ESGAR presents

Liver Imaging Workshop

Cluj-Napoca Romania

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MDCT of the Liver

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Outline:

What is the "ideal" liver CT protocol?

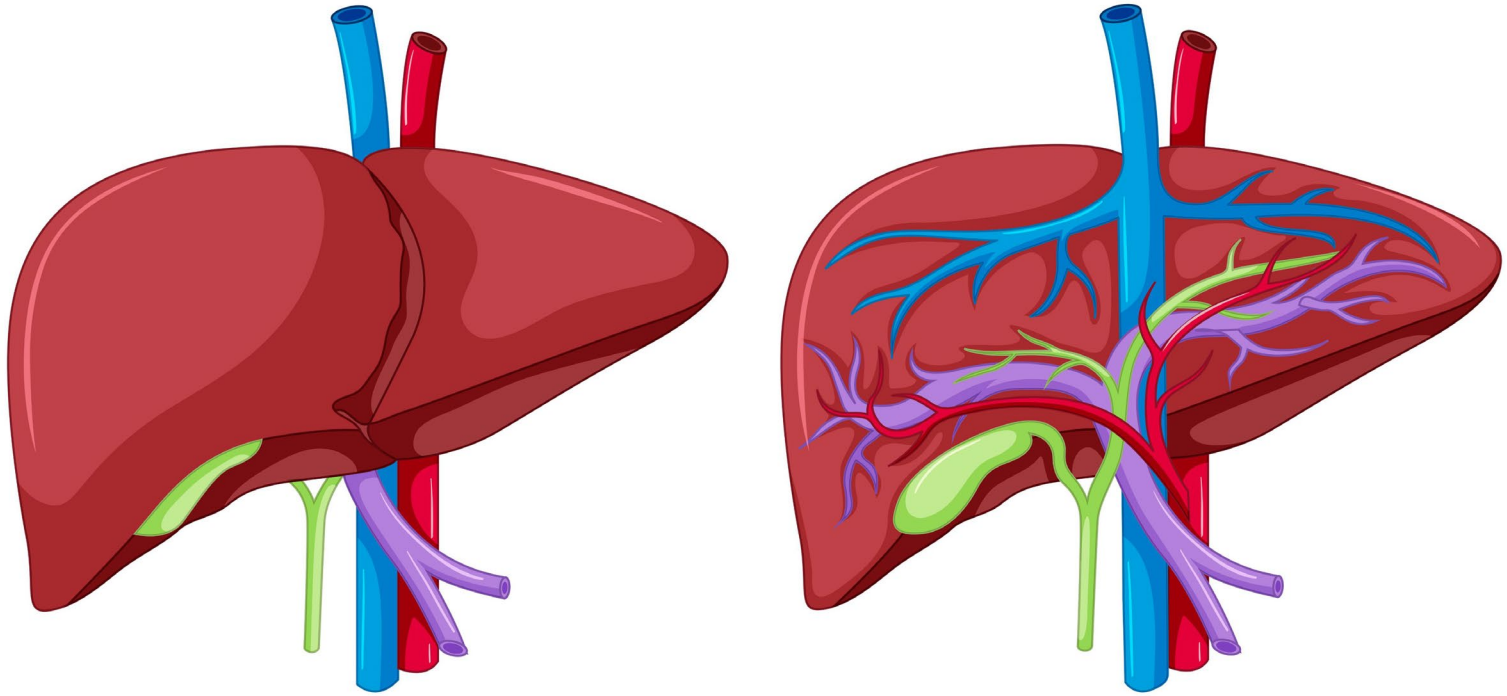
Role of bolus tracking

Angiographic and late hepatic arterial phase: when to use which

New innovations: dual energy CT in the liver.

Optimization of contrast medium

What is the ideal ‘liver’ CT protocol?



The ideal liver CT protocol

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- ✓ Tailored around the suspected diagnosis
- ✓ Almost always includes contrast media administration
- ✓ Multiphasic protocol
- ✓ Optimize technical parameters of your machine

The ideal liver CT protocol

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INDICATIONS

- Identification and characterization of suspected liver lesions
- Assess liver parenchyma (e.g., signs of cirrhosis, presence of fibrosis)
- Check vascularization (e.g., portal vein or hepatic vein patency)
- Assess anatomy
- Pre-operative planning (e.g., resection, loco-regional treatment)
- Post-operative response assessment (both surgical and non-surgical treatments)
- Trauma/suspected liver lacerations or contusions
- Suspected bleeding
- Liver transplant donors and recipients
- Biliary tree lithiasis
- ….

The ideal liver CT protocol

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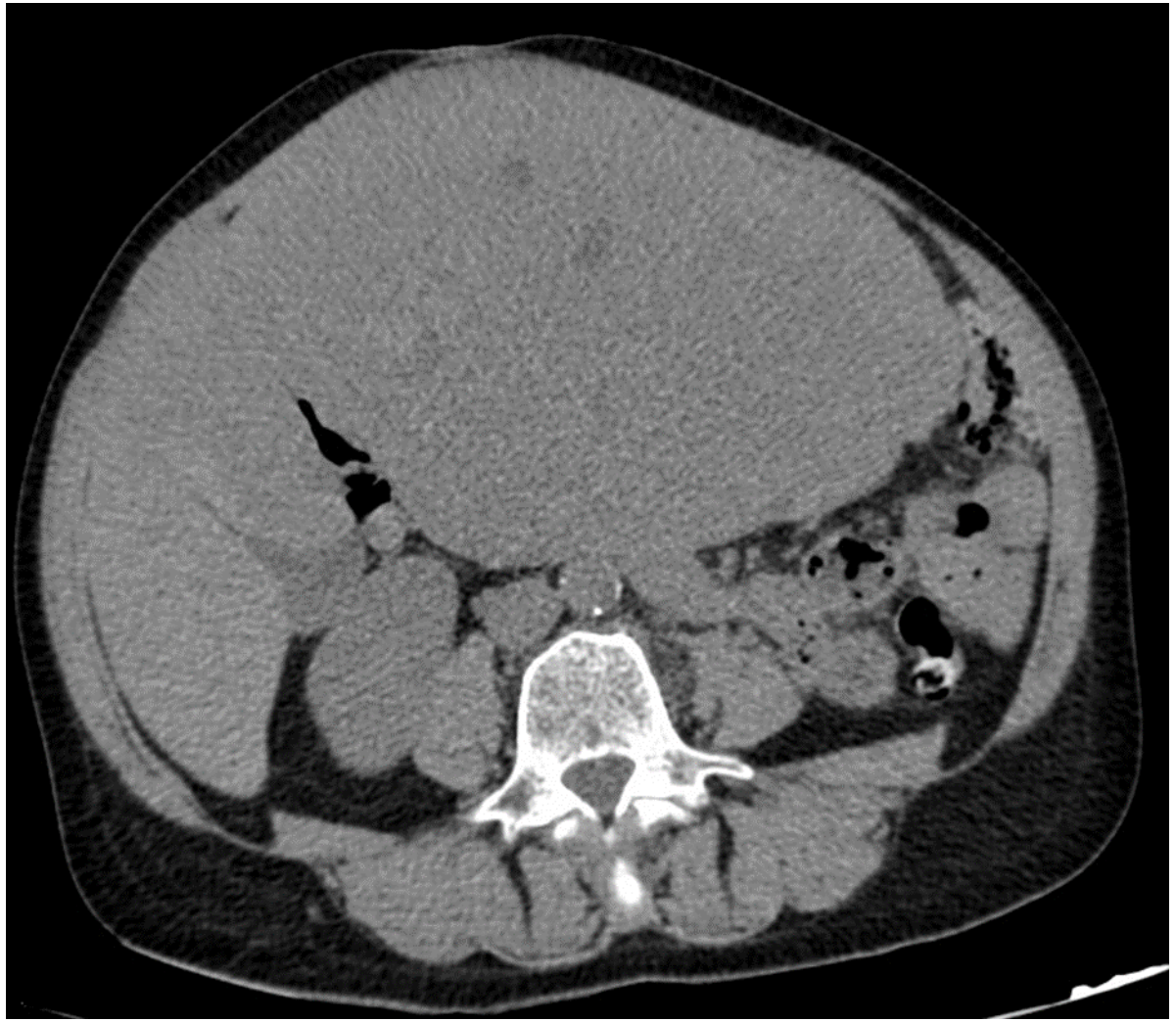
UNENHANCED SCAN



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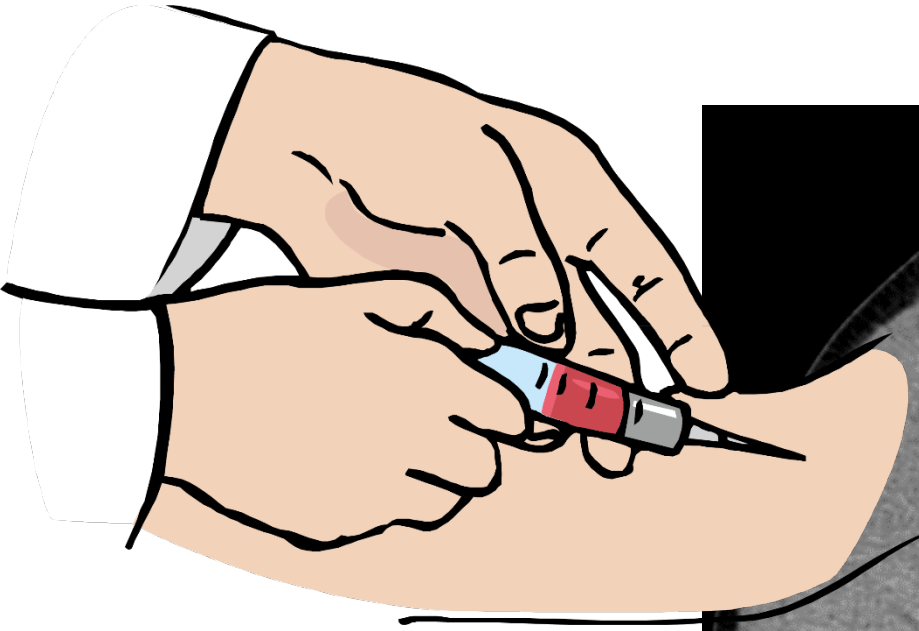

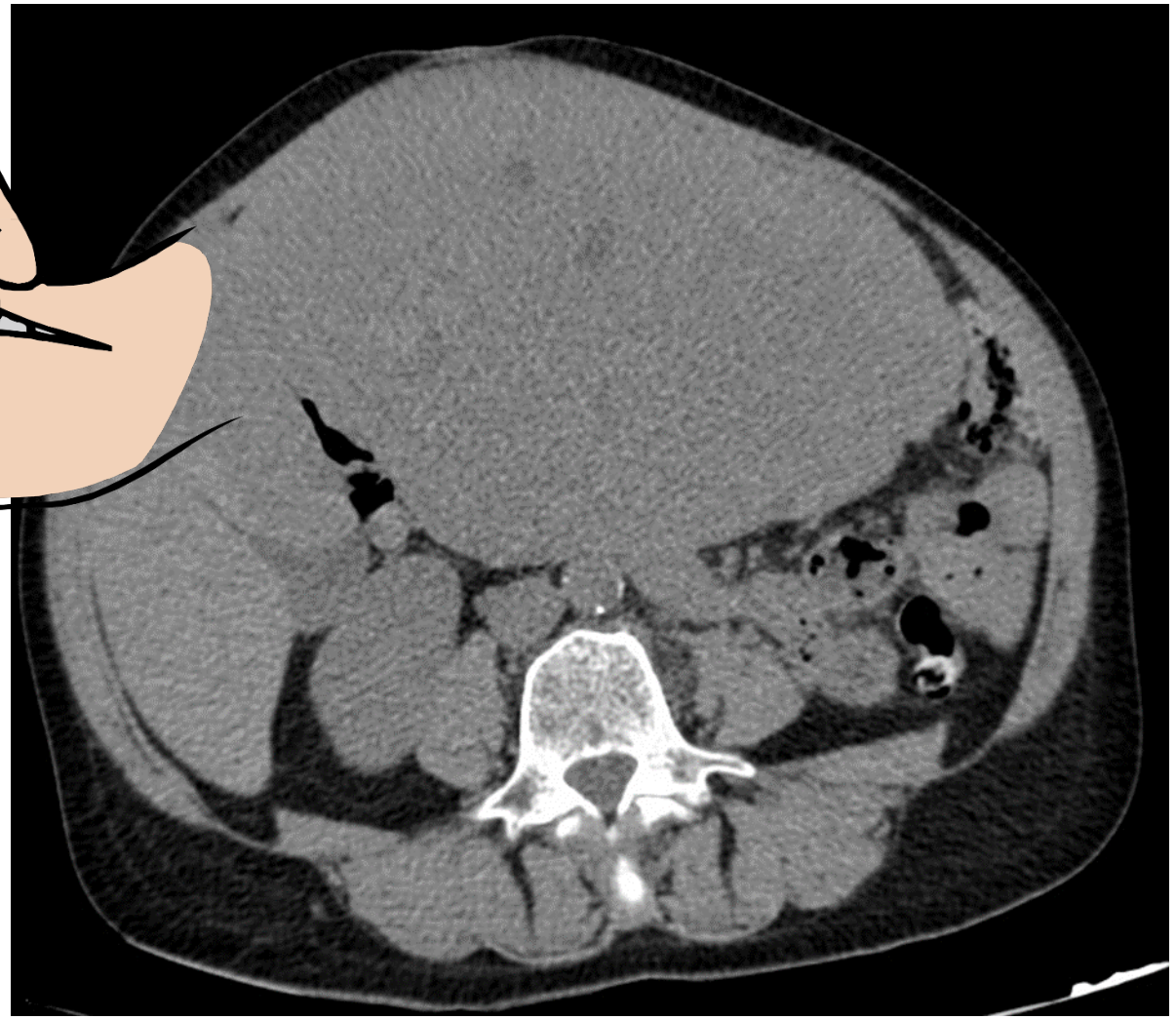

The ideal liver CT protocol

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UNENHANCED SCAN

The ideal liver CT protocol

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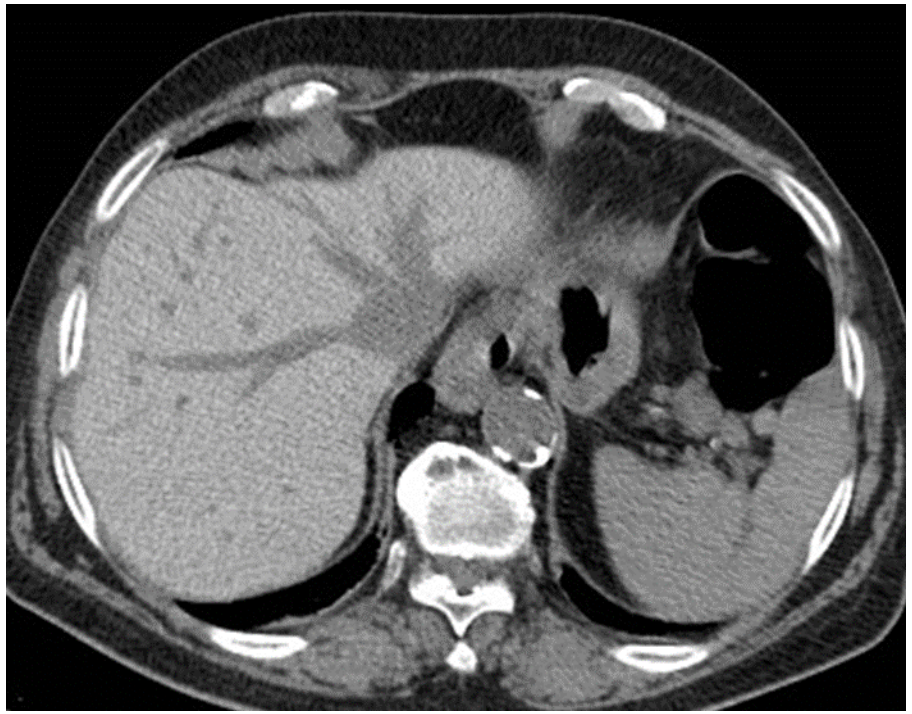
UNENHANCED SCAN

- ✓ Diffuse diseases of liver parenchyma evaluation: drug toxicity, steatosis, hemochromatosis, glycogenosis, Wilson…



