



# Dual-Energy (Spectral) CT: Applications in Ab- dominal Imaging<sup>1</sup>

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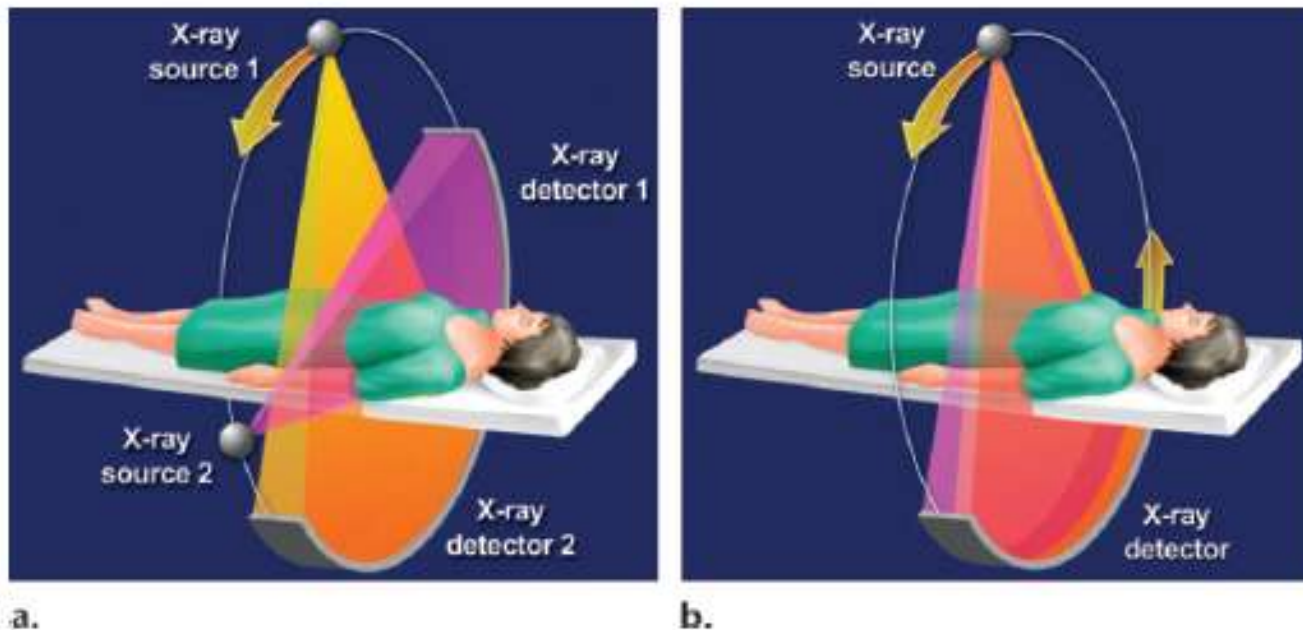
Antónia Portilha  
26.10.2011

# INTRODUÇÃO

- A expressão “**Tomografia Computorizada de Dupla Energia**” refere-se à utilização de dados obtidos a partir de dois feixes de raios X com espectros de energia diferentes para distinguir e classificar a composição de materiais.



- **Dual-detector, dual-source DECT (dsDECT)**  
(Siemens Medical Solutions)
- **Single-detector, single-source DECT (ssDECT)**  
(GE Healthcare)
  - Alternância rápida entre dois picos de Kv (“fast switching”)
  - “Spectral Imaging”



**Figure 1.** Graphics show the difference between dsDECT (a) and ssDECT (b). In dsDECT, separate x-ray tubes are used for high and low energies. In ssDECT, a single x-ray tube is used with rapid alternation between low and high energies. The latter technique uses projection data instead of image data to reconstruct computed monochromatic images as well as material density images.



