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Original Article

Role of quantitative chemical shift magnetic resonance imaging and chemical shift subtraction technique in discriminating adenomatous from non adenomatous adrenal solid lesions

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ABSTRACT

Purpose: To evaluate role of quantitative assessment of chemical shift MR imaging and chemical shift subtraction technique in differentiating adenomatous from non-adenomatous adrenal lesions with comparison of accuracy level of each technique.

Materials and methods: A prospective study was carried out from 4-2014 to 5-2016 using 1.5T MRI. In-phase/opposed phase MRI sequences were applied for 52 patients having 58 adrenal lesions, 18 were hyper functioning and 40 were non-functioning. Lesions signal changes between in- and opposed phase sequences and post processing was done to calculate different quantitative chemical shift parameters using spleen, paraspinal muscle, and liver as a reference tissues. Additionally subtraction chemical shift MR technique on selected 16 cases was applied.

Results: Signal intensity index and the two formulas of adrenal to spleen ratio were more accurate than other quantitative chemical shift MRI parameters in discrimination between adenomatous and nonadenomatous adrenal lesions with selected cutoff value 23.4% for the signal intensity index, 0.72 and −27.82% for adrenal to spleen ratio% using the old and new formulas respectively. Chemical shift subtraction technique expressed significant difference between adenomas and non-adenomatous adrenal lesions where adenomas had ratio of 108.87 or more, and the non-adenomatous lesions had ratio of 47.74 or less with selected cutoff value 173.0475.

Conclusion: The signal intensity index and adrenal to spleen ratio are the most reliable quantitative chemical shift MRI methods in differentiation of adrenal adenomas from other non-adenomatous adrenal solid lesions. Chemical shift subtraction MRI is a recent technique that gives highly confident discrimination between two categories of pathology without using of any reference organ.

1. Introduction

In spite of its small size, the adrenal gland included a wide range of diseases, up to 9% of them detected in autopsy. Disease spectrum includes hormonal dysfunction abnormalities, benign and malignant neoplastic lesions (whether primary or secondary) as well as infiltrative disease [1].

Recent revolutions in the field of laboratory investigations and radiological imaging much facilitated the diagnosis of such disease varieties [2,3].

Most of incidentalomas (incidentally discovered adrenal lesions), are non-functioning and being benign while 10% are functional and less than 5% being malignant. The difficulty that most of incidentalomas, whatever their nature, seem to be of rather similar pattern in cross sectional imaging [4–6].

Incidence of adrenal adenomas increased in correlation with patient's age reaching 6% of over sixty patients. Up to 50% of detected adrenal masses in patient with a known primary extra-adrenal malignancy considered metastatic. The dilemma being in differentiating benign adenoma from metastasis as the later will

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downgrade the staging and prognosis of their primary malignancy, hence appropriate characterization is mandatory [7].

MRI applications in adrenal imaging is of great value due to high capability for tissue characterization, limiting the differential diagnosis or reaching an accurate final diagnosis [8].

The chemical shift is being the most sensitive technique used for detection of lipid in adrenal lesion even with very minute quantities and depending on this fact, chemical shift MRI technique is sensitive for diagnosing adrenal adenoma; even it could replace unenhanced CT with avoidance of hazards of radiation exposure. High sensitivity and specificity based on differentiating adrenal adenoma with abundant intra-cytoplasmic fat content from adrenal metastasis which don't show any signal changes between in phase to out phase imaging [9].

Adrenal masses are more accurately characterized by quantitative rather than qualitative method of chemical shift MR [10,11]. Multiple quantitative chemical shift imaging studies have been reported trying to reach accurate diagnosis of adrenal masses using different methodology with variable magnetic field strengths, gradient strengths, and different Ref. tissues in the formulas used for quantitative calculation of signal changes including the spleen [12–14], the liver [15–18] and paraspinal muscles [17,19].

In current study, we aimed to evaluate role of quantitative assessment of chemical shift MR imaging and chemical shift subtraction technique in differentiating adenomatous from non-adenomatous adrenal lesions with comparison of accuracy level of each technique.

2. Materials and methods

Current prospective study was carried out between 4 and 2014 and 5–2016, included 52 patients presented with 58 solid adrenal lesions that were evaluated using MRI 1.5 T. Included patients having previously diagnosed adrenal lesion based mainly upon previous CT studies. Patient's age range was from 21 to 77 years (mean 44.77 years), equal male to female ratio and right to left side ratio was 3:2.8. The study was approved by the faculty ethics committee and informed consent was taken from each patient.