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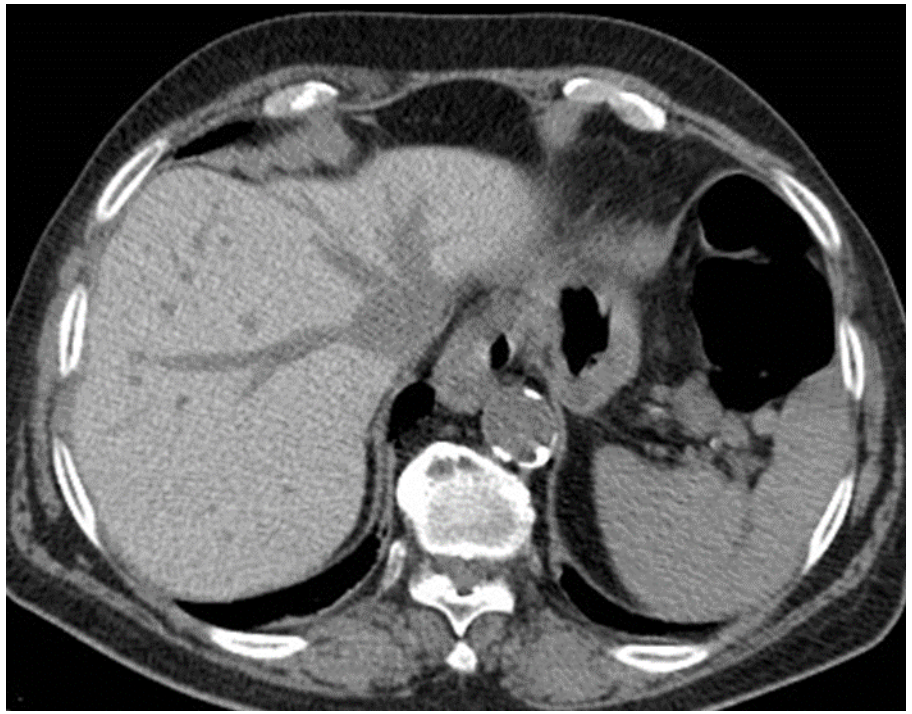

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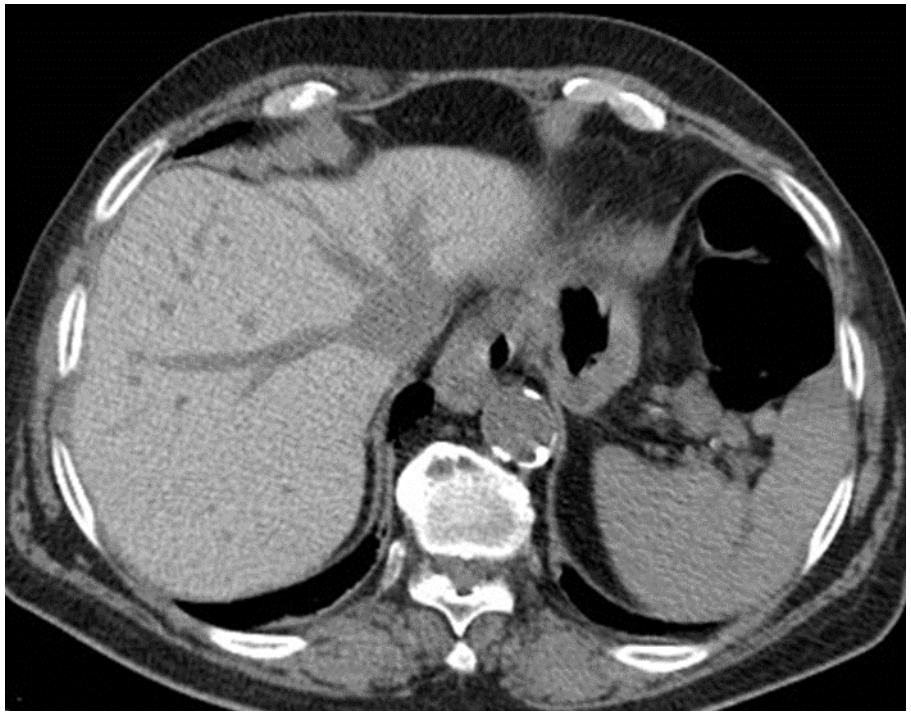

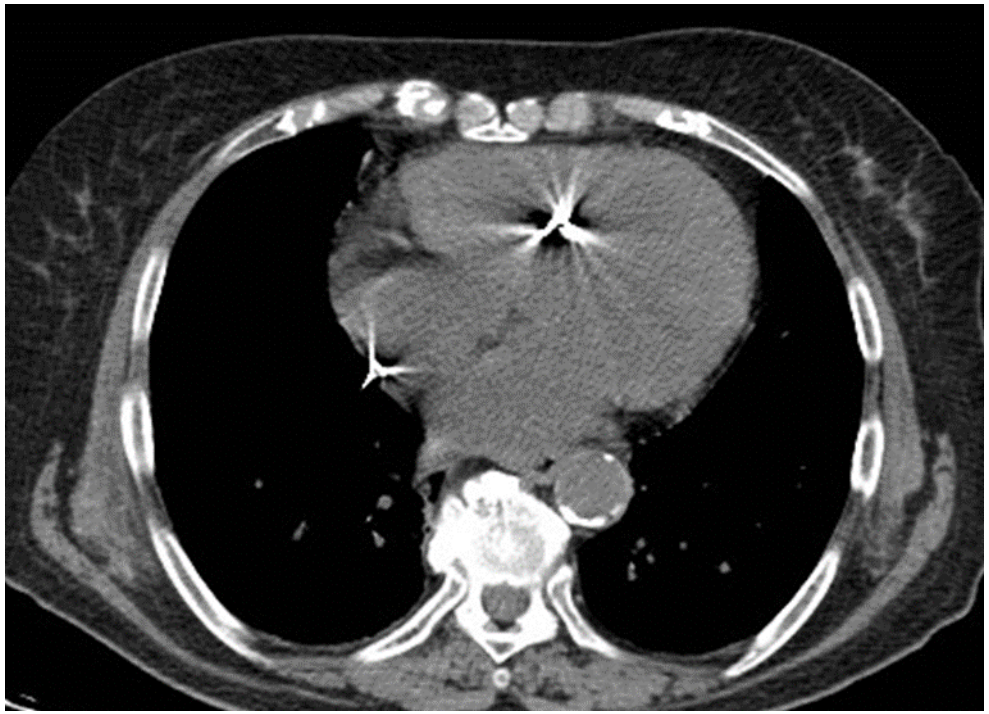

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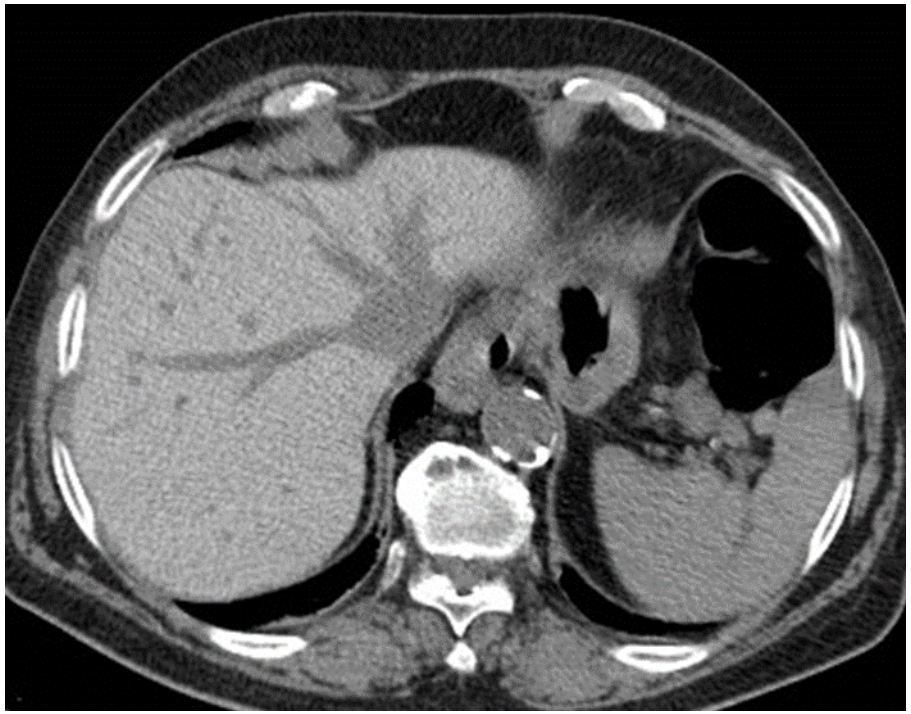
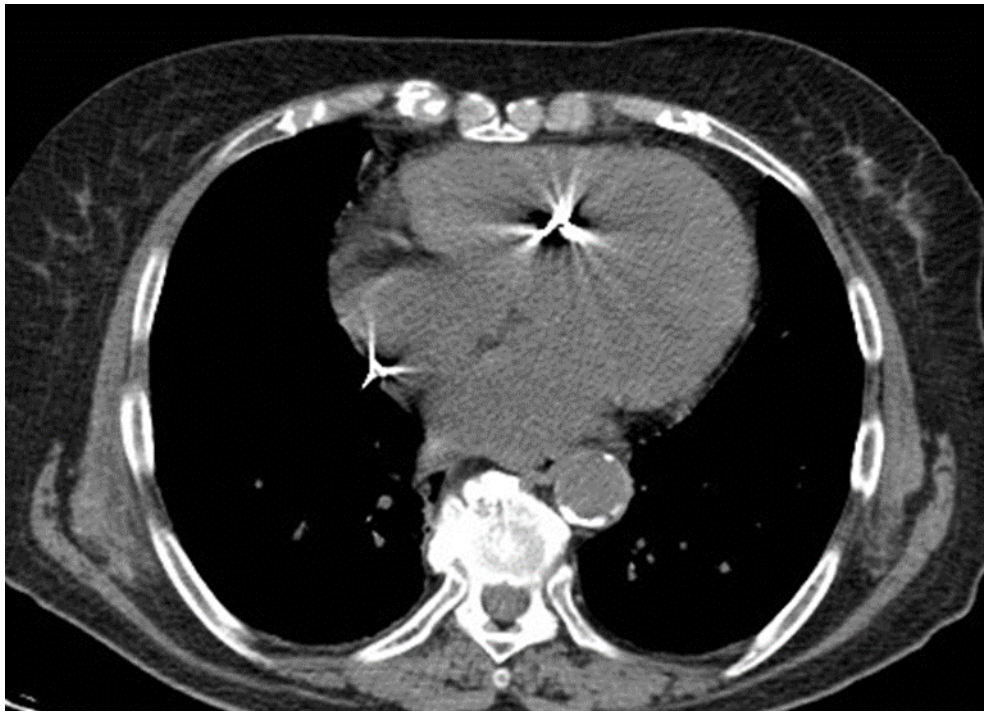
UNENHANCED SCAN

- ✓ Diffuse diseases of liver parenchyma evaluation: drug toxicity, steatosis, hemochromatosis, glycogenosis, Wilson…

✓ AMYODARONE TOXICITY DIAGNOSIS





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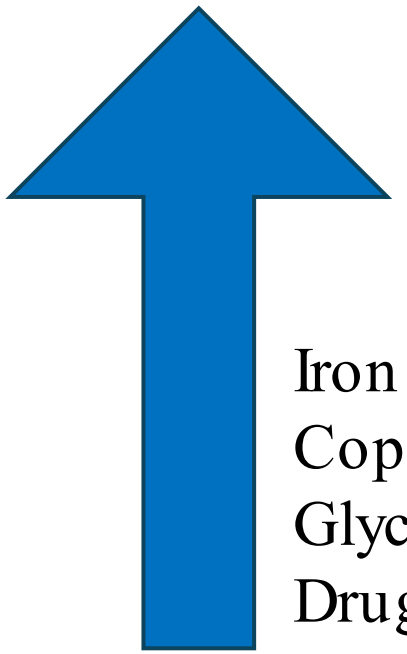

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Iron
Copper
Glycogen
Drugs (e.g., amiodarone, colloid gold)

WHEN THE LIVER GOES
HIGH

Think: substance deposition

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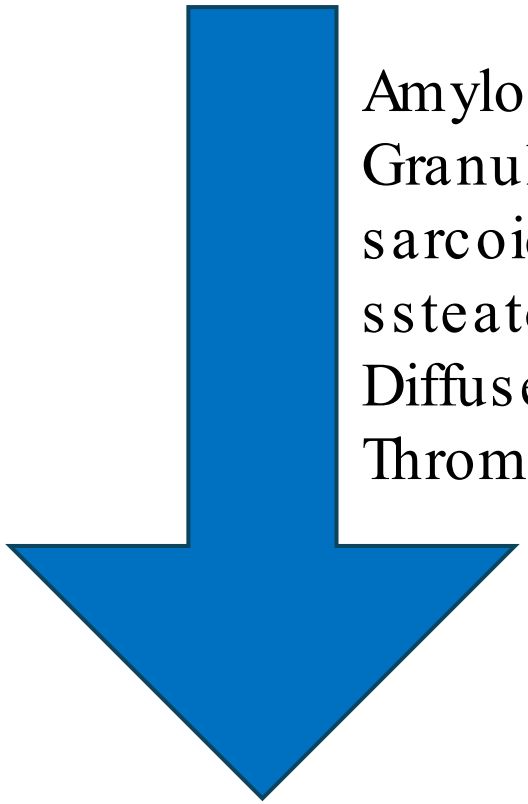

Amyloid deposition
Granulomas (tuberculosis, sarcoidosis)
ssteatosis
Diffuse malignant infiltration
Thrombosis and infarction

< 55

WHEN THE LIVER GOES LOW

Think: "bad" systemic diseases or "bad" diet

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UNENHANCED SCAN

- ✓ Diffuse diseases of liver parenchyma evaluation: steatosis, hemochromatosis, glycogenosis, Wilson…
- ✓ Post-locoregional treatment initial assessment

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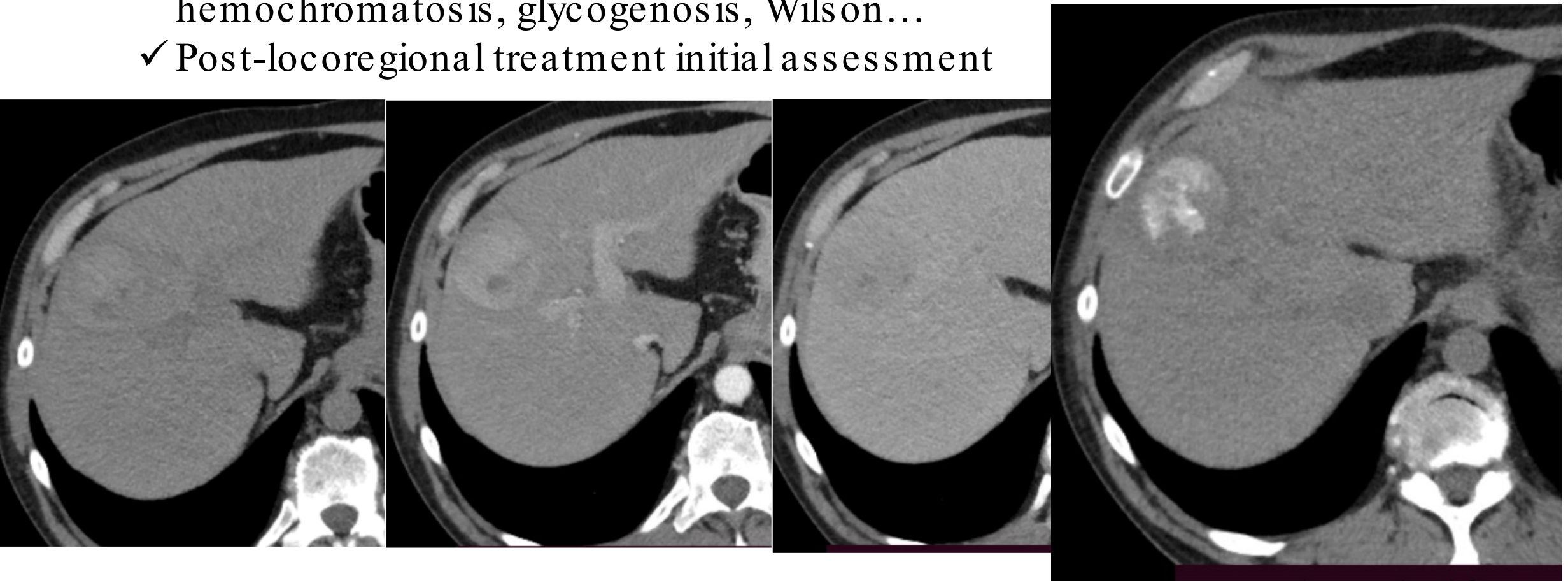

