Normal Adrenal Glands in Multidetector Computed Tomography

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ABSTRACT

Objective: To characterize normal adrenal glands in an adult Thai population using multidetector computed tomography (MDCT).

Methods: We retrospectively reviewed the scans of 175 consecutive patients who underwent renal CT angiography for potential kidney donation with attention to the location, morphology, and enhancement of both adrenal glands. Each reader measured the body and limb thickness in the axial and coronal planes, and the length in the axial plane. The interclass correlation coefficient (ICC) between the two readers was generated. We employed mean, SD, and 95th percentile of normal adrenal gland size by using pooled data of both reviewers.

Results: The 95th percentiles of normal adrenal glands, which might be useful as cutoff values to distinguish between normal and pathological adrenal gland size, were calculated. The right adrenal gland was more often relatively cephalad to the left adrenal (58.9%). The most common morphology of both adrenal glands was the inverted Y, with inverted V and linear shapes less common. Both adrenal glands showed homogeneous enhancement (100%) in the arterial and nephrographic phases.

Conclusion: The majority of normal adrenal glands were right relatively cephalad to left, inverted Y shape, and homogenous enhancement, using the 95th percentile of size normal adrenal gland as a cutoff value to differentiate between normal and thickened limbs and body.

Keywords: Size; morphology; adrenal gland; multidetector computed tomography (Siriraj Med J 2018;70: 502-506)

INTRODUCTION

Recent advances in high-resolution thin-slice multidetector computed tomography (MDCT), and the widespread use of MDCT in abdominal imaging, has led to increased detection of adrenal pathology, such as focal nodules and diffuse enlargement. The incidence of adrenal nodules is approximately 3-7% in the adult population.[1,2] The vast majority of adrenal nodules in patients without known malignancy are benign adenomas.[3,4] The incidence of adrenal nodules is slightly increased about 9-13% in oncologic patients.[5,6] Therefore, the adrenal gland is a common site for metastases, particularly those arising from lung, breast, lymphoma, gastrointestinal tract, thyroid, kidneys and melanoma. However, only 26-36% of adrenal nodules are metastases.[5] Furthermore, diffuse enlargement is another common feature of adrenal gland pathology and the causes include bilateral adrenal hyperplasia (BAH), lymphoma, metastatic disease, tuberculosis, and histoplasmosis.

CT has been the primary imaging modality in the

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detection and characterization of adrenal lesions. To better recognize pathology, basic knowledge of normal size and morphology of the adrenal glands is important, particularly with small nodules and subtle lesions. Previous studies[7-10] described the normal size and morphology of the adrenal glands worldwide. However, there is a lack of data about normal size and morphology of adrenal glands in adult Thai population by using MDCT. Moreover, BAH is commonly observed in primary aldosteronism. In BAH, both adrenal glands are usually enlarged and the mean adrenal limb width is greater than normal. In general, the normal limits of adrenal gland size usually relied on the data of Vincent et al.,[11] and Lingam et al.,[12]; although we found some limitations in their studies including small number of patients.

The purpose of our study was to determine the size of normal adrenal glands, using the 95th percentile as a cutoff value, and to evaluate the location, morphology, and enhancement pattern of normal adrenal glands in adult Thai population using MDCT.

MATERIALS AND METHODS

Patient selection

The approval for this retrospective study was obtained by the ethical committee of the institute (Si 106/2013). A total of 175 consecutive adult patients between January 2006 and December 2013 underwent renal CT angiography for potential kidney donation in our institute. The exclusion criteria of the study were:

1. Patients who had obvious abnormal adrenal gland pathology, such as mass, cyst, or calcifications
2. Patients with previous history of abdominal trauma
3. Patients with history of tuberculosis or other granulomatous infections
4. Patients with a history of coagulopathy, taking anticoagulants, or any herbal medication

The 175 patients' (65 men and 110 women, mean age 35 years ± 9.0 SD, range 19-56 years) histories were reviewed by a resident using the medical records, medical record archiving system, and laboratory report system. We did not find any excluded patient in this population.

The CT technique

All examinations were performed with 64-detector MDCT scanners (Somatom Definition, Siemens Medical Solutions Erlangen, Germany and Light Speed VCT, General Electric Medical Systems Milwaukee WI, USA). The scans were performed with the following sequences: 1) scanogram (scout), 2) axial precontrast phase (images were obtained from hepatic dome to pubic symphysis), axial arterial phase (timed using a region of interest placed at the proximal renal artery, from hepatic dome to iliac crest), 3) axial nephrographic phase (delayed 100 seconds after contrast medium injection obtained from hepatic dome to pubic symphysis), 4) axial excretory phase (delayed 10 minutes after contrast medium injection from hepatic dome to pubic symphysis). The CT parameters included: 120 kVp voltage, 500 mA (GE) or 250 mA with CARE Dose 4D® in order to reduce radiation (Siemens) current, a gantry rotation time of 0.5 second, section thickness of 1.25-1.5 mm and a pitch of 1:0.9 (Siemens) or 1: 0.984 (GE).