# CONSIDERAÇÕES TÉCNICAS

- Na TC convencional, materiais de pequeno e de elevado número atômico, se presentes em determinadas concentrações, podem causar atenuações muito semelhantes, não sendo possível a sua diferenciação.
- Um tecido mostra diferentes graus de atenuação quando é sujeito a diferentes espectros de energia → discriminação entre materiais (gordura, cálcio, iodo, água)
- Contrariamente à TC convencional, em que é adquirida uma imagem por localização a um determinado espectro de energia (120 – 140Kv), na DECT são adquiridas duas imagens por localização a dois níveis de energia – a 80Kv e 140Kv



# CONSIDERAÇÕES TÉCNICAS

- A diferenciação pode ser superior com ssDECT dado que é atribuído um tom de cinzento a cada pixel, com base na densidade específica do material
- As imagens reconstruídas (“material density images”) fornecem informação diagnóstica adicional, que não é possível obter com a TC convencional
- Na DECT, as imagens são tipicamente reconstruídas aos pares
  - Água: imagem sem contraste virtual
  - Iodo

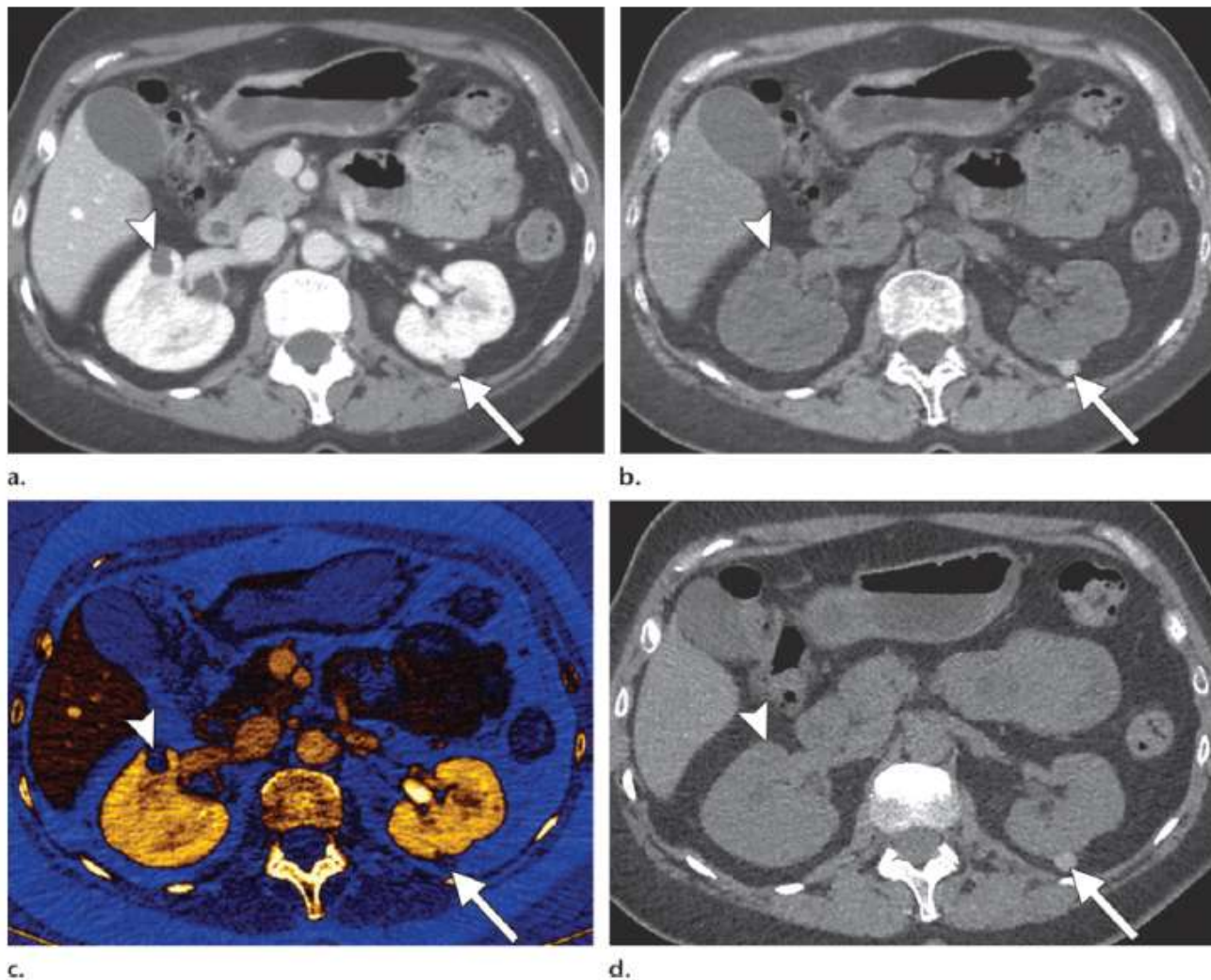


# APLICAÇÕES NA IMAGIOLOGIA ABOMINAL

- Rins