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UNENHANCED SCAN

- ✓ Diffuse diseases of liver parenchyma evaluation: steatosis, hemochromatosis, glycogenosis, Wilson…
- ✓ Post-locoregional treatment initial assessment
- ✓ Identifications of calcifications

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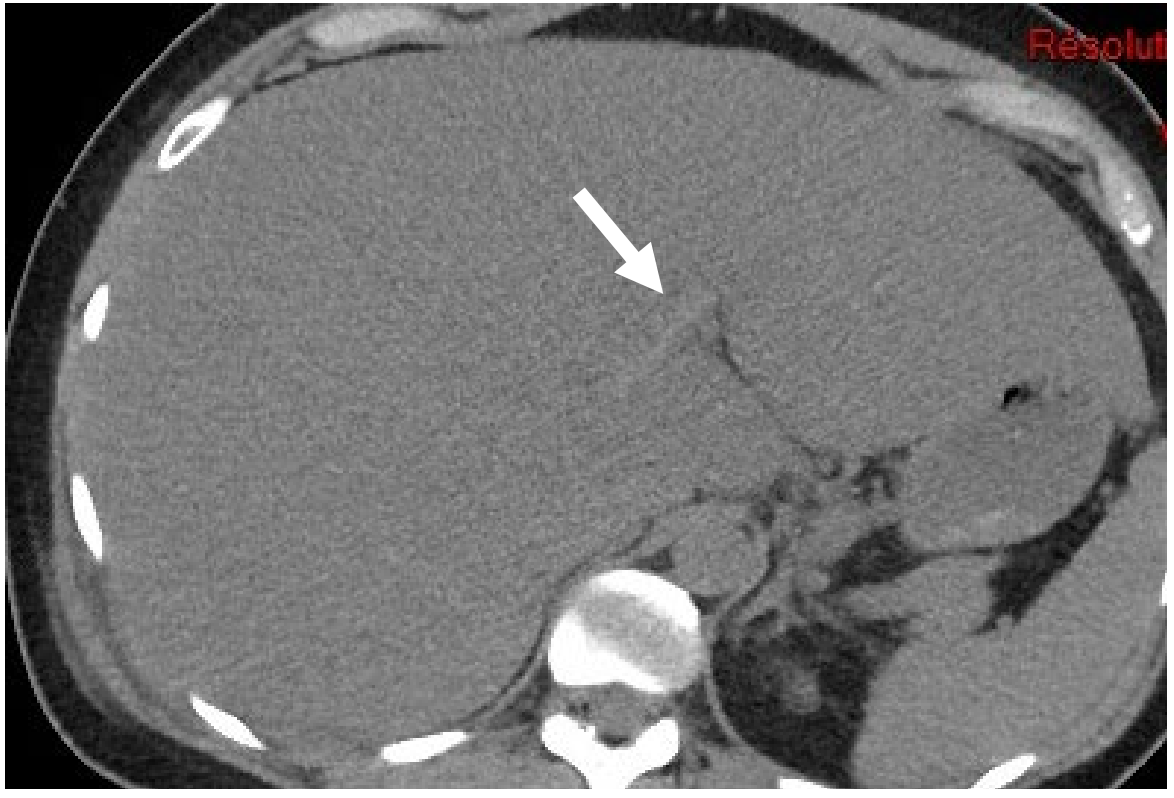
UNENHANCED SCAN

- ✓ Diffuse diseases of liver parenchyma evaluation: steatosis, hemochromatosis, glycogenosis, Wilson…
- ✓ Post-locoregional treatment initial assessment
- ✓ Identifications of calcifications
- ✓ Blood, hemorrhage
- ✓ Fresh thrombi



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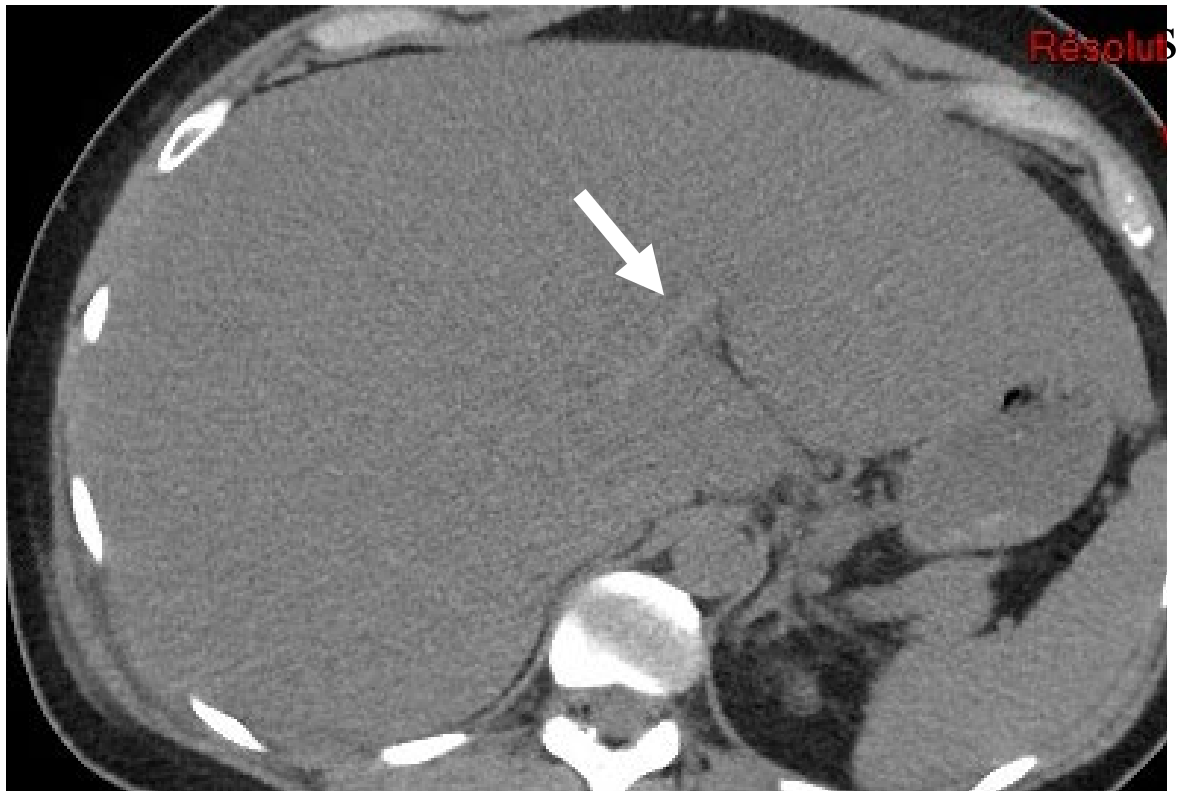

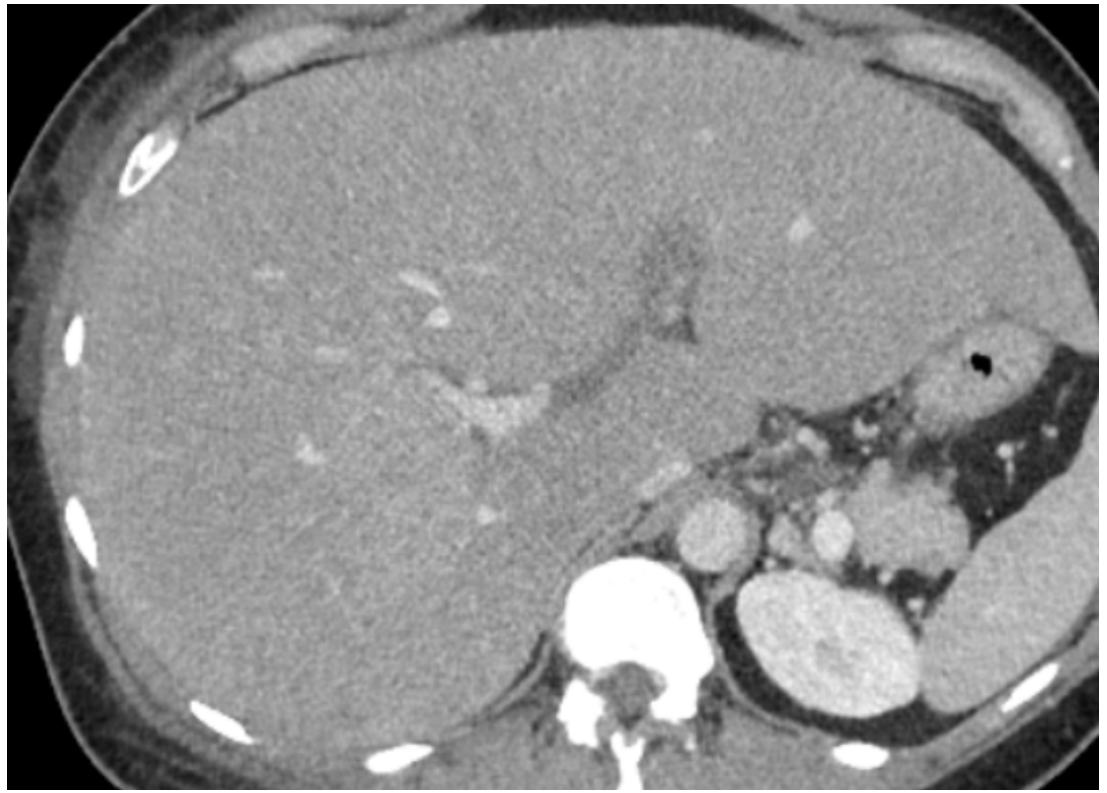

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UNENHANCED SCAN

- ✓ Diffuse diseases of liver parenchyma evaluation: steatosis, hemochromatosis, glycogenosis, Wilson…
- ✓ Post-locoregional treatment initial assessment
- ✓ Identifications of calcifications
- ✓ Blood, hemorrhage
- ✓ Fresh thrombi
- ✓ (rare) hyperdense metastases
- ✓ Cystic lesions, initial biliary tree assessment

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WHICH SEQUENCES ARE BEST THEN?

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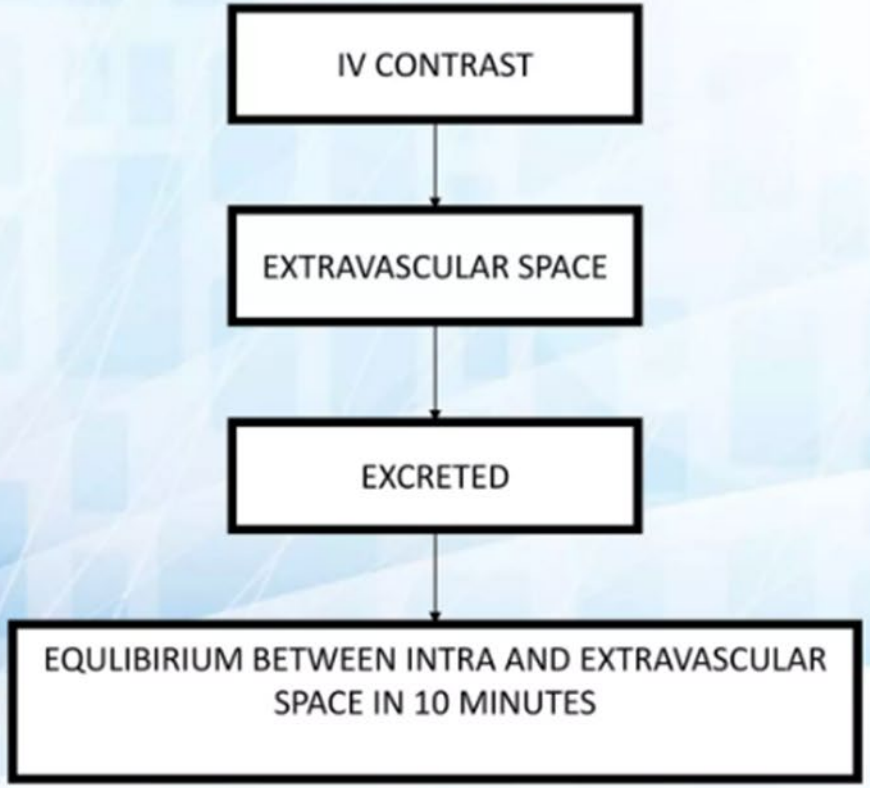
PHYSIOLOGY

- Concentration and excretion
  1) >90%: passive glomerular filtration.
  2) 1%: liver and intestine.
- Half life: 30-60 minutes.
- Do not enter the interior of cells.

- Rapidly excreted, over 90% being eliminated by glomerular filteration by kidneys within 12 hrs.
- Leaves the body within 24 hours(if normal kidney) and weeks(if diseased kidney).



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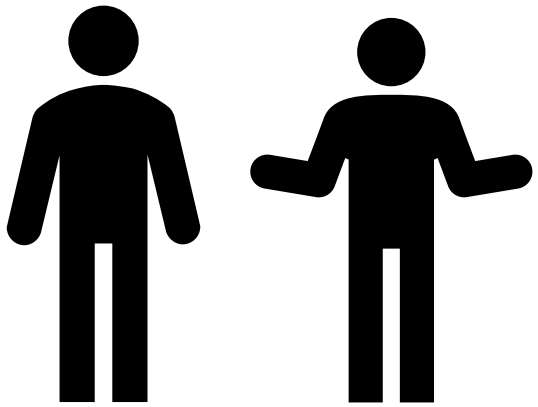

PATIENT POSITION:

- supine with arms above the head

SCOUT:

- diaphragm to iliac crests

- **scan extent**:diaphragm to iliac crests
- **scan direction:** craniocaudal

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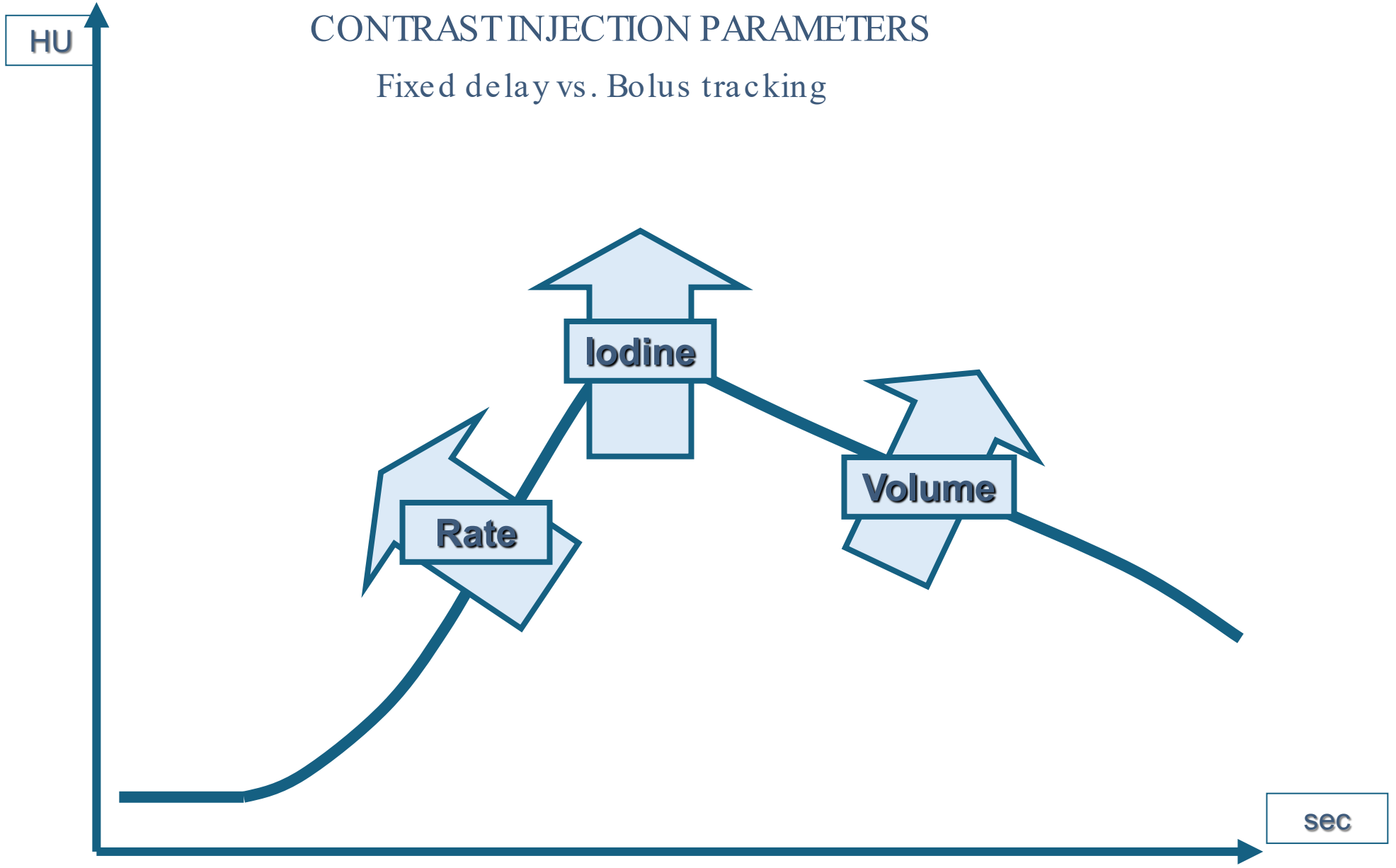

