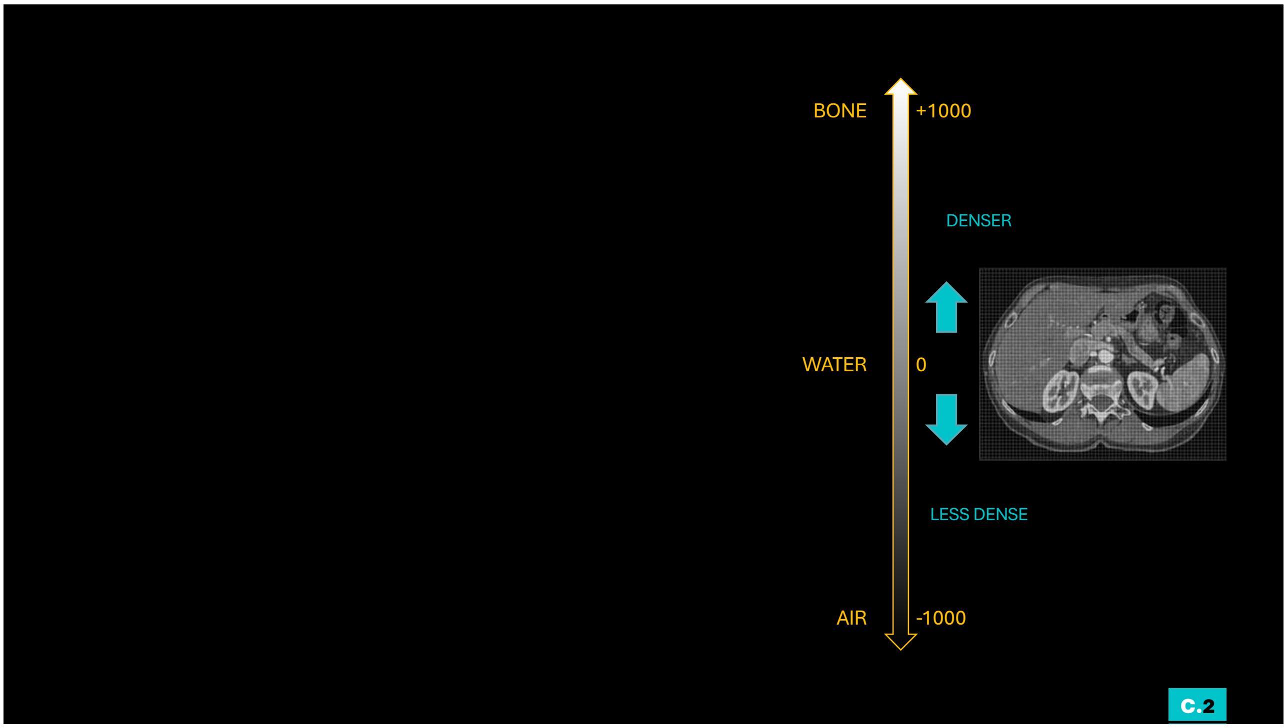
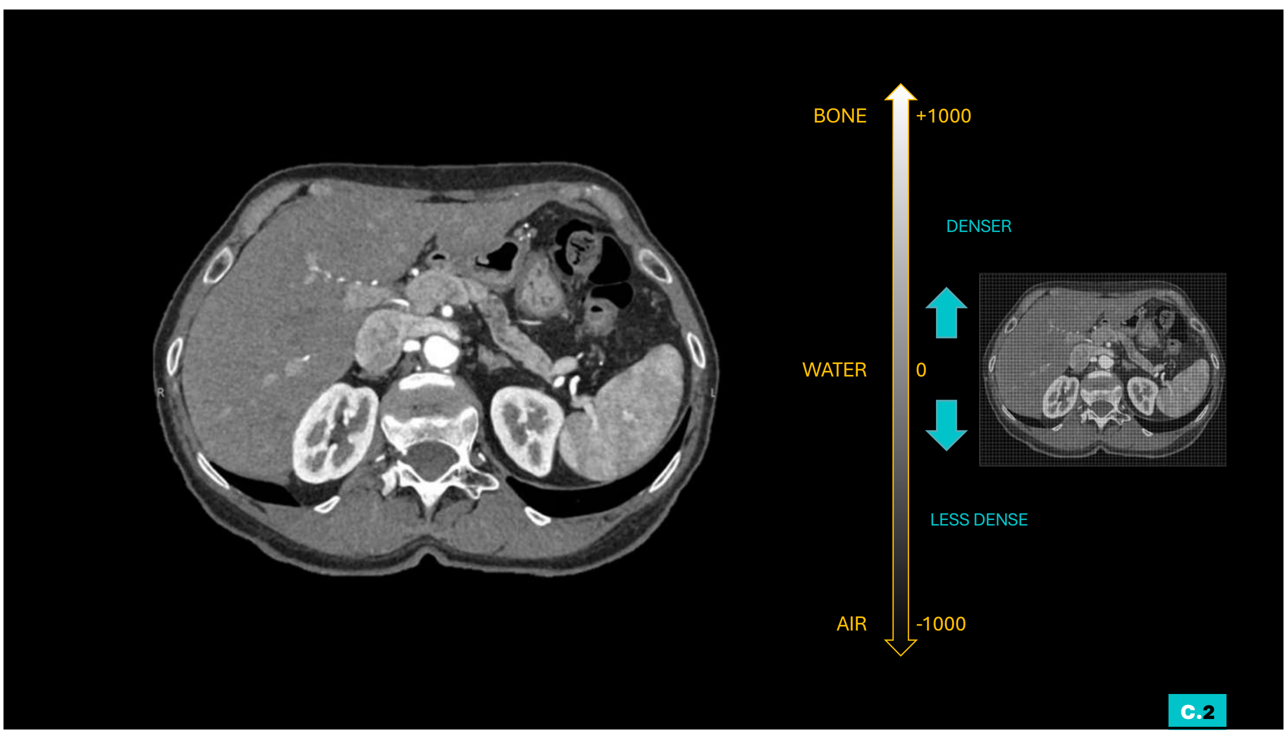
182



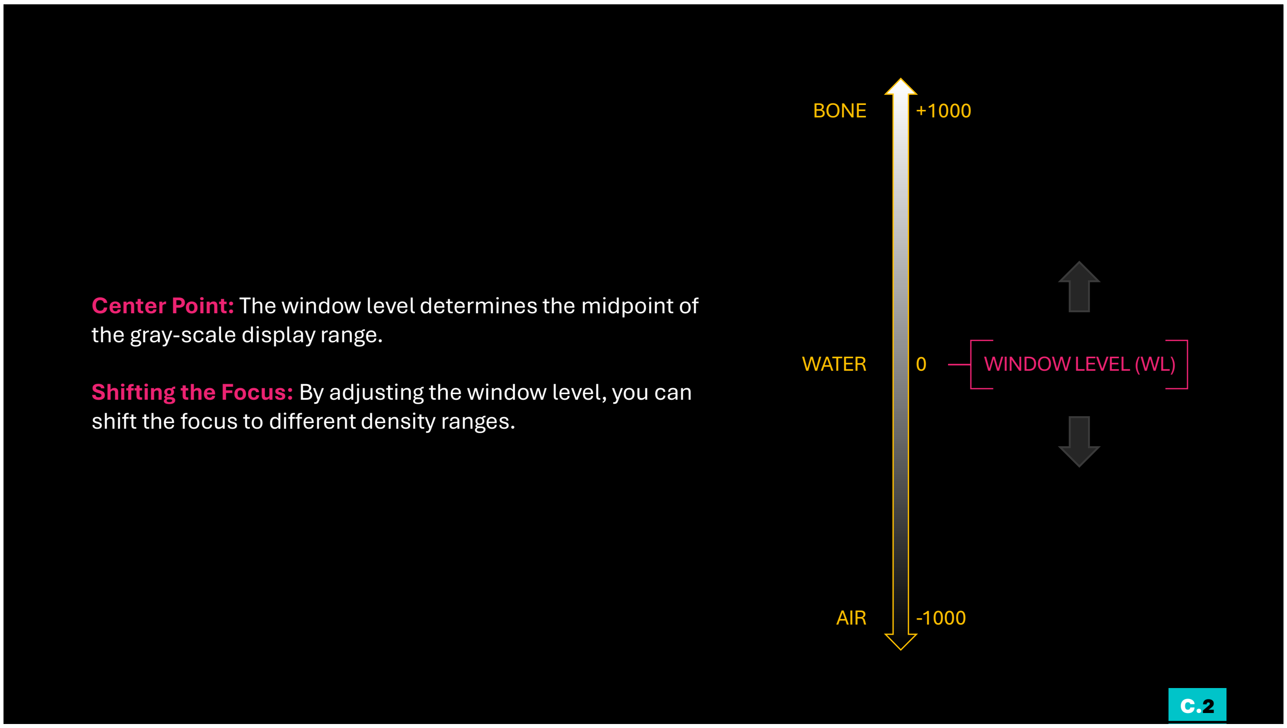
183


BONE
+1000
DENSER
WATER
0
LESS DENSE
AIR
-1000
C.2

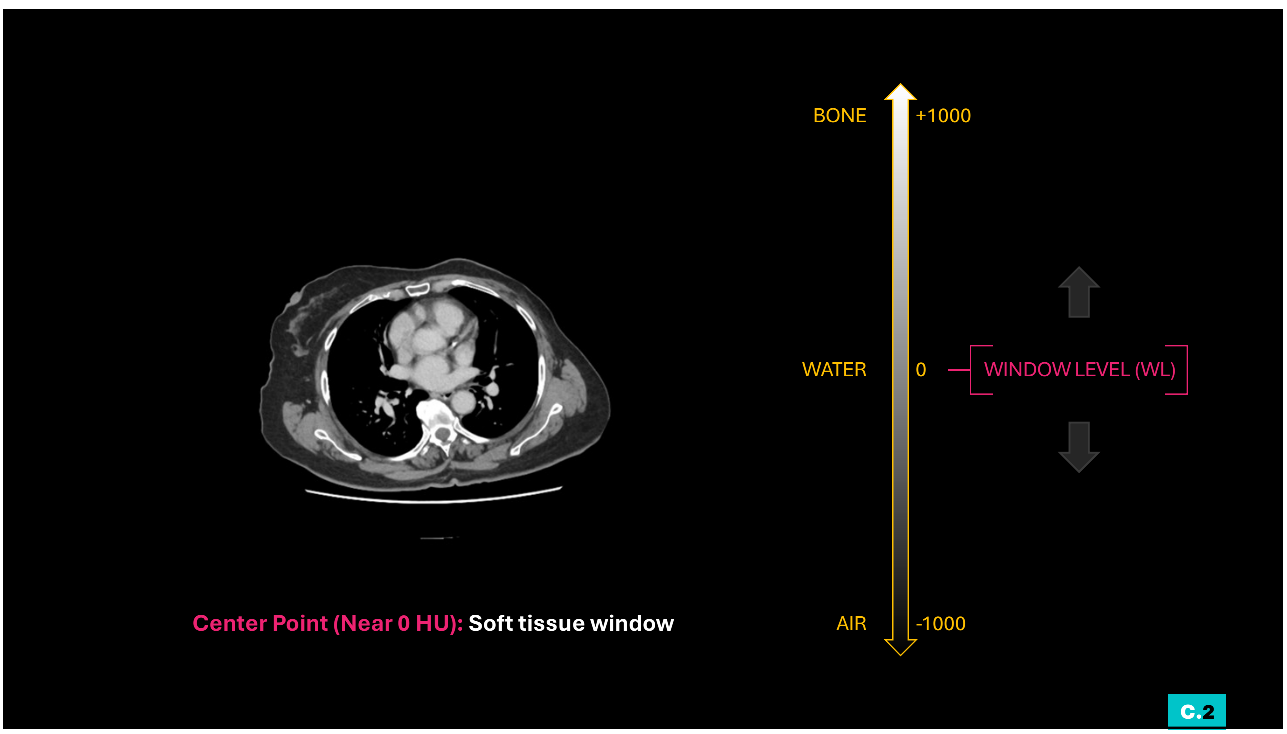
184


BONE
+1000
DENSER
WATER
0
LESS DENSE
AIR
-1000
C.2

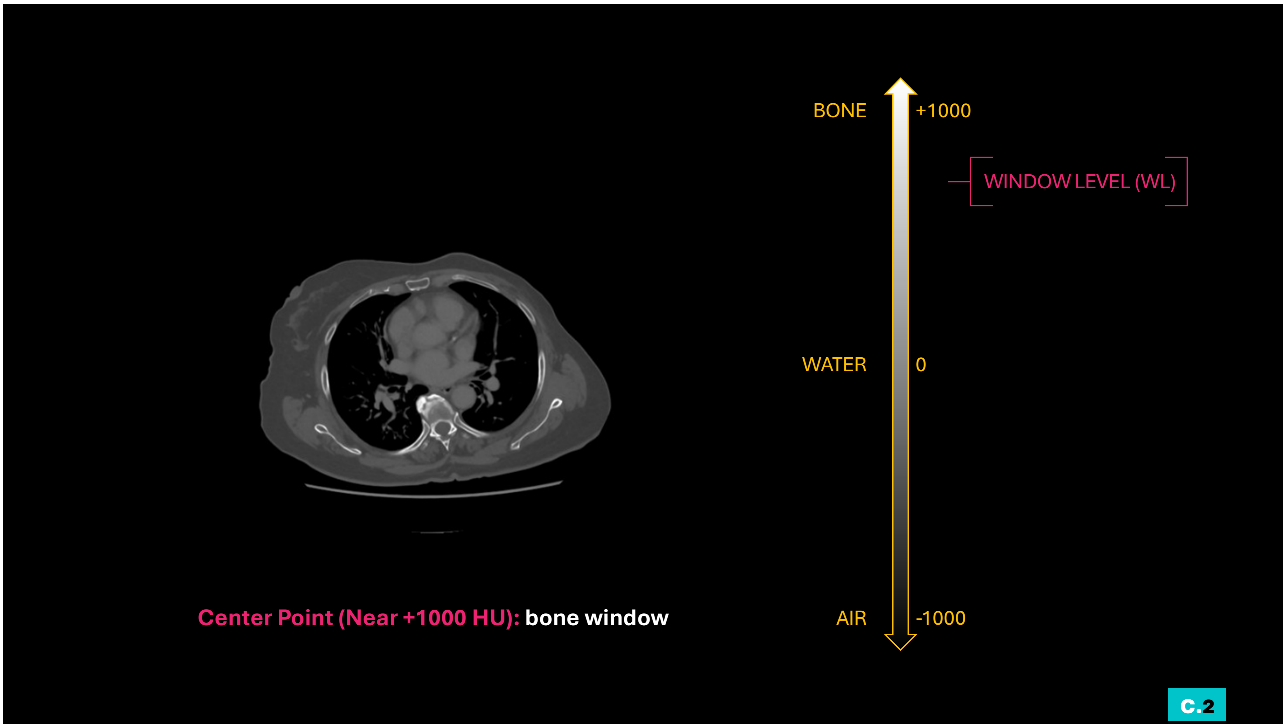
185


Center Point: The window level determines the midpoint of the gray-scale display range.
Shifting the Focus: By adjusting the window level, you can shift the focus to different density ranges.
BONE
+1000
WATER
0
WINDOW LEVEL (WL)
AIR
-1000
C.2

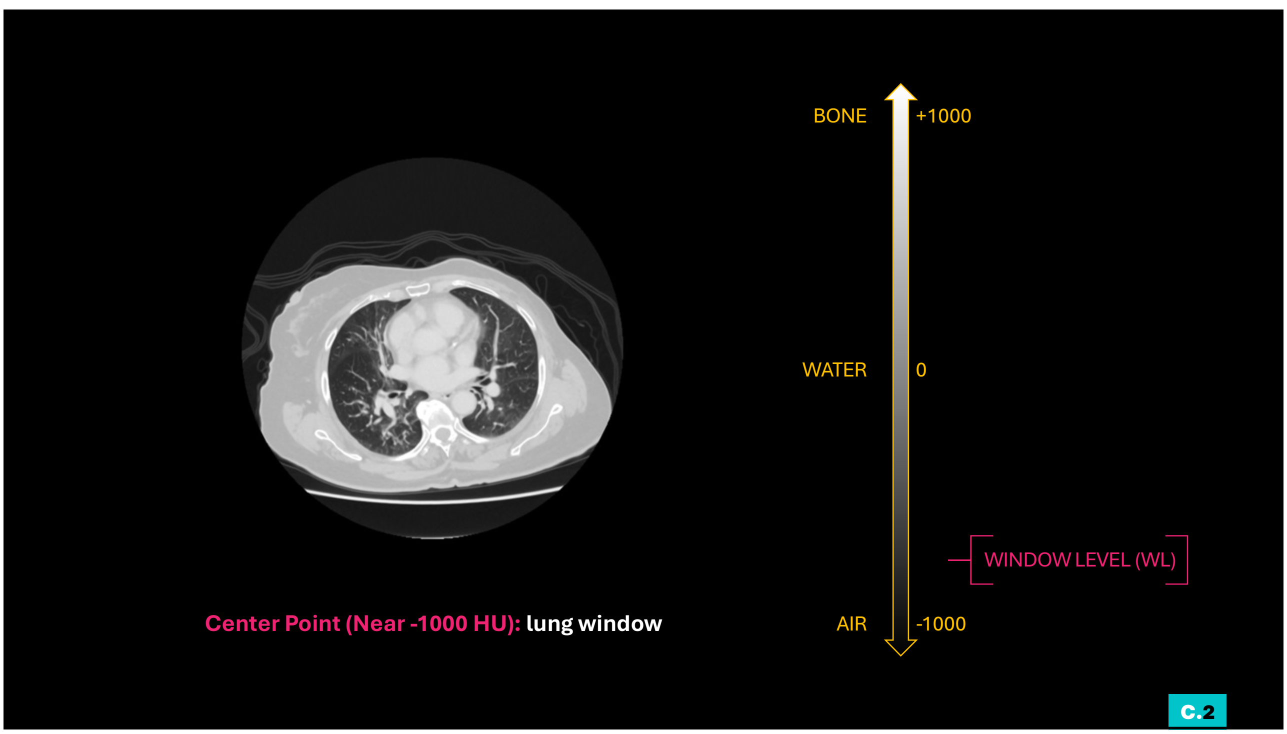
186


BONE
+1000
WATER
0
WINDOW LEVEL (WL)
AIR
-1000
Center Point (Near 0 HU): Soft tissue window
C.2

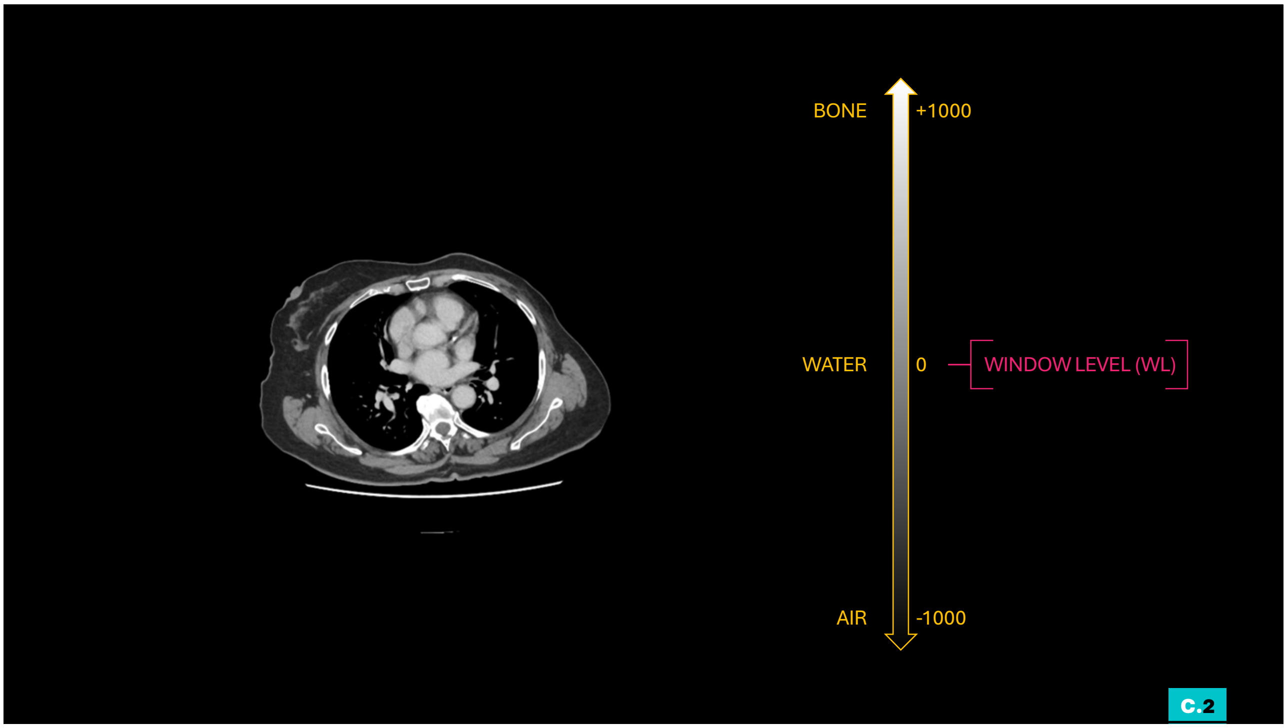
187


BONE
+1000
WINDOW LEVEL (WL)
WATER
0
AIR
-1000
Center Point (Near +1000 HU): bone window
C.2

