

Volume assessment of normal adrenal gland from computed tomography: A pilot study

Kewalee Sasiwimonphan*

Phornanong Ariyajinda*

Sasiwimonphan K, Ariyajinda P. Volume assessment of normal adrenal gland from computed tomography : A pilot study. Chula Med J 2015 May - Jun; 59(3): 275 - 84

- Background** : *In clinical practice, it is quite difficult to differentiate pathologic adrenal hyperplasia from normal adrenal gland enlargement especially in the elderly. CT scan is so far the best technique to detect and measure the size of the glands. We, hereby, try to evaluate the volume of the adrenal gland through CT scan in several age groups of Thai people to identify its normal range.*
- Objective** : *To establish age-specific ranges of the volume of a normal adrenal gland in adult patients by using CT scan.*
- Setting** : *Department of Radiology, Faculty of Medicine, Chulalongkorn University.*
- Research Design** : *Cross sectional descriptive study.*
- Material and Methods** : *A total of 154 patients who underwent CT scan that included bilateral adrenal glands from September 2012 to March 2013 were prospectively selected on a 320-MDCT scanner, using KCMH CT protocol. The volumes of the adrenal glands were taken bilaterally, by hand outlining in axial post contrast image on workstation.*

- Results** : *In total, 154 patients who underwent CT scan that included adrenal glands were included in this study; 81 men, 73 women; mean age, 62 years. The right and left adrenal gland volumes increased with age ($r = 0.485$, and 0.381 , respectively in male population and $r = 0.572$, and 0.441 , respectively in female population, all $P < 0.001$). The volume of adrenal glands were increased in male population as compared to female population, scientific significant $P < 0.001$.*
- Conclusion** : *Normal range of adrenal volume in Thai populations was done by CT scan and confirmed that adrenal volume gland volumes increase by age and more larger in male population in the same age group.*
- Keywords** : *Adrenal gland volume, computed tomography (CT), sex, age group.*

Reprint request: Sasiwimonphan K. Department of Radiology, Faculty of Medicine, Chulalongkorn University, King Chulalongkorn Memorial Hospital, Bangkok 10330, Thailand.

Received for publication. March 4, 2014.

เกวลี ศศิวิมลพันธุ์, พรอนงค์ อริยจินดา. การหาปริมาตรของต่อมหมวกไตปกติ โดยใช้เอกซเรย์คอมพิวเตอร์ (Pilot study) โรงพยาบาลจุฬาลงกรณ์ ภาควิชารังสีวิทยา คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย. จุฬาลงกรณ์เวชสาร 2558 พ.ศ. - มิ.ย.; 59(3): 275 - 84

