Clinical Imaging 40 (2016) 86–89

Contents lists available at ScienceDirect

Clinical Imaging

journal homepage: http://www.clinicalimaging.org

Evaluate the efficacy of minimum attenuation value in differentiation of adrenal adenomas from nonadenomas on unenhanced CT☆

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ARTICLE INFO

Article history:
Received 1 August 2014
Received in revised form 5 August 2015
Accepted 4 September 2015

Keywords:
Adrenal neoplasm
Computed tomography
Minimum attenuation value
CT histogram analysis

ABSTRACT

Most adrenal masses are adenomas which contain a large amount of intracytoplasmic lipid and have lower attenuation values on unenhanced computed tomography (CT) examinations. Mean atrioventricular and CT histogram analysis is commonly used for the diagnosis of adenomas; however, the former disregards tissue heterogeneities of the mass and diagnostic efficiency is decreased, and the latter demands specific post-processing workstation for analyzing the data. The purpose of our study is to develop a simple and sensitive method for the diagnosis of adenomas on unenhanced CT.

1. Introduction

Adrenal masses are incidentally demonstrated in 5% abdominal computed tomography (CT) scans [1]. The most likely causes of those masses are adenomas. Current method of using mean attenuation value (meanAV) of 10 HU as threshold on unenhanced CT can diagnose majority of adenomas, but approximately one third of adenomas are lipid poor and cannot be accurately identified from metastasis, pheochromocytomas, adrenocortical carcinomas, or lymphomas [2,3]. CT histogram analysis has been proved to hold high sensitivity and specificity in differential diagnosis of adrenal adenomas and nonadenomas [2–6], while this method demands specific postprocessing workstation for analyzing the data. Thus, it is not widely used in clinical practice. The purpose of our study is to develop a simple and sensitive method for the diagnosis of adenomas on unenhanced CT. We investigated the efficacy of minimum attenuation values (minAVs), an easily obtained parameter from radiology archiving and communication system (PACS). The efficacy of our method and the currently used 10-HU threshold meanAV were then compared.

2. Materials and methods

This is a retrospective study that was approved by our institutional review board, and the requirement for informed consent was waived. The CT images of 110 patients (68 males, 42 females; mean age, 61.3 years; age range, 17–85 years) with 114 adrenal masses including 51 adenomas in 51 patients, 42 metastases in 39 patients, 14 pheochromocytomas in 14 patients, 4 lymphomas in 3 patients, and 3 adrenocortical carcinomas in 3 patients during a period from January 2008 to November 2012 were selected. Tumors size range from 10 to 62.4 mm, including 55 patients with a size of 10–20 mm, 31 patients with a size of 20–30 mm, 14 patients with a size of 30–40 mm, and 14 patients with a size ≥40 mm. All diagnoses of the adenomas, pheochromocytomas, lymphomas, and adrenocortical carcinomas were confirmed clinically or histopathologically. The reference standards for the diagnosis of metastases are as follows [2]: pathological data obtained either by biopsy or during operation (12 patients), rapid growth of a mass (15 patients) or identification of a new mass in less than 6 months (6 patients), and regression in the size of the mass subsequent chemotherapy (6 patients). A clinical diagnostic criterion of adrenal lymphoma is lymphoma that was confirmed by superficial lymph node puncture biopsy or histologic biopsy, and adrenal tumor decreases rapidly after chemotherapy.

2.1. CT technique

All the CT images were obtained by using a light-speed 16-slice spiral CT system (General Electric Medical Systems, Milwaukee, WI, USA). Unenhanced CT examinations were preformed in all patients with the following imaging parameters: 5-mm collimation, 120 kVp, and 210 mA.

2.2. Data

All CT studies were retrieved from the hospital image archive to a clinical PACS workstation. (Radinfo Systems, Zhejiang, China). The

☆ Conflict of Interest: The authors declared no conflicts of interest.