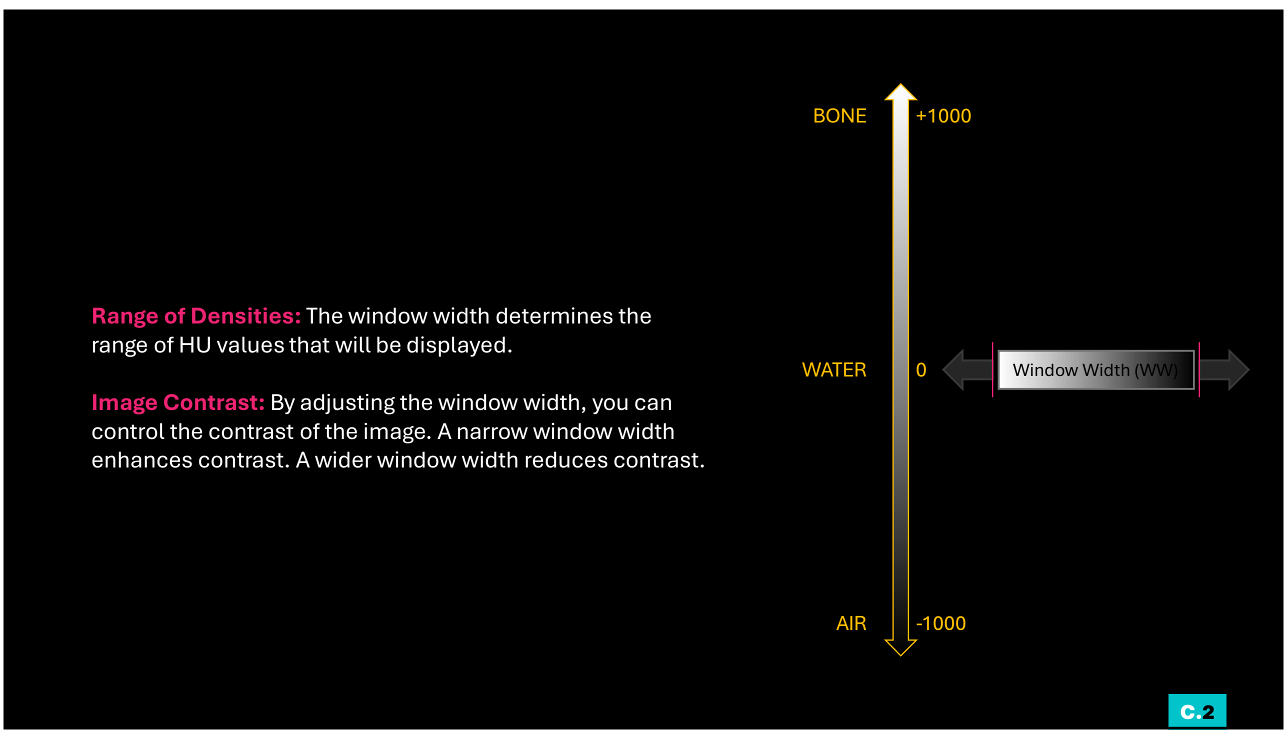
188


BONE
+1000
WATER
0
WINDOW LEVEL (WL)
AIR
-1000
Center Point (Near -1000 HU): lung window
C.2

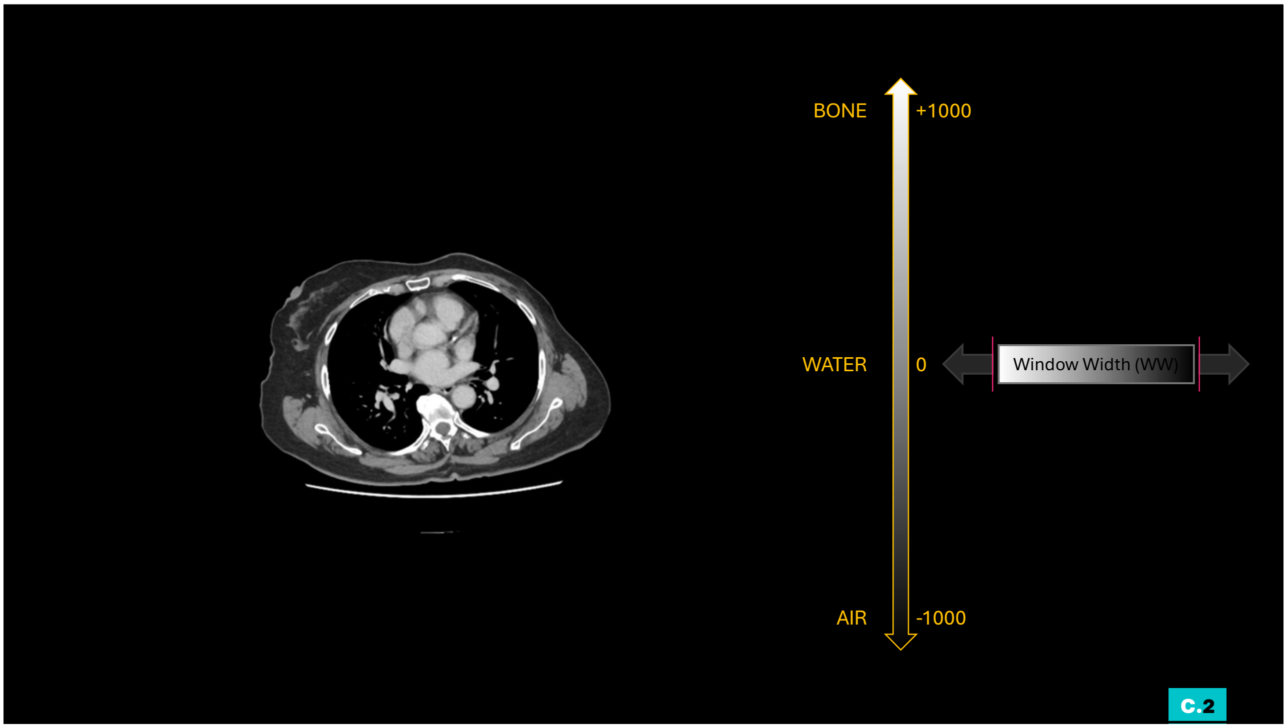
189


BONE
+1000
WATER
0
WINDOW LEVEL (WL)
AIR
-1000
C.2

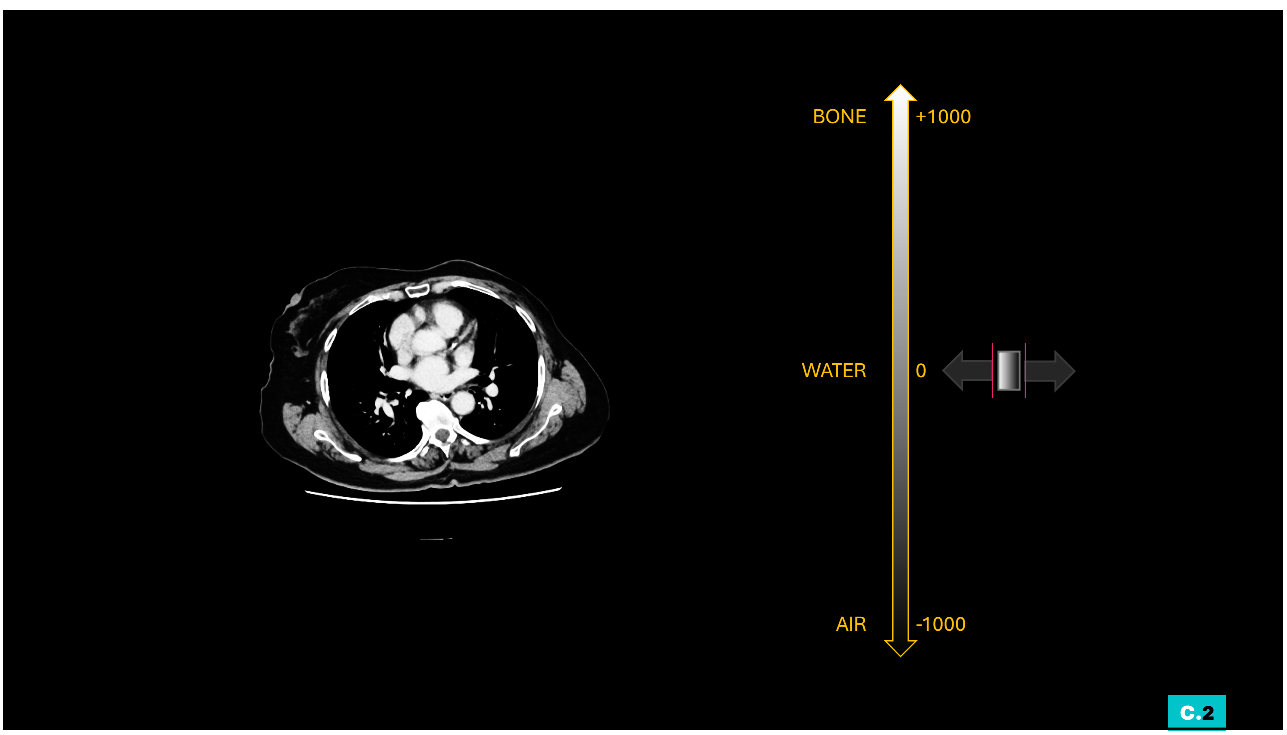
190


Range of Densities: The window width determines the range of HU values that will be displayed.
Image Contrast: By adjusting the window width, you can control the contrast of the image. A narrow window width enhances contrast. A wider window width reduces contrast.
BONE
+1000
WATER
0
Window Width (WW)
AIR
-1000
C.2

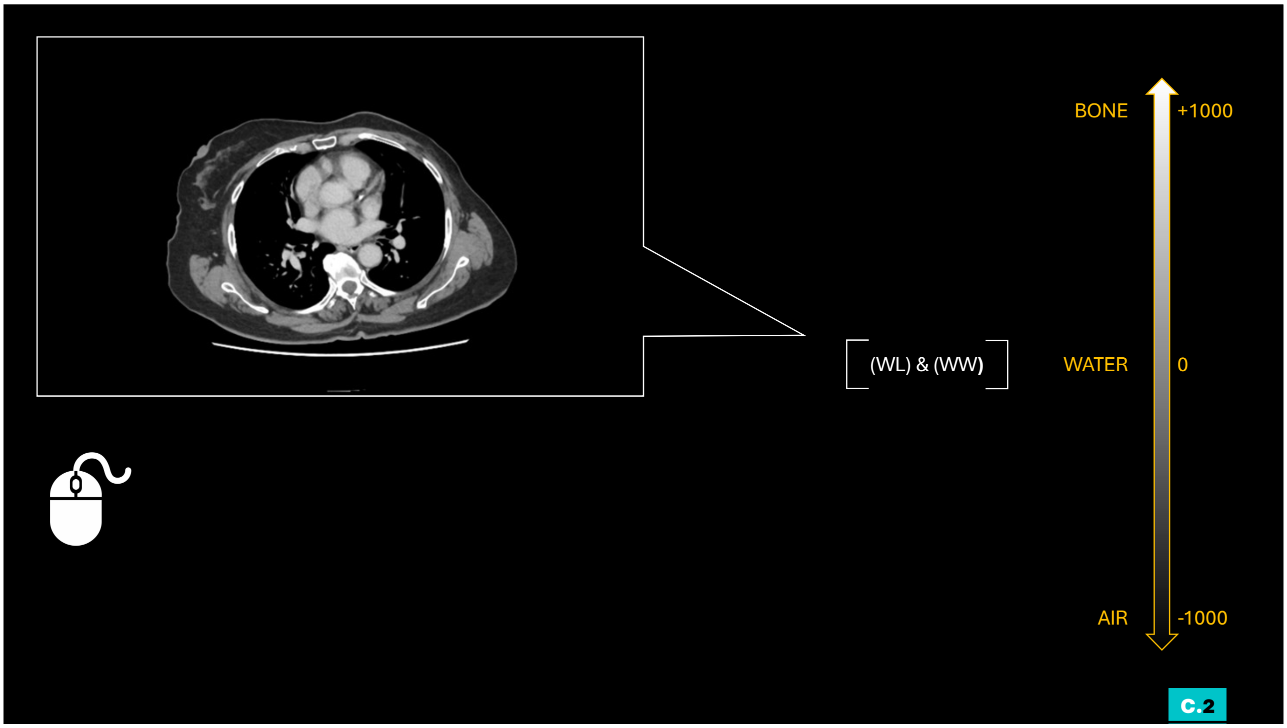
191


BONE
+1000
WATER
0
Window Width (WW)
AIR
-1000
C.2

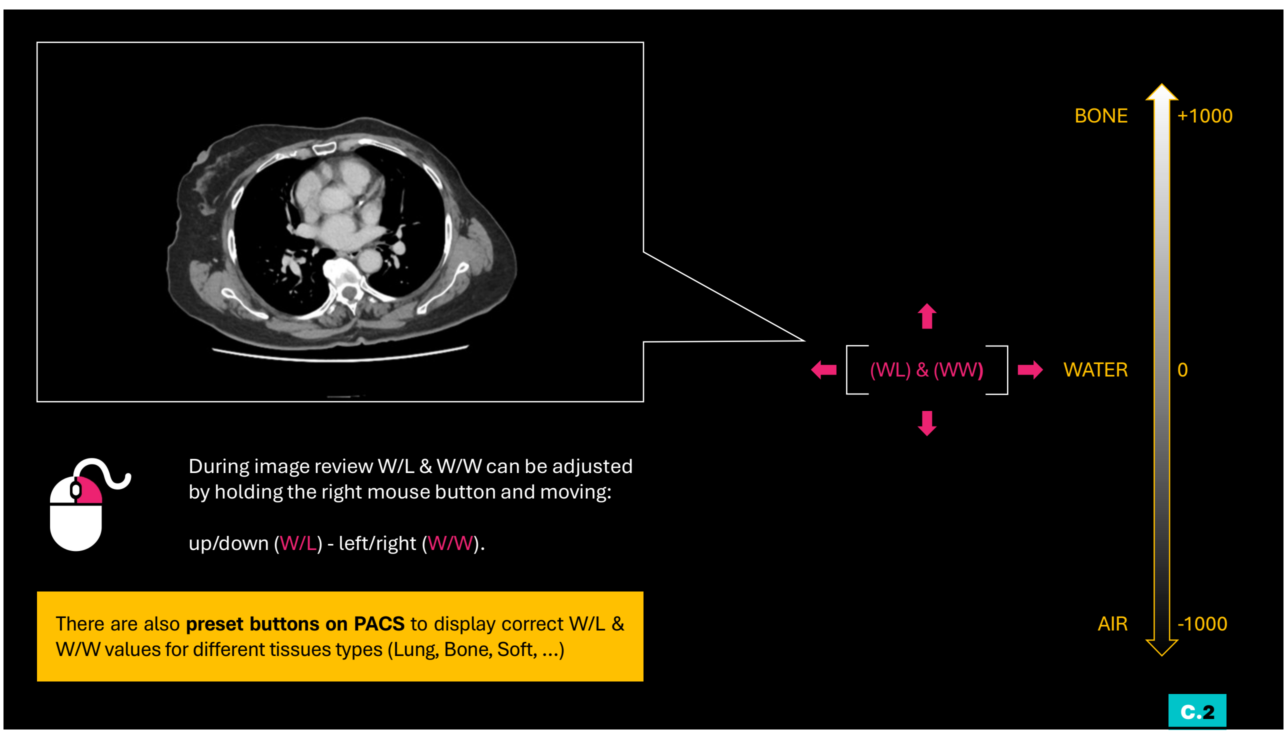
192


BONE
+1000
WATER
0
AIR
-1000
C.2

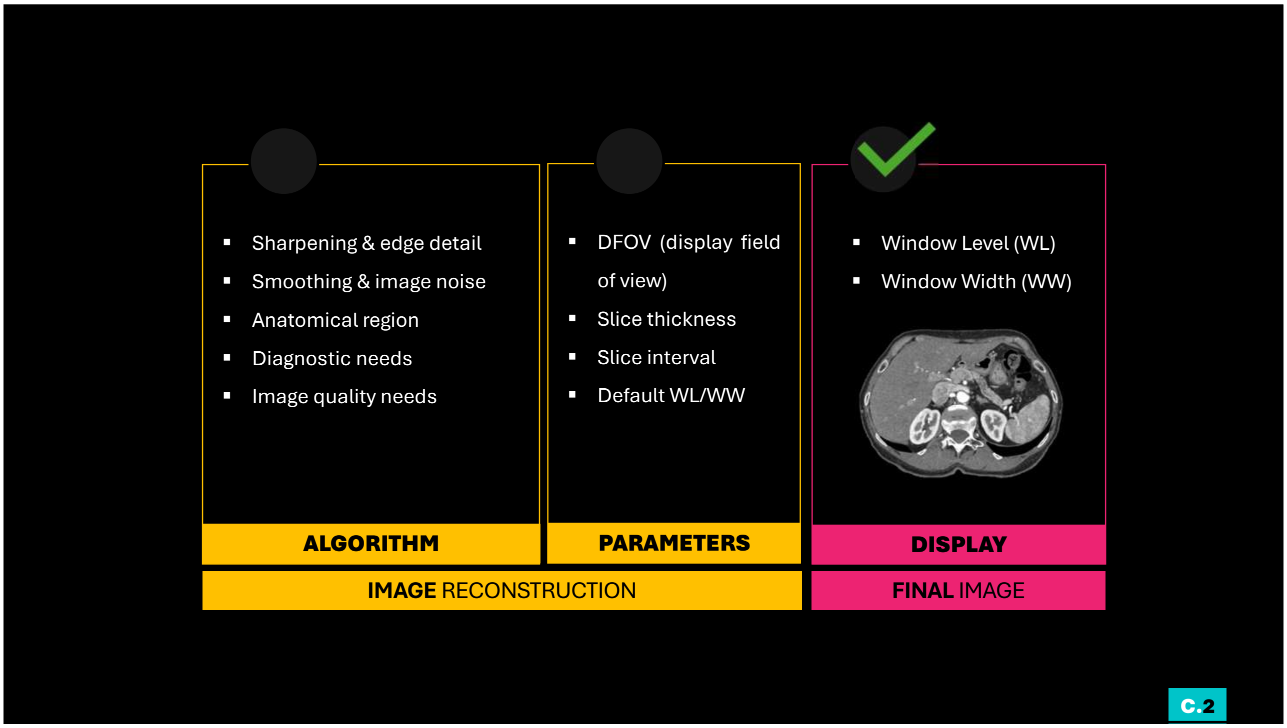
193


BONE
+1000
(WL) & (WW)
WATER
0
AIR
-1000
C.2

194

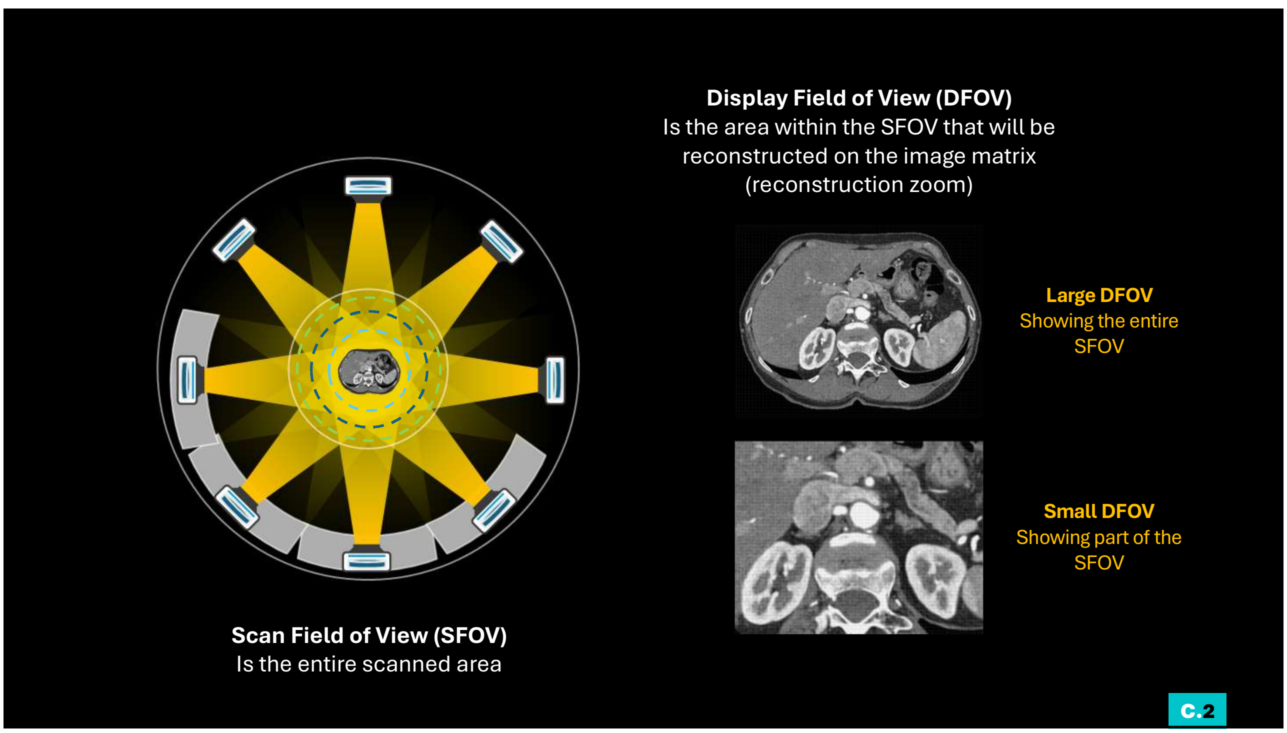

BONE
+1000
(WL) & (WW)
WATER
0
During image review W/L & W/W can be adjusted by holding the right mouse button and moving:
up/down (W/L) - left/right (W/W).
There are also **preset buttons on PACS** to display correct W/L & W/W values for different tissues types (Lung, Bone, Soft, ...)
AIR
-1000
C.2