- เหตุผลของการทำวิจัย** : จากการปฏิบัติงาน มีความยากในการแยกระหว่างต่อมหมวกไตที่มีขนาดใหญ่ขึ้นจากตัวโรคที่ทำให้ต่อมหมวกไตทำงานมากขึ้นผิดปกติ กับภาวะต่อมหมวกไตขนาดใหญ่ขึ้นเองจากอายุที่เพิ่มมากขึ้น โดยเครื่องเอกซเรย์คอมพิวเตอร์สามารถใช้วัดขนาดของต่อมหมวกไตได้อย่างแม่นยำ ซึ่งการศึกษาของเราใช้เอกซเรย์คอมพิวเตอร์ในการหาปริมาตรของต่อมหมวกไตในแต่ละกลุ่มอายุของประชากรคนไทย
- วัตถุประสงค์** : เพื่อหาค่าปริมาตรของต่อมหมวกไตซึ่งแบ่งตามเพศและกลุ่มอายุต่าง ๆ โดยใช้เอกซเรย์คอมพิวเตอร์
- รูปแบบการวิจัย** : การศึกษาเชิงพรรณนา ณ เวลาจุดใดจุดหนึ่ง
- สถานที่ทำการศึกษา** : โรงพยาบาลจุฬาลงกรณ์ จังหวัดกรุงเทพมหานคร
- ตัวอย่างและวิธีการศึกษา** : ผู้ป่วยจำนวน 154 ราย ที่มาตรวจเอกซเรย์คอมพิวเตอร์ด้วยเครื่องเอกซเรย์คอมพิวเตอร์รุ่น Aquilion ONE ของบริษัทโตชิบา (Toshiba) ตั้งแต่เดือนกันยายน พ.ศ. 2555 ถึงเดือนมีนาคม พ.ศ. 2556 ซึ่งทำการตรวจครอบคลุมต่อมหมวกไตทั้ง 2 ข้าง การวัดปริมาตรของต่อมหมวกไตใช้วิธีวัดที่ละภาพด้วยมือในภาพหลังฉีดสารทึบรังสีโดยใช้โปรแกรมคำนวณหาปริมาตรของบริษัทจีอี (GE)
- ผลการศึกษา** : ผู้ป่วยจำนวน 154 ราย ที่มาตรวจเอกซเรย์คอมพิวเตอร์ด้วยเครื่องเอกซเรย์คอมพิวเตอร์ ซึ่งทำการตรวจครอบคลุมต่อมหมวกไตทั้ง 2 ข้าง เพศชายจำนวน 81 คน เพศหญิงจำนวน 73 คน อายุเฉลี่ย 62 ปี ปริมาตรต่อมหมวกไตทั้งข้างขวาและข้างซ้ายเพิ่มขึ้นตามอายุ โดย $r = 0.485$ และ 0.381 , ตามลำดับ ในกลุ่มประชากรเพศชาย และ $r = 0.572$, และ 0.441 , ตามลำดับ ในกลุ่มประชากรเพศหญิง อย่างมีนัยสำคัญทางสถิติ ($P < 0.001$) ทั้งเพศชายและหญิง
- สรุป** : ค่าปริมาตรของต่อมหมวกไตซึ่งแบ่งตามเพศและกลุ่มอายุต่าง ๆ โดยใช้เอกซเรย์คอมพิวเตอร์มีประโยชน์อย่างยิ่งในการแยกระหว่างต่อมหมวกไตที่มีขนาดใหญ่ขึ้น จากตัวโรคที่ทำให้ต่อมหมวกไตทำงานมากขึ้นผิดปกติ กับภาวะต่อมหมวกไตขนาดใหญ่ขึ้นเองจากอายุที่เพิ่มมากขึ้น
- คำสำคัญ** : ปริมาตรต่อมหมวกไต, เครื่องเอกซเรย์คอมพิวเตอร์, เพศ, กลุ่มอายุ.

The adrenal gland, approximately the same attenuation value as kidney, is delineated from its adjacent structures by the surrounding retroperitoneal fat. CT can show abnormal size, shape and mass of the glands, and also can safely, rapidly, and effectively demonstrate their normal anatomy or pathological enlargements. Previous studies that analyzed the size and configuration of the adrenal glands shown by CT were well correlated with the data available from post-mortem studies.⁽¹⁾

In clinical practice, to differentiate between normal and adrenal enlargements in elderly in whom abnormal enlargements are difficult to detect are crucial. Vincent *et al.*⁽²⁾ and Montagne *et al.*⁽³⁾ measured the size of normal adrenal glands by using CT, providing the maximum width of normal adrenal glands.

However, On the CT scan the shape of normal adrenal glands show varied shape from inverted V, triangle and linear shapes.^(2, 11) The maximal width has been incorrectly applied to measure the size in different shapes of the adrenal glands.