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"Adequate hepatic enhancement is defined as an increase in hepatic density measured during the hepatic parenchymal phase (PVP) > 50 HU from the unenhanced baseline density"

Brink et al. Radiology, 1995 – Awai K et al. Radiology, 2004

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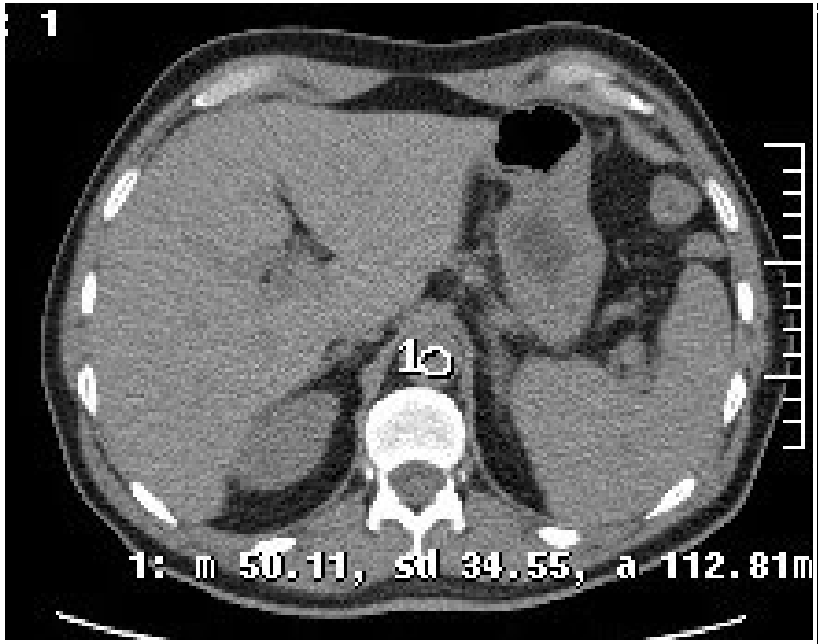
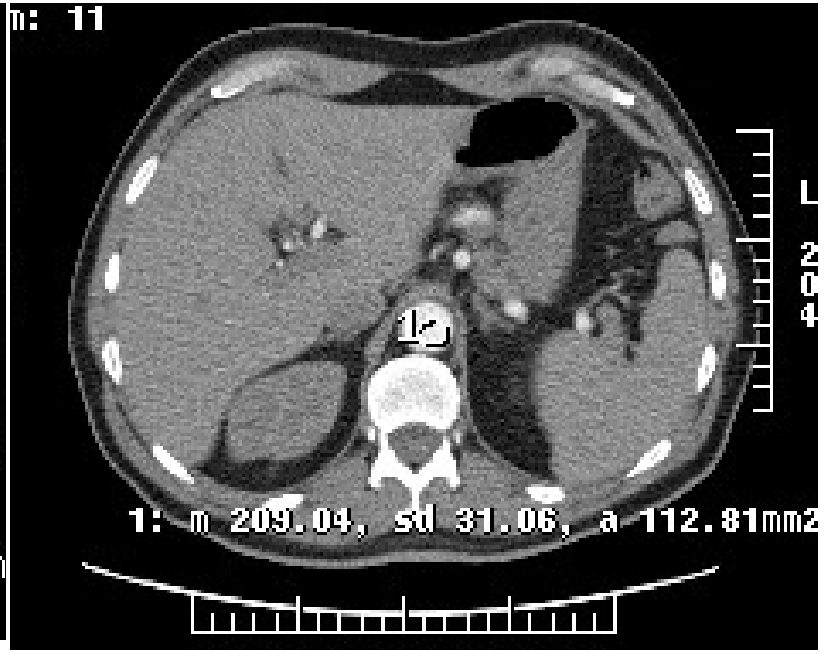
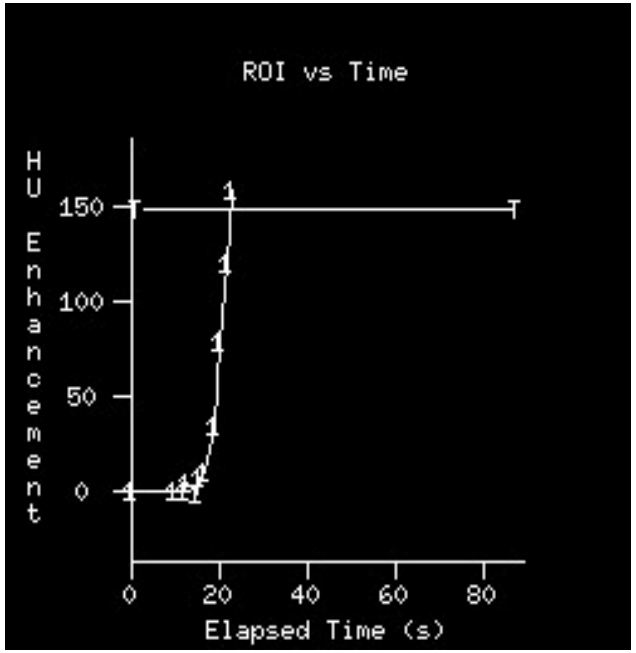
CONTRAST INJECTION PARAMETERS

Fixed delay vs. Bolus tracking

- ✓ Standardization of acquisition
- ✓ With fixed delay, the correct enhancement of the liver (50 HU) might not be reached
- ✓ Automatically initiates diagnostic scans triggered by the contrast enhancement itself.







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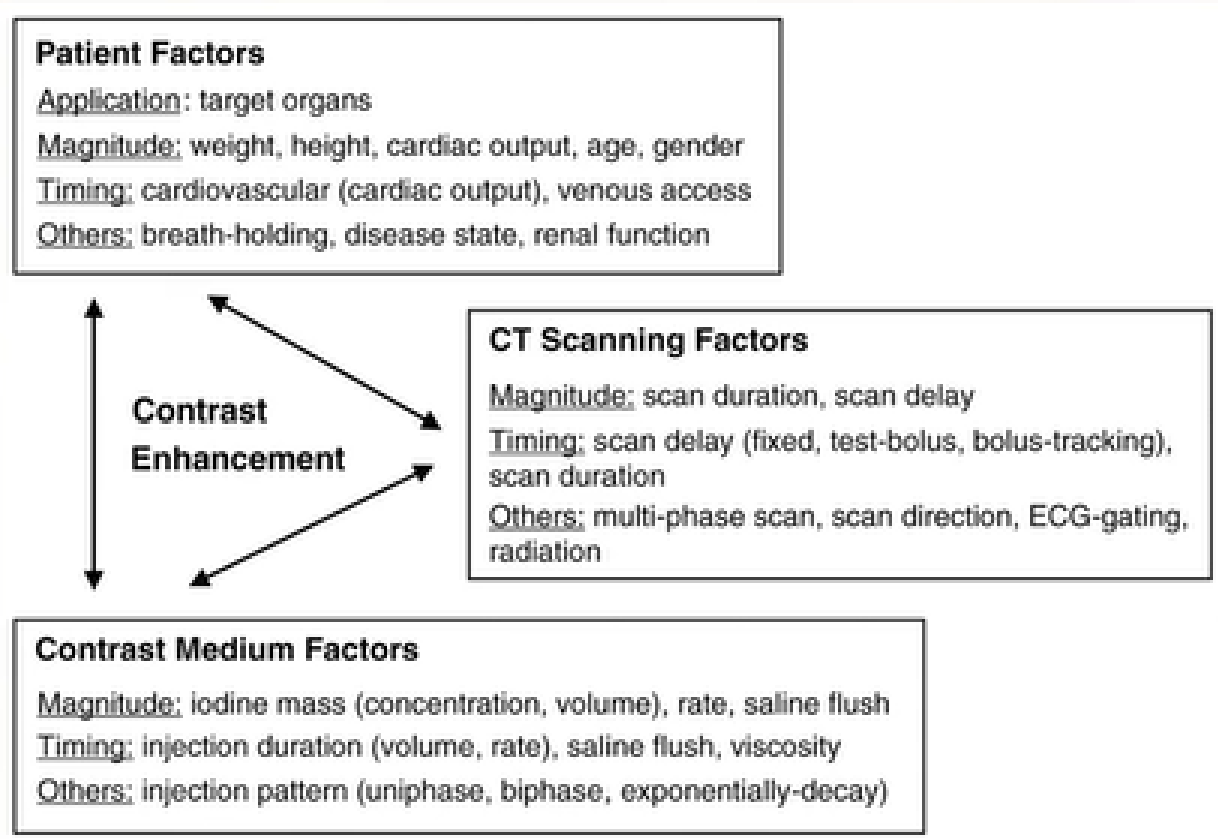
CONTRAST INJECTION PARAMETERS

Fixed delay vs. Bolus tracking

- ✓ Individualization of acquisition



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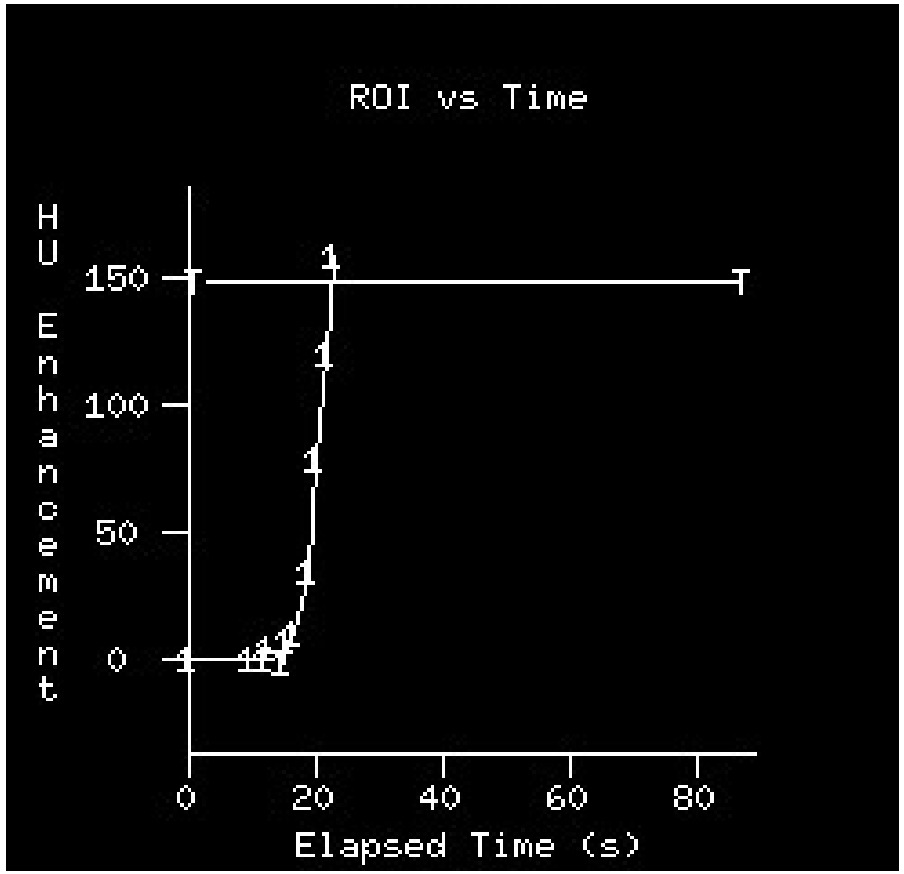
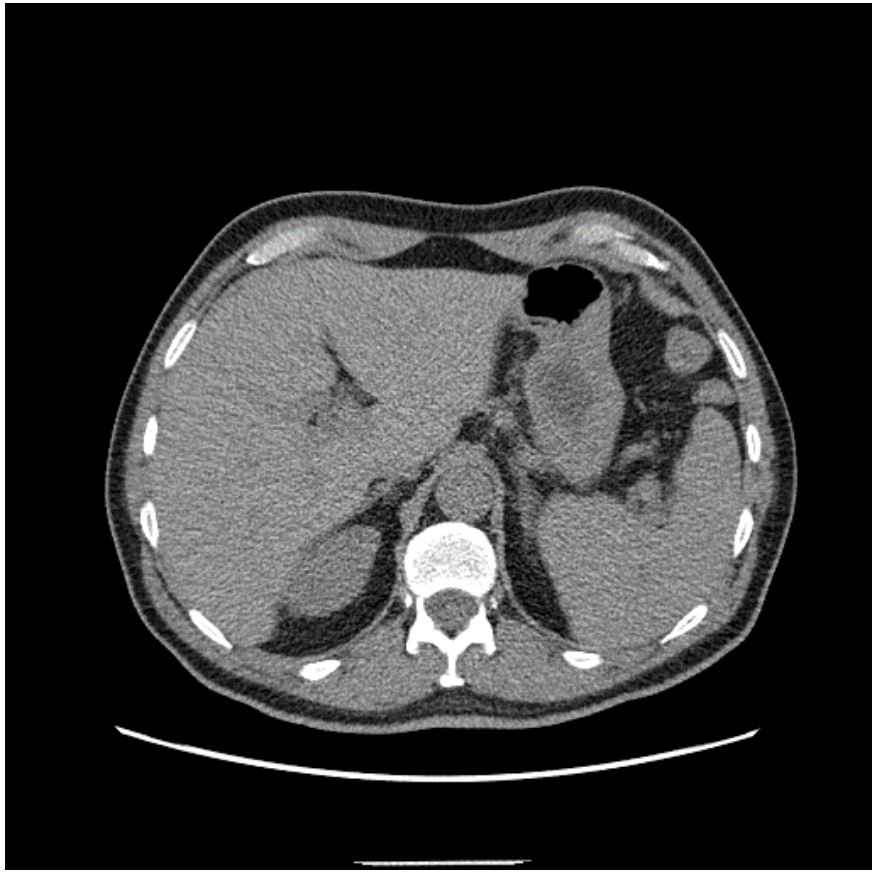
CONTRAST INJECTION PARAMETERS

Fixed delay vs. Bolus tracking





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- **Bolus tracking:**
  - monitoring slice (region of interest)
    - level of the diaphragmatic hiatus or first lumbar vertebra at the aorta
- **Threshold:150 HU**
- **Volume**
  - 100-120 mL; 3 to 5 mL/s (higher flow rate = higher enhancement)