195



Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
ALGORITHM
DFOV (display field of view)
Slice thickness
Slice interval
Default WL/WW
PARAMETERS
IMAGE RECONSTRUCTION
Window Level (WL)
Window Width (WW)
DISPLAY
FINAL IMAGE
C.2

196



Display Field of View (DFOV)
Is the area within the SFOV that will be reconstructed on the image matrix (reconstruction zoom)
Large DFOV
Showing the entire SFOV
Small DFOV
Showing part of the SFOV
Scan Field of View (SFOV)
Is the entire scanned area
C.2

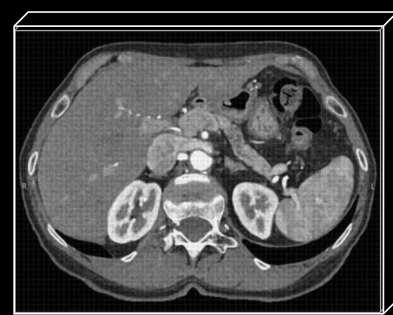
197

CT slices are made of voxels (3D Pixels)

Depth of voxel = slice thickness

CT images can be reconstructed at any desirable slice thickness. The minimum thickness is determined by the detector cell size.

The spacing between each CT slice (Slice Interval) can also be reconstructed at any desired value. Slices can be back to back, overlapped or reconstructed with gaps in-between.



Thicker slices have less image noise compared to thin slices but they suffer from **Partial Volume Effect**.

C.2

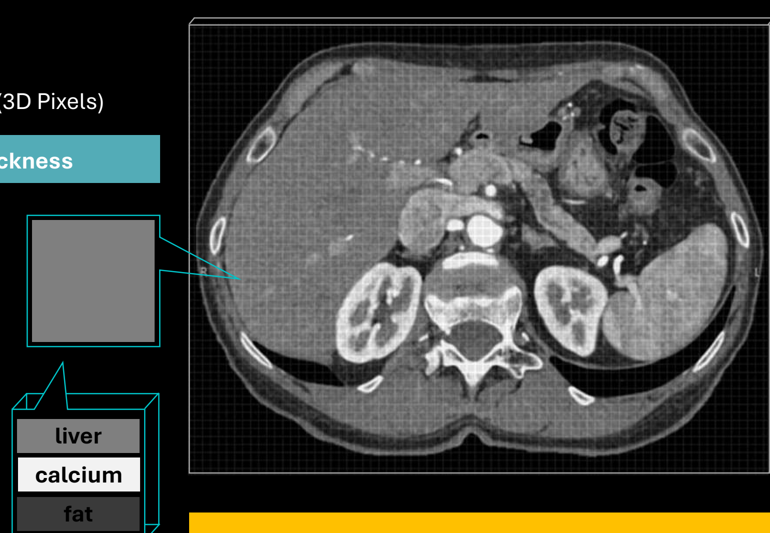
198

CT slices are made of voxels (3D Pixels)

Depth of voxel = slice thickness

We only see the face of the voxel (as a pixel on a screen). However, the voxel has depth and within that depth many structures can exist.

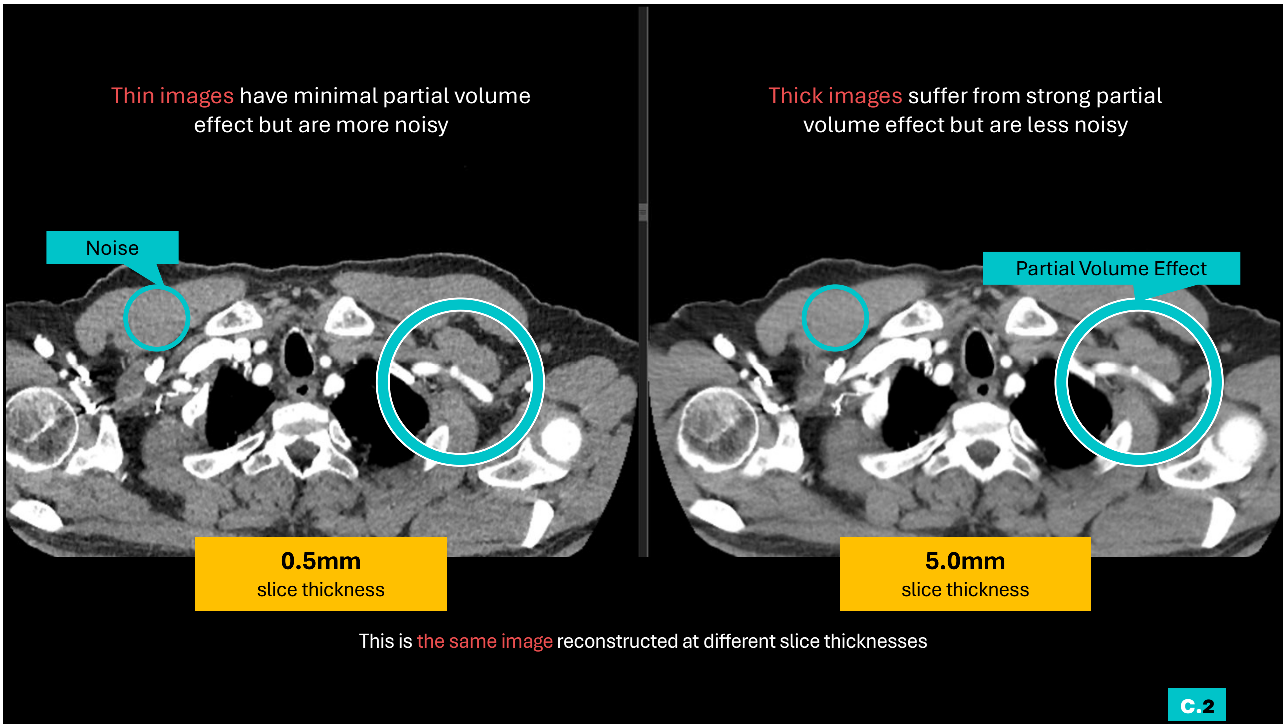
Unfortunately, this means we have to represent many different structures using a single pixel on the screen. This undesirable effect is called partial volume.



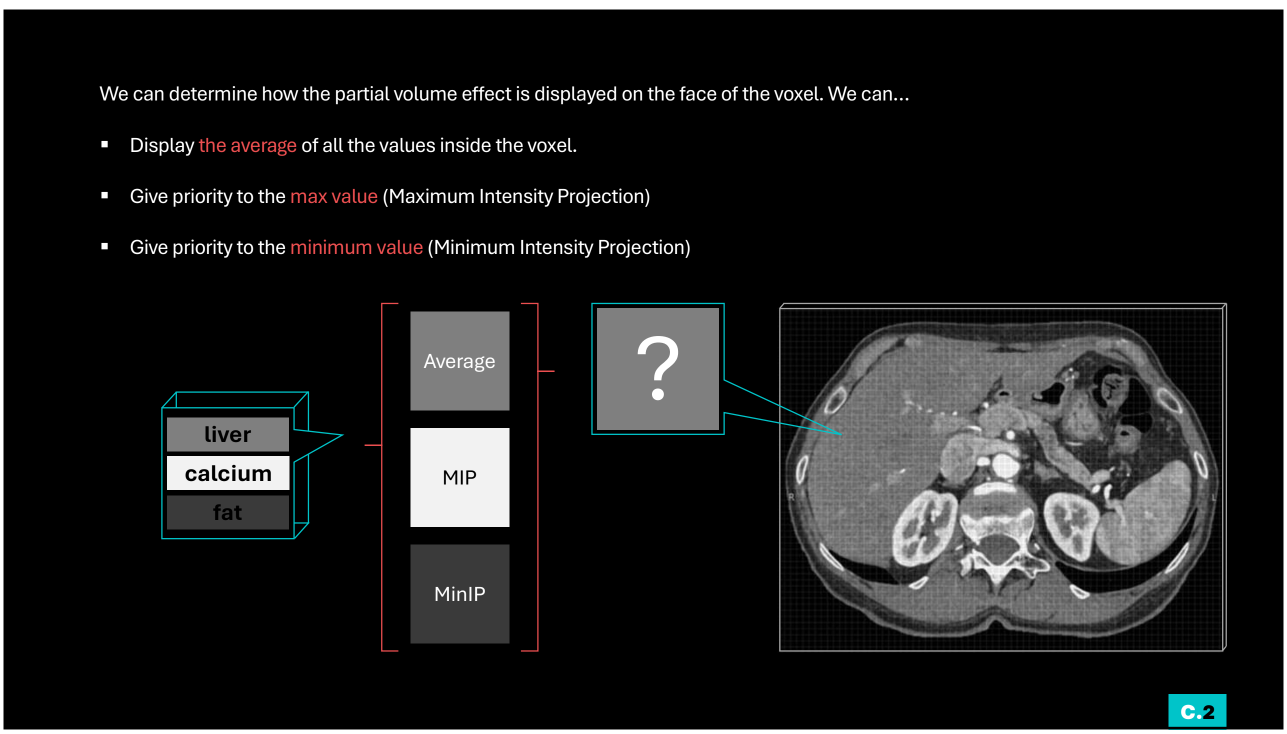
The thicker the slice the stronger the partial volume effect.

C.2

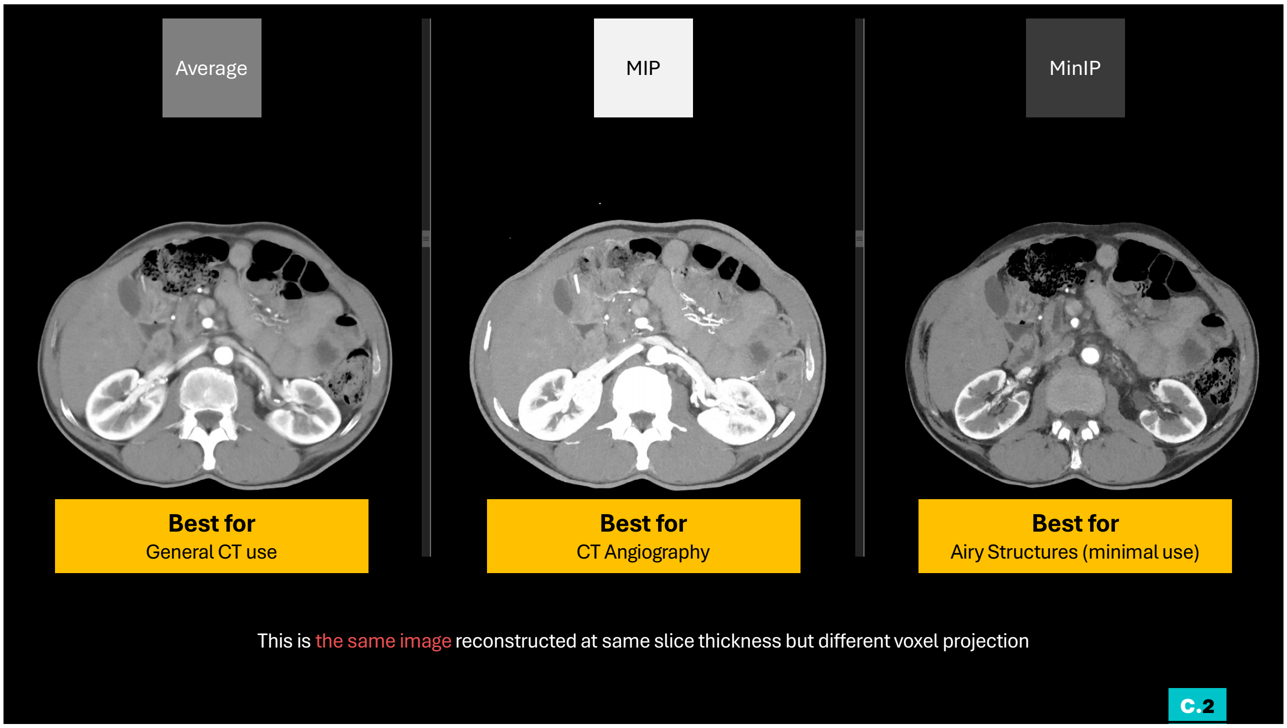
199


Thin images have minimal partial volume effect but are more noisy
Thick images suffer from strong partial volume effect but are less noisy
Noise
Partial Volume Effect
0.5mm
slice thickness
5.0mm
slice thickness
This is the same image reconstructed at different slice thicknesses
C.2

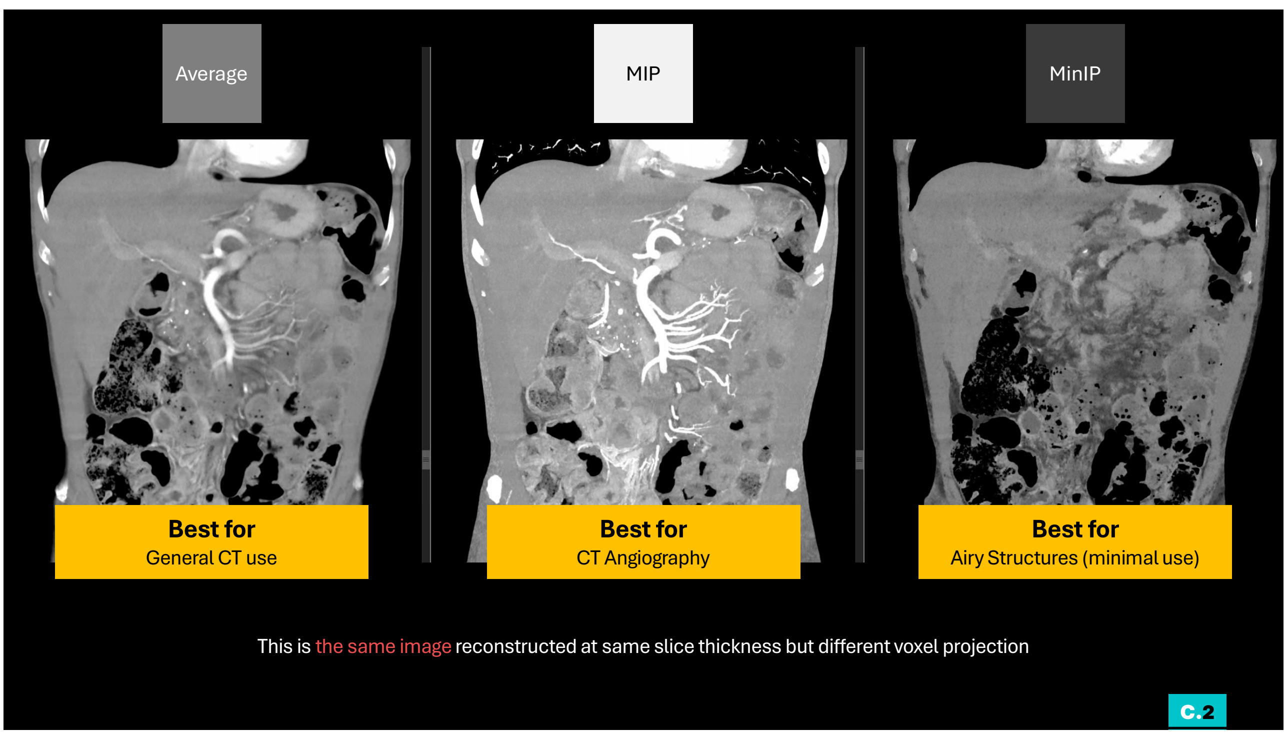
200


We can determine how the partial volume effect is displayed on the face of the voxel. We can…
▪ Display the average of all the values inside the voxel.
▪ Give priority to the max value (Maximum Intensity Projection)
▪ Give priority to the minimum value (Minimum Intensity Projection)
liver
calcium
fat
Average
MIP
MinIP
?
C.2

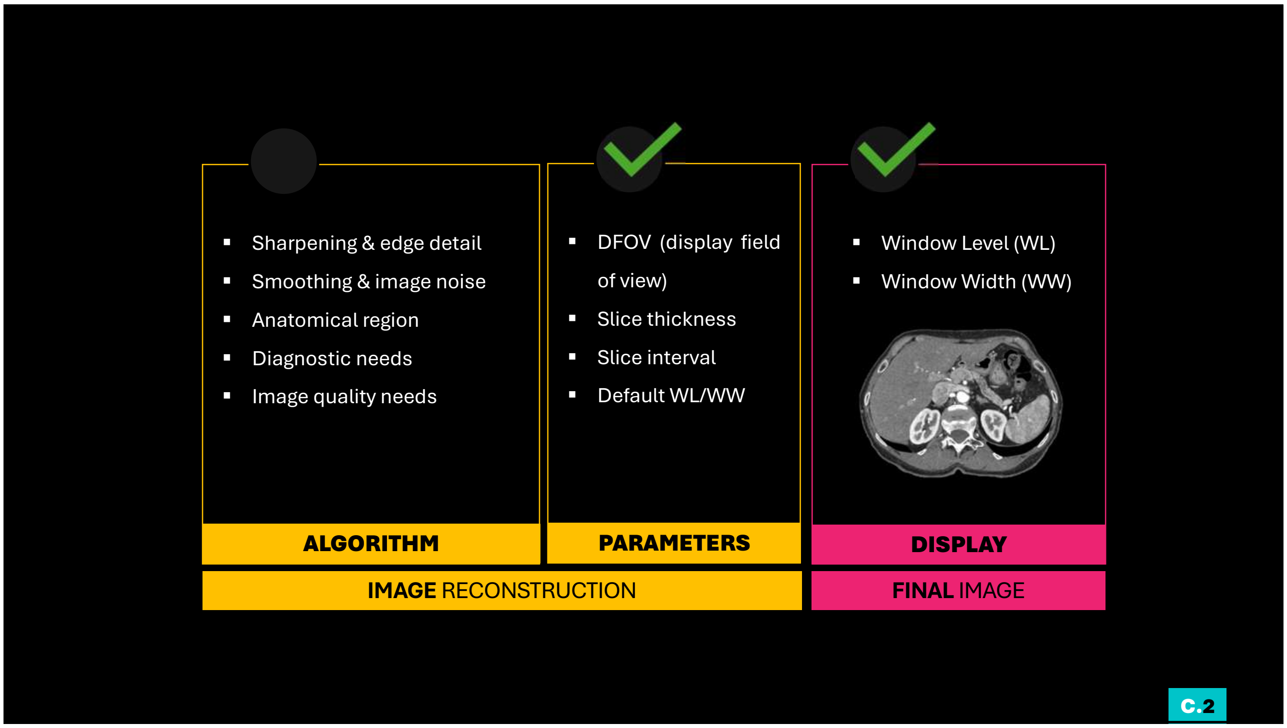
201


Average
MIP
MinIP
Best for
General CT use
Best for
CT Angiography
Best for
Airy Structures (minimal use)
This is the same image reconstructed at same slice thickness but different voxel projection
C.2