The CT systems producing images can measure volume of the organ accurately. The sex-specific ranges of normal volumes of a solid abdominal organ were outlined by each hand-on CT image each by using a computer, corrected for the height and weight of the patient, were determined for the kidneys, adrenals, liver, pancreas, spleen and the first lumbar vertebrae.⁽⁵⁾ Unfortunately, the sex-specific ranges of the volume of normal adrenal gland have been incorrectly applied because of adrenal enlargements in elderly. Previous studies assessed abdominal structure and function with CT and PET

with significantly increased volume of the adrenal gland with age.⁽⁴⁾ Relative increased volume of adrenal gland in male patient is noted⁽⁷⁾ but no significant differences in later study on 2013.⁽⁵⁾

We have investigated the capacity of CT to establish age-specific ranges of the volumes of a normal adrenal gland in adult Thai patients, which is useful for optimal interpretation of CT scan in patient with suspected diffuse adrenal gland enlargements, especially to evaluate correlation between the volume of adrenal gland and age.

Materials and Methods

Patient population:

Consecutive patients, who underwent CT scan that included bilateral adrenal glands (CT chest, CTPA, CTA aorta, CT upper abdomen or whole abdomen) at the Department of Radiology, King Chulalongkorn Memorial Hospital from September 2012 to March 2013, were prospectively recruited. Each patient was recruited only once. The CT studies were performed for routine clinical evaluation. Informed consent from the patient was performed.

Patients who were less than 21 years, those with history of malignancy or conditions known to affect the adrenal gland were excluded from the study. Adrenal glands with focal mass lesion, as judges by CT, were also excluded; those with CT scans that had abnormal features such as bilateral cutoff edges or movement artifacts that could influence various measurements of this study were also excluded.

In general, the adrenal glands were considered normal bases on information available in the CT images, the patient's chart and the radiologist's

report, coupled with clinical judgment in case by case assessment. Based on these criteria, 154 subjects remained in the study.

Image acquisition

All CT examinations were performed on a 320-MDCT scanner (Aquilion ONE, Toshiba Medical systems Corporation) using KCMH CT chest, CTA aorta, CT abdomen or CTPA protocol (Table 2). The patients were in supine position and requested to take quiet respiration. Caudo-cranial scan was performed on each patient.

Image analysis

All CT scan images were downloaded from our research PACS system, then transferred to the GE healthcare workstation using volume assessment program (AW volume share 5). The studies were viewed on the monitor of the workstation for review of DICOM header information (age and sex), which could subsequently be recorded on spreadsheet.

Window and level setting were selectable in custom software, but setting was typically close to a window of 500 and a level of 70. All outlining was performed by the researcher and the advisor. The boundaries of the right and left adrenal glands were hand-outlined in axial post contrast images as shows in figure 1. The volumes of the right and left adrenal glands were calculated by summation of the slice volumes of 1 mm thick and determined by multiplying the surface area by each slice thickness using a volume program, calculating the volume in cubic centimeters. The image files were saved as DICOM files.

All images were privately reviewed in the film reading room by the researcher and the advisor. The

patients' data were kept secret. The research proposal has been reviewed and approved by the Ethics Committee of the Faculty of Medicine, Chulalongkorn University.

Data collection

The demographic data including age, sex, clinical history and underlying diseases of all patients were collected.

The volumes of the adrenal glands were measured bilaterally.

Data analysis

The volume of each adrenal gland was presented as mean and standard deviation (SD). Statistical analyses were computed with a statistical software package (SPSS, version 17.0; IBM Corporation, Armonk, NY).

The analysis of correlation between the volume of the adrenal gland and age was used to Pearson correlation with statistical significance was considered to be present when p values were less than 0.001.

Comparison between the volume of adrenal gland and sex was used by un-paired t-test and statistical significant was considered to be present when P values were less than 0.005.

Results

A total of 154 patients underwent CT scan that included adrenal glands (CT chest, upper abdomen or whole abdomen, CTPA, CTA aorta) on 320-MDCT scanner (Aquilion ONE) during the study period, 81 (53%) men and 73 (47%) women with age range between 21 years and 91 years, with the mean age of 62 years were included in this study (Table 1).

Table 1. Distribution of the final population according to sex and age groups.

Age (yrs) \ Sex	Male	Female
21 - 40	14	11
41 - 60	25	28
More than 60	39	33
Total	78	72

The ranges of age-specific and sex-specific groups of each ad right and left adrenal gland volume in male and female populations are shown in Table 2, 3.

