

**ORIGINAL ARTICLE**DOI: <https://doi.org/10.3329/mediscope.v8i1.52198>**Histomorphometric Study of the Proportion of Cortex and Medulla of the Adrenal Gland-A Postmortem Study****D Siddiqua¹, ASM Nurunnabi², F Johora³, H Hena⁴, S Shahriah⁵, S Ara⁶****Abstract**

Background: The human adrenal gland shows a distinct proportion of two histological zones, named the cortex and the medulla, from outer inwards, in its histological appearance with differences in its cellular components and functions. **Objective:** The present study aims to see the variation in the proportion of the cortex and the medulla of the adrenal glands with age in a Bangladeshi population. **Methods:** A cross-sectional, descriptive study was done in the Department of Anatomy, Dhaka Medical College, Dhaka, from July 2008 to June 2009, based on collection of 140 postmortem human adrenal glands from 70 unclaimed dead bodies, in the Department of Forensic Medicine, Dhaka Medical College, Dhaka. The samples were divided into four age-groups including A (11-20 years), B (21-30 years), C (31-40 years) & D (41-60 years). Histological slides were prepared by using routine haematoxylin and eosin stain (H & E). Five best prepared slides from each group were examined under light compound microscope with low magnification. The thickness of adrenal cortex and medulla were measured by using ocular and stage micrometer and then converted into percentage volume. **Results:** The mean volume of the right adrenal cortex were found $83.64 \pm 3.71\%$ in group A, $83.90 \pm 1.75\%$ in group B, $83.74 \pm 5.78\%$ in group C, $84.80 \pm 3.82\%$ in group D, while the mean volume of the corresponding medulla were found $18.16 \pm 3.23\%$ in group A, $15.70 \pm 2.71\%$ in group B, $16.26 \pm 3.97\%$ in group C, $16.20 \pm 4.04\%$ in group D. The mean volume of the left adrenal cortex were found $84.64 \pm 3.49\%$, $84.90 \pm 1.75\%$, $84.20 \pm 3.40\%$, $85.44 \pm 2.66\%$ in group A, B, C and D respectively, while the mean volume of the corresponding medulla were found $17.26 \pm 3.84\%$, $17.00 \pm 2.37\%$, $16.00 \pm 3.20\%$ and $14.36 \pm 2.33\%$ in group A, B, C and D respectively. The differences among the groups were not statistically significant. **Conclusion:** No difference was found in the proportion of the cortex and the medulla of adrenal gland in different age-groups.

Key wards: Human adrenal gland, Adrenal cortex, Adrenal medulla.

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Introduction

The adrenal gland is composed of two distinct portions: an outer cortex (mesodermal origin) and an inner medulla (neuroectodermal origin)¹. The medulla is completely enclosed by the cortex, except at the hilum². The collagenous connective tissue capsule that covers the adrenal gland sends thin septa to the interior of the gland as trabeculae^{1,2}. The stroma consists of rich network of the reticular fibres that support the secretory cells¹. The central portion of the adrenal gland, the medulla, is composed of endocrine parenchymal cells i.e. chromaffin cells, along with connective tissue, numerous blood vessels and nerves¹. The chromaffin cell, named for the yellow-brown colour imparted to its epinephrine containing granules by chromatic salts, is the major cell type in adrenal medulla³. Chromaffin cells are rounded or polygonal and arranged in nests or cords¹⁻³. However, when specific immunostains are used, chromaffin cells have been found in the human adrenal cortex and cortical cells have been found in the adrenal medulla, which provides a cellular basis for potential intraadrenal interactions⁴. Hence, controversies prevail in the accurate histological proportion of the cortex and medulla in adrenal gland. Therefore, a sound knowledge on proportion of cortical and medullary regions of the adrenal gland is essential for clinical decision making in endocrinology, pathology, radiology and surgery for better diagnosis and management of diseases of this essential organ. The present study aims to see the variation in the proportional volume of the cortex and the medulla of the adrenal glands with advancing age in a Bangladeshi population and compare with the previous studies and available text references.

Materials and methods

A cross-sectional, descriptive study was done in the Department of Anatomy, Dhaka Medical College, Dhaka, between July 2008 and June 2009, to see the variation in the proportion of the cortex and the medulla of the adrenal glands in different age-groups in a Bangladeshi population. The study was based on collection of 140 postmortem human adrenal glands collected from 70 unclaimed dead bodies which were in the morgue under examination in the Department of Forensic Medicine, Dhaka Medical College, Dhaka. All the samples were collected within 24-36 hours of death without any sign of putrefaction and taken from medicolegal cases excluding poisoning, any cutting or crushing injury to the adrenal glands, and adrenal glands found in one side and diseased.