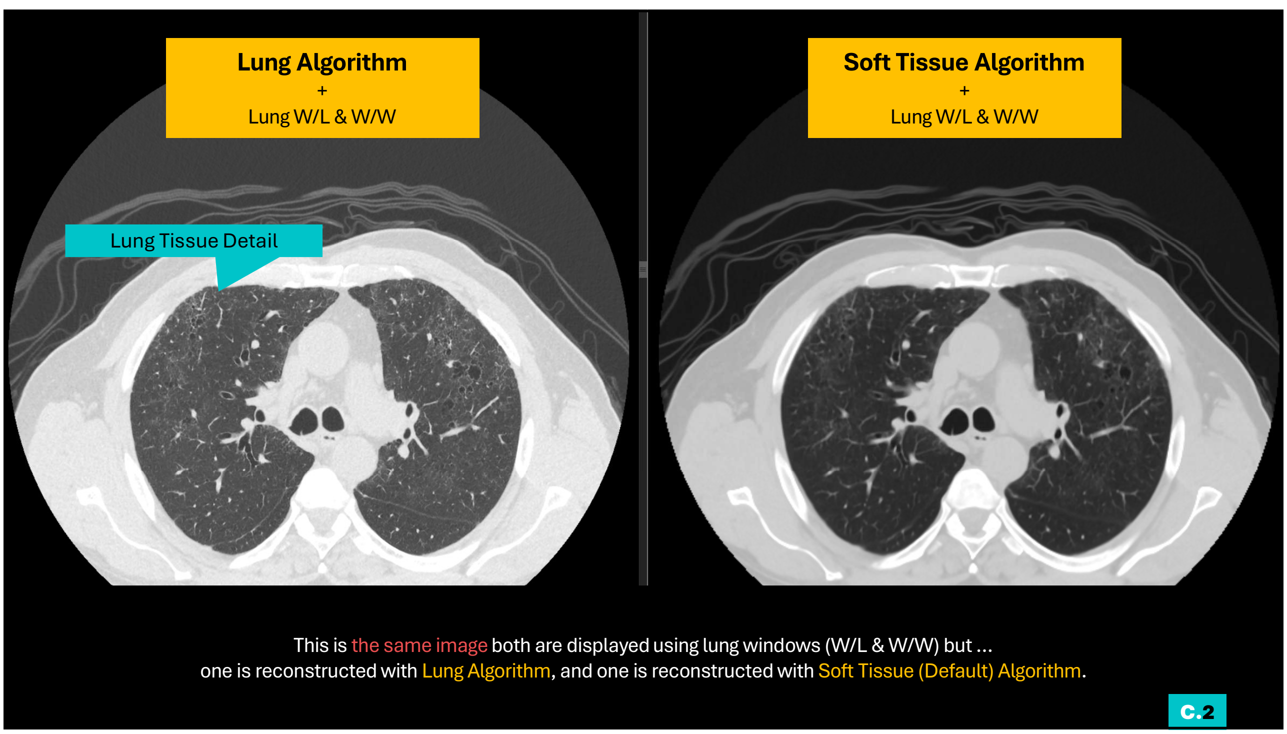
202


Average
MIP
MinIP
Best for
General CT use
Best for
CT Angiography
Best for
Airy Structures (minimal use)
This is the same image reconstructed at same slice thickness but different voxel projection
C.2

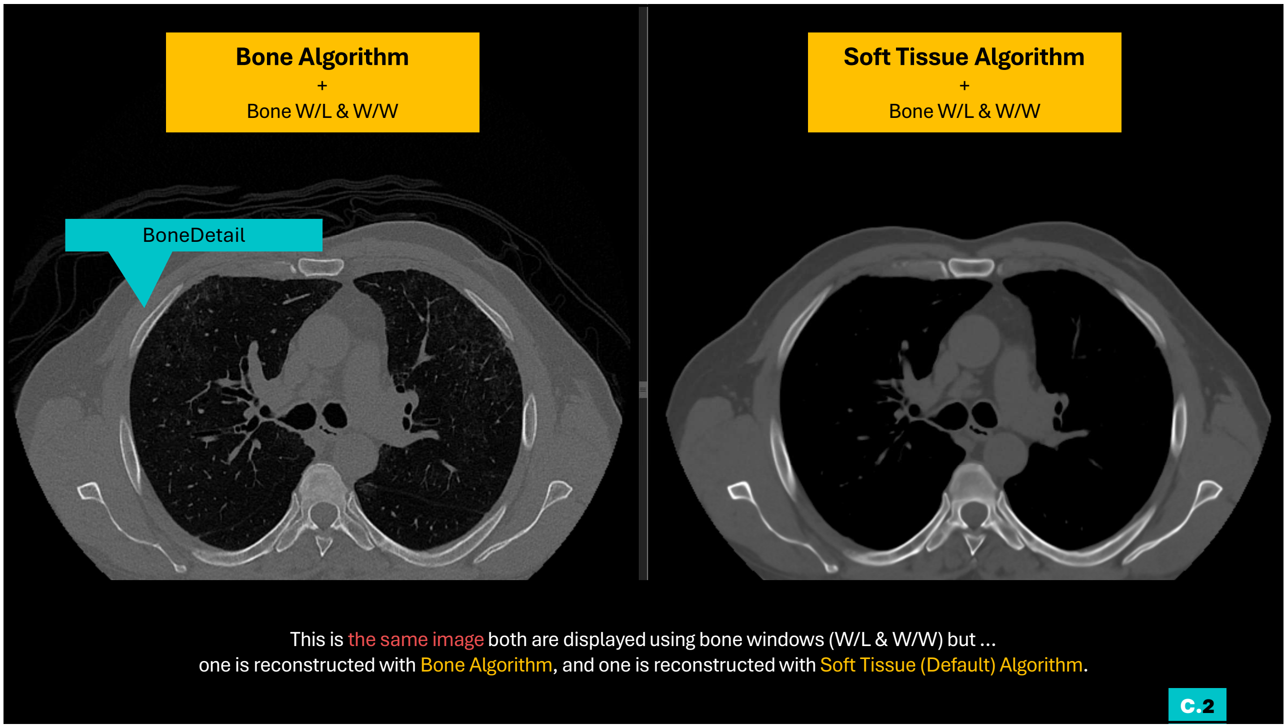
203


Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
DFOV (display field of view)
Slice thickness
Slice interval
Default WL/WW
Window Level (WL)
Window Width (WW)
ALGORITHM
PARAMETERS
DISPLAY
IMAGE RECONSTRUCTION
FINAL IMAGE
C.2

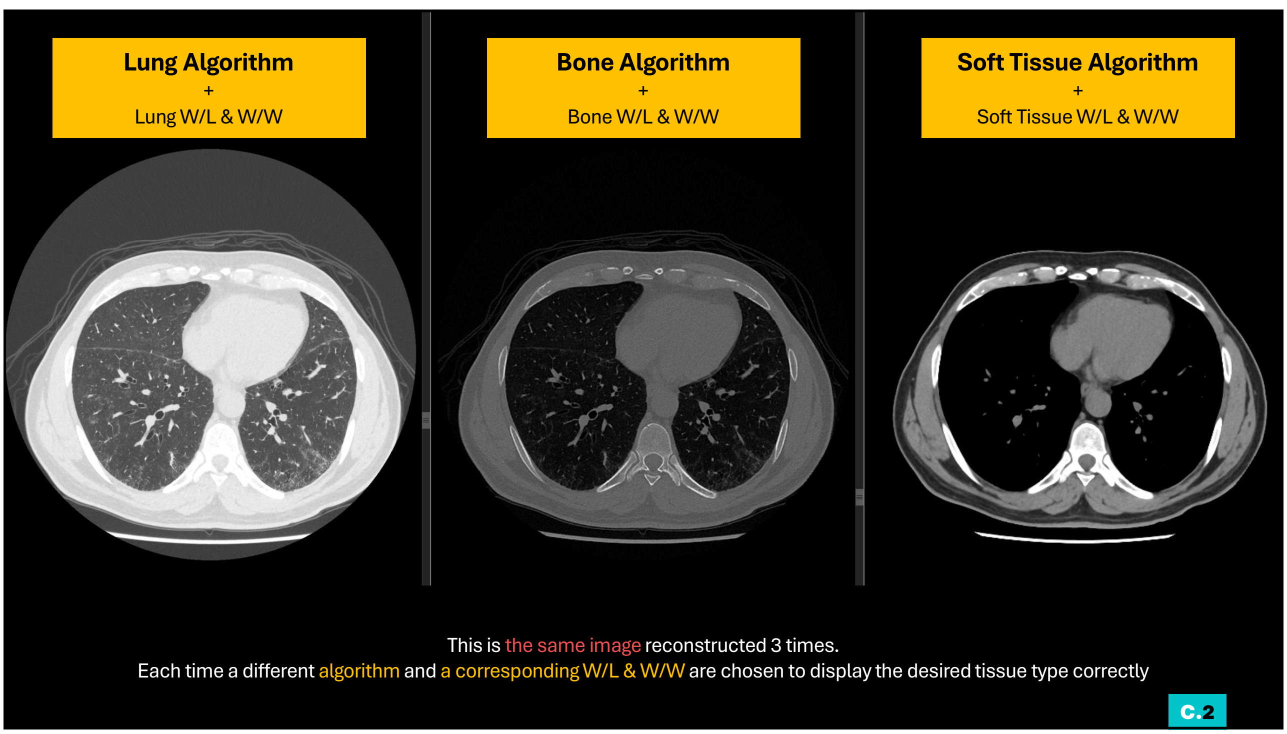
204


Lung Algorithm
+
Lung W/L & W/W
Soft Tissue Algorithm
+
Lung W/L & W/W
Lung Tissue Detail
This is the same image both are displayed using lung windows (W/L & W/W) but …
one is reconstructed with Lung Algorithm, and one is reconstructed with Soft Tissue (Default) Algorithm.
C.2

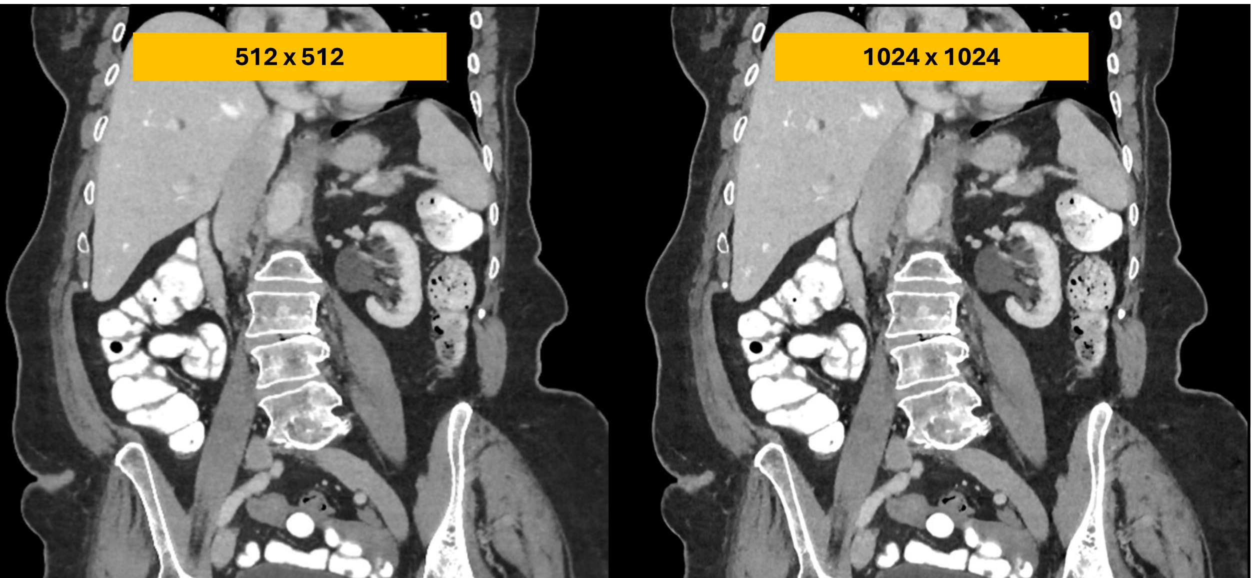
205


Bone Algorithm
+
Bone W/L & W/W
Soft Tissue Algorithm
+
Bone W/L & W/W
BoneDetail
This is the same image both are displayed using bone windows (W/L & W/W) but ...
one is reconstructed with Bone Algorithm, and one is reconstructed with Soft Tissue (Default) Algorithm.
C.2

206


Lung Algorithm
+
Lung W/L & W/W
Bone Algorithm
+
Bone W/L & W/W
Soft Tissue Algorithm
+
Soft Tissue W/L & W/W
This is the same image reconstructed 3 times.
Each time a different algorithm and a corresponding W/L & W/W are chosen to display the desired tissue type correctly
C.2

207



This is the same image both are using Soft Tissue Algorithm and Soft Tissue windows (W/L & W/W) but ...
One is reconstructed with 512 x 512 matrix and one with 1024 x 1024 matrix.

C.2

208

- Sharpening & edge detail
- Smoothing & image noise
- Anatomical region
- Diagnostic needs
- Image quality needs

ALGORITHM

- DFOV (display field of view)
- Slice thickness
- Slice interval
- Default WL/WW

PARAMETERS

IMAGE RECONSTRUCTION

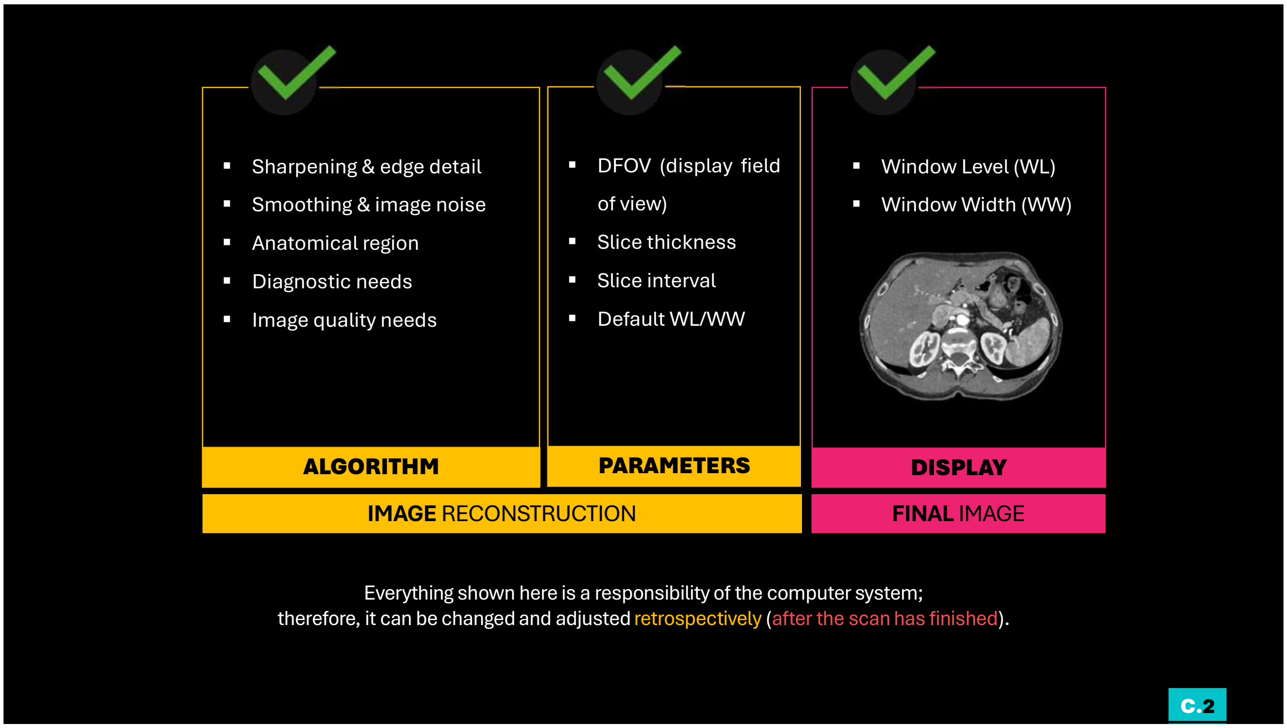
- Window Level (WL)
- Window Width (WW)

DISPLAY

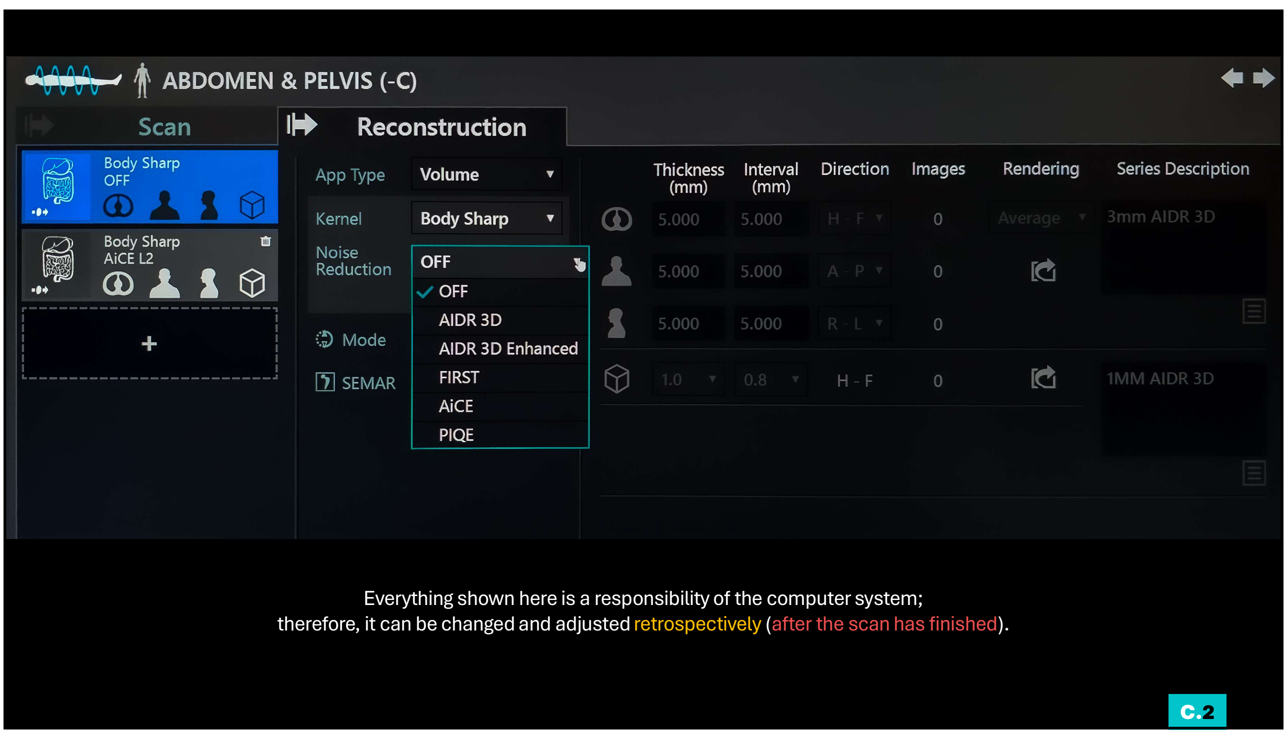
FINAL IMAGE

C.2

209


Sharpening & edge detail
Smoothing & image noise
Anatomical region
Diagnostic needs
Image quality needs
DFOV (display field of view)
Slice thickness
Slice interval
Default WL/WW
Window Level (WL)
Window Width (WW)
ALGORITHM
PARAMETERS
DISPLAY
IMAGE RECONSTRUCTION
FINAL IMAGE
Everything shown here is a responsibility of the computer system;
therefore, it can be changed and adjusted retrospectively (after the scan has finished).
C.2