Imaging analysis

Two experienced radiologists (W.T. and V.S., with 7 and 4 years of experience in abdominal imaging, respectively), interpreted the CT images of the adrenal glands at picture archiving and communication systems workstations (PACS; Synapse, Fujifilm Medical Systems, Tokyo, Japan). Each reader independently assessed the images and any disagreements were subjected to consensus. The location (cephalad and caudal relative to contralateral adrenal gland), morphology of each gland (linear, inverted V, inverted Y, and triangular shapes) and enhancement (homogeneous or heterogeneous enhancement, were evaluated in arterial and nephrographic phases). Each reader measured the thickness of the body (defined as the maximum thickness of the body perpendicular to the long axis in axial and coronal views [measured only in inverted V, inverted Y and triangular shape]) and the width of both limbs (defined as the maximum width of each limb in the axial and coronal planes [measured only in inverted V, inverted Y and linear shape]) the length of the glands (defined as the longest length from tip to the longest limb of the adrenal gland in the axial plane) using electronic calipers.

Statistical analysis

The location, morphology, and enhancement pattern of both adrenal glands measured by each reader were determined in terms of percentage. The size (including thickness, width and length) of both adrenal glands were determined in terms of mean, range, standard deviation (SD) and the 95th percentile (equal to mean + 1.96 SD). The interclass correlation coefficient (ICC) in measurement of size of both adrenal glands between the two readers was generated. An ICC value < 0.4 indicated poor inter-rater reliability; ≥ 0.4 < 0.75 which indicated fair or good inter-rater reliability, and ≥ 0.75 indicated excellent inter-rater reliability. The 95th percentile of normal adrenal gland size was determined as the cutoff value. Statistical analysis was performed using SPSS version 15.0 for Windows (IBM, Chicago IL, USA).

RESULTS

Size of adrenal glands

Table 1 shows the size of both adrenal glands measured by both readers (W.T. and V.S.). The ICCs in measurement of thickness, width, and length of both adrenal glands were about 0.3-0.4, 0.25-0.5, and 0.6-0.8, respectively. Furthermore, we evaluated the mean, SD, and 95th percentile of thickness, width and length of both adrenal glands by using pooled data of both reviewers.

Location of adrenal glands

The location of the right adrenal gland was more commonly cephalad to the left gland (58.9%).

Morphology of adrenal glands

The most common morphology of both adrenal glands was the inverted Y (85.8% on the right side and 93.7% on the left side). The less common morphologies of the adrenal glands were inverted V and linear shapes. The morphologies are shown in Table 2 and Fig 1.

TABLE 1. Measurement size of both adrenal glands.

	Parameters	Reader 1 (W.T)				Reader 2 (V.S)				Both readers
		Mean	Range	SD	P 95	Mean	Range	SD	P 95	Mean±SD (P 95)
Right adrenal gland	Axial thickness	4.91 mm.	2.8-6.75	0.72	6.04	4.52 mm.	2.33-6.73	0.87	6.04	4.7±0.64 (5.9)
	Coronal thickness	4.50 mm.	2.1-14.0	1.2	6.3	3.73 mm.	2.05-6.05	0.94	5.46	4.1±0.86 (5.5)
	Axial width medial limb	3.98 mm	2.53-6.75	0.68	5.14	3.27 mm.	1.43-5.32	0.77	4.66	3.6±0.62 (4.6)
	Coronal width medial limb	4.20 mm.	2.13-14.0	1.1	5.57	3.31 mm.	1.41-6.39	0.80	4.68	3.7±0.77 (4.8)
	Axial width lateral limb	3.83 mm.	2.12-6.75	0.81	5.13	3.05 mm.	1.48-5.65	0.78	4.55	3.4±0.66 (4.6)
	Coronal width lateral limb	3.68 mm.	1.9-14.0	1.14	5.08	2.72 mm.	1.28-5.72	0.78	4.17	3.2±0.75 (4.3)
	Axial length	3.32 cm.	2.36-4.8	0.42	4.00	3.14 cm.	1.44-5.20	0.58	4.08	3.2±0.44 (4.0)
Left adrenal gland	Axial thickness	5.03 mm.	2.53-12.4	1.27	6.90	4.45 mm.	2.39-7.79	1.06	6.48	4.7±0.97 (6.2)
	Coronal thickness	4.69 mm.	2.76-11.34	1.12	6.62	4.11 mm.	1.98-8.33	1.06	5.88	4.4±0.9 (6.0)
	Axial width medial limb	5.00 mm.	3.2-7.8	0.9	6.6	4.14 mm.	2.26-7.23	0.84	5.54	4.6±0.7 (5.7)
	Coronal width medial limb	4.88 mm.	3.04-7.11	0.87	6.28	4.06 mm.	1.88-9.45	1.05	5.68	4.5±0.74 (5.7)
	Axial width lateral limb	4.05 mm.	1.98-6.34	0.87	5.40	3.26 mm.	1.15-5.85	0.88	4.74	3.6±0.7 (4.8)
	Coronal width lateral limb	3.81 mm.	2.22-6.79	0.90	5.47	3.04 mm.	1.40-7.62	0.93	4.87	3.4±0.7 (4.6)
	Axial length	2.99 cm.	1.32-5.79	0.70	4.30	2.70 cm.	1.23-5.37	0.74	4.21	2.8±0.7 (4.2)