Grouping of the Sample: For convenience of description of various changes of the adrenal gland in relation to age, the collected samples were divided into four groups including A (11-20 years), B (21-30 years), C (31-40 years) & D (41-60 years), according to Kangarloo et al.⁵.

Procedure of histological study: The tissue blocks of the adrenal glands were fixed in 10% formol saline in a plastic container. The tissues were washed in running tap water, dehydration was done with ascending grades of alcohol, cleared with xylene, infiltrated and embedded in paraffin. Paraffin blocks were cut at 5 m thickness and were stained with routine Harris' Haematoxylin and Eosin (H & E) stain. All the measurements were taken by using an Olympus CHB light microscope, made in Tokyo, Japan. At first, the thickness of the adrenal cortex and medulla were determined (Fig. 1). For measuring the thickness of cortex and medulla of adrenal gland 5 best prepared slides were selected from each group.

Hence, a total of 20 slides were examined low magnification (10 objectives, 10 eyepiece). Three different fields were chosen for measuring the thickness from each slide. The thickness was measured by using a stage micrometer and an ocular micrometer.

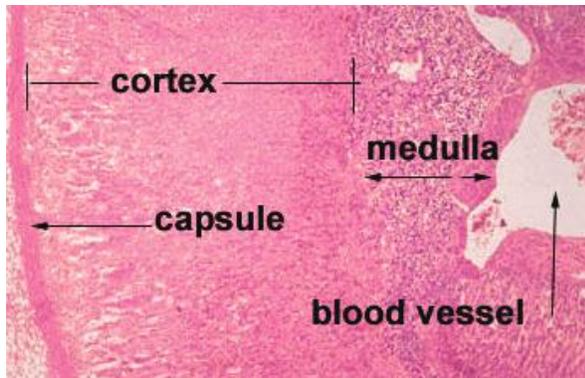


Fig. 1. Photomicrograph of the human adrenal gland showing the extent of cortex and medulla, taken from group B (21-30 years), ($\times 100$ magnification) (H & E stain).

Three measurements were taken for each slide and the average was recorded. The stage micrometer calibration was focused under the objective to be used and the ocular micrometer calibration was superimposed on them in such a way that starting mark on the ocular micrometer matched exactly with a starting mark on the stage micrometer. Then the marker on the stage and ocular micrometer that corresponds to each other most closely was noted. Then determination of how many of the smallest division of the ocular micrometer corresponded with how many smallest division of the stage micrometer was done, according to Nurunnabi et al.⁶. After getting the thickness in μm , it was converted into percentage proportion which signifies percentage volume of cortex and medulla as well.

Statistical processing of data: The data collected were processed and statistical analyses were done by using SPSS version 13.0. The comparison between the right and the left was done by unpaired Student's 't' test and in between different groups by One-way ANOVA.

Ethical Clearance: The present study was approved by the Ethical Review Committee of Dhaka Medical College, Dhaka.

Results

Proportion (percentage volume) of the right and left adrenal cortex: In the present study, the mean percentage volume of the right adrenal cortex were found $83.64 \pm 3.71\%$ in group A, $83.90 \pm 1.75\%$ in group B, $83.74 \pm 5.78\%$ in group C, $84.80 \pm 3.82\%$ in group D (Table 1, Fig. 2). Besides, the mean percentage volume of the left adrenal cortex were found $84.64 \pm 3.49\%$, $84.90 \pm 1.75\%$, $84.20 \pm 3.40\%$, $85.44 \pm 2.66\%$ in group A, B, C and D respectively (Table 1, Fig. 2). The difference between the groups was not statistically significant ($P > 0.05$).

Proportion (percentage volume) of the right and left adrenal medulla: The mean percentage volume of the right adrenal medulla were found $18.16 \pm 3.23\%$ in group A, $15.70 \pm 2.71\%$ in group B, $16.26 \pm 3.97\%$ in group C, $16.20 \pm 4.04\%$ in group D (Table 2, Fig. 2). Besides, the mean percentage volume of the left adrenal medulla were found $17.26 \pm 3.84\%$, $17.00 \pm 2.37\%$, $16.00 \pm 3.20\%$ and $14.36 \pm 2.33\%$ in group A, B, C and D respectively (Table 2, Fig. 2). The difference between the groups was not statistically significant.

