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PEDRO ANTÓNIO DE MASCARENHAS SANTOS BELO SOARES

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Dual-Energy CT for Characterization of Adrenal Nodules: Initial Experience

Rajan T. Gupta[1]
Lisa M. Ho[1]
Daniele Marin[1]
Daniel T. Boll[1]
Huiman X. Barnhart[2]
Rendon C. Nelson[1]

[1]Department of Radiology, Duke University Medical Center, DUMC 3808, Durham, NC 27710. Address correspondence to R. T. Gupta (rajan.gupta@duke.edu).

[2]Department of Biostatistics and Bioinformatics, Duke Clinical Research Institute, Duke University, Durham, NC.

Introdução

Many adrenal masses require additional workup with contrast enhanced CT and delayed imaging to evaluate for washout characteristics [6, 7].

Previous studies have shown that lipid-containing tissues undergo a characteristic decrease in attenuation as tube voltage is decreased [13–15].

Preliminary observations [8, 9] have suggested that dual-energy CT can be used to evaluate adrenal masses,

but to our knowledge the attenuation behavior of adrenal nodules at dual-energy CT has not been investigated.

Objectivos

The purpose of this study was to determine whether use of dual-energy technique can improve the performance of CT in the differential diagnosis of adrenal adenomas and metastatic lesions.

Material e métodos

SUBJECTS AND METHODS. Thirty-one adrenal nodules were prospectively identified in 17 patients who underwent dual-energy CT at 140 and 80 kVp. Attenuation measurements were performed for each nodule at both tube voltages. The mean attenuation change (increase or decrease) between 140 kVp and 80 kVp was determined for each adrenal nodule.

No IV contrast material was administered

we used a single-source 64-MDCT scanner (LightSpeed VCT, GE Healthcare) equipped with a dual-energy software package (Volume Dual Energy, GE Healthcare).

140-kVp and 80-kVp images can be obtained in a single acquisition during two consecutive 0.8-second gantry revolutions separated by 0.2 seconds for switching the tube settings (total acquisition time, 1.8 seconds).

Material e métodos

The imaging parameters for dual-energy CT were as follows:

- axial mode;
- 385 mA at 140 kVp, 675 mA at 80 kVp;
- gantry rotation time, 0.8 second;
- reconstruction slice thickness, 2.5 mm;
- collimation 64 × 0.625 mm.

Material e métodos

Adrenal Nodule Classification and Reference Standard

- lipid-rich adenomas - mean attenuation of +10 HU or less on unenhanced CT images at 140 kVp [17].

- lipid-poor adenomas - mean attenuation greater than +10 HU at 140 kVp if the size varied less than 30% during CT follow-up for a minimum of 1 year.

- metastatic nodules - if they had a 30% or greater increase in size during 1 year of imaging follow-up

  and occurred in a patient with a history of extra-adrenal malignancy.

Resultados

The mean attenuation values at 140 kVp and 80 kVp and mean transverse diameters for all adenomas, lipid-rich adenomas, and lipid-poor adenomas were significantly lower than those of metastatic lesions ($p < 0.001$).

The mean attenuation change between 140 and 80 kVp for all adenomas (0.4 ± 7.1 HU), lipid-rich adenomas (0.2 ± 7.7 HU), and lipid-poor adenomas (1.3 ± 4.6 HU) was significantly lower than the mean attenuation change of metastatic lesions (9.2 ± 4.3 HU) ($p<0.003$, $p < 0.01$, *and* $p < 0.002$) *(Table 1).*

Resultados

In 50% (13 of 26) of adrenal adenomas, attenuation decreased as the tube voltage settings were decreased from 140 to 80 kVp (mean attenuation change, -5.5 ± 2.9 HU).

This trend was more pronounced for lipid-rich adenomas (55%, 11 of 20; mean attenuation change, -5.8 ± 3.0HU) (Fig1)

compared with lipid-poor adenomas (33%, two of six; mean attenuation change, -3.9 ± 0.9HU) (Fig2)

In all cases, adrenal metastatic lesions had an attenuation increase at 80 kVp (mean attenuation change, 9.2 ± 4.3 HU);

Resultados

Considering a decrease in attenuation at 80 kVp as a diagnostic tool, dual-energy CT had

- 50% sensitivity,
- 100% specificity,
- 100% positive predictive value,
- 28% negative predictive value

in the diagnosis of adenoma.