INSPIRATION
BREATH HOLD

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SCAN DELAY AND PHASES

LATE ARTERIAL PHASE

- Bolus: 15-30 s
- Fixed Delay:35-45 s
  s

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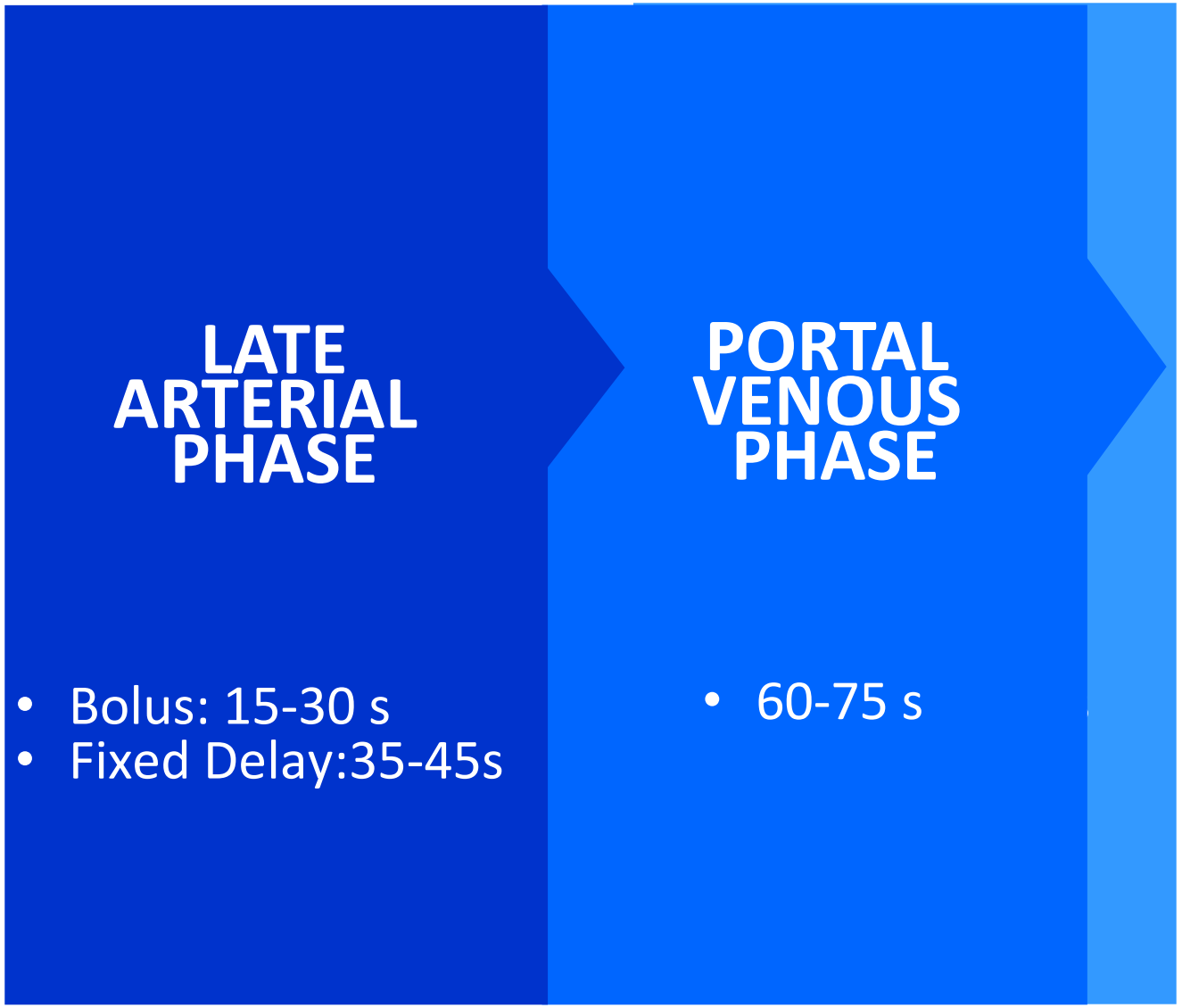
SCAN DELAY AND PHASES



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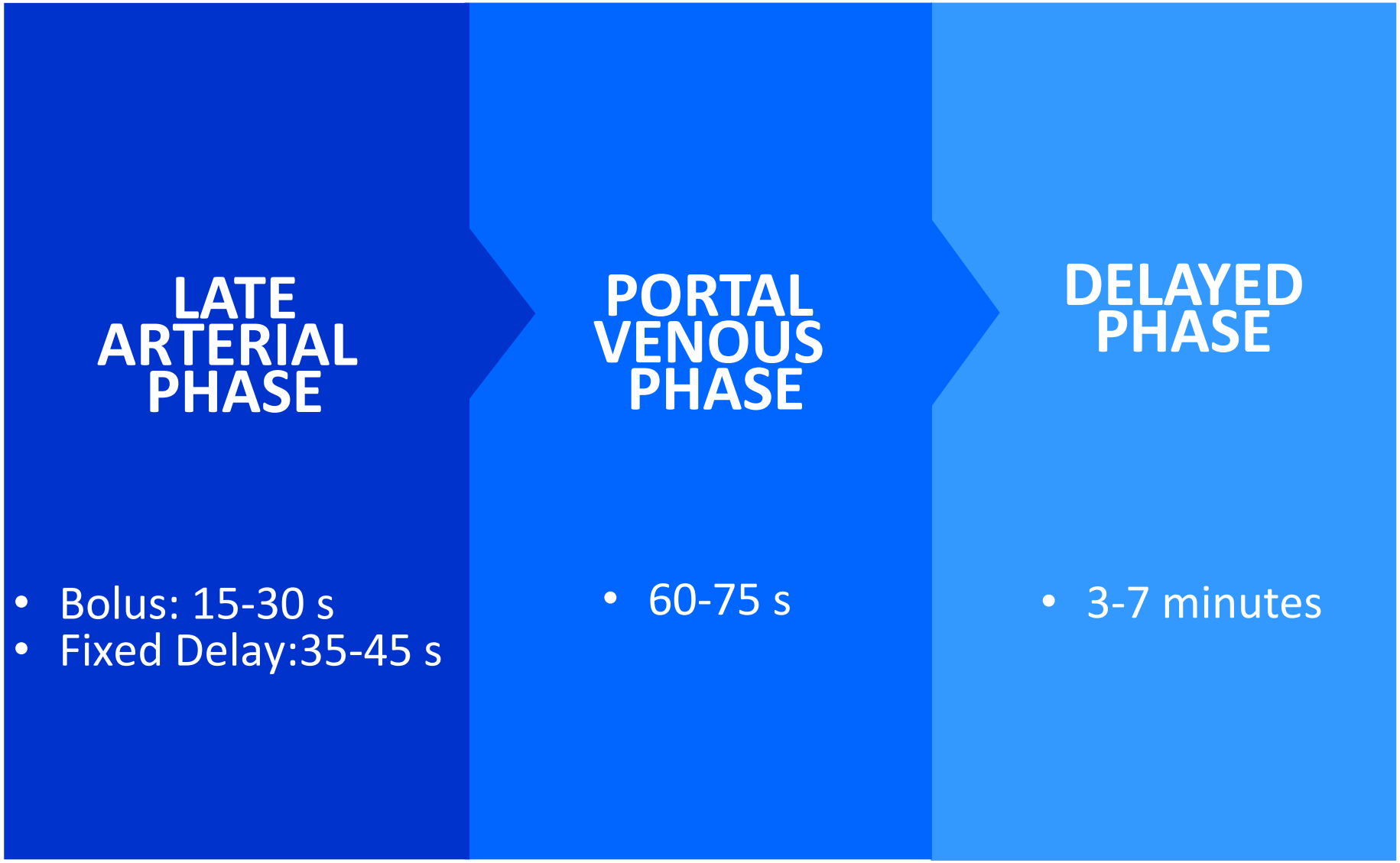
SCAN DELAY AND PHASES



Early vs. Late Arterial Phase

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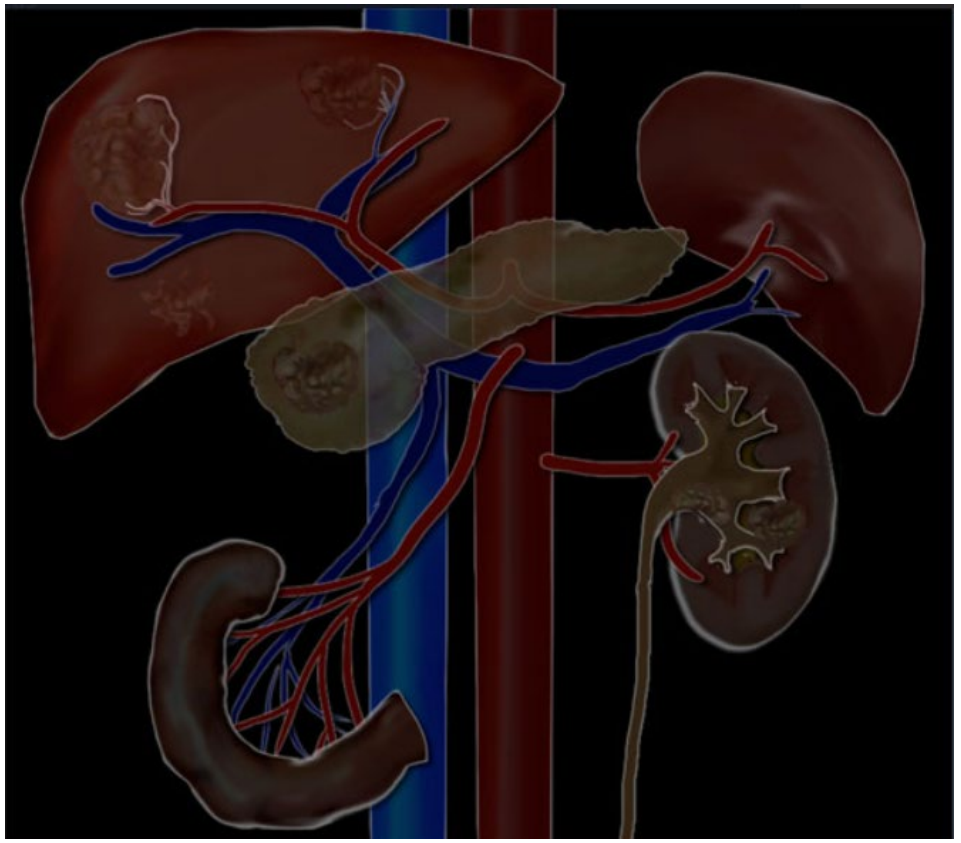

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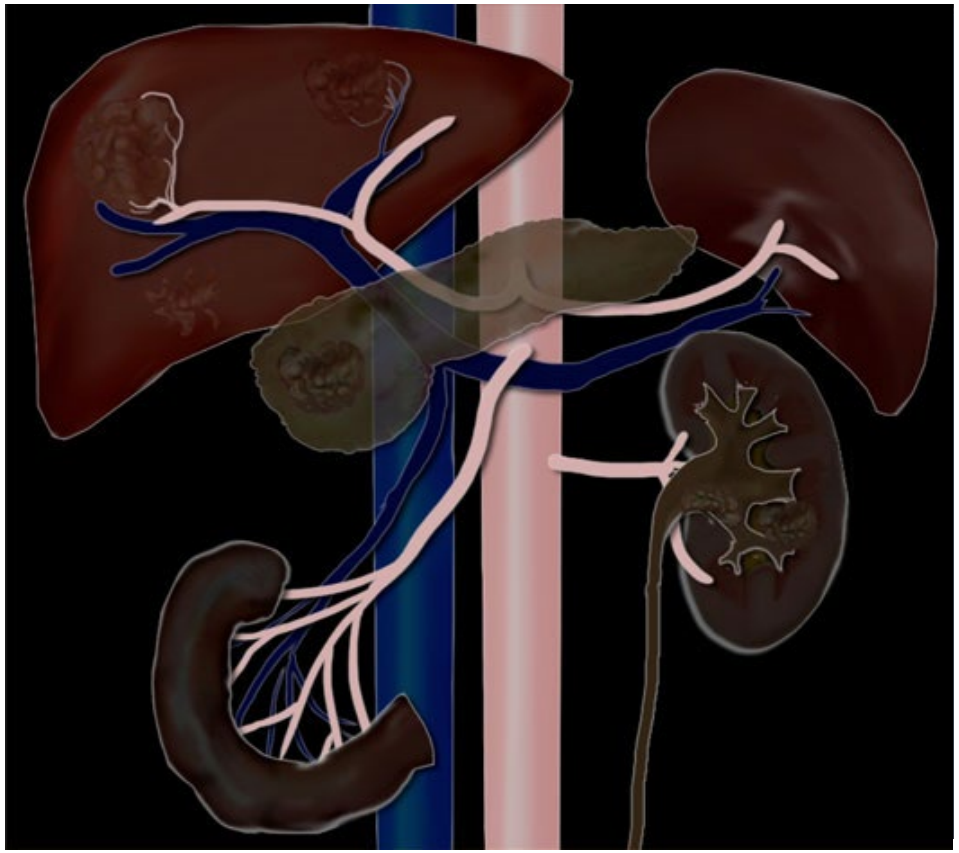

- ✓ 15-20 s post-injection or immediately after bolus tracking
- ✓ Bleeding
- ✓ Dissection
- ✓ Arterial thrombosis and stenosis (esp. liver transplant)
- ✓ Hepatic artery aneurisms
- ✓ Rare: hypervascular liver masses (hemangiomas, FNH)

Early vs. Late Arterial Phase

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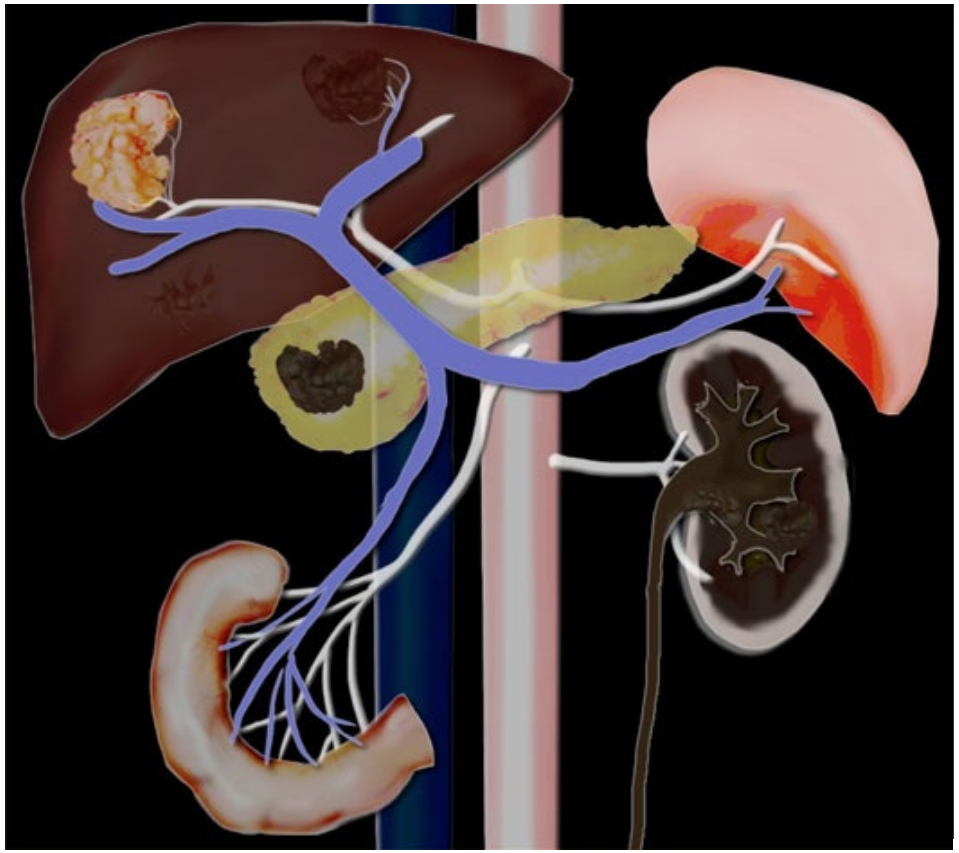

- ✓ Ideal for liver evaluation (75% of vascularization is from portal vein!)
- ✓ 35 - 45 s post-injection or 15 – 30 s after bolus tracking
- ✓ Hypervascular masses (HCC, HCA, hemangiomas, FNH, hypervascular metastases…)
- ✓ Shunt, perfusion anomalies
- ✓ Liver vascular injuries in trauma

Early vs. Late Arterial Phase

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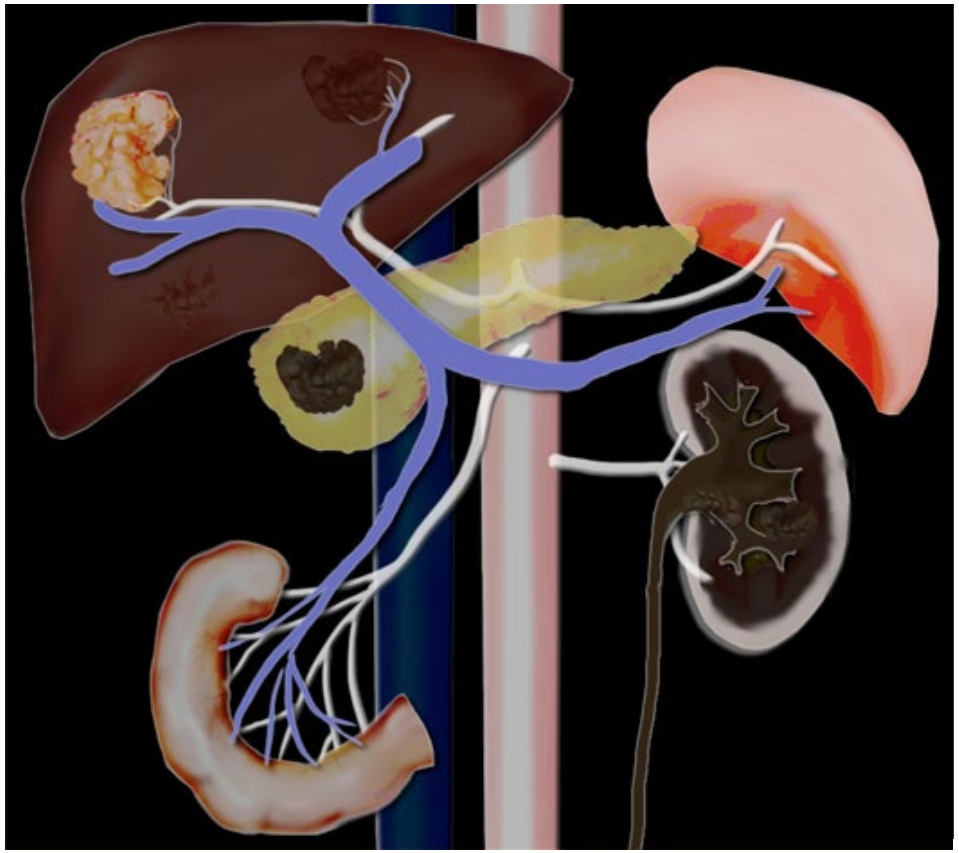