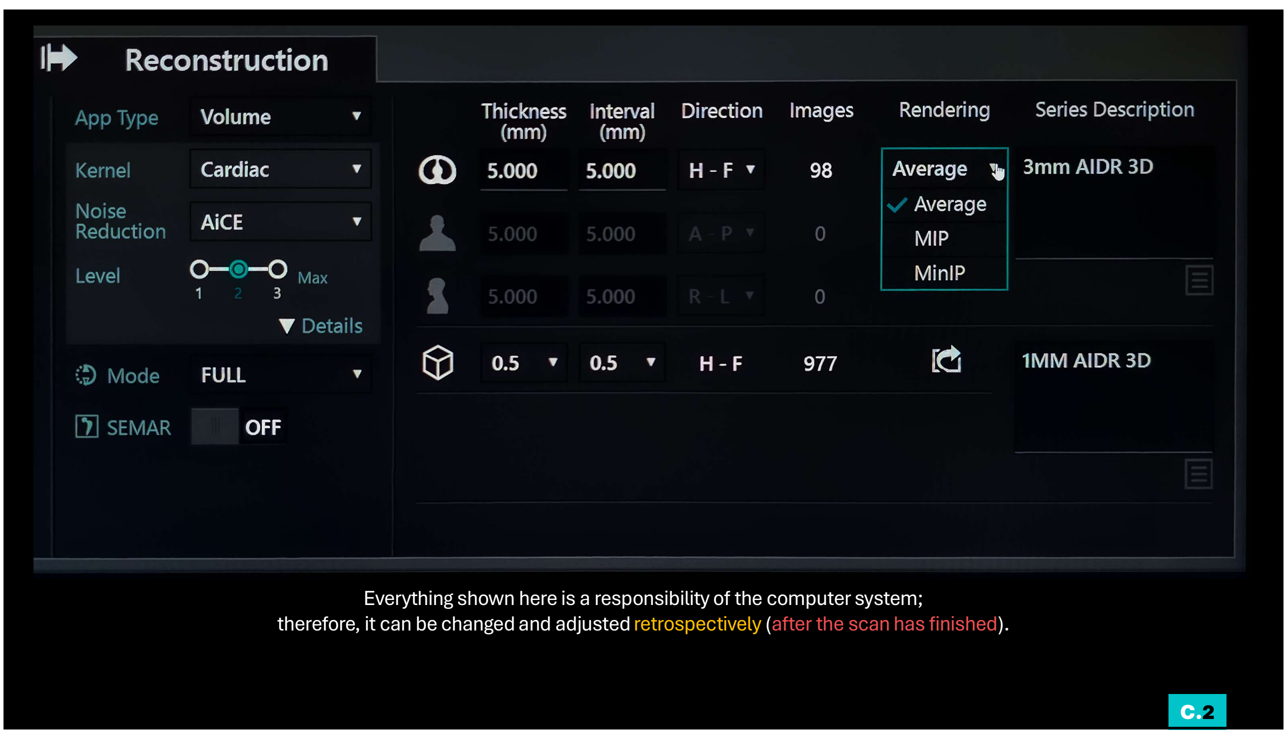
210


ABDOMEN & PELVIS (-C)
Scan
Reconstruction
Body Sharp
OFF
Body Sharp
AiCE L2
App Type
Volume
Kernel
Body Sharp
Noise Reduction
OFF
OFF
AIDR 3D
AIDR 3D Enhanced
FIRST
AiCE
PIQE
Mode
SEMAR
Thickness (mm)
Interval (mm)
Direction
Images
Rendering
Series Description
5.000
5.000
H - F
0
Average
3mm AIDR 3D
A - P
R - L
1.0
0.8
1MM AIDR 3D
Everything shown here is a responsibility of the computer system;
therefore, it can be changed and adjusted retrospectively (after the scan has finished).
C.2

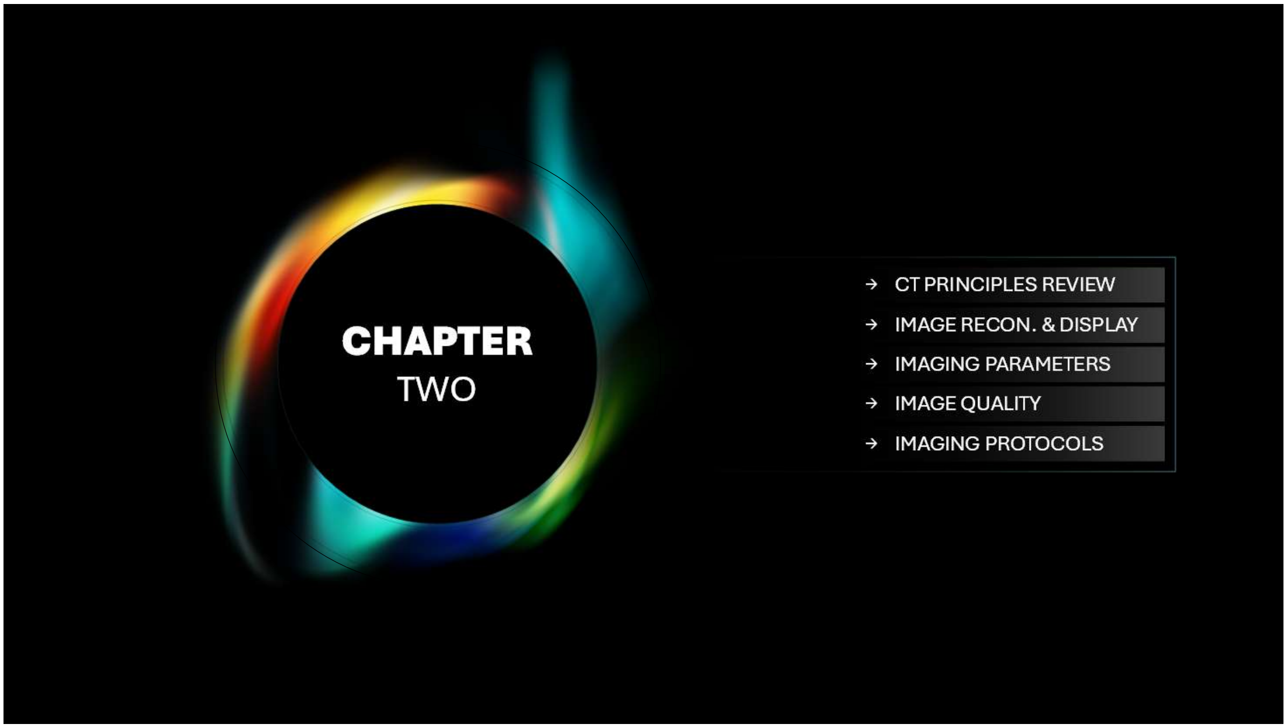
211


ABDOMEN & PELVIS (-C)
Scan
Reconstruction
Body Sharp AIDR 3D Enhanced L2
Body Sharp AiCE L2
App Type
Volume
Kernel
Body Sharp
Noise Reduction
Level
Mode
SEMAR
Brain B2
Brain Pediatric
Lung
Lung Sharp
Body
Body Sharp
Cardiac
Cardiac Sharp
CTA Brain
CTA Body
CTA Body Sharp
Bone
Bone Sharp
Thickness (mm)
Interval (mm)
Direction
Images
Rendering
Series Description
3mm AIDR 3D
1MM AIDR 3D
Everything shown here is a responsibility of the computer system;
therefore, it can be changed and adjusted retrospectively (after the scan has finished).
C.2

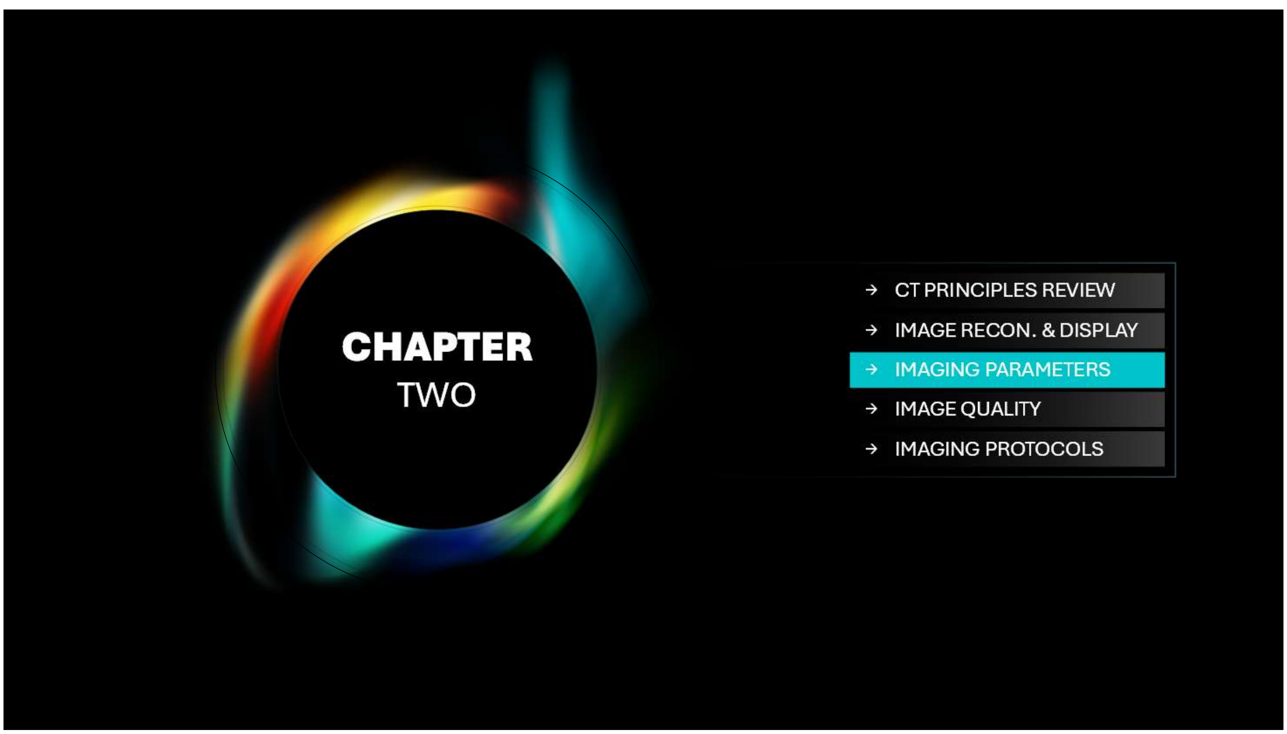
212


Reconstruction
App Type
Volume
Kernel
Cardiac
Noise Reduction
AiCE
Level
Max
Details
Mode
FULL
SEMAR
OFF
Thickness (mm)
Interval (mm)
Direction
Images
Rendering
Series Description
5.000
H - F
98
Average
MIP
MinIP
3mm AIDR 3D
0.5
977
1MM AIDR 3D
Everything shown here is a responsibility of the computer system;
therefore, it can be changed and adjusted retrospectively (after the scan has finished).
C.2

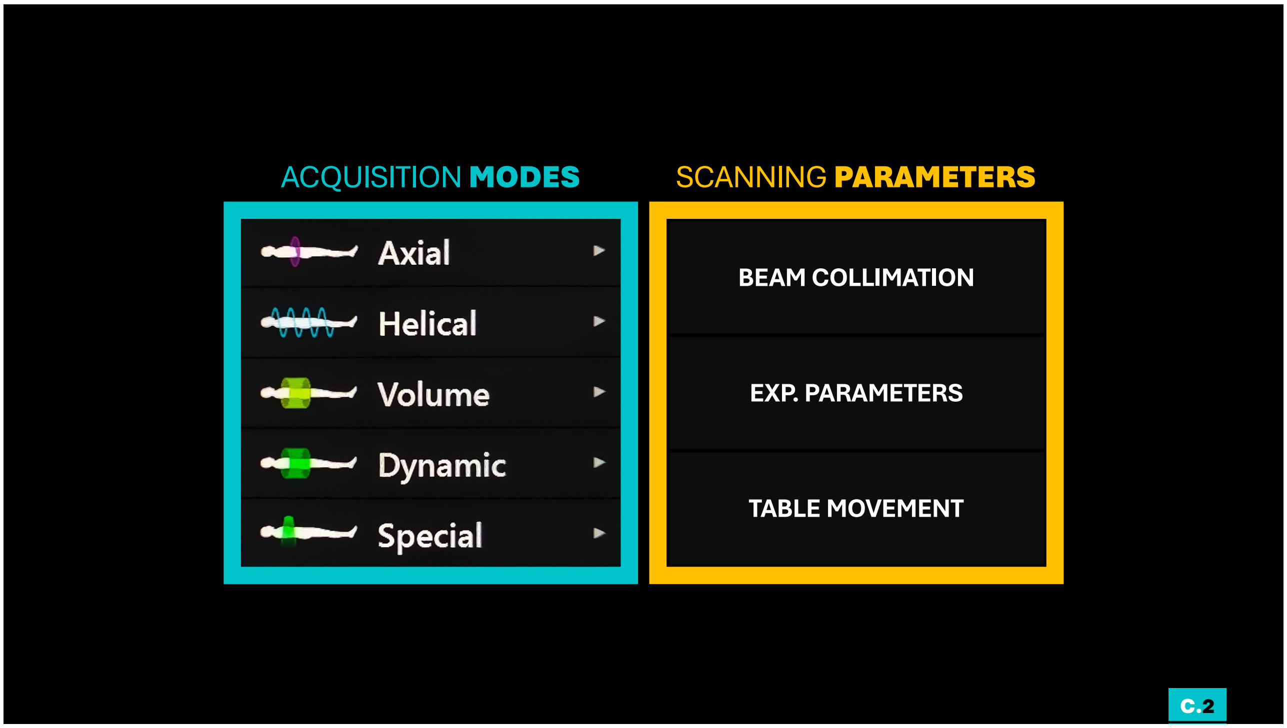
213


CHAPTER
TWO
CT PRINCIPLES REVIEW
IMAGE RECON. & DISPLAY
IMAGING PARAMETERS
IMAGE QUALITY
IMAGING PROTOCOLS

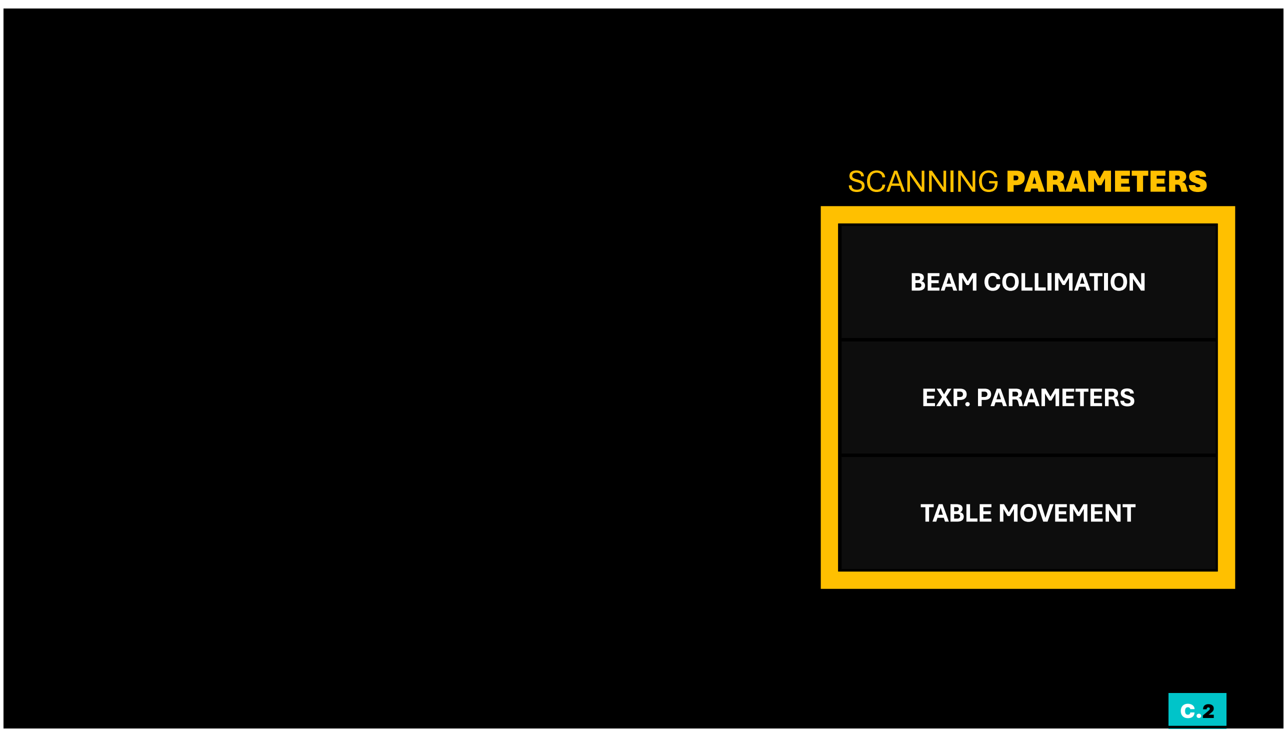
214


CHAPTER
TWO
CT PRINCIPLES REVIEW
IMAGE RECON. & DISPLAY
IMAGING PARAMETERS
IMAGE QUALITY
IMAGING PROTOCOLS

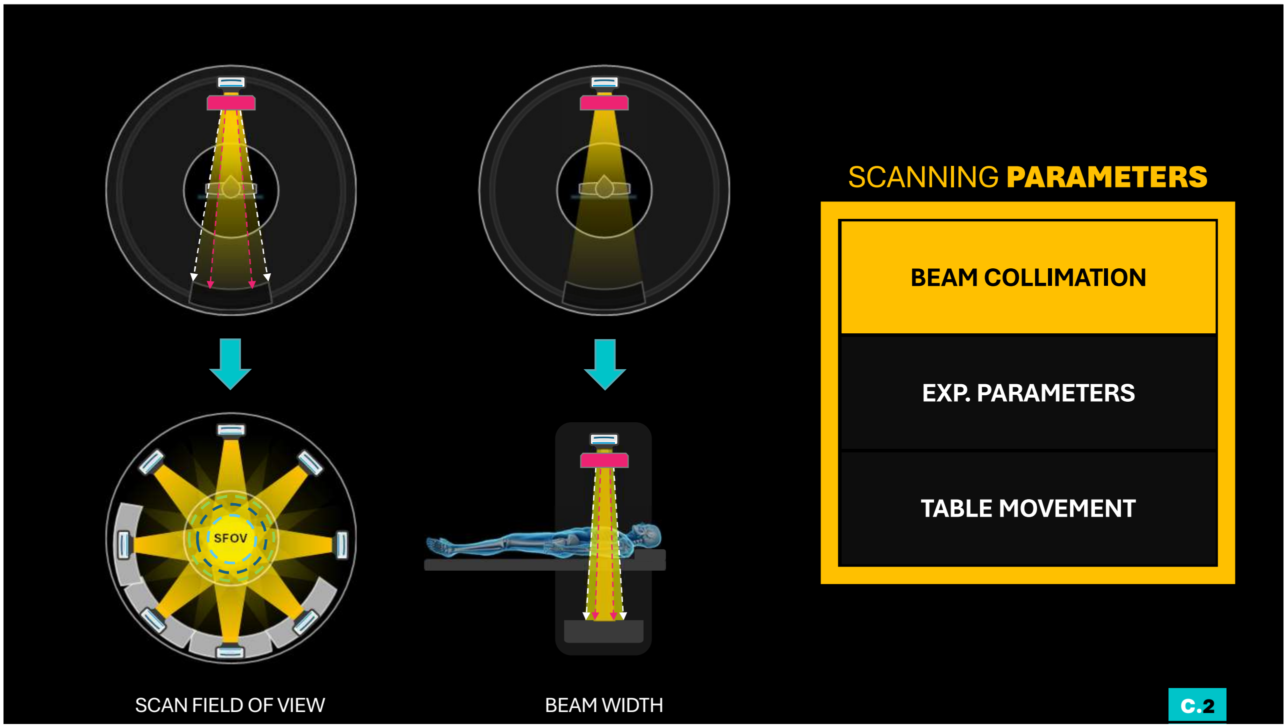
215


ACQUISITION MODES
Axial
Helical
Volume
Dynamic
Special
SCANNING PARAMETERS
BEAM COLLIMATION
EXP. PARAMETERS
TABLE MOVEMENT
C.2