Table 2. Protocol for CT of Aquillion ONE at KCHM.

CT	CT chest	CT whole abdomen	CT upper abdomen	CT whole aorta	CT abdominal aorta	CTA lower extremity	CTPA
kV	120	120	120	120	120	120	100
Slice collimation	80 × 0.5	80 × 0.5	80 × 0.5	100 × 0.5	100 × 0.5	64 × 0.5	100 × 0.5
Slice thickness	1 mm	2 mm	2 mm	3 mm	3 mm	3 mm	1 mm
Overlap	0.8 mm	1 mm	1 mm	1.5 mm	1.5 mm	1.5 mm	0.8 mm
Gantry rotation time	0.5 sec	0.5 sec	0.5 sec	0.5 sec	0.5 sec	0.65 sec	0.35 sec
Pitch	65	65	65	103	103	53	103
Non-ionic contrast media (300 mgI/ml)	80 ml	100 ml	100 ml	(Scan time + 10) × flow rate	(Scan time + 10) × flow rate	110 ml	40 ml
Flow rate (ml/sec)	2	2 (venous) 3 (dual)	2	5	5	Phase I : 4.5 Phase li : 3.0	4
Bolus tacking	180 HU	180 HU	180 HU	180 HU	180 HU	250 HU	120 HU
Threshold level	Aorta at mid scan range	Aorta at mid scan range	Aorta at mid scan range	Aorta at mid scan range	Aorta at mid scan range	Aorta at mid scan range	at pulmonary trunk

The volumes of the right and left adrenal glands increased with age ($r = 0.485$, and 0.381 , respectively in male population and $r = 0.572$, and 0.441 , respectively in female population, all $P < 0.001$. There are scattered plot of the adrenal volumes and age showed in figure 2 and 3 according on male and female population, respectively.

Comparison with male and female group shows larger volume of adrenal gland in male population than female population scientific significantly, p value < 0.005 . (p value < 0.001 in right adrenal gland volume and p value = 0.001 in left adrenal gland volume)

Left adrenal gland shows more volume than right adrenal glands in all age groups.

Table 3. Ranges of volumes of sex-specific and age-specific groups of normal bilateral adrenal glands, in male and female population.

Age group	Mean age		Right adrenal volume		Left adrenal volume	
	Male	Female	Male	Female	Male	Female
20 - 40	32	31	2.56 ± 0.82	1.92 ± 0,54	3.34 ± 0.57	2.56 ± 0.53
40 - 60	51	51	3.25 ± 0.94	2.51 ± 0.91	4.25 ± 1.06	3.53 ± 0.87
More than 60	72	74	3.75 ± 0.96	3.16 ± 0.76	4.46 ± 0.88	3.99 ± 1.13



Figure 1. Contrast enhanced CT scan of the upper abdomen showed white thin line outline surrounding of the left adrenal gland (arrow) and repeat outline in continuous slides to calculate adrenal volume.