Table 01: Percentage volume of right and left adrenal cortex in different age group

Age group	Percentage volume of adrenal cortex		P value
	Right Mean±SD	Left Mean±SD	
A (11-20 years) (n=5)	83.64±3.71 (78.20-88.00)	84.64±3.49 (79.00-88.20)	>0.50 ^{ns}
B (21-30 years) (n=5)	83.90±1.75 (82.00-85.50)	84.90±1.75 (83.00-86.50)	>0.10 ^{ns}
C (31-40 years) (n=5)	83.74±5.78 (74.00-88.20)	84.20±3.40 (79.00-88.50)	>0.50 ^{ns}
D (41-60 years) (n=5)	84.80±3.82 (79.00-88.50)	85.44±2.66 (82.00-88.20)	>0.50 ^{ns}
	P value	P value	
A vs B	>0.50 ^{ns}	>0.50 ^{ns}	
A vs C	>0.50 ^{ns}	>0.50 ^{ns}	
A vs D	>0.50 ^{ns}	>0.50 ^{ns}	
B vs C	>0.50 ^{ns}	>0.50 ^{ns}	
B vs D	>0.50 ^{ns}	>0.50 ^{ns}	
C vs D	>0.50 ^{ns}	>0.50 ^{ns}	

Figures in the parentheses indicate range. Comparison between right and left side done by unpaired Student's 't' test

and comparison between different age groups done by One-way ANOVA (PostHoc), ns = not significant.

Table 02: Percentage volume of right and left adrenal medulla in different age group

Age group	Percentage volume of adrenal medulla		P value
	Right Mean±SD	Left Mean±SD	
A (11-20 years) (n=5)	18.16±3.23 (15.00-22.00)	17.26±3.84 (14.00-21.80)	>0.50 ^{ns}
B (21-30 years) (n=5)	15.70±2.71 (13.50-18.00)	17.00±2.37 (14.50-20.00)	>0.10 ^{ns}
C (31-40 years) (n=5)	16.26±3.97 (12.00-21.00)	16.00±3.20 (13.50-21.00)	>0.50 ^{ns}
D (41-60 years) (n=5)	16.20±4.04 (12.00-21.00)	14.36±2.33 (22.00-28.00)	>0.10 ^{ns}
	P value	P value	
A vs B	>0.10 ^{ns}	>0.50 ^{ns}	
A vs C	>0.10 ^{ns}	>0.50 ^{ns}	
A vs D	>0.10 ^{ns}	>0.10 ^{ns}	
B vs C	>0.50 ^{ns}	>0.50 ^{ns}	
B vs D	>0.50 ^{ns}	>0.10 ^{ns}	
C vs D	>0.50 ^{ns}	>0.10 ^{ns}	

Figures in the parentheses indicate range. Comparison between right and left side done by unpaired Student's 't' test

and comparison between different age groups done by One-way ANOVA (PostHoc), ns = not significant.

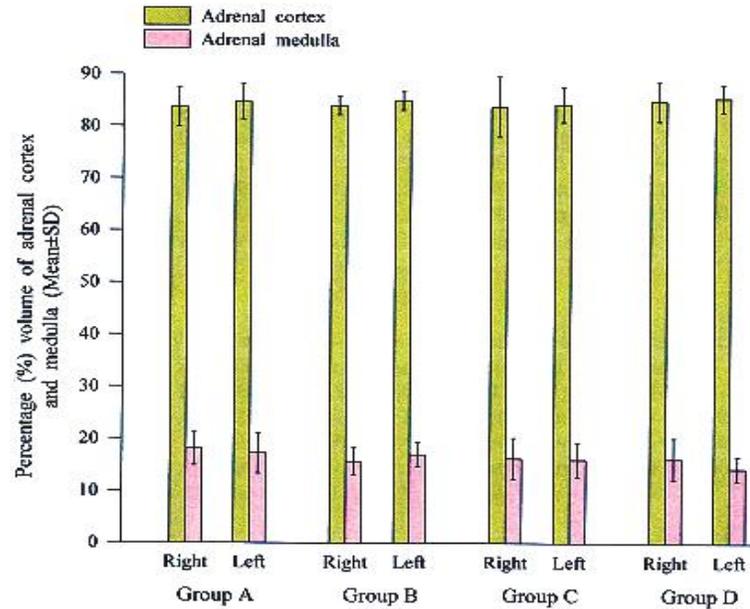


Figure 03: Percentage of volume of right and left adrenal cortex and medulla in different age groups.