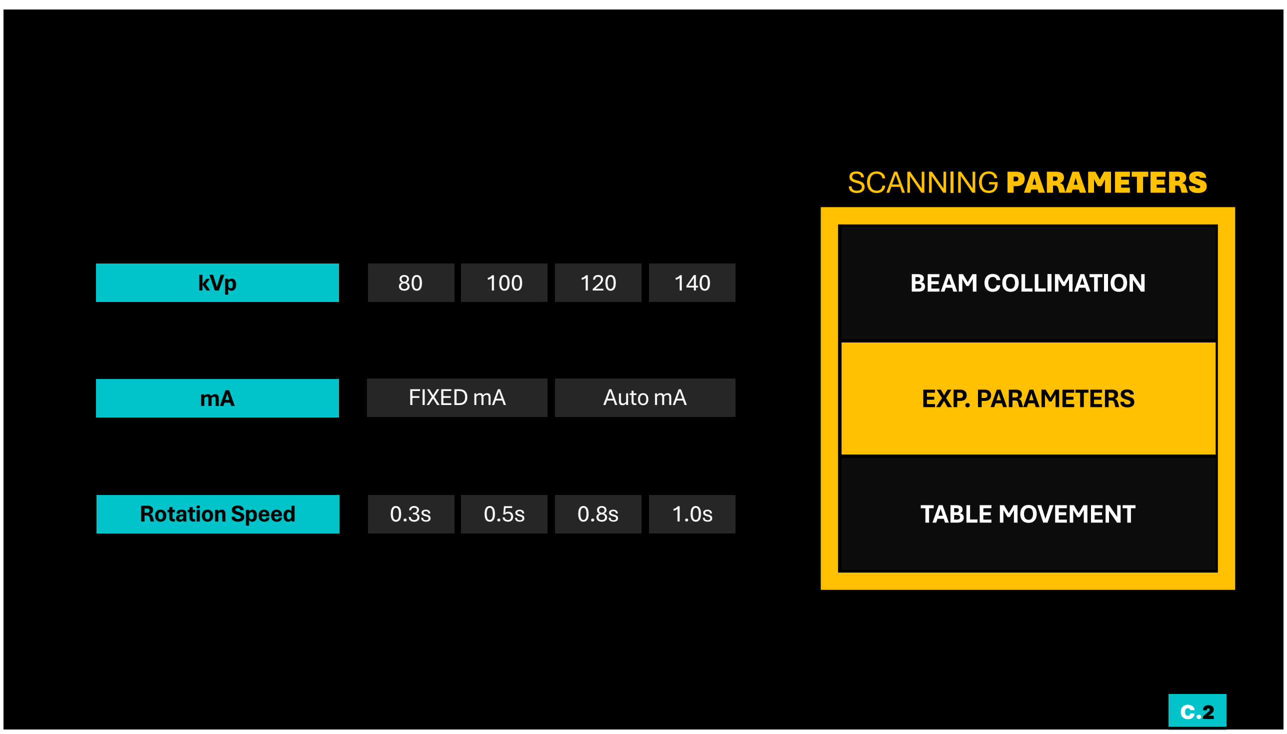
216


SCANNING PARAMETERS
BEAM COLLIMATION
EXP. PARAMETERS
TABLE MOVEMENT
C.2

217


SCANNING PARAMETERS
BEAM COLLIMATION
EXP. PARAMETERS
TABLE MOVEMENT
SFOV
SCAN FIELD OF VIEW
BEAM WIDTH
C.2

218


SCANNING PARAMETERS
BEAM COLLIMATION
EXP. PARAMETERS
TABLE MOVEMENT
kVp
80
100
120
140
mA
FIXED mA
Auto mA
Rotation Speed
0.3s
0.5s
0.8s
1.0s
C.2

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SCANNING **PARAMETERS**

BEAM COLLIMATION

EXP. PARAMETERS

TABLE MOVEMENT

Axial Scanning

No Effect: The beam is turned off during table movement.

Volume & Dynamic Scanning

No Effect: There is no table movement in this type of scanning.

Helical Scanning

Table speed plays an important role during helical scanning.
It affects the helical pitch.

C.2

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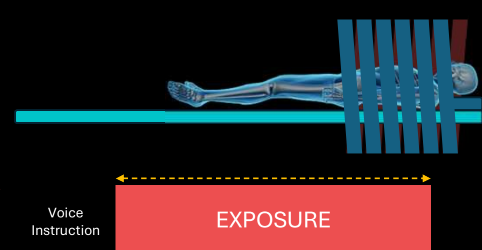
HELICAL (SPIRAL) PITCH

It describes the relationship between the table feed (how fast the patient table moves) and the x-ray beam collimation (the width of the x-ray beam).

Pitch<1: The table moves less than the beam width during one rotation. This results in overlapping slices, increased image quality, and higher radiation dose.

Pitch=1: The table moves the same distance as the beam width during one rotation. This results in contiguous slices with no overlap or gaps.

Pitch>1: The table moves more than the beam width during one rotation. This results in gaps between slices, decreased image quality, and lower radiation dose.



C.2

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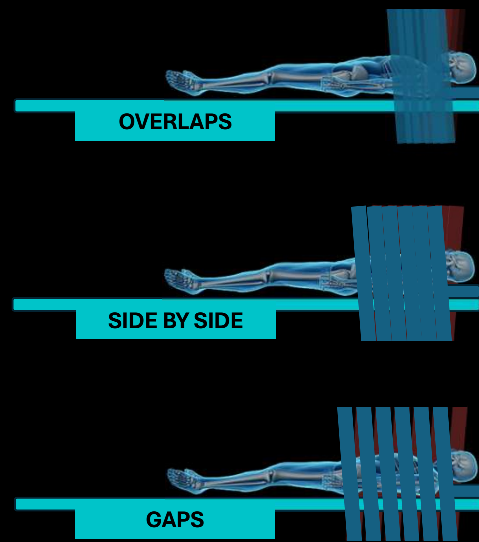
Pitch<1: The table moves less than the beam width during one rotation. This results in overlapping acquisitions, increased image quality, and higher radiation dose.

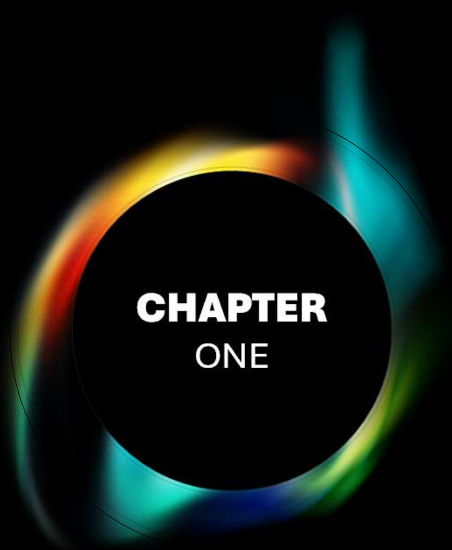
Pitch=1: The table moves exactly the same distance as the beam width during one rotation. This results in contiguous acquisitions with no overlap or gaps.

Pitch>1: The table moves more than the beam width during one rotation. This results in gaps between acquisitions, decreased image quality, and lower radiation dose.



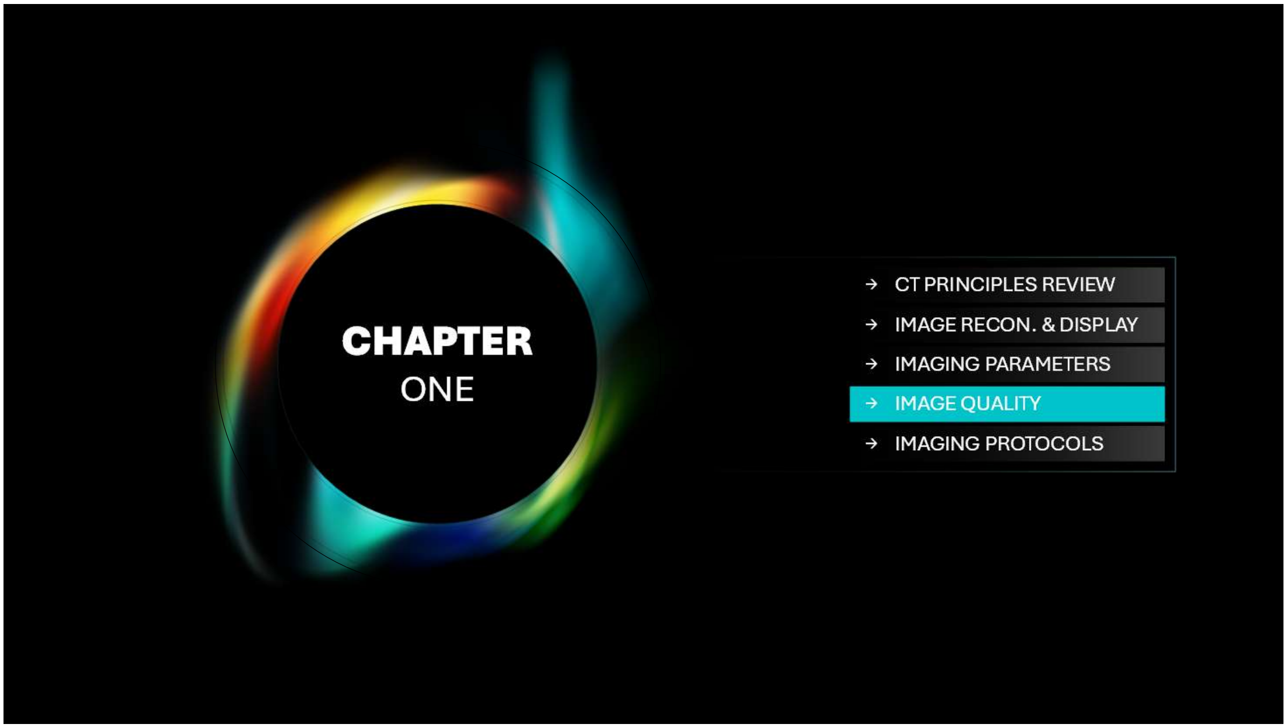
C.2

222



- CT PRINCIPLES REVIEW
- IMAGE RECON. & DISPLAY
- IMAGING PARAMETERS
- IMAGE QUALITY
- IMAGING PROTOCOLS

223


CHAPTER
ONE
CT PRINCIPLES REVIEW
IMAGE RECON. & DISPLAY
IMAGING PARAMETERS
IMAGE QUALITY
IMAGING PROTOCOLS

224

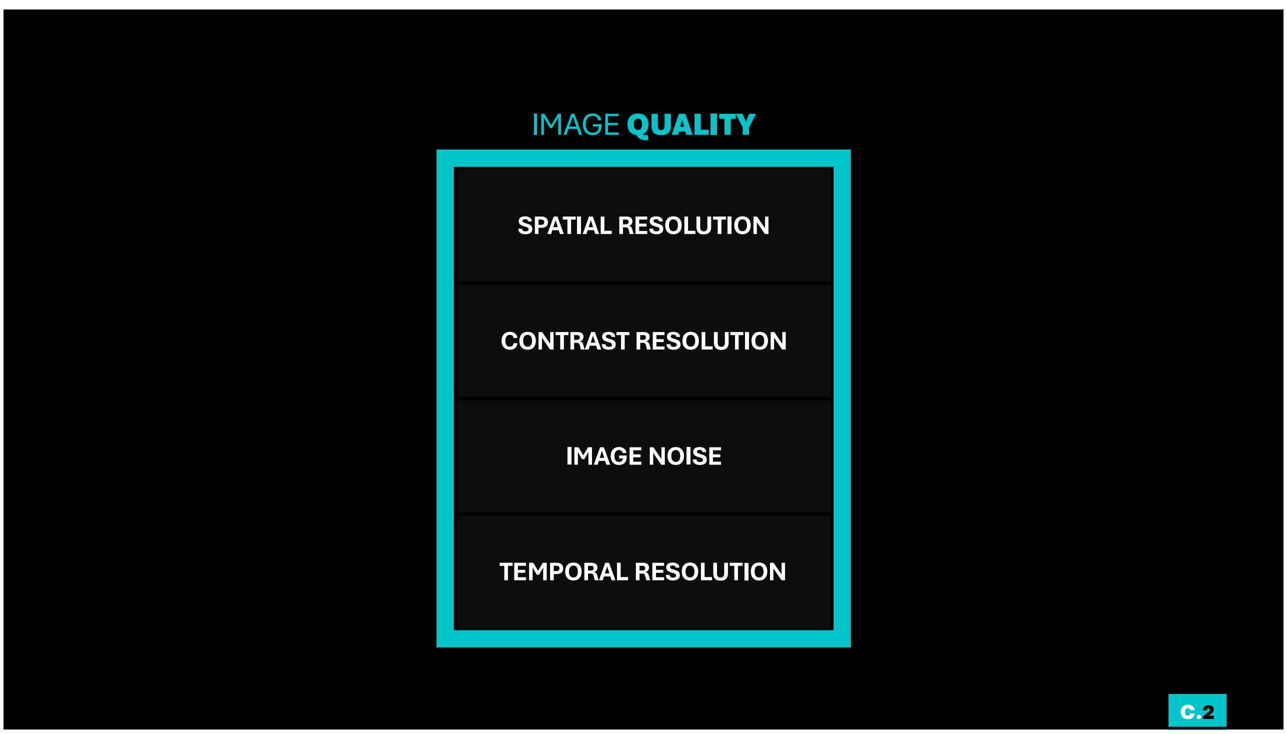


IMAGE QUALITY
SPATIAL RESOLUTION
CONTRAST RESOLUTION
IMAGE NOISE
TEMPORAL RESOLUTION
C.2

225

IMAGE **QUALITY**

- SPATIAL RESOLUTION
- CONTRAST RESOLUTION
- IMAGE NOISE
- TEMPORAL RESOLUTION

C.2

226

DEFINITION

Spatial Resolution is the measure of how far apart two objects must be before they can be seen as separate details in the image.

HOW IT'S MEASURED

Resolution is measured in line pairs per centimeter (lp/cm) … the number of line pairs that can be imaged as separate structures within one centimeter.

X-Y RESOLUTION

Z SENSITIVITY

IMAGE **QUALITY**

- SPATIAL RESOLUTION
- CONTRAST RESOLUTION
- IMAGE NOISE
- TEMPORAL RESOLUTION

C.2

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X-Y
RESOLUTION

. Detector cell size (X-Y-Axis)

Smaller is better

- Focal spot size

Smaller is better (but limits max mA)

- Number of projections

More is better

- Reconstruction algorithm (kernel)

Sharper or higher matrix is better (but noisier images)

- Pixel size (pixel size= FOV/image matrix)

Smaller pixel size (smaller DFOV or Higher matrix)

- Noise

Less is better (higher mA, Slower Rotation, Thicker slices)

Z
SENSITIVITY

. Detector cell size (Z-Axis)

Smaller is better

- Focal spot size

Smaller is better

- Helical Pitch

Smaller is better (overlapping acquisitions)

- Reconstructed slice thickness

thinner is better (reduce partial volume effect)

- Noise

Less is better (higher mA, Slower Rotation, Thicker slices)

C.2

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describe how the detector "sees" or responds to anatomical information along the z-axis (the scan direction). It's not uniform; there's usually a peak sensitivity at the center of the slice and a gradual decrease towards the edges.

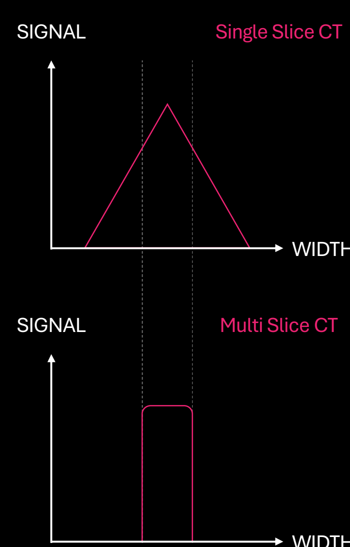
Slice Thickness: The width of the SSP effectively determines the nominal slice thickness. A wider SSP means a thicker slice, and a narrower SSP means a thinner slice.

Shape: The shape of the SSP influences the sharpness of the slice boundaries and the degree of partial volume averaging.

Axial scanning is better than Helical scanning – Slower Pitch is better than faster Pitch

Z
SENSITIVITY

SLICE SENSITIVITY PROFILE (SSP)



C.2

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IMAGE **QUALITY**

SPATIAL RESOLUTION

CONTRAST RESOLUTION

IMAGE NOISE

TEMPORAL RESOLUTION

C.2

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DEFINITION

Contrast resolution in CT refers to the ability of the system to distinguish between two objects or tissues with slightly different linear attenuation coefficients (or densities)

HOW IT'S MEASURED

Contrast resolution can be measured with phantoms, measurements (CNR) or with subjective observations.

Contrast to Noise Ratio =
(HU object **–** HU background**) /** Noise or Standard Deviation

IMAGE **QUALITY**

SPATIAL RESOLUTION

CONTRAST RESOLUTION

IMAGE NOISE

TEMPORAL RESOLUTION

C.2

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FACTORS THAT AFFECT IMAGE CONTRAST

- Beam kilovoltage: a higher beam energy will generally reduce the contrast between Objects
- Noise: a higher noise will obscure any contrast between objects
- Tube current: a higher tube current reduces the noise in the image
- Inherent tissue properties: the difference in the linear attenuation coefficient of adjacent imaged objects will determine the contrast between those objects
- Use of contrast media

C.2

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IMAGE QUALITY

SPATIAL RESOLUTION
CONTRAST RESOLUTION
IMAGE NOISE
TEMPORAL RESOLUTION

C.2

233

DEFINITION

Image noise refers to the random variations in pixel values that appear as graininess or a speckled appearance in the image.

HOW IT'S MEASURED

Using an ROI (region-of-interest) measurement in a uniform subject. The standard deviation of the Hounsfield units in a uniform subjection gives the mean noise measurement.

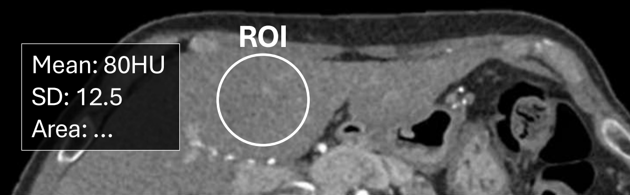

IMAGE **QUALITY**

- SPATIAL RESOLUTION
- CONTRAST RESOLUTION
- **IMAGE NOISE**
- TEMPORAL RESOLUTION

C.2

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FACTORS THAT AFFECT IMAGE NOISE

- mA: higher tube current reduces noise
- Rotation Time: Slower tube rotation (longer time) reduces noise
- Slice Thickness: Thicker slices are less noisy
- Reconstruction Algorithm (kernel): Some reconstruction algorithms with suppress noise better than others

C.2

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FIXED mA

. The tube current (mA) is fixed to a specific value for the entire scan (start to finish).

. Can work for certain cases where the density of the subject does not vary throughout the scan length.

. If variation in density (thickness) is present the slices will have different noise levels from one to another.

AUTO mA

. The tube current (mA) is modulated or varied to compensate for changes in density (thickness) of the subject throughout the length of the scan.

. Most used setting

. The variation in tube current allows a consistent noise level throughout all slices.

. Uses the scout image as a reference.

. Attempts to keep the “Standard Deviation” constant for a given slice thickness throughout all slices by varying the mA between a minimum and maximum value set by the user.