Exclusion criteria included lesions having predominate extracellular fat contents as myelolipoma, cases of adrenal hyperplasia and hemorrhage (in newborns or due to trauma), purely cystic lesions (simple cyst or pseudo-cyst) and adrenal lymphatic malformation. Also solid lesions with longest diameter less than 1 cm were excluded because of the technical difficulty of setting the region of interest over them without avoidance of partial volume artifacts production at the lesion edges.

Histopathological date (whether open or laparoscopic adrenalectomy) used to confirm the diagnosis of all adrenal lesions. Metastatic tumors were assessed by percutaneous needle biopsy in 4 cases presented with 6 adrenal masses.

MRI examinations was done using 1.5-T superconductive unit (1.5 T Philips Achieva Gyroscan, Best, Netherlands) for 52 cases, using phased-array body coil. Lesion localization done first using routine sequences followed with chemical shift sequence at the adrenal lesion level using in-phase/opposed-phase sequence.

Chemical shift sequence is a refocused dual gradient echo sequence using the following parameters (fast field echo (FFE), TR 130 ms, double TEs of 4.6 and 2.3 ms) used for out-of-phase and in-phase images respectively, (flip angle 80°, slice thickness 3 mm, intersection gap 0.3 mm, FOV390/1.4 and 192 × 256 matrix size, number of echoes = 2).

Spleen, liver, and para-spinal muscles were imaged at same slice as the adrenal lesion whenever possible. Patients held their breath after full expiration with each breath-hold lasted about 16–20 s and the total imaging time was less than 2 min.

Last group of cases (17 cases) presented throughout the past year of the study (distributed as 11 adenomas, 4 pheochromocytomas, 1 metastasis and 1 carcinoma)subjected to additional chemical shift MRI sequence which performed using a double-echo fast low-angle shot (FLASH) sequence obtained at the level of the adrenal lesion using the following parameters(single 19 s breath hold, TR 133 ms, doublets of2.2 and 4.4 ms for opposed-phase and in-phase respectively, flip angle 75°, 6-mm slice thickness, 192 × 256 matrix, field of view of 300–350 mm, intersection gap 0.6 mm, and one signal acquisition). Subtraction images obtained by subtracting opposed phase images from in-phase images using the system's commercially available software.

Post processing with Philips-EWS workstation where signal intensities of adrenal lesions and their reference tissues (spleen, liver and ipsilateral para-spinal muscles) measured using generated circular regions of interest (ROI) covering widest dimension of the adrenal lesion, avoid partial volume artifact at the lesion edge, avoiding necrotic, cystic, hemorrhagic and calcific portions whenever possible.

Regarding the reference tissues, ROI must be as large as possible to be representative of the particular tissue excluding intrahepatic blood vessels (best at posterior segment of right lobe) and also avoid putting the ROI on obvious fat striations in the paraspinal muscle and other reference organs whenever possible. If splenic tissue was not present on the same slice, the closest available slice was used.

Measurements were repeated at same axial images and same adrenal position and selected reference tissues in both in-phase and out of phase corresponding images with similar surface area of ROI in similar location in both sequences. In post processing, subtraction of out of phase from in-phase chemical shift images was done then the subtracted images were quantitatively calculated.

Four quantitative chemical shift parameters of signal intensity (SI) changes between the out of-phase and the in-phase images were calculated as follows:

- ***Signal intensity index (SII)***: calculated used this formula [(SI on in-phase imaging-SI on opposed-phase imaging)/(SI on in-phase imaging)] × 100%.
- ***Adrenal to spleen ratio:*** calculated using **new formula** as {[(adrenal SI on opposed-phase imaging/spleen SI on opposed-phase imaging)/(adrenal SI on in-phase imaging/spleen SI on in-phase imaging)]–1} × 100%.
- ***Adrenal to liver ratio:*** calculated as {[(adrenal SI on opposed-phase imaging/liver SI on opposed-phase imaging)/(adrenal SI on in-phase imaging/liver SI on in-phase imaging)] – 1} × 100%.
- ***Adrenal to muscle ratio:*** calculated as {[(adrenal SI on opposed-phase imaging/muscle SI on opposed-phase imaging)/(adrenal SI on in-phase imaging/muscle SI on in-phase imaging)] – 1} × 100%.

Previously, adrenal to spleen ratio was calculated as {[(adrenal SI on opposed-phase imaging/spleen SI on opposed-phase imaging)/(adrenal SI on in-phase imaging/spleen SI on in-phase imaging)] and that was included in current study to distinguish the most sensitive and specific ratio for diagnosis of adrenal adenoma.

3. Radiologist's observations and statistical analysis

Images of different adrenal lesions were presented for two experienced radiologists of abdominal MRI interpretation (A.R. and A.H.) who had 6 and 12 years experience in the field of genitourinary imaging respectively. Both of them were asked to classify lesions whether adenomatous or non-adenomatous depending on