Resultados

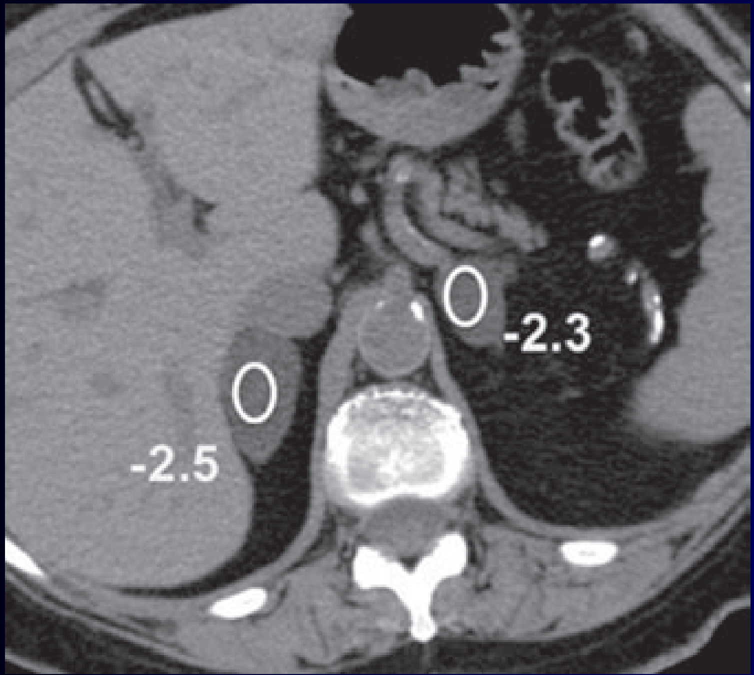
TABLE 1: Comparison of Mean Attenuation Values, Mean Attenuation Change, and Transverse Diameter of All Lesions and Fat

Finding	All Adenomas ($n = 26$)	Lipid-Rich Adenomas ($n = 20$)	Lipid-Poor Adenomas ($n = 6$)	Metastatic Lesions ($n = 5$)	Spleen ($n = 16$)	Fat ($n = 17$)
Mean attenuation at 140 kVp (HU)	2.2 ± 9.9	−2.2 ± 6.0	16.6 ± 5.4	28.5 ± 2.9	41.6 ± 4.8	−106.9 ± 8.8
Mean attenuation at 80 kVp (HU)	2.6 ± 13.3	−2.0 ± 10.7	17.9 ± 9.4	37.7 ± 6.0	49.0 ± 5.2	−133.5 ± 11.0
Mean attenuation change (140–80 kVp) (HU)	0.4 ± 7.1	0.2 ± 7.7	1.3 ± 4.6	9.2 ± 4.3	7.4 ± 3.1	−26.6 ± 2.7
Mean transverse diameter (mm)	15.9 ± 6.8	15.6 ± 6.6	16.6 ± 8.0	40.7 ± 21.9	N/A	N/A
Mean attenuation change in comparison with metastatic lesions (p)	0.003	0.01	0.002	N/A	0.07	< 0.001
Mean attenuation change in comparison with spleen (p)	< 0.001	0.002	< 0.001	0.07	N/A	< 0.001

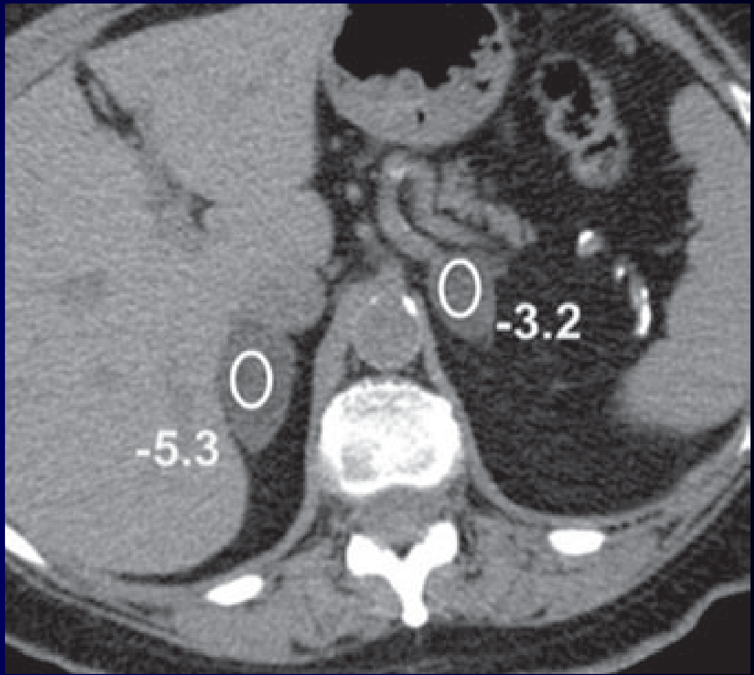
Note—N/A = not applicable.

Resultados

84-year-old woman with incidental finding of bilateral adrenal nodules.