Discussion

According to Kopin⁷, adrenal medulla constitutes 5%-10% and cortex constitutes 90%-95% of the gland. Fawcett⁸ and Nussey & Whitehead⁹ mentioned that the outer cortex accounts for about 80%-90% and inner medulla for 10%-20%. According to O'Brien³ and Aron et al.¹⁰, the outer cortex comprises 90% and the inner medulla constitutes 10% of the total glandular volume. Barrett et al.¹¹ mentioned that the cortex constitutes 72% and the medulla is 28% of the mass of the adrenal gland. Hall¹² reported that the adrenal medulla constitutes the central 20% and the outer cortex is about 80% of the gland. Roy¹³ stated that the adrenal cortex is bright yellow (90%) and much thicker than the medulla (10%), which is reddish brown. According to Gartner & Hiatt¹⁴, the outer cortex accounts for about 80%-90% and medulla for 10%-20% of the volume of the adrenal glands. In the present autopsy-based study, on an average the volume of cortex and medulla were

found 83.64-85.44% and 14.36-18.16% respectively in human adrenal glands. Our findings are similar to those reported by Fawcett⁸, Nussey & Whitehead⁹, Hall¹² and Gartner & Hiatt¹⁴, but slightly deviated from as described by Kopin⁷, O'Brien³, Aron et al.¹⁰ and Roy¹³ and much lower than that of Barrett et al.¹¹. However, there is no previous study in our country on proportion of the cortex and the medulla of human adrenals, as to compare with the present study.

Conclusion

No difference was found in cortex and medulla of adrenal gland in different age-groups. To our knowledge, this is the first ever study in our country on determining the proportion of cortex and medulla of the adrenal gland. However, further studies with larger samples and advanced stereological techniques are recommended. The results of the present study can be used as a standard reference for the adrenal glands of Bangladeshi people and to determine the abnormal evidence in pathological cases.

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References

1. Mescher AL. ed. Junqueira's basic histology: text and atlas. 13th ed. New York: McGraw-Hill; 2013: p.414-8.
2. Borley NR. Suprarenal (adrenal) gland. In: Standring S, Borley NR, Collins P, Crossman AR, Gatzoulis MA, Healy JC, et al. eds. Gray's anatomy: the anatomical basis for clinical practice. 40th ed. Edinburgh: Elsevier Churchill Livingstone; 2008: p.1197-1201.
3. O'Brien DMA. Morphology of the adrenal cortex and medulla. In: Becker KL, Bilezikian JP, Bremner WJ, Hung W, Kahn CR, Loriaux DL, et al. eds. Principles and practice of endocrinology and metabolism. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2001: p.698-704.
4. Bornstein SR, Gonzalez-Hernandez JA, Erhart-Bornstein M, Adler G, Scherbaum WA. Intimate contact of chromaffin and cortical cells within the human adrenal gland forms the basis for important intraadrenal interactions. *J Clin Endocrinol Metab* 1994;78(1):225-32.
5. Kangarloo H, Diament MJ, Gold RH, Barrett C, Lippe B, Geffner M, et al. Sonography of adrenal glands in neonates and children: changes in appearances with age. *J Clin Ultrasound* 1986;14(1):43-7.
6. Nurunnabi ASM, Mahbub S, Shahriah S, Begum GN, Ara S. Thyroid follicles and parenchyma are found to increase with advancing age during the first 50 years of life in Bangladeshi people. *J Bangladesh Soc Physiol* 2009;4(2):88-92.
7. Kopin IJ. Catecholamines, adrenal hormones, and stress. In: Krieger DT, Hughes JC. eds. *Neuroendocrinology*. Sunderland: Sinauer Associates; 1980: p.159.
8. Fawcett DW. Bloom & Fawcett – a textbook of histology. 12th ed. New York: Chapman & Hall; 1994: p.503-15.
9. Nussey S, Whitehead S. The adrenal gland. In: *Endocrinology: an integrated approach*. 1st ed. Oxford: BIOS Scientific Publishers Ltd.; 2001: p.122.
10. Aron DC, Findling JW, Tyrrell JB. Glucocorticoids & adrenal androgens. In: Gardner DG, Shoback D. eds. *Greenspan's Basic & clinical endocrinology*. 8th ed. New York: McGraw-Hill; 2007: p.346-95.
11. Barrett KE, Barman SM, Boitano S, Brooks HL. eds. *The adrenal medulla & adrenal cortex*. *Ganong's review of medical physiology*. 23rd ed. New York: McGraw-Hill; 2010: p.337-61.
12. Hall JE. Adrenocortical hormones. In: Guyton and Hall: *textbook of medical physiology*. 12th ed. Philadelphia: Saunders Elsevier; 2011: p.921-4.
13. Roy H. The adrenal gland. In: *Short textbook of surgery with focus on clinical skills*. 1st ed. New Delhi: Jaypee; 2011: p.163-8.
14. Gartner LP, Hiatt JL. *Color atlas and text of histology*. 6th ed. Baltimore: Lippincott Williams & Wilkins; 2014: p.246-8.