C.2

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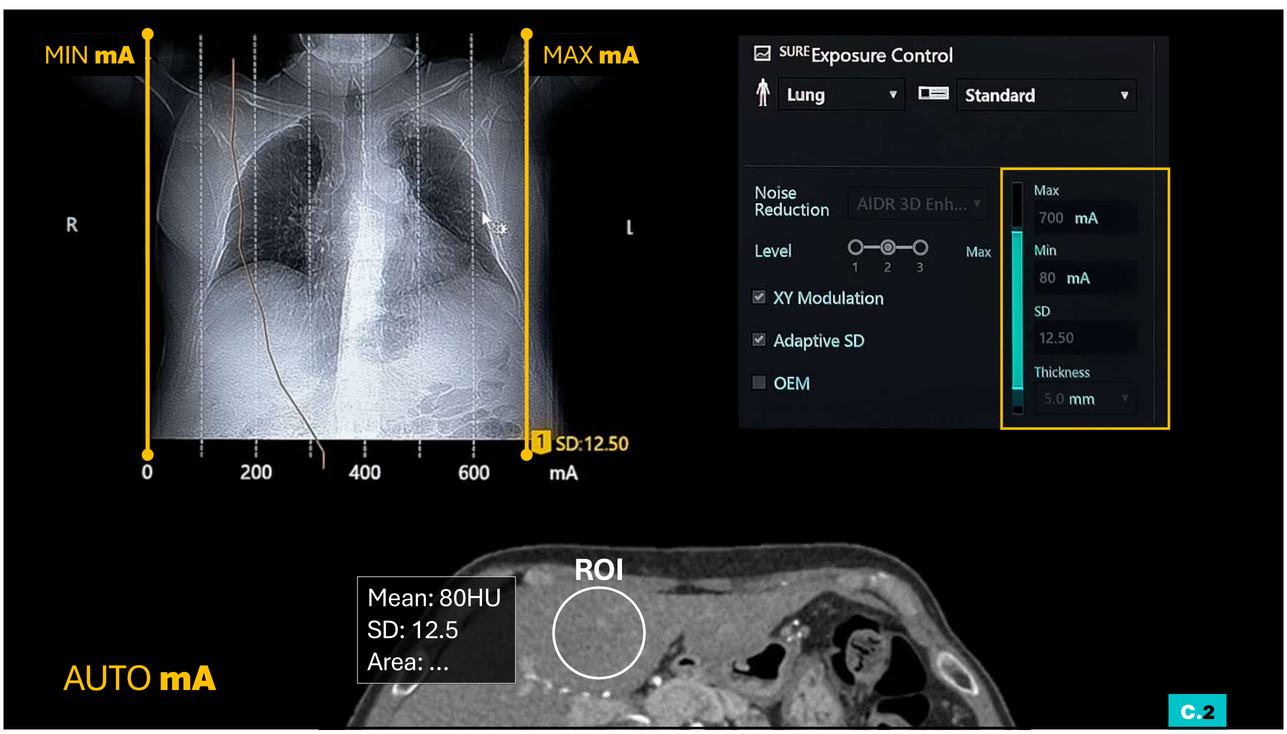

237

IMAGE **QUALITY**

- SPATIAL RESOLUTION
- CONTRAST RESOLUTION
- IMAGE NOISE
- TEMPORAL RESOLUTION

C.2

238

DEFINITION

Temporal resolution in CT refers to the ability of the scanner to capture changes in anatomy or function over time. It essentially quantifies how quickly the scanner can acquire data to create an image, and therefore how well it can visualize moving structures or dynamic processes.

HOW IT'S MEASURED

It is directly related to the tube rotation speed (other factors such as detector Z-Axis width also play a key role).

IMAGE **QUALITY**

- SPATIAL RESOLUTION
- CONTRAST RESOLUTION
- IMAGE NOISE
- **TEMPORAL RESOLUTION**

C.2

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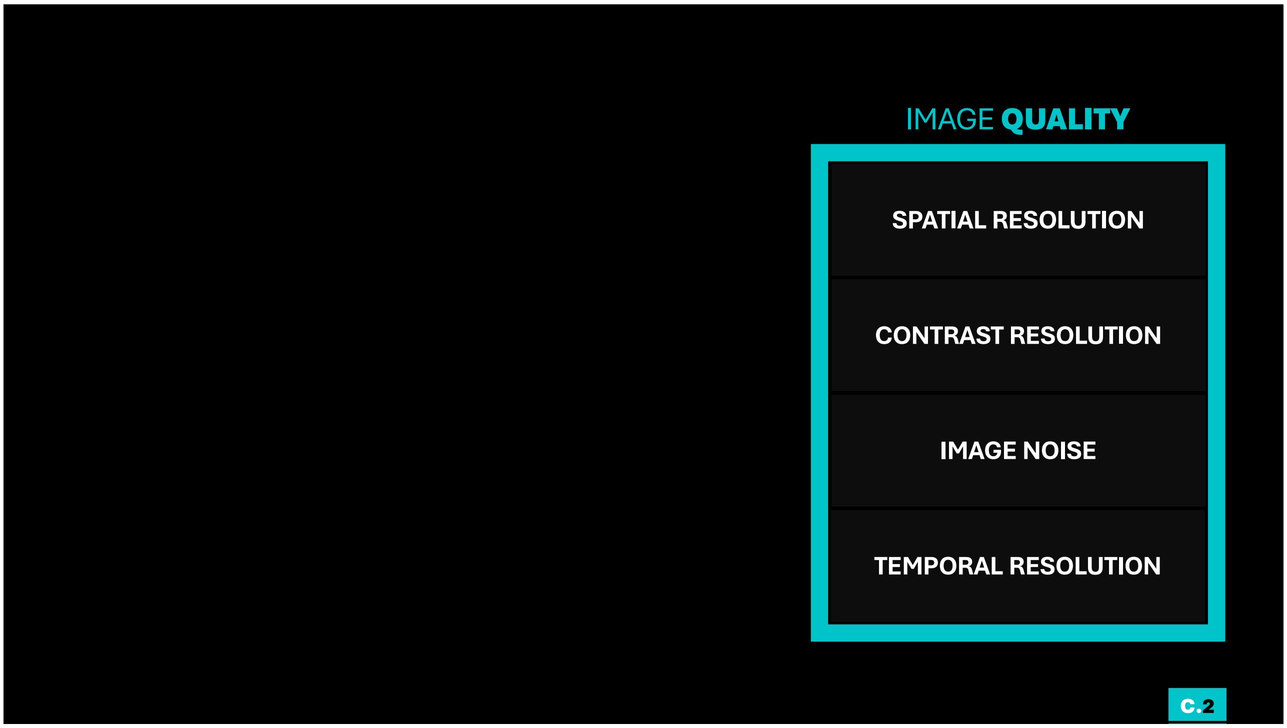