- Fígado
- Pâncreas
- Vasos





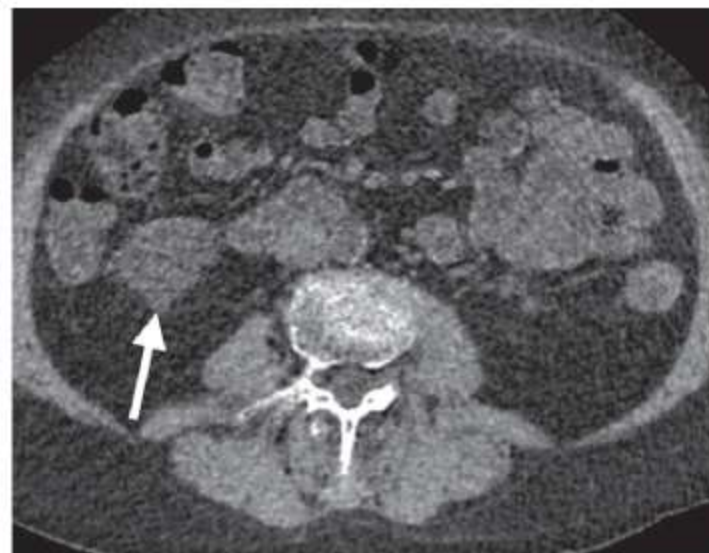


**Figure 2.** Simple renal cyst and hemorrhagic renal cyst. (a) Conventional contrast material-enhanced CT image shows a hyperdense lesion (arrow) in the left kidney and a hypodense lesion (arrowhead) in the right kidney. (b) Water material density (virtual unenhanced) image from ssDECT shows that the left renal lesion (arrow) has persistent hyperdensity after the exclusion of iodine-containing pixels, a finding that precludes iodine-related enhancement and instead indicates hemorrhagic or proteinaceous debris. Compare this appearance with the hypodensity of the right renal cyst (arrowhead). (c) Iodine material density image from ssDECT shows no iodine content in either the left (arrow) or the right (arrowhead) renal lesion, meaning that both lesions are avascular. (d) Conventional unenhanced CT image shows that the left renal lesion is hyperdense (arrow), whereas the right renal lesion is faintly hypodense (arrowhead), substantiating the appearance on the virtual unenhanced image (b).

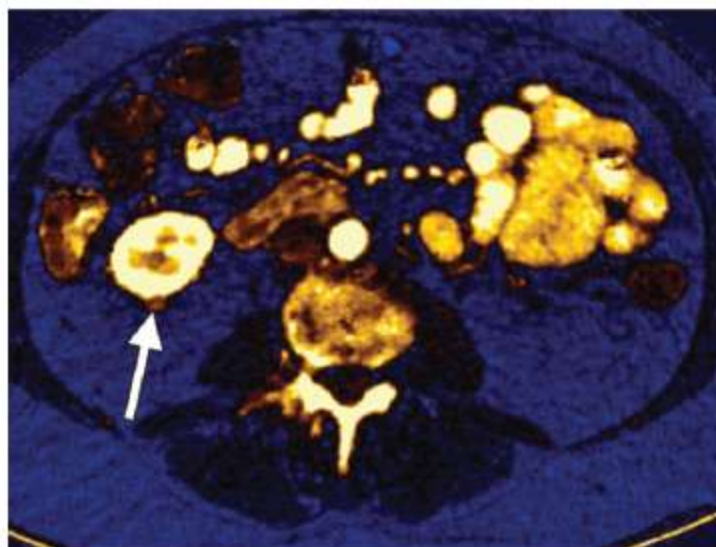




a.



b.