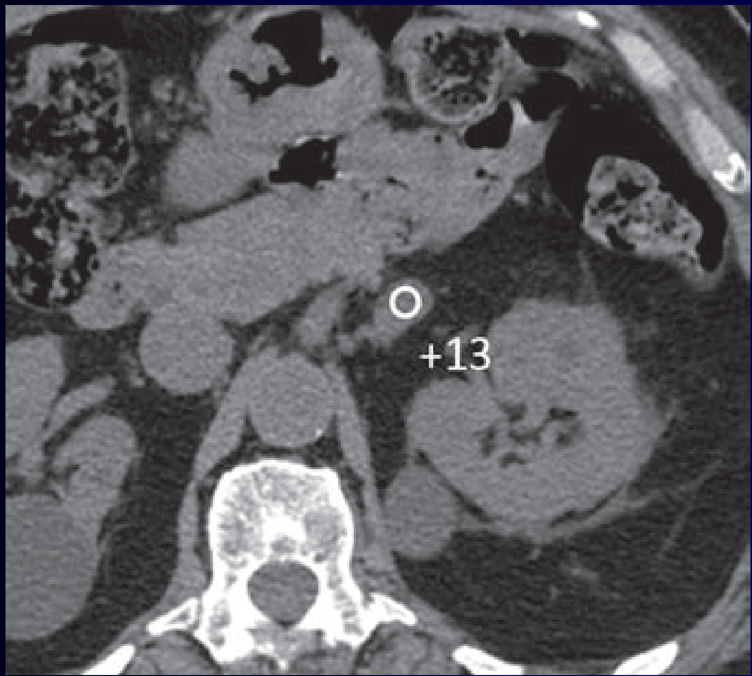
A, Transverse unenhanced 140-kVp CT image shows bilateral adrenal nodules with attenuation values of -2.5 HU and -2.3 HU, diagnostic of lipid-rich Adenomas.

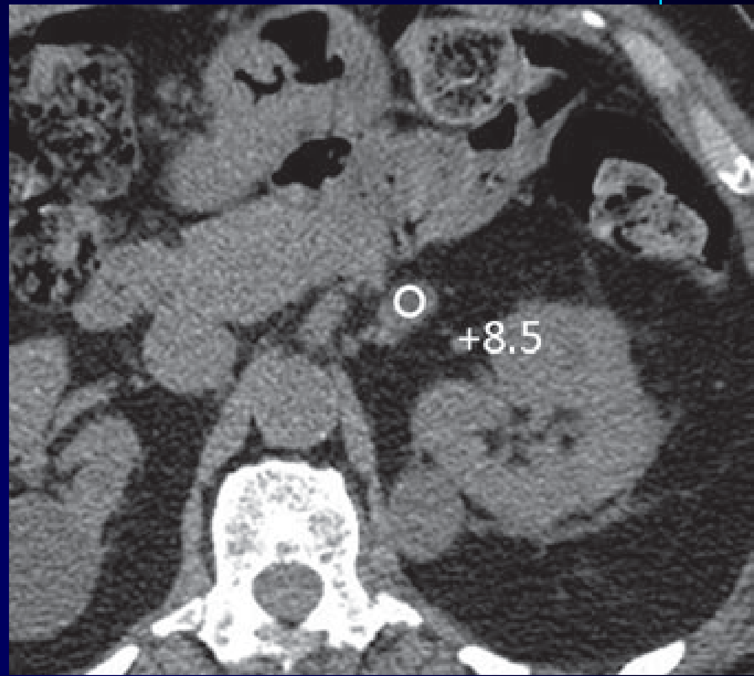


B, Transverse unenhanced 80-kVp CT image shows attenuation decrease in both lesions, measuring -5.3HU and -3.2 HU, indicating presence of intracellular lipid.

Resultados

82-year-old man with lung cancer and left adrenal nodule.





A, Transverse unenhanced 140-kVp CT image shows indeterminate left adrenal nodule with attenuation value of +13 HU.

B, Transverse unenhanced 80-kVp CT image shows attenuation decrease in lesion to +8.5 HU, suggesting presence of intracellular lipid.

Because of CT stability over 12 months, lesion is considered lipid-poor adenoma.

Discussão

Adrenal adenomas, which generally have large amounts of intracellular lipid, had a mean attenuation change of approximately zero when the tube voltage applied was decreased from 140 kVp to 80 kVp

We speculate that this distribution of results is related

to the relative proportion of intracellular lipid

to the fact that adenomas contain fat and soft tissue

Because of the relatively lower sensitivity of dual-energy CT compared with use of a mean attenuation threshold of +10 HU on unenhanced images at 140 kVp (sensitivity, 71% [17]),

the 80-kVp dual-energy CT scans of the adrenal glands may be best used as an adjunct tool in the evaluation of indeterminate nodules:

Discussão

if the mean attenuation value of an adrenal nodule is greater than +10 HU on the 140-kVp images, attention would be directed to the 80-kVp images

a) An attenuation decrease at 80 kVp would help to characterize the lesion as lipid-poor adenoma, and no further workup would be needed

33% of lipid-poor adenomas had a decrease in attenuation at low tube voltage

b) If the lesion were found to have increased attenuation on 80-kVp images, further workup with contrast-enhanced CT including delayed acquisition or MRI with in- and out-of-phase imaging would be required.

Conclusões

Our initial results indicate that dual-energy CT is less sensitive than conventional single-energy unenhanced CT techniques, such as mean attenuation threshold in the differentiation of adenomas from metastatic lesions.

Our results also indicate that the combination of low-energy CT with conventional high-energy unenhanced CT may increase the overall sensitivity of unenhanced CT, possibly reducing the need for contrast-enhanced CT with delayed acquisition