- Some contrast media is seen in the PV
- NO contrast in the hepatic veins or ICV
- Heterogeneous (“zebra”) enhancement of the spleen
- Cortical enhancement of the kidney (corticomedullary phase)

Early vs. Late Arterial Phase

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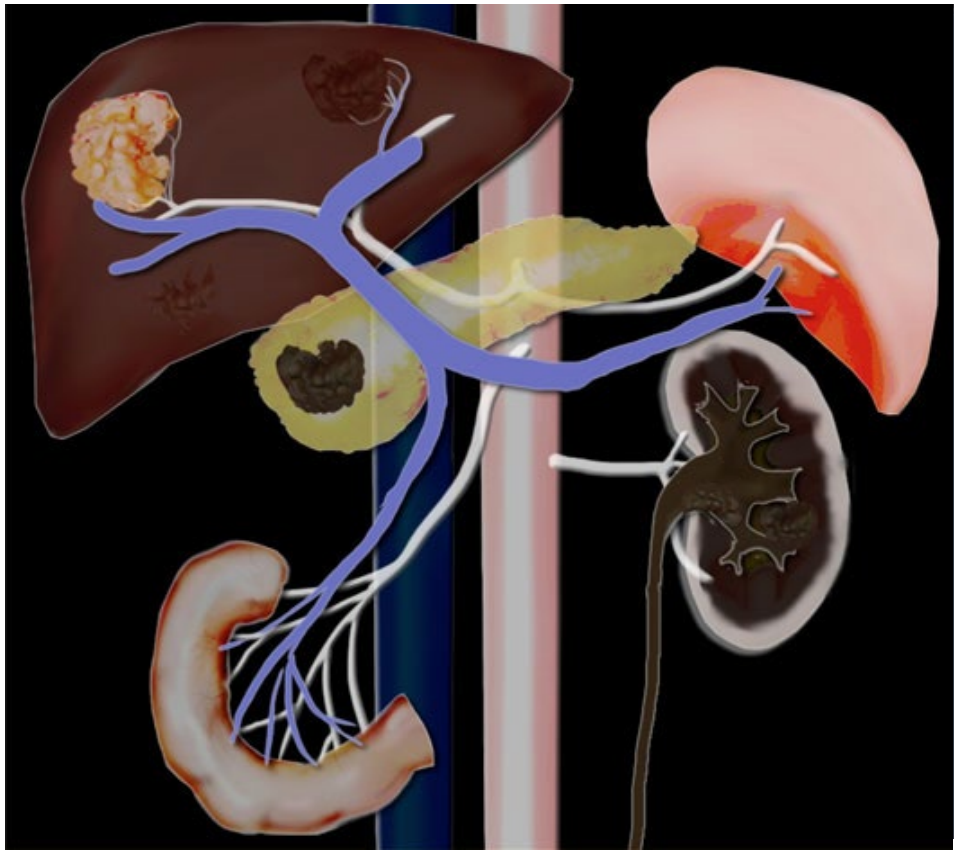

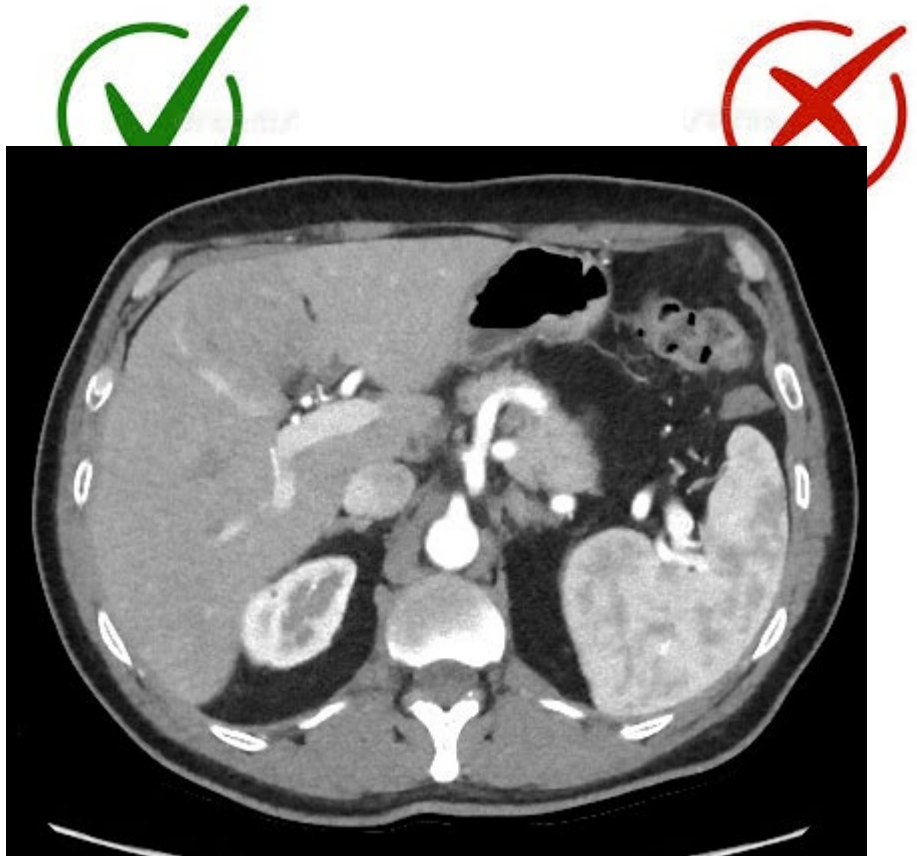

Portal Phase

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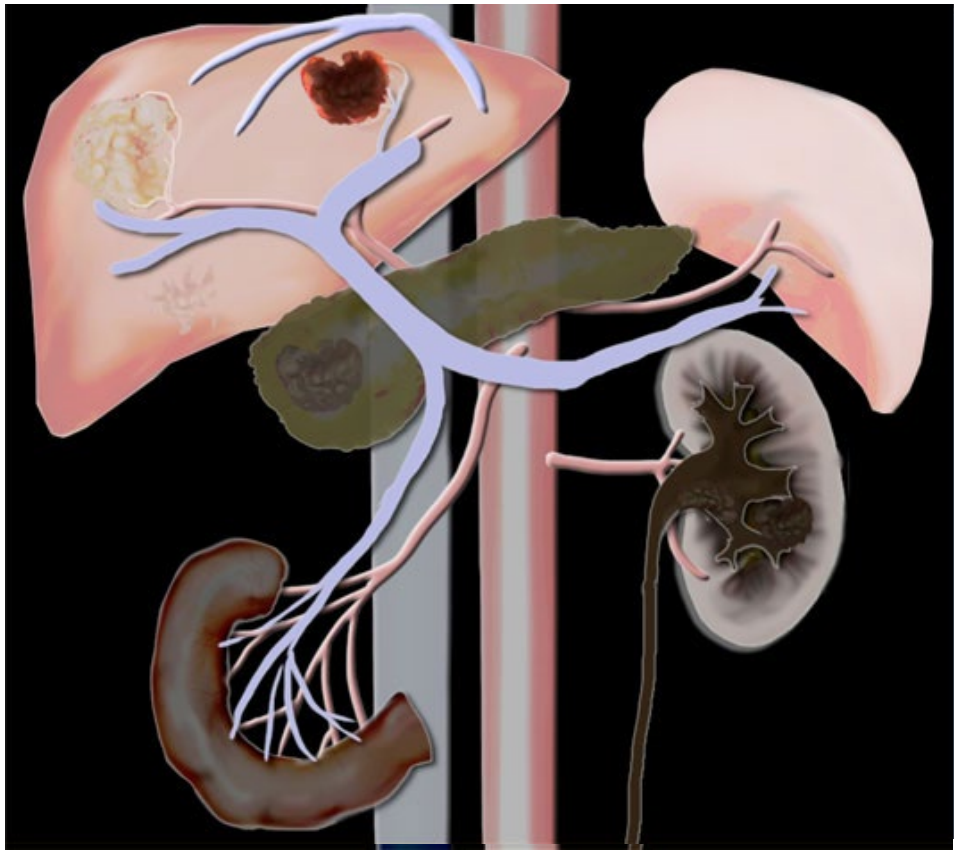
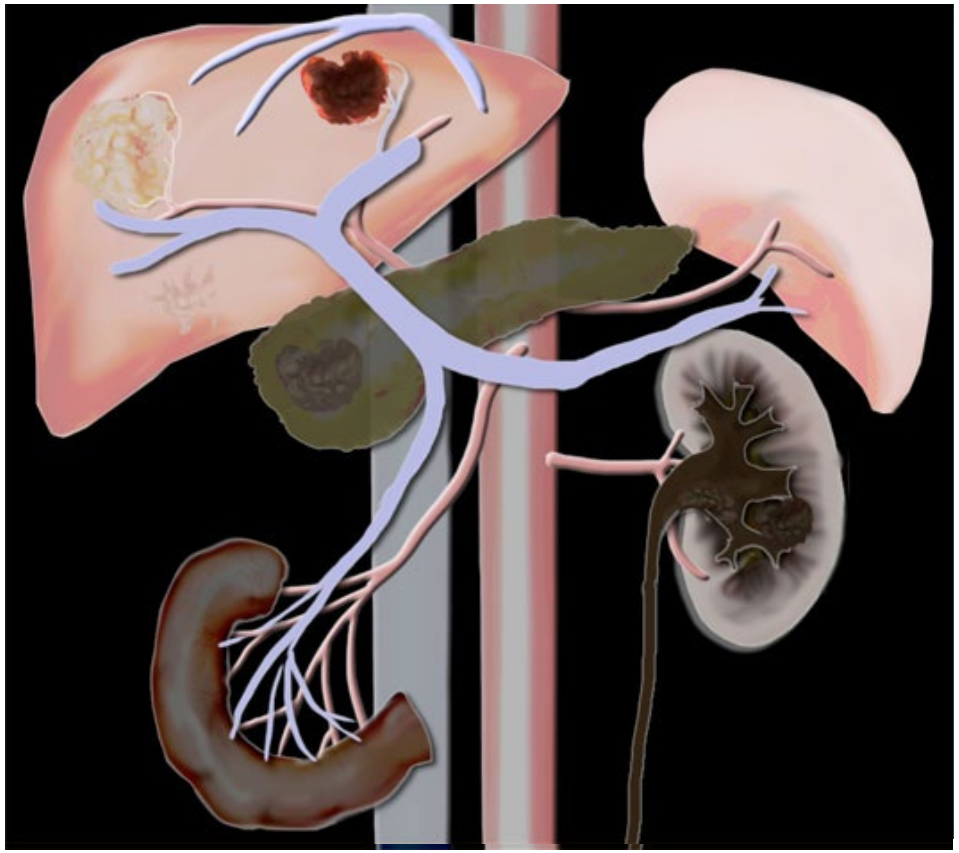


- ✓ 60-75 s post-injection or bolus
- ✓ Liver parenchyma best enhancement
- ✓ Contrast is seen in both portal veins and hepatic veins
- ✓ Best detection of hypovascular liver lesions (metastases, abscess, cyst, HCC washout, etc.)

Portal Phase



- Contrast in the hepatic veins / ICV
- Homogeneous spleen
- Nephrographic phase on the kidneys

Delayed Phase

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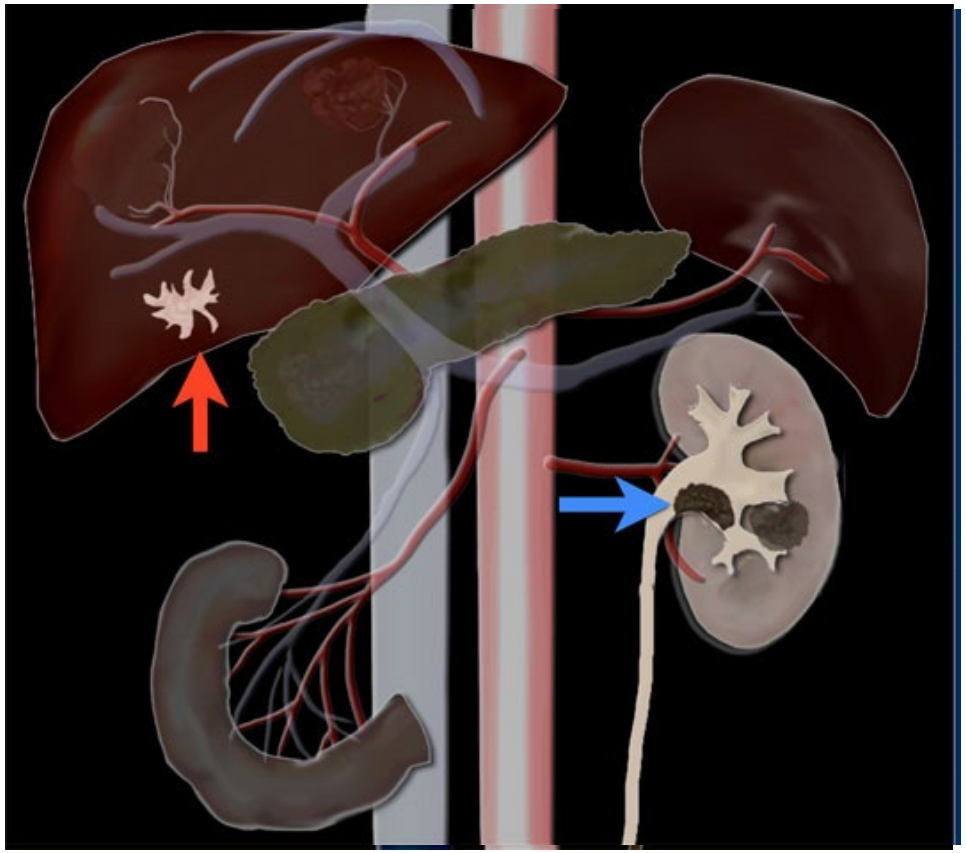

- ✓ 3 – 7’ post-injection or bolus
- ✓ Enhancement of fibrotic lesions
- ✓ HCC washout and capsule
- ✓ Detection of intrahepatic cholangiocarcinoma, fibrotic metastases, fibrotic areas in cirrhosis, hemangiomas, FNH fibrotic scars
- ✓ Assessment of liver vascular injuries in trauma settings
- ✓ Kidney: excretory phase

The ideal liver CT protocol

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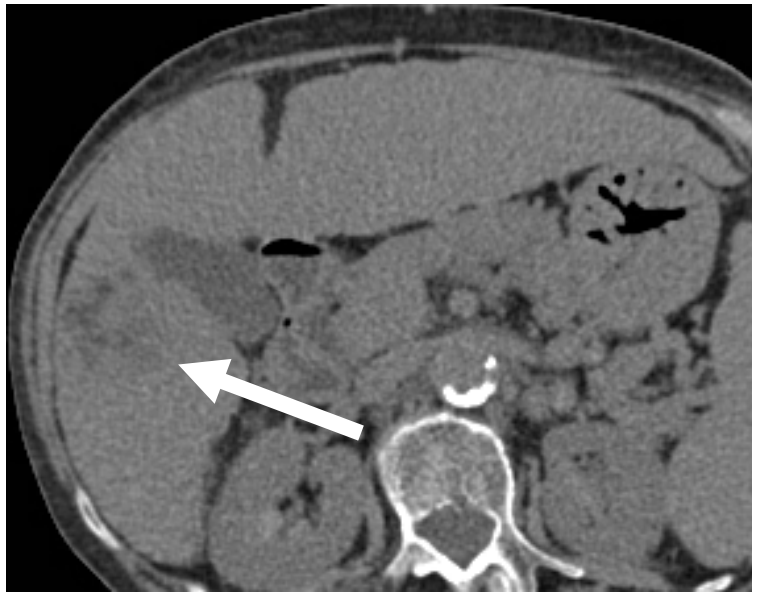