Abbreviations: P 95 = 95th percentile, SD = standard deviation

TABLE 2. Morphology of both adrenal glands.

Adrenal gland	Morphology/Shape	Number (%)
Right adrenal gland	Linear	2/175 (1.1%)
	Inverted V	23/175 (13.1%)
	Inverted Y	150/175 (85.8%)
	Triangular	0/175 (0%)
Left adrenal gland	Linear	1/175 (0.6%)
	Inverted V	10/175 (5.7%)
	Inverted Y	164/175 (93.7%)
	Triangular	0/175 (0%)



Fig 1. The morphology of normal adrenal glands.
A. Portovenous phase of CT shown inverted Y shape of left adrenal gland.
B. Portovenous phase of CT shown inverted V shape of right adrenal gland.
C. Portovenous phase of CT shown linear shape of left adrenal gland.

Pattern of enhancement

All glands showed homogeneous enhancement (100%) in the arterial and nephrographic phases.

DISCUSSION

Improvement in CT scanner technology increases the ability to demonstrate normal and abnormal adrenal glands. In our study, using 64-detector MDCT in all CT examinations with 1.25–1.5 mm. slice thickness, all normal adrenal glands were clearly identified. Our study was performed in potential renal donors that were representative of the normal population and we used a larger number of patients (175 patients) than the previous studies.[11,12] Additionally, our study performed thin-slice CT imaging which is more accurate. Our study found poor-to-fair interrater reliability of ICC in measurement of the thickness and width of both adrenal glands and fair-to-excellent inter-rater reliability of ICC in length of both adrenal glands. Although the ICC of our study had poor-to-fair interrater reliability in measurement of thickness and width of both adrenal glands, we found that the difference of measurement in adrenal gland size between the two readers was < 1 mm, suggesting no real essential impact on clinical practice. From our results, we recommend a 95th percentile cutoff value from both readers' data to determine the maximum normal size of the adrenal gland as shown in Table 1. Montagne JP et al.[7] suggested that adrenal limb width was the most useful of the measurements in clinical practice. The 95th percentile of normal size adrenal limb width in our study were as follows: 1) right adrenal gland: axial width medial limb 4.6 mm., coronal width medial limb 4.8 mm., axial width lateral limb 4.6 mm., coronal width lateral limb 4.3 mm. and 2) left adrenal gland: axial width medial limb 5.7 mm., coronal width medial limb 5.7 mm., axial width lateral limb 4.8 mm., coronal width lateral limb

4.6 mm. Interestingly, the measurement of thickness and limb widths of the normal adrenal gland in the coronal plane was first described in our study. Thus, either the axial or coronal plane can be used for determining the size of the adrenal glands, depending on which plane shows better delineation.

For frequency of the location, the right gland was slightly more frequently cephalad to the left gland, similar to the previous study by Montagne JP et al.[7]

Our study illustrated that the inverted Y shape was the most common shape of both right and left adrenal glands, 85.8% and 93.7%, respectively. The less common shapes were inverted V and linear shapes. Our result was the same as Karstaedt N et al.,[8] that found most common type was inverted Y. However, our study did not find a triangular shape among normal adrenal glands.

Finally, our study revealed that all normal adrenal glands had homogeneous enhancement in the arterial and nephrographic phases.

There were some limitations in our study. First, we could not perform CT of the abdomen on normal volunteers because of the radiation exposure and the associated ethical issues. Our study chose the population of potential renal donors that were available for CT of the abdomen and most resembled the normal population. Second, the cut-off value that we used, the 95th percentile of normal-sized adrenal gland, was not evaluated in its accuracy in distinguishing between normal and pathologic adrenal glands in clinical practice. Further investigation is required to determine the accuracy of this criterion.

CONCLUSION

The majority of normal adrenal glands were right relatively cephalad to left, inverted Y shape, and homogenous enhancement. The 95th percentile of size normal adrenal gland should be used as a cutoff value to differentiate between normal and thickened limbs and body.

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