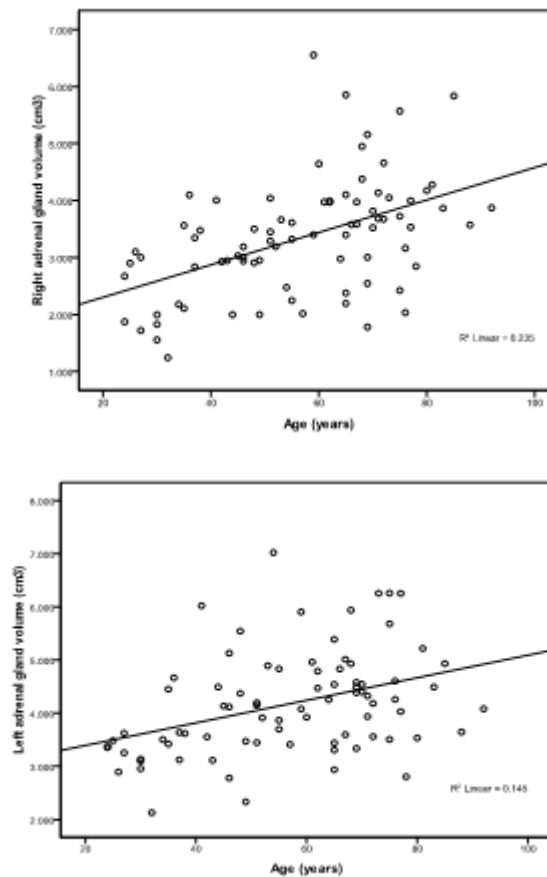


Figure 2. Scatterplot showing the results of regression analysis of adrenal gland volume in the right and left side in male population. (n = 81)

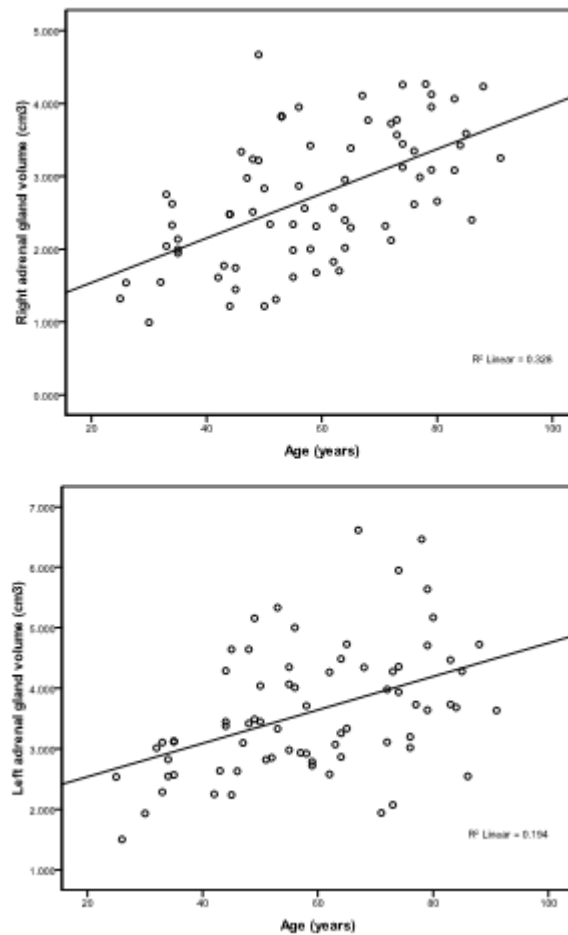


Figure 3. Scatterplot showing the results of regression analysis of adrenal gland volume in the right and left side in female population. ($n = 73$)

Discussion

The current diagnostic utility of CT images relies primarily on subjective interpretation, but as CT systems has advanced and as the number of CT examinations increase, the quantitative nature of this modality may play an ever-increasing role in improving diagnostic accuracy.^(2, 8) High labor intensive hand-outlining techniques were used in the previous study for solid organ volumes.⁽⁵⁾

The results of our study demonstrated normal range of adrenal gland volume in adult patients without conditions known to affect the adrenal glands, history of malignancy disease or focal mass lesion by hand-

outlining technique. In our study, the adrenal glands grow in volume to statistically significant degree with increasing age with correlated to the previous study of Meier *et al.*⁽⁴⁾

Regarding to sex, our study showed significant larger of the adrenal gland volume on male population compared to female population contrast with prior study from 2013. However, the size of organ is relative to another person depending on a number of factors; in general, a 2-m 100-kg person is likely to have larger organs than a 1.5-m 50 kg individual. Averaged over the seven soft tissue organs that were the focus of a previous study^(4,6), corrections for height

and weight reduce the variance by 24.3% (range, 5.8 – 39.0%) as compared with the uncorrected data of the volumes of organs. Our study do not corrected volume of the adrenal with patient size which resulted in relative higher volume of adrenal gland in male patient similar on study from Geraghty EM et al since 2009.