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http://dx.doi.org/10.1016/j.clinimag.2015.09.006
0899-7071/

image with the largest cross-section was used for the measurements to eliminate partial volume effects from the periphery of the mass. Our study placed five regions of interest (ROIs) at the following locations: the intersection of the long- and short-axis diameters and midpoints of the distance from the edge of the mass to the intersection of the long- and short-axis diameters (Fig. 1). The size of the ROI was set between 19 and 24 mm^2, and areas of necrosis that were defined as a focal area of hypoattenuation compared with the remainder of the adrenal mass were excluded from measurements [3]. Each ROI gave an ROI meanAV and an ROI minAV, then we calculated the meanAV and the minAV of the mass by averaging the ROI meanAVs or ROI minAVs. For differential diagnosis of adenomas from nonadenomas, we applied a threshold of 10 HU for the meanAV and a threshold of 0 HU for the minAV.

The exclusion criteria were as follows [2]: (1) masses with diameters less than 10 mm, (2) masses with a cystic appearance indicating adrenal cyst, (3) masses with large visible amounts of fat possibly representing myelolipomas, and (4) masses containing large hemorrhage, calcified or necrotic areas.

2.3. Data analysis

The percentage of each type of adrenal masses with a meanAV of 10 HU or less or the minAV of 0 HU or less was calculated. The sensitivity, specificity, false positive rate (FPR), false negative rate (FNR), positive predictive value (PPV), negative predictive value (NPV), and accuracy of using the two thresholds to diagnose adenomas were calculated and compared. To evaluate the sensitivity, specificity, FPR and FNR, PPV, NPV, and accuracy of all five ROIs with minAV ≤0 HU, we also investigated the percentage of each type of adrenal masses with ≤0 HU in one ROI to five ROIs.

3. Results

The meanAVs of the 51 adenomas on unenhanced CT ranged from −22 to 42.4 HU (mean: 7.9 HU). Of the 51 adenomas, 32 (62.8%) had a meanAV of ≤10 HU, and 19 showed a meanAV of >10 HU. The minAVs ranged from −63.8 to 36 HU (mean: −24 HU). Of these adenomas, 46 (90.1%) had a minAV of ≤0 HU, and 5 (9.9%) had a minAV of >0 HU. The meanAVs of 63 nonadenomas ranged from 22.4 to 76 HU (mean: 38.4 HU). All the 63 nonadenomas (100%) showed a meanAV of >10 HU. The minAVs of nonadenomas ranged from −3.2 to 46.3 HU (mean: 12.2 HU). Of the 63 nonadenomas, 2 (3.2%) had a minAV of ≤0 HU, and 61 (96.8%) showed a minAVs of >0 HU.

In the five ROIs, 2 adrenal masses had ROI minAV less than 0 HU in one ROI, 1 mass had ROI minAV less than 0 HU in two ROIs, no adrenal mass had ROI minAV less than 0 HU in three ROIs, 4 masses had ROI minAV less than 0 HU in four ROIs, and 41 masses had ROI minAV less than 0 HU in five ROIs. For nonadrenal masses, 6 masses had ROI minAV less than 0 HU in one ROI, 3 masses had ROI minAV less than 0 HU in two ROIs, one mass had ROI minAV less than 0 HU in 3 ROIs, and no mass shows ROI minAV less than 0 HU in four or five ROIs. Using the number of ROIs with minAV ≤0 HU as criteria for the diagnosis of adenomas gave a sensitivity of 3.9%, 2.0%, 0%, 7.8%, and 80.4%, respectively. Using all five ROIs with minAV ≤0 HU as criteria for diagnosing adenoma gave a sensitivity of 80.4%, a specificity of 100%, an FPR of 0%, an FNR of 19.6%, a PPV of 100%, an NPV of 86.3%, and an accuracy of 91.2% (Table 1).

Using meanAV of 10 HU as threshold for diagnosing adenomas gave an area under the receiver operating characteristic (ROC) curve (AUC) of 0.965 (Fig. 2), a sensitivity of 62.8%, a specificity of 100%, an FPR of 0%, an FNR of 37.3%, a PPV of 100%, an NPV of 76.8%, and an accuracy of 83.3%. Using minAV of 0 HU as threshold for diagnosing adenomas gave an AUC of 0.962 (Fig. 2), a sensitivity of 90.1%, a specificity of 96.8%, an FPR of 3.2%, an FNR of 9.8%, a PPV of 95.8%, an NPV of 93.8%, and an accuracy of 93.9% (Table 2).