**Figure 3. Renal cell carcinoma.** (a) Conventional contrast-enhanced CT image shows a small hyperdense lesion (arrow) in the right kidney, an indeterminate finding that could be either a complicated cyst or an enhancing mass. (b) Water material density image from ssDECT shows that the lesion is isodense (arrow) to adjacent renal parenchyma, an appearance that helps exclude a simple cyst. (c) Iodine material density image from ssDECT shows iodine content (yellow-orange foci) in the lesion (arrow), a finding indicative of vascularity. With DECT, the renal lesion was accurately characterized with a single-phase contrast-enhanced acquisition instead of the multiphase acquisition generally required for conventional CT with a dedicated renal mass protocol.





**Figure 4.** Nephrolithiasis. (a) Monochromatic image from ssDECT during the excretory phase fails to show a 2-mm calculus in the left lower pole renal collecting system, a feature obscured by iodine-related opacification. (b) Water material density (virtual unenhanced) image from ssDECT clearly depicts a calculus (arrow). (c) Conventional unenhanced CT image confirms the presence of the calculus (arrow).



a.

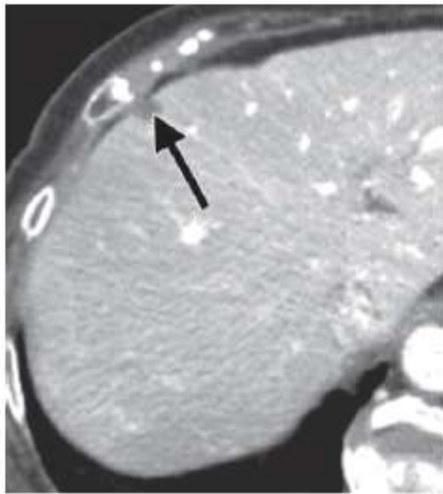


b.



c.

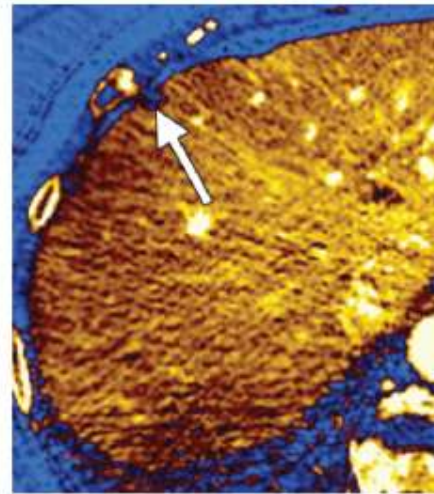




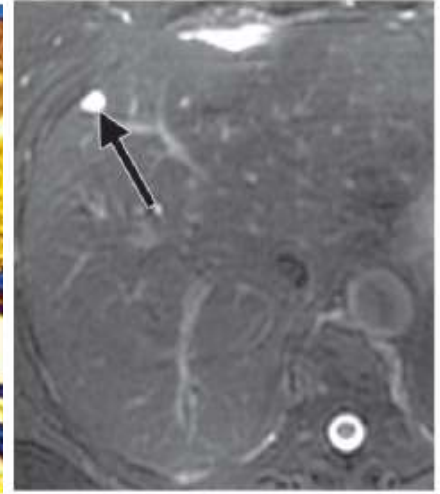
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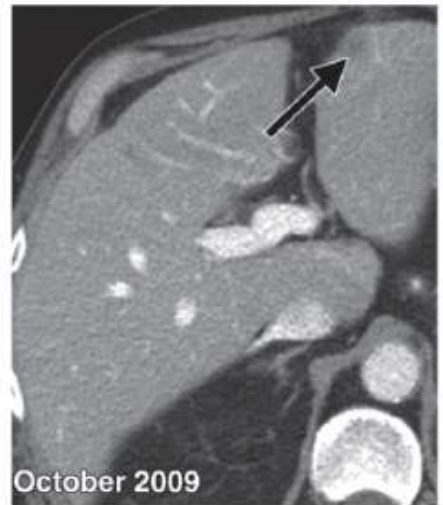
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5c.