Limitations of our study were not approach the body size, which might be limited for application in specific patient, small numbers of patient in each age groups might not represent the whole population and for the measurement, there was merely identifying and distinguishing the adrenal gland from the adjacent structures, especially contiguous the lateral limb of the right adrenal gland with the liver without intervening the fat plane. However our intra-observer variability of this study shows almost perfect agreement.

Last, volume measurement of solid organ on CT scan is commonly uses now in clinical practice, however still take long time and inconvenience to do in routine work. Other simple parameter such as adrenal gland thickness or width of the gland may be easier to do for evaluate adrenal gland size and pathology⁽⁵⁾ and required study to establish cut point between normal and pathology diffuse enlargement of adrenal glands.

Conclusion

Normal range of adrenal volume in Thai populations was done by CT scan and confirmed that adrenal volume gland volumes increase by age and more larger in male population in the same age group. Further investigation for searching cut off value from normal and hyperplasia of the adrenal gland should be considered to more useful in clinical setting.

References

1. Wilms G, Baert A, Marchal G, Goddeeris P. Computed tomography of the normal adrenal glands: correlative study with autopsy specimens. *J Comput Assist Tomogr* 1979 Aug;3(4):467-9
2. Vincent JM, Morrison ID, Armstrong P, Reznek RH. The size of normal adrenal glands on computed tomography. *Clin Radiol* 1994 Jul; 49(7):453-5
3. Montagne JP, Kressel HY, Korobkin M, Moss AA. Computed tomography of the normal adrenal glands. *AJR Am J Roentgenol* 1978 May; 130(5):963-6
4. Meier JM, Alavi A, Iruvuri S, Alzeair S, Parker R, Houseni M, Hernandez-Pampaloni M, Mong A, Torigian DA. Assessment of age-related changes in abdominal organ structure and function with computed tomography and positron emission tomography. *Semin Nucl Med* 2007 May;37(3):154-72
5. Wang X, Jin ZY, Xue HD, Liu W, Sun H, Chen Y, Xu K. Evaluation of Normal Adrenal Gland Volume by 64-slice CT. *Chin Med Sci J* 2013 Jan;27(4):220-4
6. Breiman RS, Beck JW, Korobkin M, Glenny R, Akwari OE, Heaston DK, Moore AV, Ram PC. Volume determinations using computed tomography. *AJR Am J Roentgenol* 1982 Feb; 138(2): 329-33
7. Geraghty EM, Boone JM, McGahan JP, Jain K. Normal organ volume assessment from abdominal CT. *Abdom Imaging* 2004 Jul; 29(4):482-90
8. Schultz CL, Haaga JR, Fletcher BD, Alfidri RJ, Schultz MA. Magnetic resonance imaging

- of the adrenal glands: a comparison with computed tomography. *AJR Am J Roentgenol* 1984 Dec; 143(6):1235-40
9. Vincent JM, Morrison ID, Armstrong P, Reznek RH. Computed tomography of diffuse, non-metastatic enlargement of the adrenal glands in patients with malignant disease. *Clin Radiol* 1994 Jul;49(7):456-60
10. Johnson PT, Horton KM, Fishman EK. Adrenal imaging with multidetector CT: evidence-based protocol optimization and interpretative practice. *Radiographics* 2009 Sep; 29(5):1319-31
11. Karstaedt N, Sagel SS, Stanley RJ, Melson GL, Levitt RG. Computed tomography of the adrenal gland. *Radiology* 1978 Dec; 129(3):723-30
12. Koehler PR, Anderson RE, Baxter B. The effect of computed tomography viewer controls on anatomical measurements. *Radiology* 1979 Jan;130(1):189-94
13. Amsterdam JD, Marinelli DL, Arger P, Winokur A. Assessment of adrenal gland volume by computed tomography in depressed patients and healthy volunteers: a pilot study. *Psychiatry Res* 1987 Jul;21(3):189-97