4. Discussion

Most of adrenal masses are adenomas that contain large amount of intracytoplasmic lipid and have lower attenuation values on unenhanced CT examinations. meanAV and CT histogram analysis are commonly used for the diagnosis of adenomas [2–10]. meanAV averages tissue densities over the pixels; thus, inadequate information

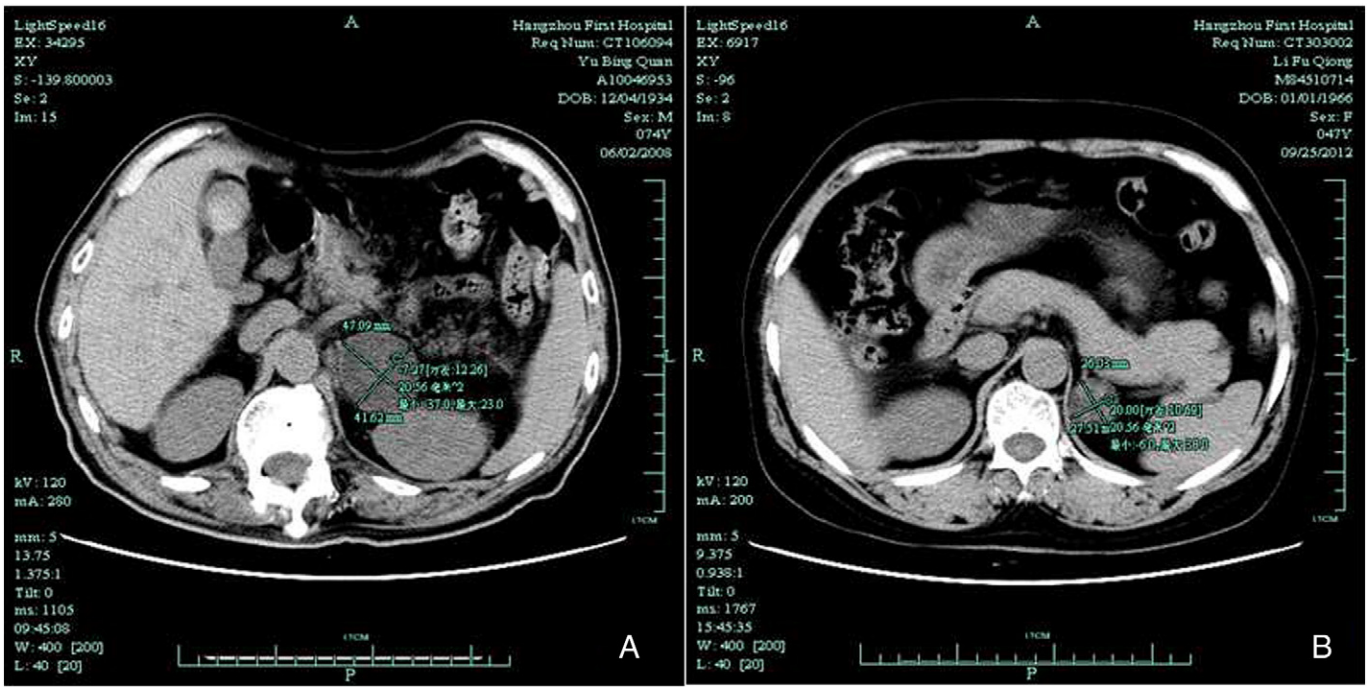

Fig. 1. (A and B) The images of adrenal adenoma from two representative patients. **(A)** A 74-year-old man with left adrenal adenoma, a meanAV of −7.27 HU, and a minAV of −37.0 HU. **(B)** A 47-year-old woman with left adrenal adenoma, a meanAV of 20.00 HU, and a minAV of −6.0 HU.