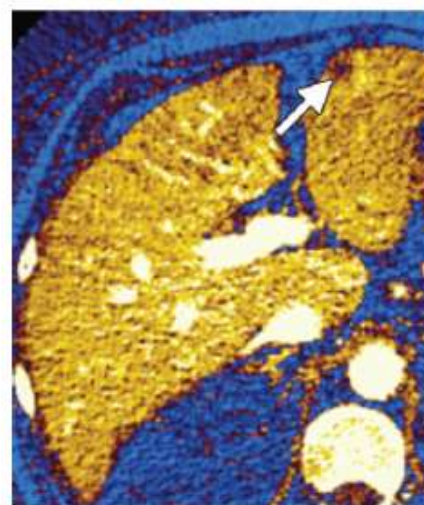
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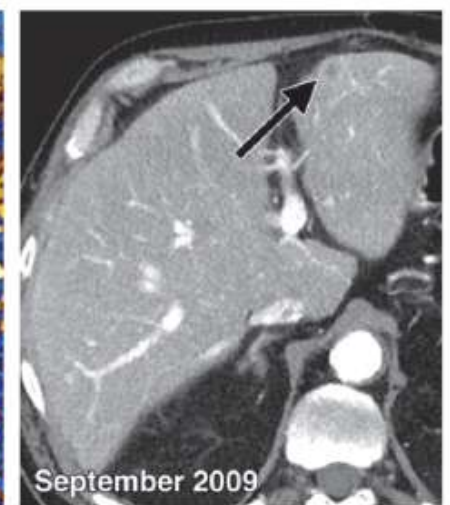
6a.



6b.



6c.

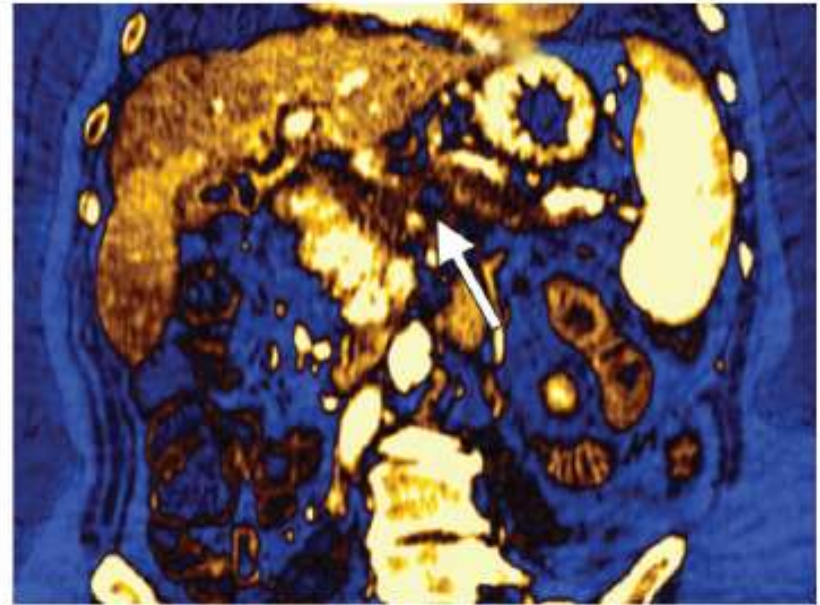


6d.