IMAGE QUALITY
SPATIAL RESOLUTION
CONTRAST RESOLUTION
IMAGE NOISE
TEMPORAL RESOLUTION
C.2

240

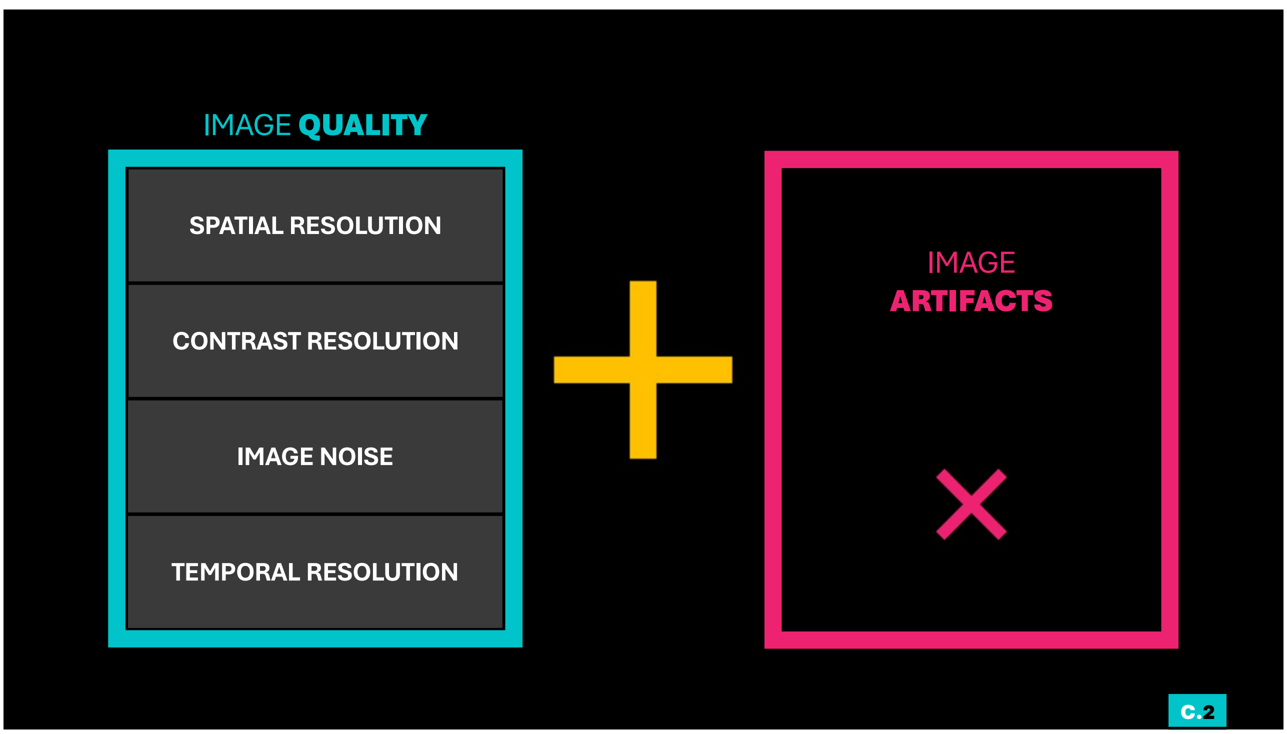


IMAGE QUALITY
SPATIAL RESOLUTION
CONTRAST RESOLUTION
IMAGE NOISE
TEMPORAL RESOLUTION
IMAGE
ARTIFACTS
C.2

241

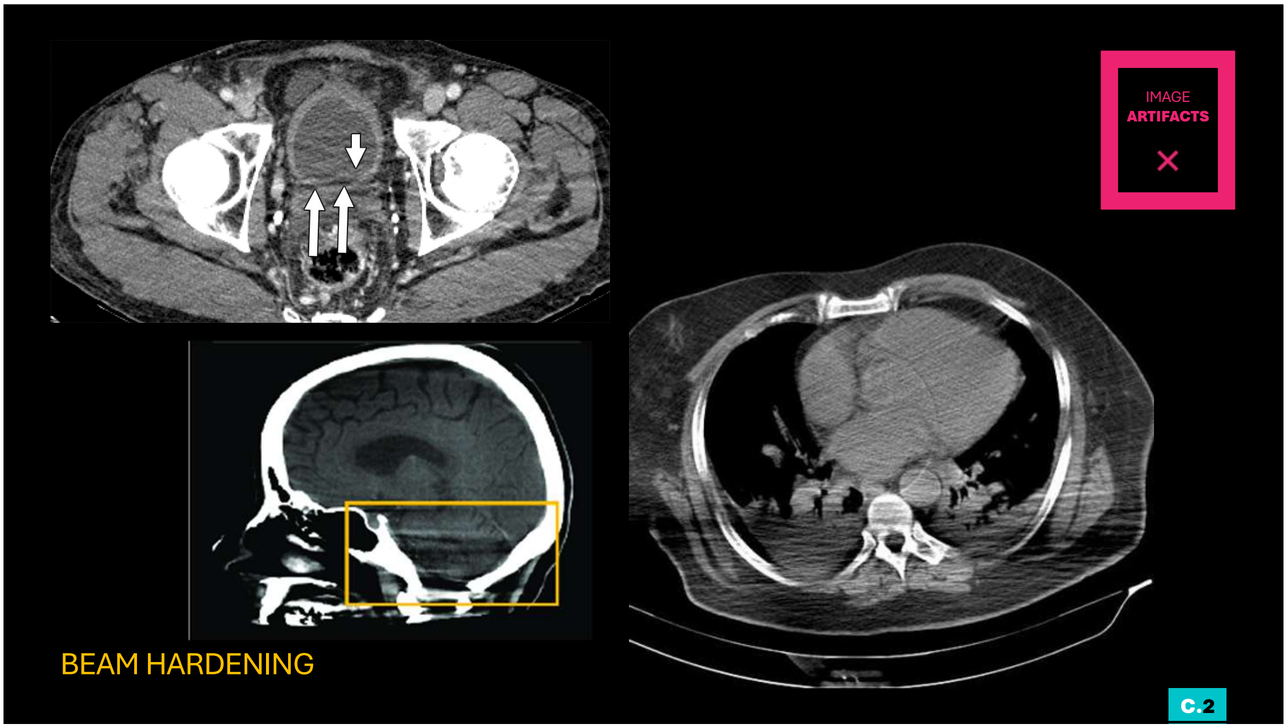


IMAGE
ARTIFACTS
BEAM HARDENING
C.2

242

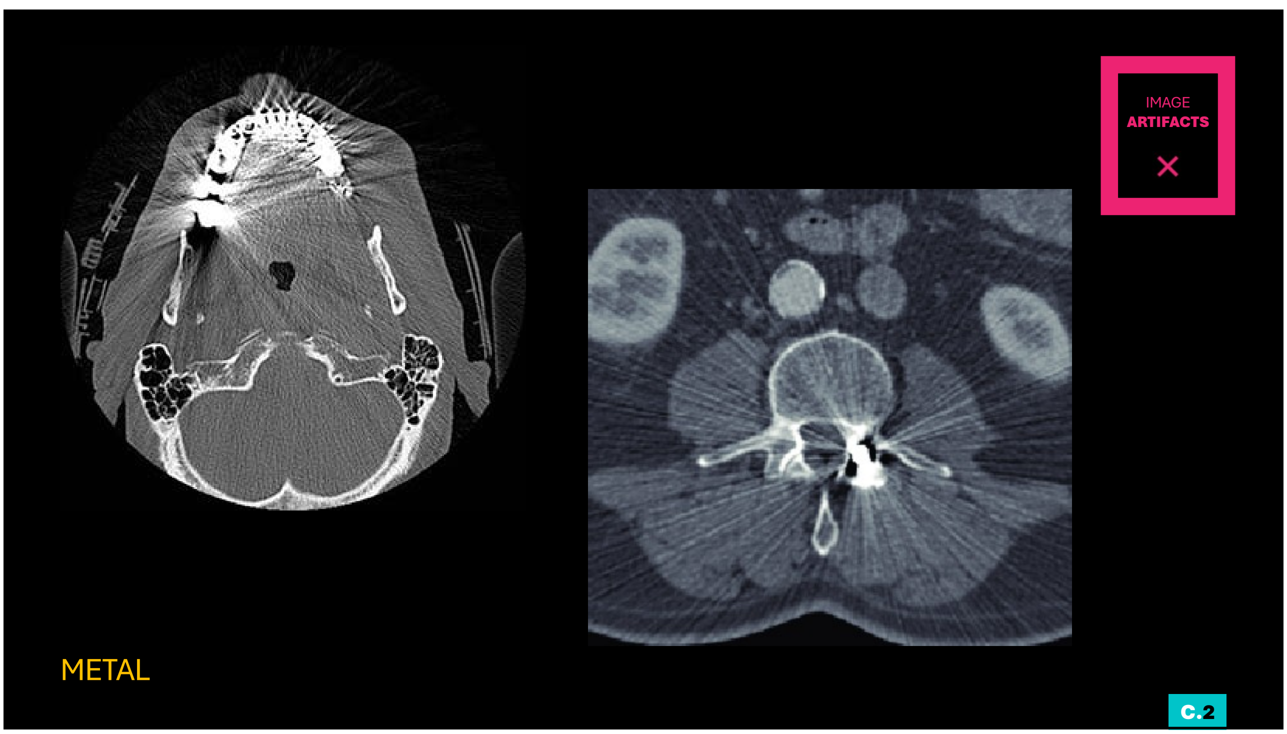


IMAGE
ARTIFACTS
METAL
C.2

243

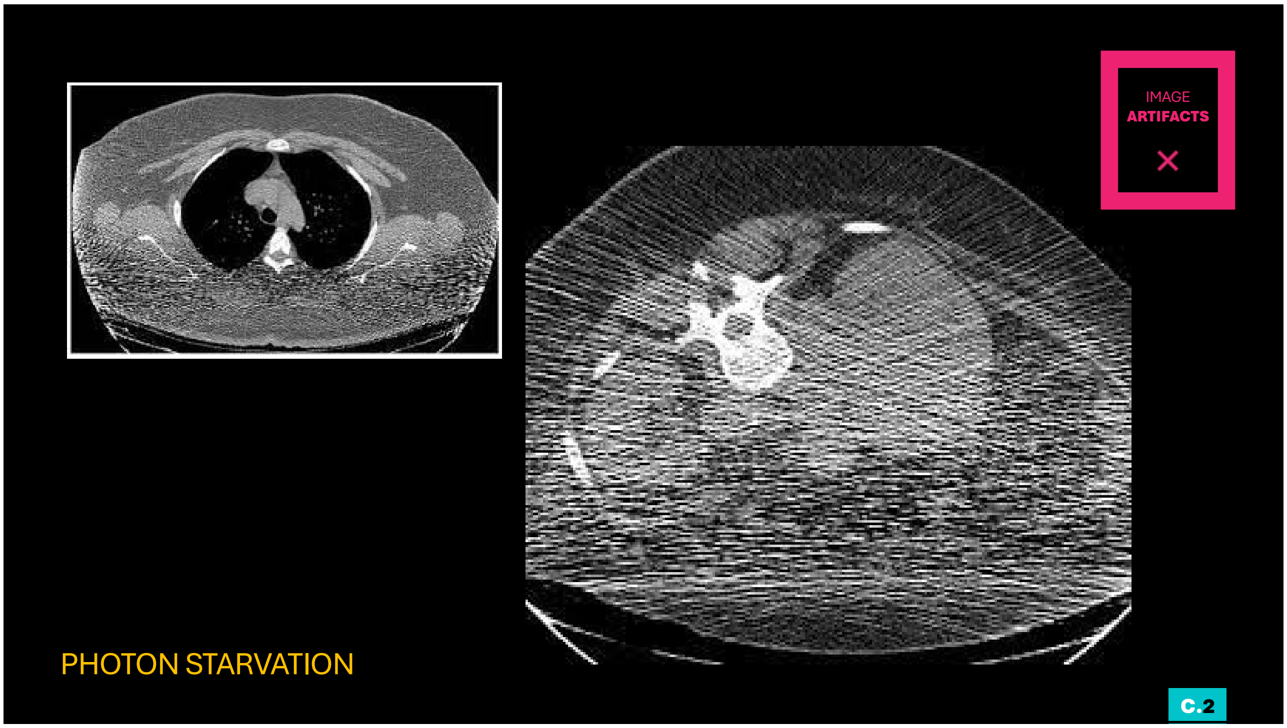


IMAGE
ARTIFACTS
PHOTON STARVATION
c.2

244

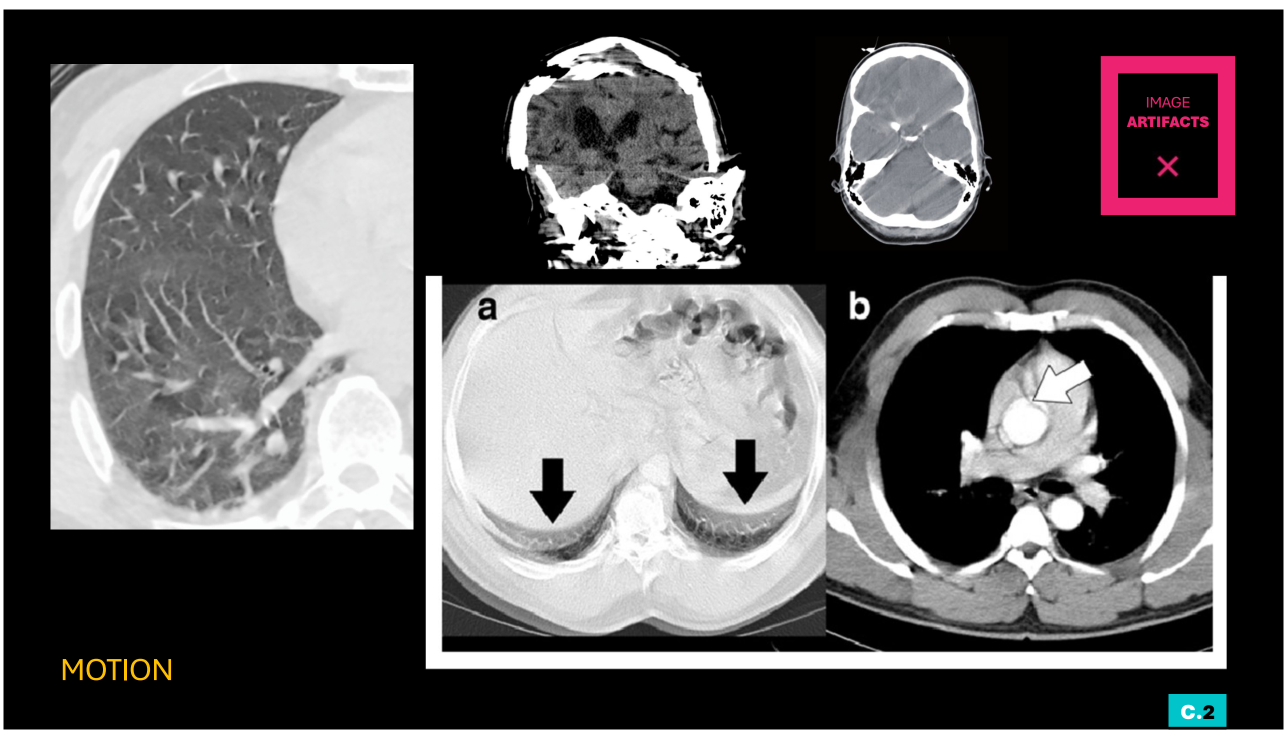
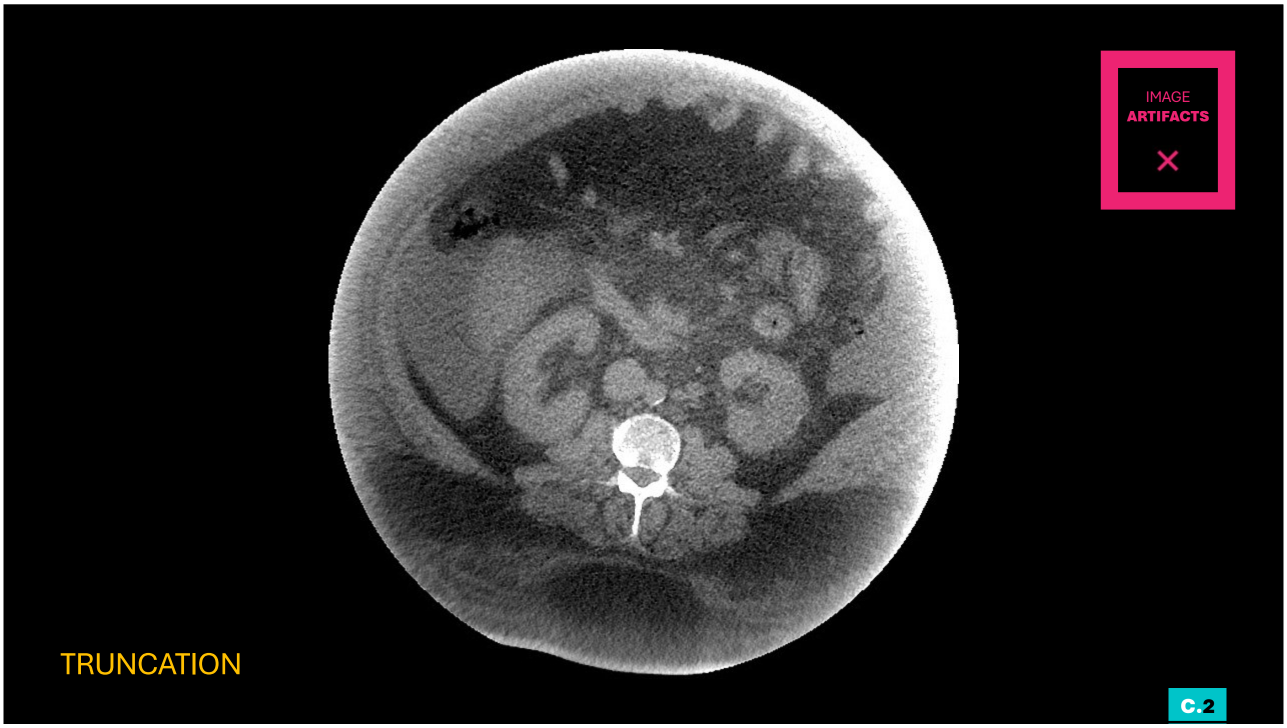


IMAGE
ARTIFACTS
a
b
MOTION
c.2

245



246

247

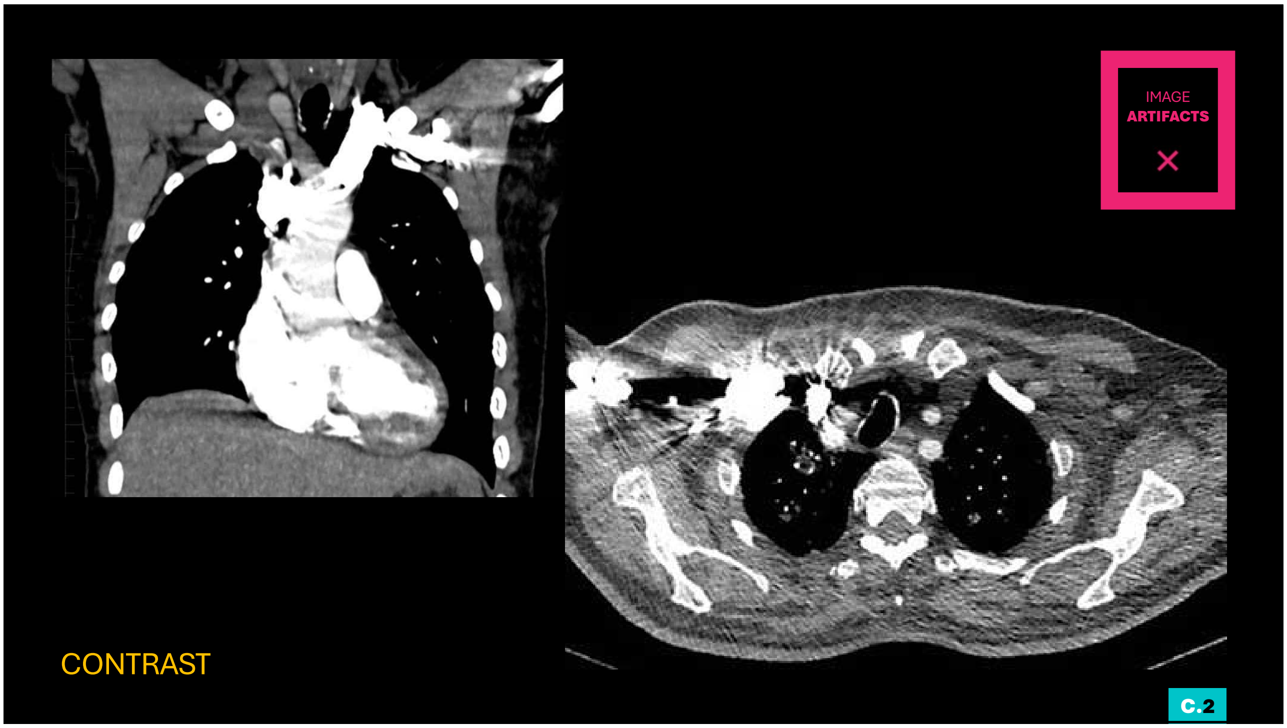
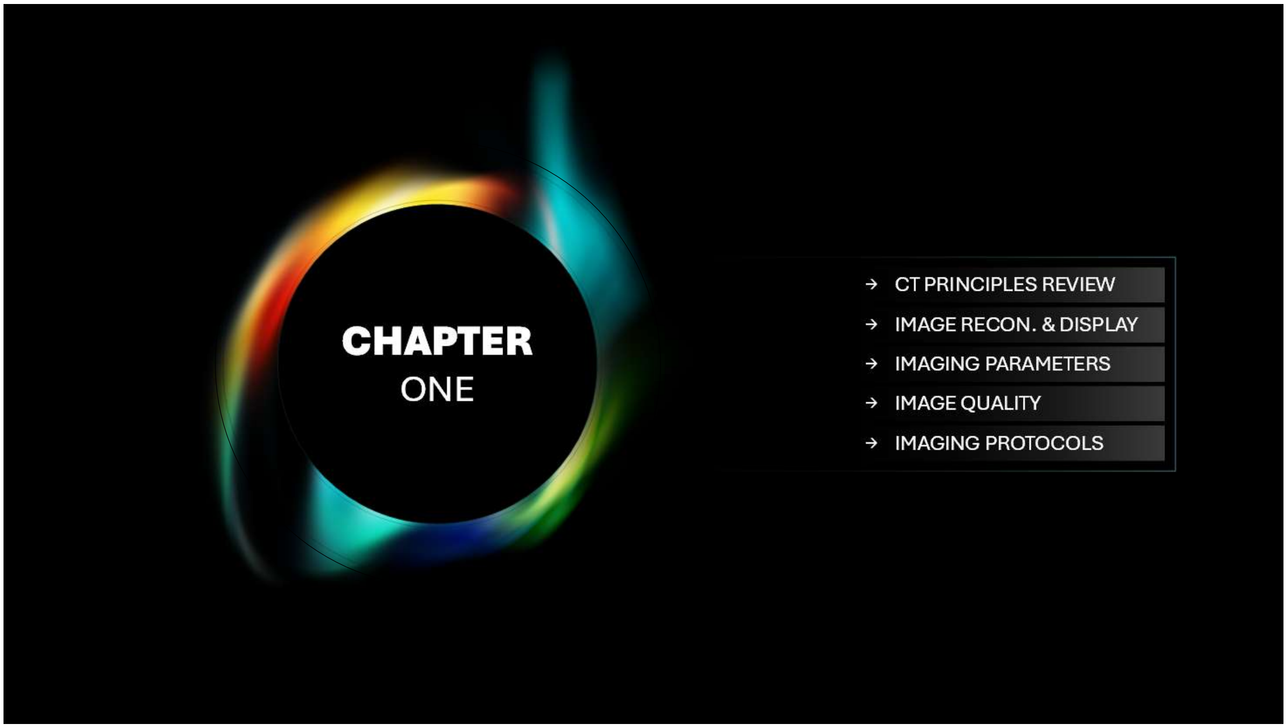


IMAGE
ARTIFACTS
CONTRAST
C.2

248


CHAPTER
ONE
CT PRINCIPLES REVIEW
IMAGE RECON. & DISPLAY
IMAGING PARAMETERS
IMAGE QUALITY
IMAGING PROTOCOLS

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CHAPTER
ONE
CT PRINCIPLES REVIEW
IMAGE RECON. & DISPLAY
IMAGING PARAMETERS
IMAGE QUALITY
IMAGING PROTOCOLS

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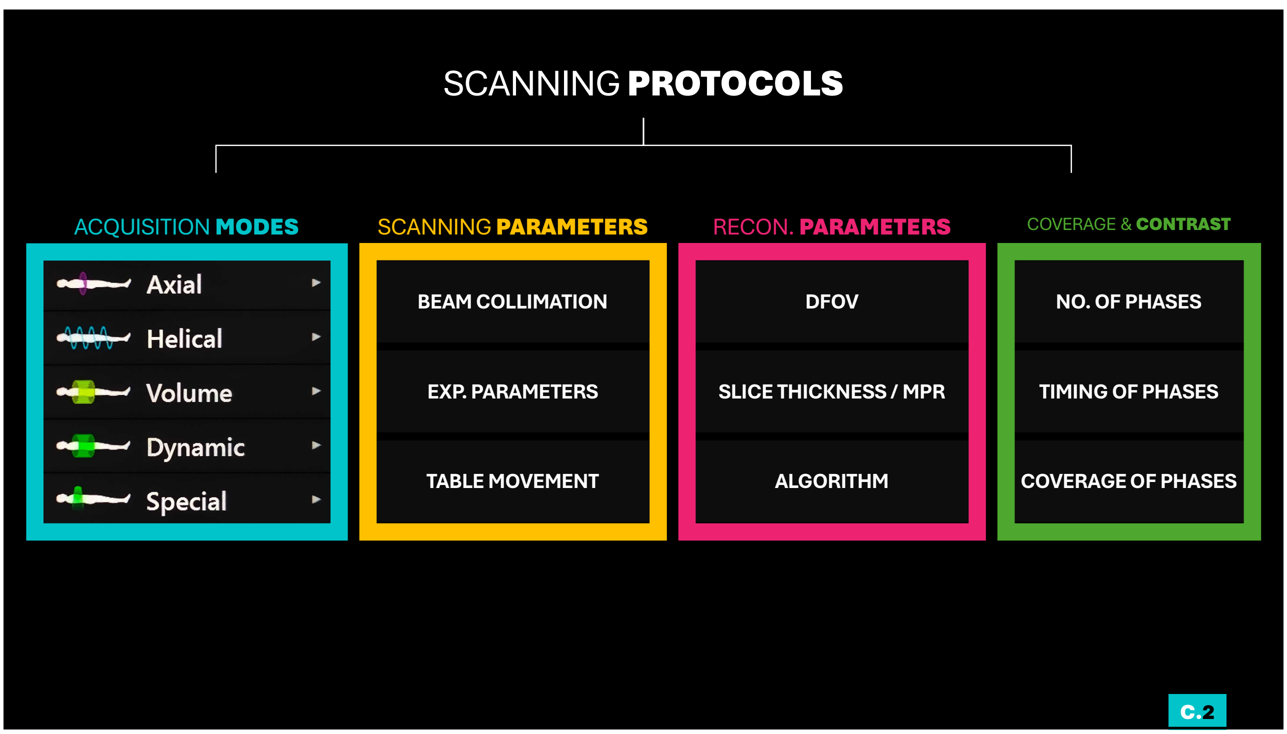
SCANNING PROTOCOLS
ACQUISITION MODES
Axial
Helical
Volume
Dynamic
Special
SCANNING PARAMETERS
BEAM COLLIMATION
EXP. PARAMETERS
TABLE MOVEMENT
RECON. PARAMETERS
DFOV
SLICE THICKNESS / MPR
ALGORITHM
COVERAGE & CONTRAST
NO. OF PHASES
TIMING OF PHASES
COVERAGE OF PHASES
C.2

251

ORAL & RECTAL **CONTRAST**

Purpose: Used to opacify the gastrointestinal tract, making it easier to distinguish bowel loops from other abdominal structures. Helps visualize bowel walls, identify obstructions, and improve the detection of intra-abdominal masses.

CODE	TARGET AREA	CONTRAST AGENT		VOLUME	ADMINISTRATION PROTOCOL
1	UPPER ABDOMEN	A	WATER ONLY	1L	Total amount to be given over 30mins period
		B	WATER SOLUBLE	1L	Total amount to be given over a 1-hour period
		C	BARIUM	1L	Total amount to be given over a 1-hour period
		⚠ 200mL EVERY 15MINS FOR 45 MINS + 200mL ON CT TABLE			
2	ABDOMEN AND PELVIS	A	WATER ONLY	2L	Total amount to be given over 1-hour period
		B	WATER SOLUBLE	2L	Total amount to be given over a 2-hour period
		C	BARIUM	2L	Total amount to be given over a 2-hour period
		⚠ 300mL EVERY 15MINS FOR 75 MINS + 200mL ON CT TABLE			
3	RECTUM AND DISTAL COLON	A	WATER ONLY	1L	Total amount to be given as quickly as possible. Scanning can be started immediately after.
		B	WATER SOLUBLE	1L	
		C	BARIUM	1L	
		⚠ CONTRAST AMOUNT AND RATE MAY BE ADJUSTED AS PER PATIENT TOLERANCE			

C.2

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IV **CONTRAST**

Purpose: Primarily used to visualize blood vessels, enhance organ parenchyma (like liver, kidneys, pancreas), and highlight certain lesions. Essential for CT angiography (CTA), perfusion studies, and visualizing tumor vascularity.

SLOW **INJECTION**

. To visualize organ parenchyma and lesions

. Accurate timing is not required

. Fixed delay time form start of injection to initiate the scan

FAST **INJECTION**

. To visualize blood vessels (CT Angiography)

. Accurate timing is essential

. Bolus tracking (or bolus timing) are used to accurately start the scan when the arteries are opacified

C.2

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102	CHEST / ABDOMEN / PELVIS (-C/+C)					
	PRE-CONTRAST	CHEST TO PELVIS	AX			SOFT TISSUE
			AX			LUNG
	VENOUS (75s)	CHEST TO PELVIS	AX	COR	SAG	SOFT TISSUE

103	CHEST / ABDOMEN / PELVIS (TWO PHASE)					
	PRE-CONTRAST	CHEST TO PELVIS	AX			SOFT TISSUE
			AX			LUNG
	ARTERIAL SUREstart	CHEST TO ILIAC CREST	AX	COR	SAG	SOFT TISSUE
	VENOUS (75s)	ABDOMEN TO PELVIS	AX	COR	SAG	SOFT TISSUE

104	CHEST / ABDOMEN / PELVIS (THREE PHASE)					
	PRE-CONTRAST	CHEST TO PELVIS	AX			SOFT TISSUE
			AX			LUNG
	ARTERIAL SUREstart	CHEST TO ILIAC CREST	AX	COR	SAG	SOFT TISSUE
	VENOUS (75s)	ABDOMEN TO PELVIS	AX	COR	SAG	SOFT TISSUE
	DELAY (5 MINS)	LIVER	AX			SOFT TISSUE

ROUTINE PROTOCOLS **EXAMPLES**

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C.2

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105	PULMONARY CTA					
	CTA SUREstart	CHEST	AX	COR	SAG	CTA
				COR	SAG	MIP
			AX			LUNG

106	AORTIC CTA					
	PRE-CONTRAST	CHEST TO PELVIS	AX			LUNG
			AX			SOFT
	CTA SUREstart	CHEST TO PELVIS	AX	COR	SAG	CTA
				COR	SAG	MIP

FOR DISSECTION CASES, USE PROTOCOL 107

107	AORTIC CTA WITH ECG GATING (vHP)					
	PRE-CONTRAST	ABOVE SHOULDERS TO PELVIS	AX			LUNG
			AX			SOFT
	CTA SUREstart	ABOVE SHOULDERS TO PELVIS	AX	COR	SAG	CTA
				COR	SAG	MIP

USED TO GENERATE MOTION-FREE AORTIC ROOT IMAGES FOR DISSECTION/ANEURYSM ASSESSMENT

CT ANGIO PROTOCOL **EXAMPLES**

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C.2

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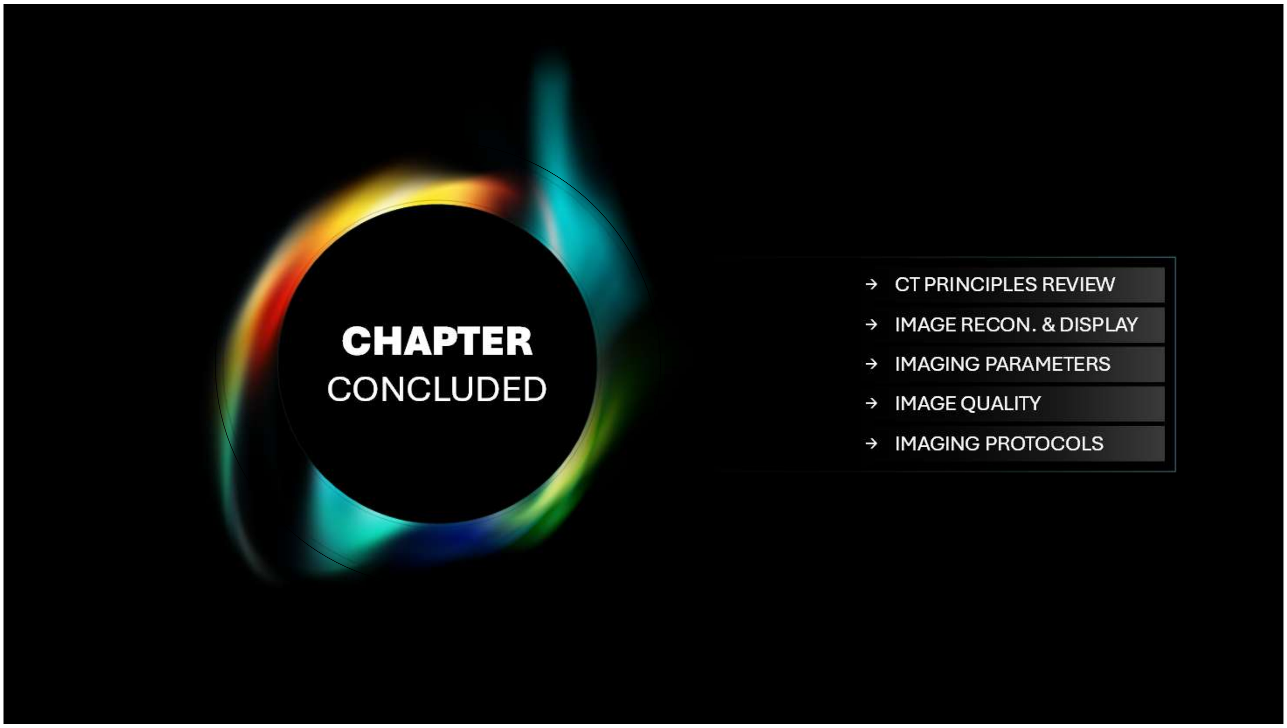
CHAPTER
CONCLUDED
CT PRINCIPLES REVIEW
IMAGE RECON. & DISPLAY
IMAGING PARAMETERS
IMAGE QUALITY
IMAGING PROTOCOLS

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