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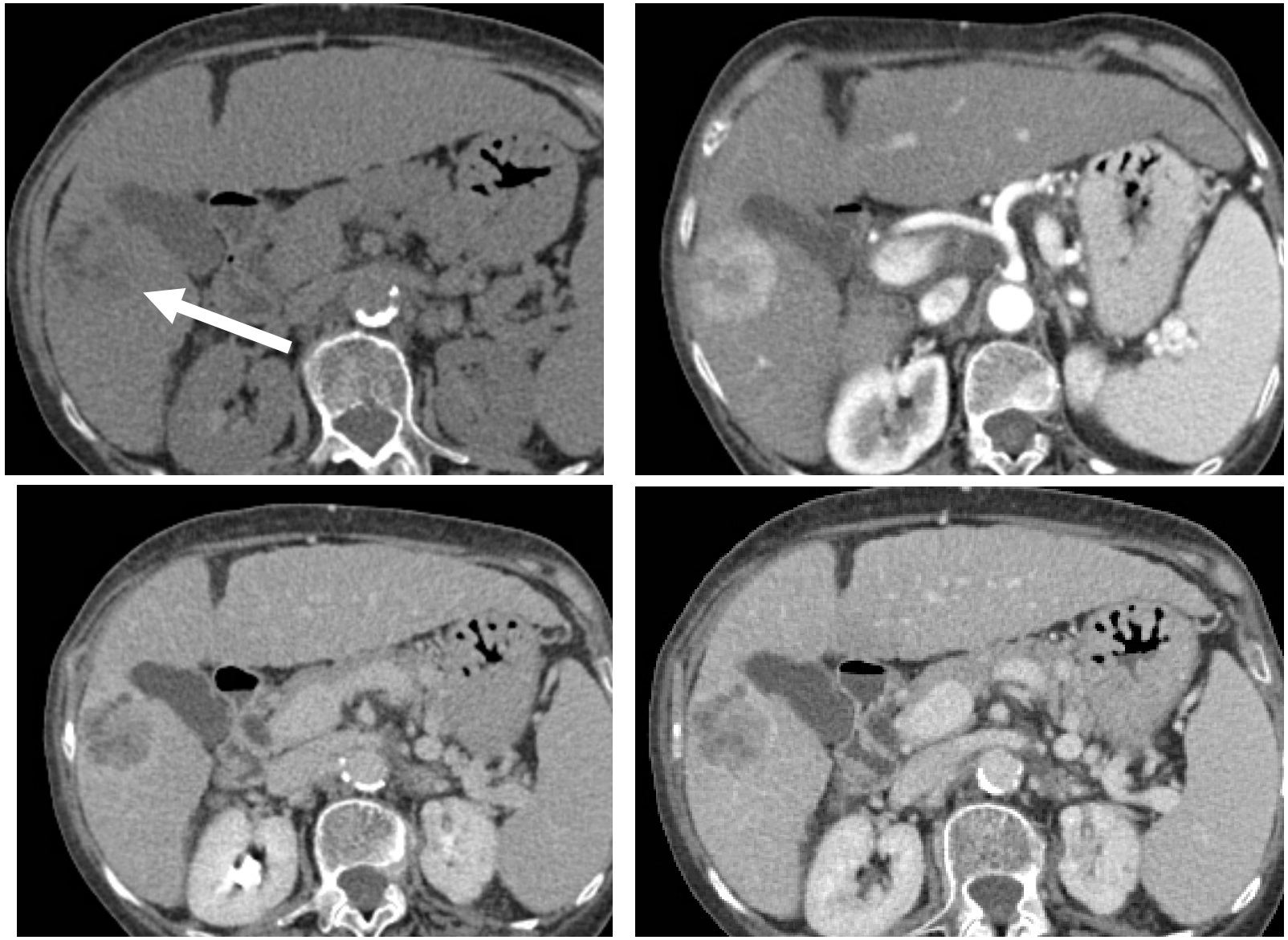

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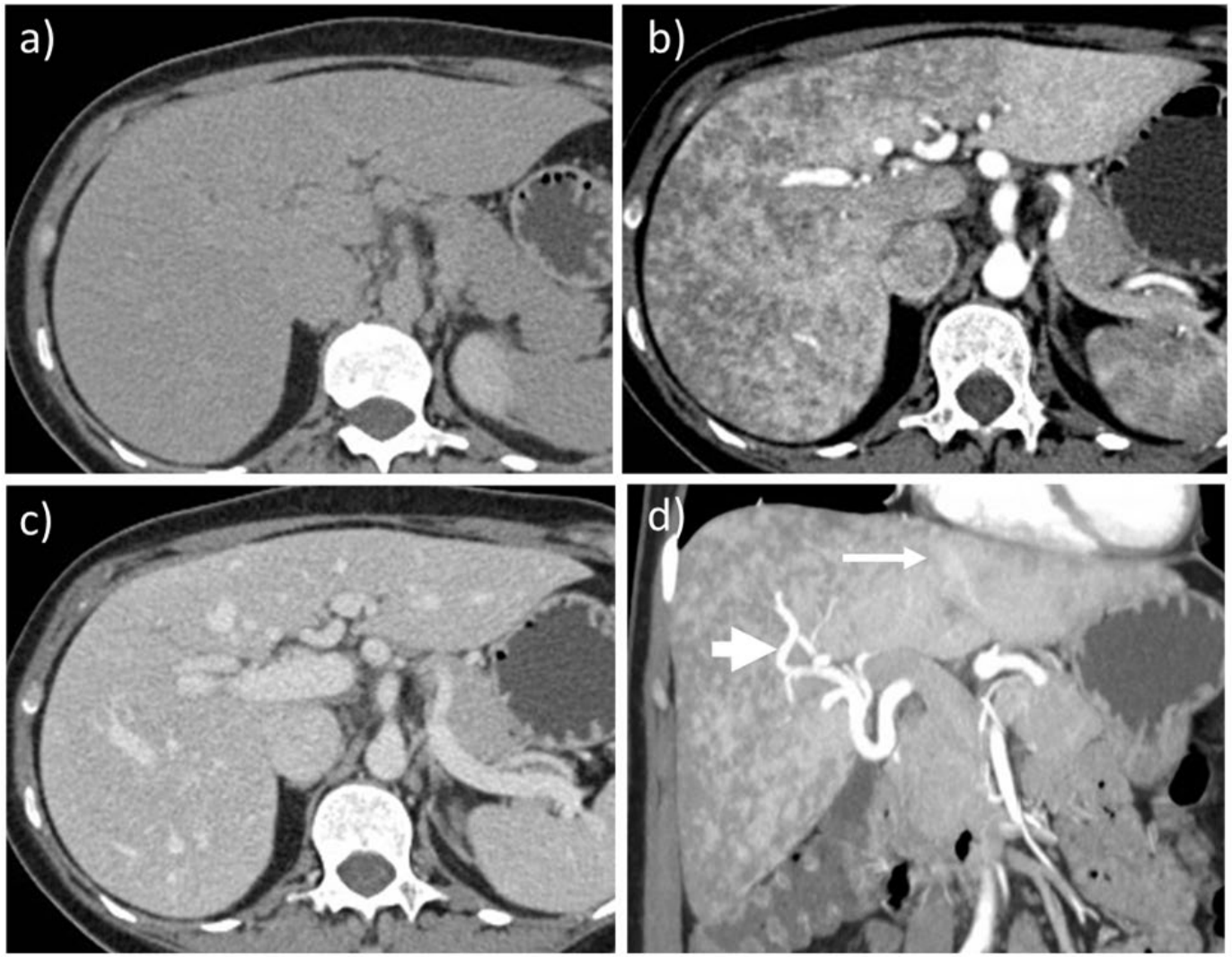
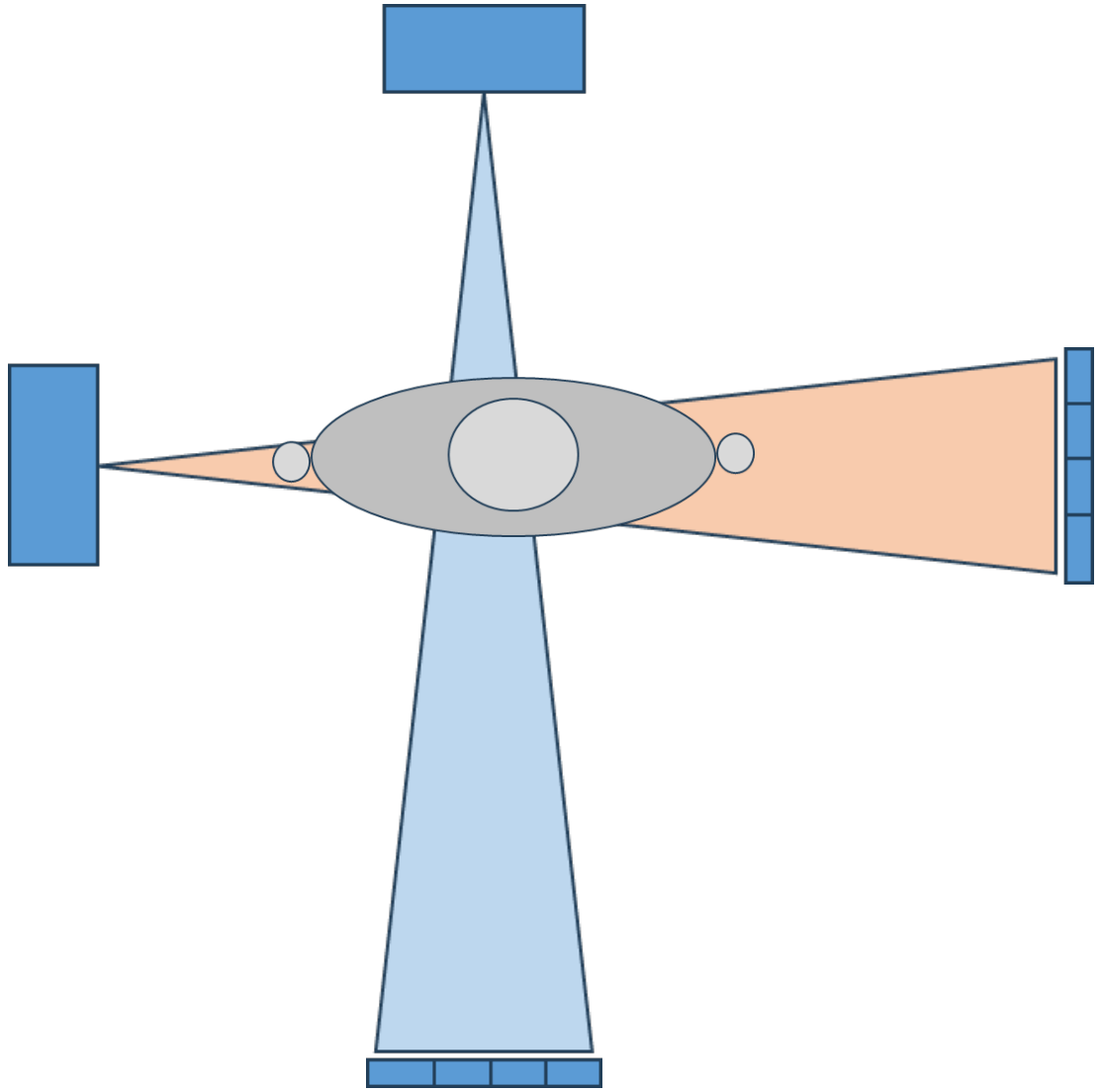


Porrello G. Insights Imaging. 2024 doi: 10.1186/s13244-024-01622-x.

New Perspectives: Dual Energy



Dual Energy CT scan

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Types:

- Dual-source CT
- Single-source with ultrafast kV switching.
- Single-source without ultrafast kV switching.
- Single-source with dual-layer detector.
- Single-source with split-filter.

@Radiographics. 2010 May;30(3):685-98. doi: 10.1148/rg.303095101

Dual Energy CT scan

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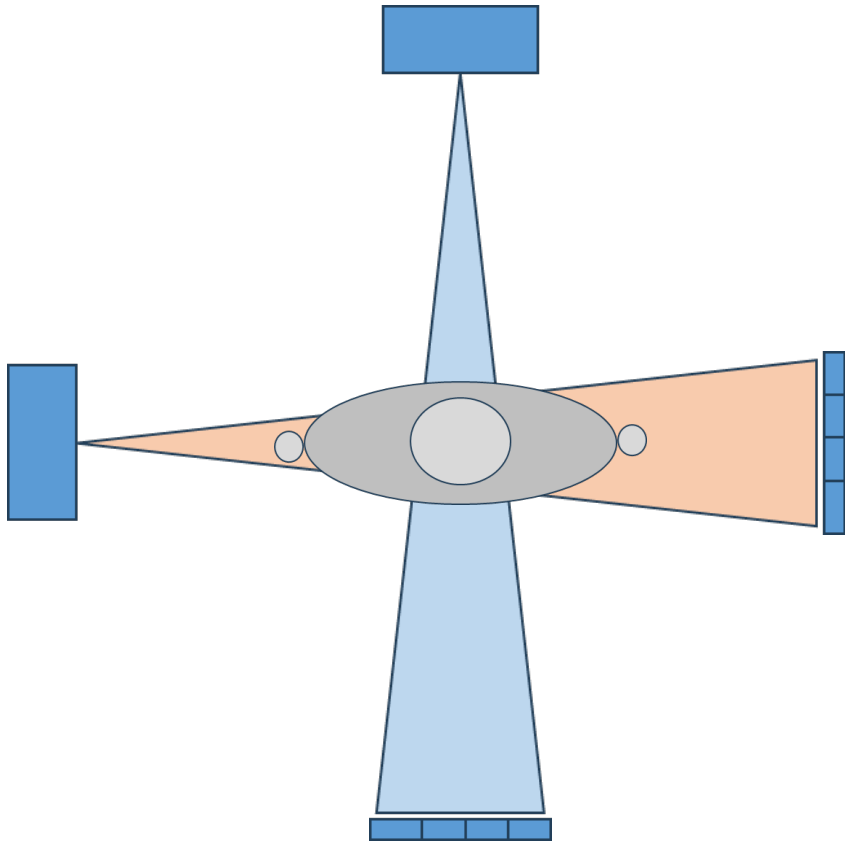
Dual-source CT:

- Two tube-detector systems with 90° angle.
- One low-potential operating tube (70kV), one high potential operating tube (120 kV).



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Dual Energy CT scan

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NEW APPLICATIONS OF DUAL-ENERGY CT:

- Evaluation of matter composition based on different attenuation from different tissues and materials at different energy levels.
- Multienegy CT scanner provide CT data able to create images specific to the material examined, giving information about the presence, distribution and concentration of a certain material inside tissues.

@Radiographics. 2010 May;30(3):685-98. doi: 10.1148/rg.303095101

Dual Energy CT scan

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NEW APPLICATIONS OF DUAL-ENERGY CT:

- Evaluation of matter composition based on different attenuation from different tissues and materials at different energy levels.
- Multienegy CT scanner provide CT data able to create images specific to the material examined, giving information about the presence, distribution and concentration of a certain material inside tissues.

@Radiographics. 2010 May;30(3):685-98. doi: 10.1148/rg.303095101

Dual Energy CT scan

G. Porrello

TYPE OF IMAGES:

- ✓ Routine Images

@Radiographics. 2010 May;30(3):685-98. doi: 10.1148/rg.303095101

Dual Energy CT scan

TYPE OF IMAGES:

✓ Routine Images

In a double source CT combined or mixed images are created, born from the linear fusion of low and high energy images

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G. Porrello

Dual Energy CT scan

TYPE OF IMAGES:

- ✓ Routine Images
- ✓ Monoenergetic virtual images

Simulates a scan using a monocromatic Xray beam and allows to choose the energy level, in keV, for the reconstruction.

@Radiographics. 2010 May;30(3):685-98. doi: 10.1148/rg.303095101

Dual Energy CT scan

G. Porrello

TYPE OF IMAGES:

- ✓ Routine Images
- ✓ Monoenergetic virtual images

- Simulates CT
- Gray scale
- MVI from 35 to 200 keV

Simulates a scan using a monocromatic Xray beam and allows to choose the energy level, in keV, for the reconstruction.

@Radiographics. 2010 May;30(3):685-98. doi: 10.1148/rg.303095101

G. Porrello

Dual Energy CT scan

TYPE OF IMAGES:

- ✓ Routine Images
- ✓ Monoenergetic virtual images

- Simulates CT
- Gray scale
- MVI from 35 to 200 keV

Simulates a scan using a monocromatic Xray beam and allows to choose the energy level, in keV, for the reconstruction.