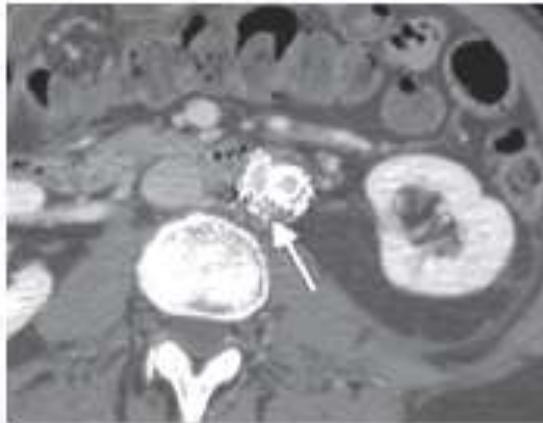
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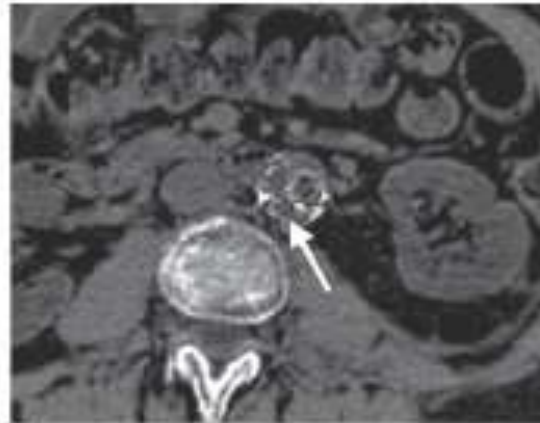
b.

**Figure 8.** Pancreatitis with focal necrosis. (a) Conventional contrast-enhanced coronal CT image shows generalized hypoenhancement of the pancreatic body and tail, with a central region of even lower attenuation (arrow), an indeterminate finding that could signify either more severe ischemia or frank infarction and necrosis. (b) Iodine material density ssDECT image shows no iodine content in the central region (arrow), a finding indicative of focal necrosis.

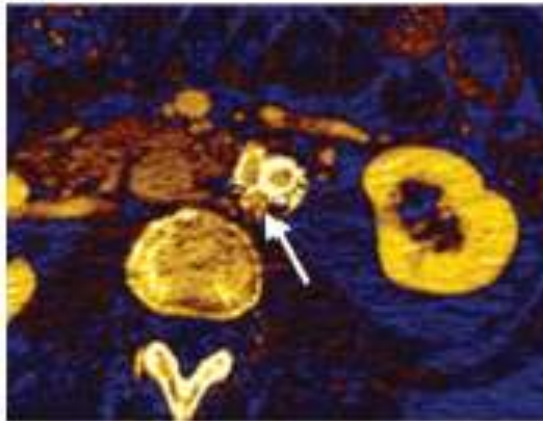




9a.



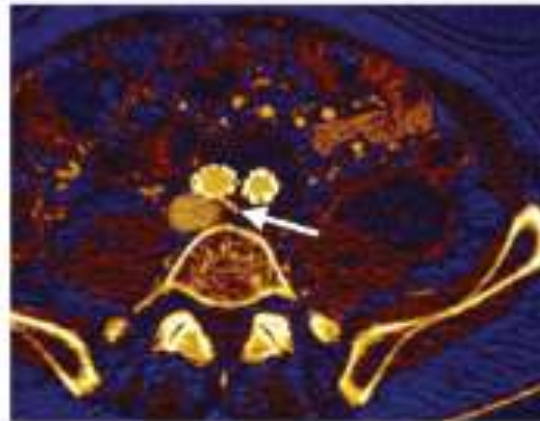
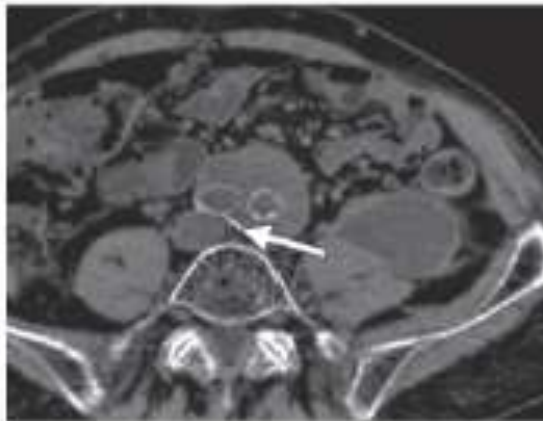
9b.



9c.



10a.



- ssDECT permite gerar imagens monocromáticas, que são menos susceptíveis a artefactos (“beam hardening”) e de pseudo-realce e proporcionam uma relação sinal-ruído superior à TC convencional







**a.**



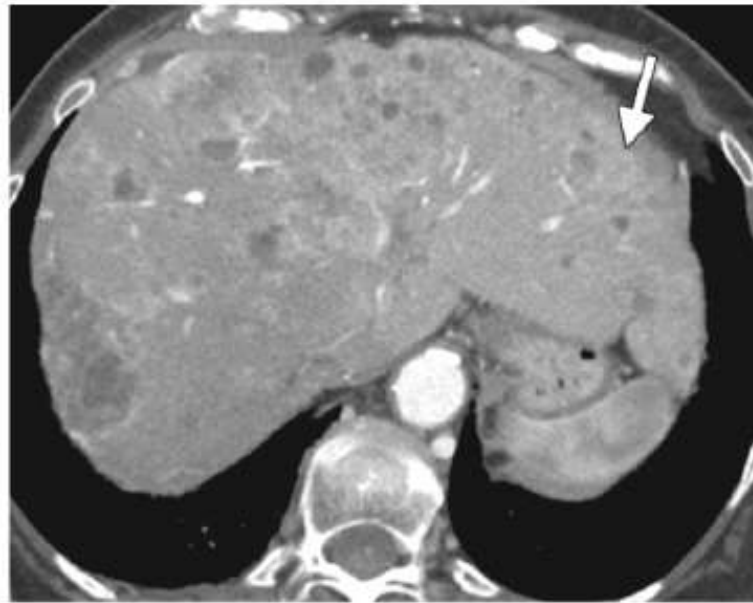
**b.**

**Figure 13.** Reduction of metal-related artifacts. **(a)** Coronal CT image obtained after bilateral total hip arthroplasty shows a severe beam hardening artifact that precludes accurate evaluation of intrapelvic soft tissues. **(b)** DECT image obtained with an artifact reduction protocol shows substantial reduction of streak and photon starvation artifacts, allowing clear depiction of anatomic structures adjacent to the prostheses as well as of intrapelvic soft tissues.





a.



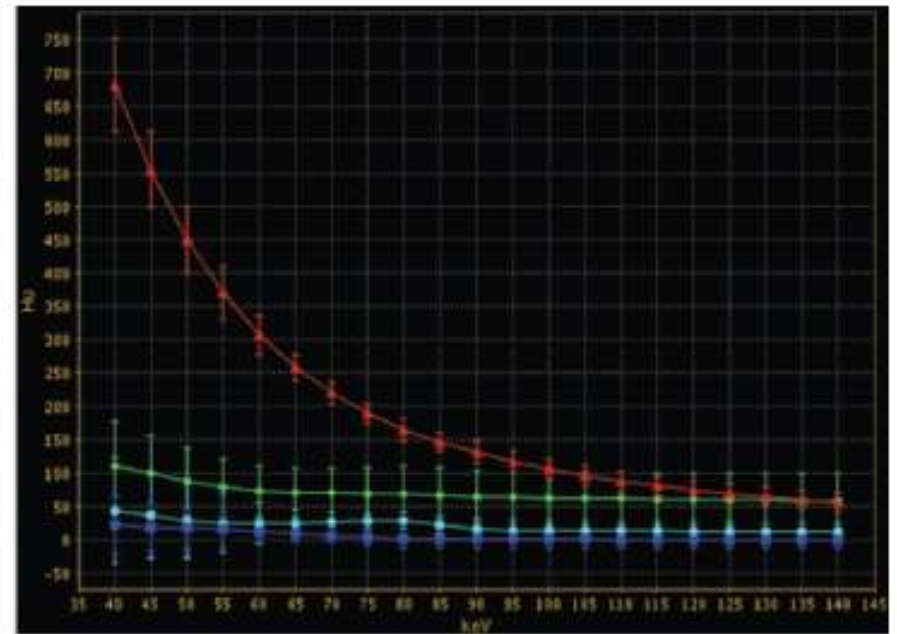
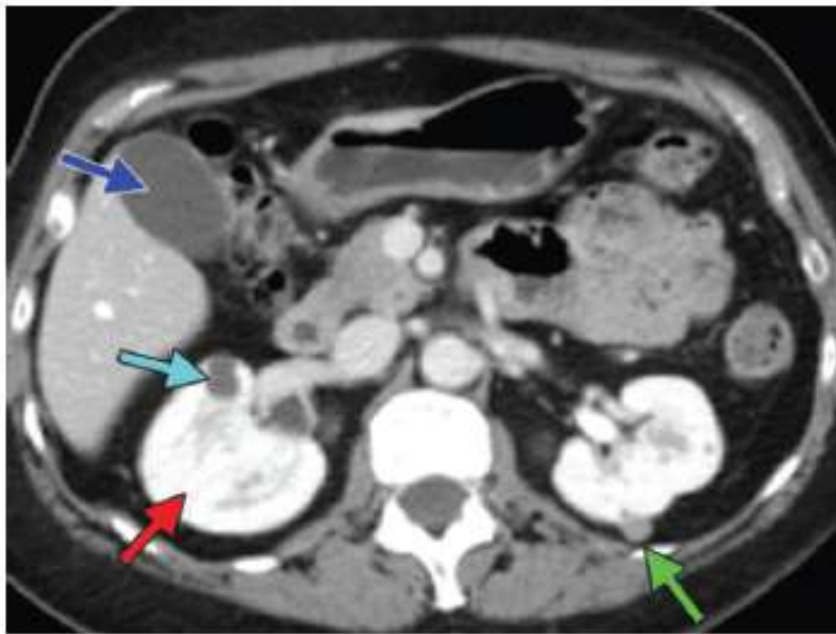
b.