- 70 keV MVI corresponds to conventional 120 kV, providing similar attenuation but lower artifacts and noise

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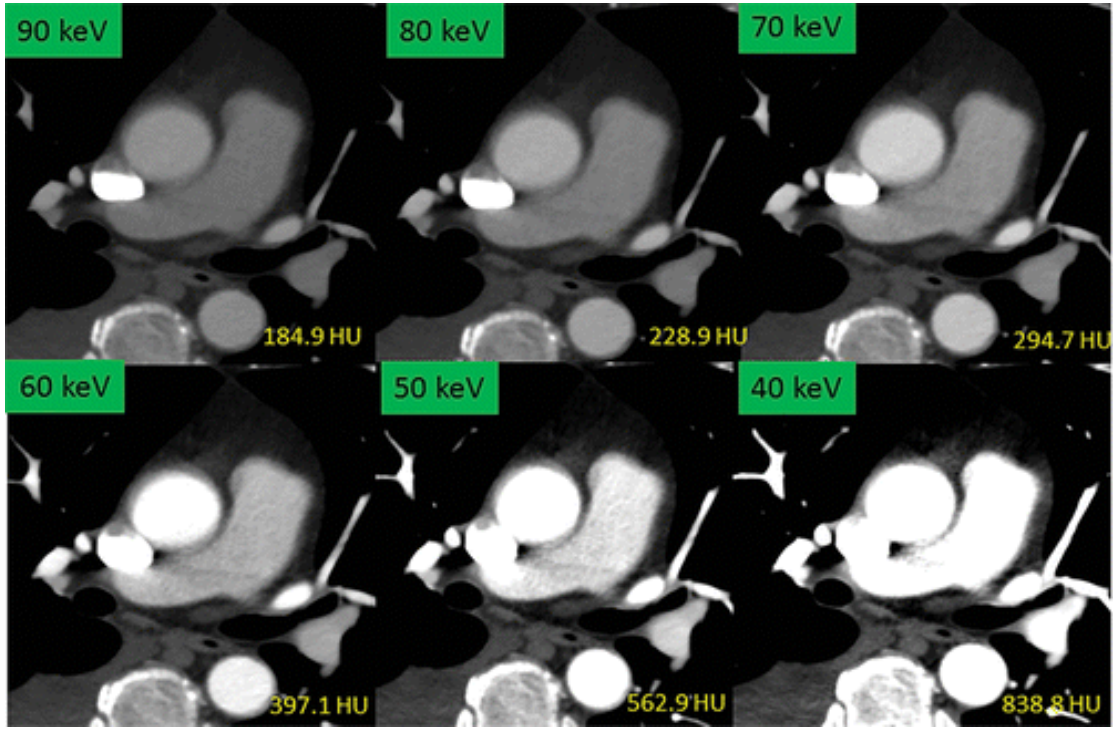
Dual Energy CT scan

TYPE OF IMAGES:

- ✓ Routine Images
- ✓ Monoenergetic virtual images

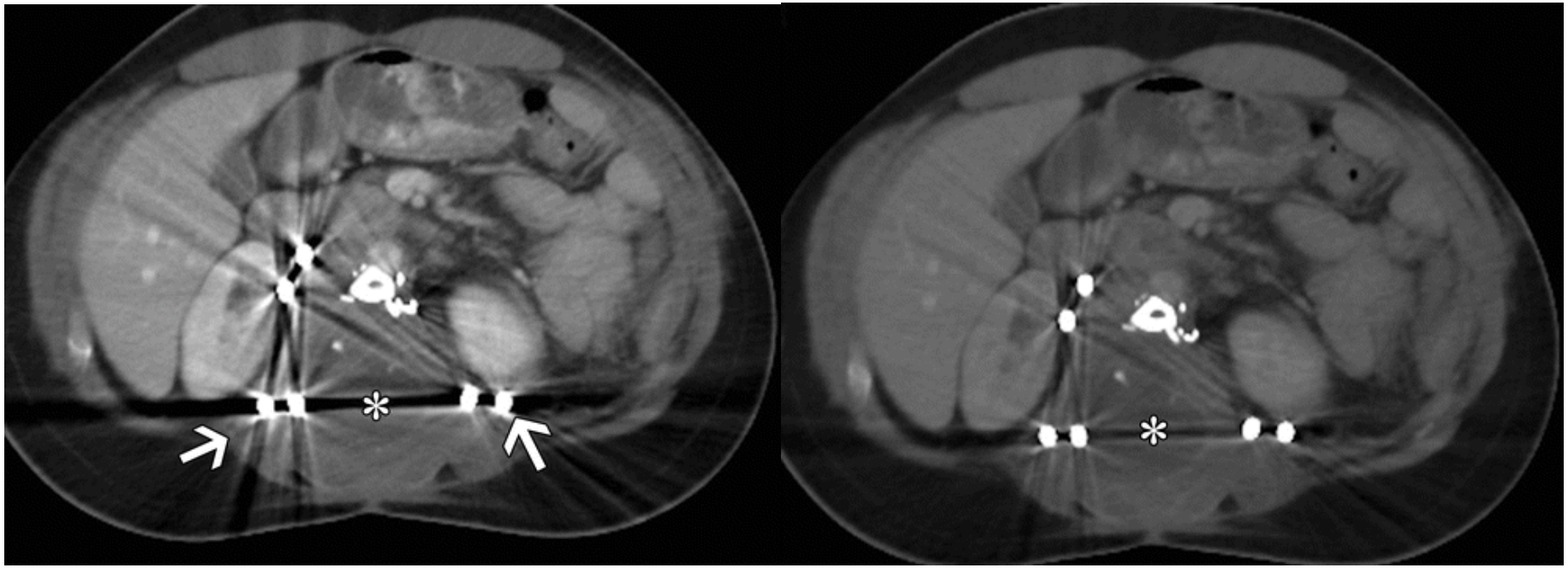


@Radiographics. 2020 Sep-Oct;40(5):1284-1308. doi: 10.1148/rg.2020200038.

Dual Energy CT scan

TYPE OF IMAGES:

- ✓ Routine Images
- ✓ Monoenergetic virtual images



@Radiographics. 2020 Sep-Oct;40(5):1284-1308. doi: 10.1148/rg.2020200038.

Dual Energy CT scan

G. Porrello

TYPE OF IMAGES:

- ✓ Routine Images
- ✓ Monoenergetic virtual images
- ✓ Iodine Maps

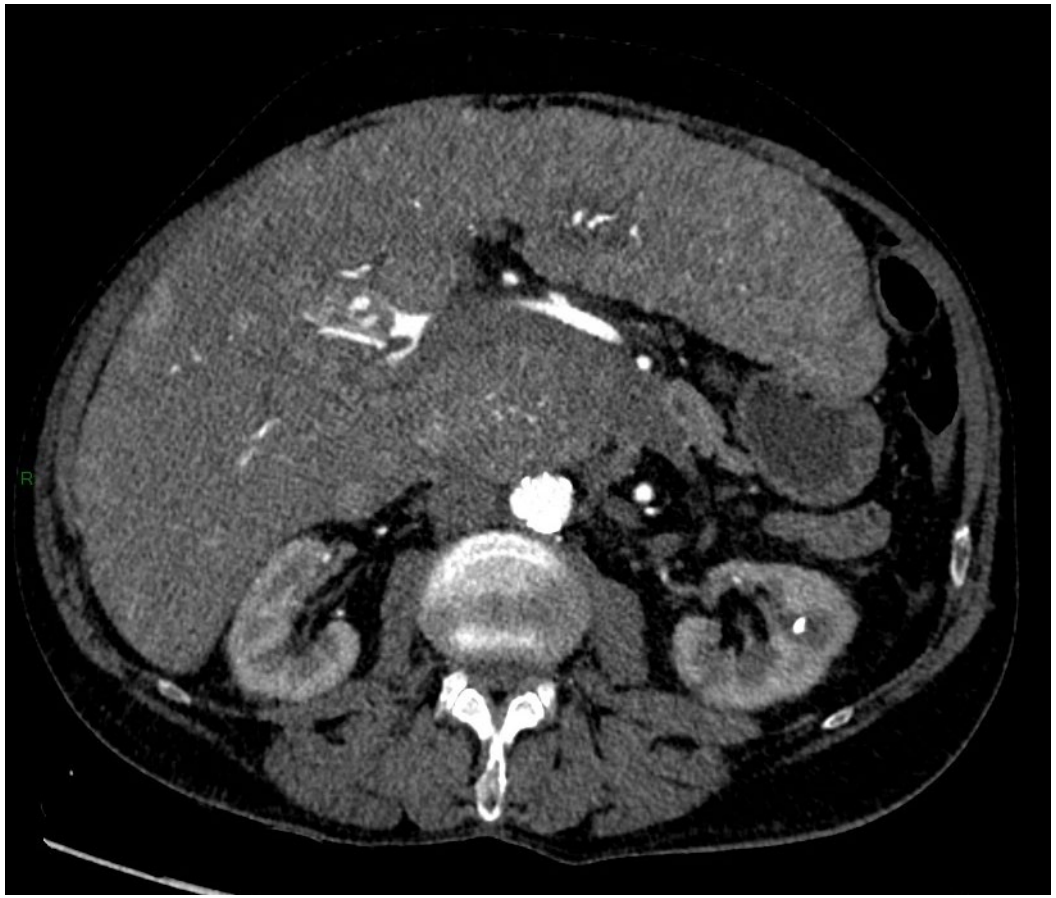
- Multienergy CTs that underlines iodine-containing pixels
- Different attenuation properties at different energies, due to the k value of Iodium (33 keV) provide a good separation among iodine and water
- Gray scales or coloured maps

@Radiographics. 2010 May;30(3):685-98. doi: 10.1148/rg.303095101

Dual Energy CT scan

TYPE OF IMAGES:

- ✓ Iodine Maps



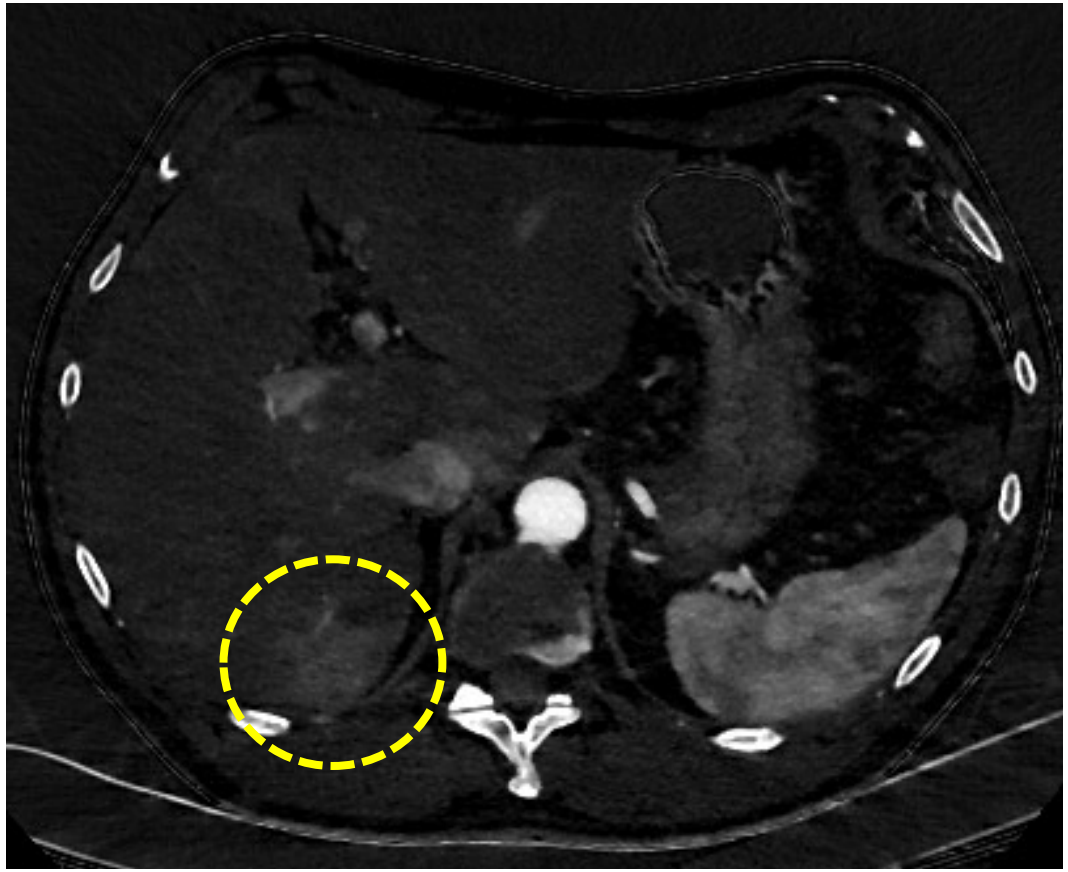
@Radiographics. 2010 May;30(3):685-98. doi: 10.1148/rg.303095101

Dual Energy CT scan

G. Porrello

TYPE OF IMAGES:

- ✓ Iodine Maps



@Radiographics. 2010 May;30(3):685-98. doi: 10.1148/rg.303095101

Dual Energy CT scan

G. Porrello

TYPE OF IMAGES:

- ✓ Routine Images
- ✓ Monoenergetic virtual images
- ✓ Iodine Maps
- ✓ Virtual Non-Contrast Images

VNC or only water images are obtained through the removal of iodine components from each pixel, through iodine-water decomposition.
Looks like a conventional non-contrast CT, but at a much lower dose.

@Radiographics. 2010 May;30(3):685-98. doi: 10.1148/rg.303095101

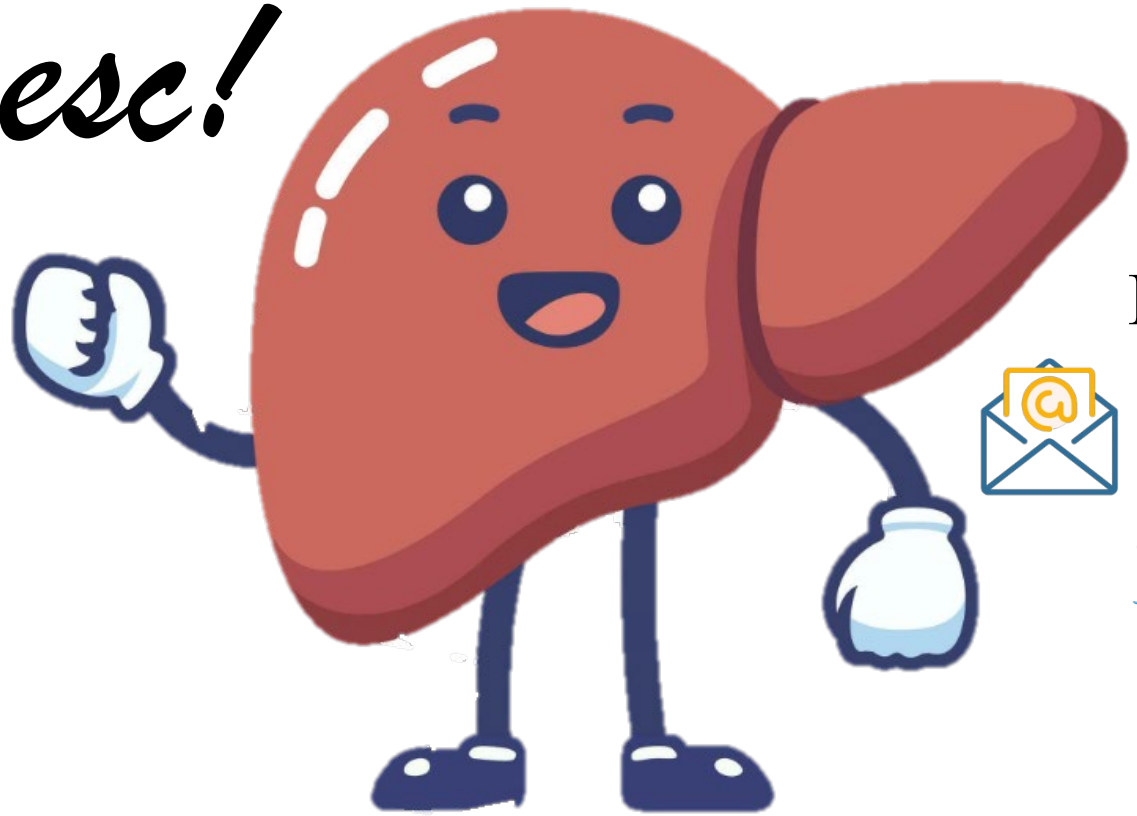
Dual Energy CT scan

ADVANTAGES OF DUAL ENERGY:

- ✓ Doses reduction
- ✓ Lesions are better seen and characterized
- ✓ Reduction of beam hardening artifacts.

@Radiographics. 2010 May;30(3):685-98. doi: 10.1148/rg.303095101

Mulţumesc!



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