c.

**Figure 14.** Use of monochromatic display for optimization of contrast-to-noise ratio. (a, b) Conventional contrast-enhanced CT images show marked enhancement of a hypervascular metastasis in the left lobe of the liver at 80 kVp (arrow in a) but near imperceptibility of the lesion at 140 kVp (arrow in b). The difference in lesion appearance between the two images is due to the fact that the attenuation produced by iodinated contrast material at 80 kVp is nearly double that at 140 kVp. However, the disadvantage of low-energy acquisitions is inherent increased noise, as seen in a. (c) Monochromatic ssDECT image shows improved contrast resolution when compared with b, but without the increased noise associated with low-energy acquisition. Arrow = metastasis.





a.

b.

**Figure 16.** Simple and hemorrhagic renal cysts. (a) Monochromatic ssDECT image shows a hyperattenuating left renal lesion (green arrow) and a hypoattenuating right renal lesion (light blue arrow). The right renal lesion, with attenuation similar to that of gallbladder fluid (dark blue arrow), is likely to be a cyst. The left renal lesion has an indeterminate appearance that could signify either an enhancing mass or a hyperdense cyst. The red arrow indicates renal parenchymal enhancement due to iodinated contrast material. (b) Graph shows DECT spectral attenuation curves for the left renal lesion (green), right renal lesion (light blue), gallbladder bile (dark blue), and normally enhancing renal parenchyma (red) at various kiloelectron-volt values. Both renal lesions have flat curves similar to that of nonenhancing gallbladder fluid, indicating that they are avascular. If the left renal lesion were an enhancing mass, its curve would more closely resemble that for enhancing renal parenchyma, since iodine has a more steeply increasing slope at lower energies. Comparison of these four spectral attenuation curves helps determine that the hyperdense appearance of the left renal lesion is not due to iodine-induced enhancement but, rather, to its nonenhancing internal contents, which are characteristic of a hemorrhagic or proteinaceous cyst.

## ○ Pitfalls

- Cálcio
- Lipiodol

## ○ Limitações

- Dose de radiação
- Aperfeiçoamentos
- Integração na prática clínica



# SÍNTESE

- ssDECT ajuda a caracterizar lesões (menor radiação)
- Imagens monocromáticas da ssDECT oferecem várias vantagens em relação à TC convencional:
  - Menor susceptibilidade a artefactos
  - Aumentar a capacidade de quantificar realce através da construção de curvas espectrais
- Estudos adicionais para determinar a melhoria na caracterização de lesões relativamente à TC convencional

