

# Histomorphological Study of the Wall Thickness and Luminal Diameter of Cadaveric Vermiform Appendix in Bangladeshi People

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**Abstract** Vermiform appendix is a blind-ending tubular structure, arises from the posteromedial aspect the cecum inferior to the ileocecal junction. It has a thick wall and narrow lumen due to presence of large lymphoid follicles within its wall. Appendicitis is the most common clinical condition of vermiform appendix, caused by obstruction of the lumen. The causes of the obstruction include lymphoid hyperplasia secondary to irritable bowel disease (IBD) or infections (more common during childhood and in young adults), fecal stasis and fecaliths (more common in elderly patients), parasites (especially in Eastern countries), or, more rarely, foreign bodies and neoplasms. This study was done to find out the wall thickness and luminal diameter of the vermiform appendix in Bangladeshi people to magnify the knowledge regarding the diverse anatomy of vermiform appendix in our population. It was a descriptive cross-sectional study with some analytical components performed on 60 (sixty) cadaveric vermiform appendices of Bangladeshi people of different ages in the department of Anatomy, Sir Salimullah Medical College, Dhaka, from January 2008 to June 2009. For convenience of differentiating the wall thickness and luminal diameter of vermiform appendix in relation to different age, the collected samples were divided into five groups (group A-0 to 20 years, group B-21 to 30 years, group C-31 to 40 years, group D-41 to 50 years and group E->50 years). From each age group, six (6) fresh samples were selected for histological study. From each vermiform appendix three slides were prepared each from its base, middle part and near the tip and were stained with routine H & E stain. The wall thickness and luminal diameter was measured through micrometry. In the present study, average wall thickness of the vermiform appendix ranged from 2.25 mm to 3.10 mm. The average wall thickness was highest in group A (2.53±0.01 mm), which gradually decreased through group B, C, D and the lowest value was in group E (2.26±0.07 mm). Average luminal diameter ranged from 1.90 mm to 2.96 mm. Average luminal diameter was lowest in group A (2.04±0.45 mm) and highest in group D (2.68±0.57 mm). In group E, the value (2.32±0.98 mm) was higher than that of group D. There was negative correlation between age and average wall thickness, and positive correlation between age and average luminal diameter, both of which reached the level of significance ( $p < 0.001$ \*\*\*).

**Keywords:** wall thickness, luminal diameter, vermiform appendix, Bangladeshi people

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## 1. Introduction

Appendicitis is the most common clinical condition of the vermiform appendix. Many cases of acute appendicitis result from obstruction of the lumen of the appendix by lymphoid hyperplasia, fecalith, fecal stasis, foreign body, worms or tumors, followed by infection [1]. In 60% of patients, obstruction is caused by hyperplasia of the intramural lymphoid follicles [2]. These follicles enlarge and increase steadily in number to a maximum of 200 at 15 to 20 years of age, and then decrease and practically disappear after the age of 60 [1,3]. The lumen is small,

irregular and wider in the young child and may be partially or completely closed after mid-adult life [4,5]. Diameter of the lumen is 1 to 3 mm. Thickness of the wall of the appendix is 1 to 2.5 mm [6]. There is a strong relationship between diameter of lymphoid follicles, wall thickness and luminal diameter. The luminal diameter decreases when either wall thickness or diameter of lymphoid follicle increases, suggesting that obstruction can occur at such sites, leading to development of appendicitis [7]. In most textbooks [8,9,10] the mentioned anatomic variations in the gross and histomorphological characteristics are based on the studies of Western people. Moreover, only few histomorphological studies were carried out on the wall thickness and luminal diameter of

the vermiform appendix. The present study was done with a view to establish a standard baseline data for various age groups of Bangladeshi people regarding wall thickness and luminal diameter of the vermiform appendix by histomorphological study.

## 2. Materials and Methods

The study was carried out in the department of Anatomy, Sir Salimullah Medical College, Dhaka, from January 2008 to June 2009, on sixty (60) postmortem vermiform appendices of different age groups of Bangladeshi people after approval of the protocol of the research by the Ethical Review Committee of Sir Salimullah Medical College, Dhaka. Specimens of vermiform appendices were collected within 12 to 36 hours of death from unclaimed human dead bodies that showed no sign of putrefaction and that were autopsied on the different dates in the morgues of the Departments of Forensic Medicine of Dhaka Medical College (DMC) and Sir Salimullah Medical College (SSMC), Dhaka. The collected samples were divided into five groups; Group-A (0-20 years), Group-B (21-30 years), Group-C (31-40 years), Group-D (41-50 years) and Group-E (>50 years) as was shown in Table 1.

**Table 1. Age grouping of the vermiform appendices, following [11]**

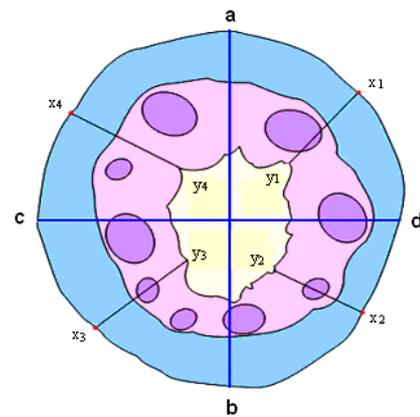
Groups	Age in years	No. of samples (n=60)	Percentage frequency
A	0-20	9	15
B	21-30	19	31.67
C	31-40	12	20
D	41-50	14	23.33
E	>50	6	10

The vermiform appendices were preserved in 10% formol saline. From each age group, six (6) fresh samples were selected for histological study. Three pieces of tissues were taken from three different regions i.e. the base, middle part and near the tip of the appendix. One paraffin block was prepared with each piece of tissue. Then, several transverse sections were prepared for each region of each of the six appendices of each group. One good slide prepared as above from each tissue block was chosen for the study. As three slides were chosen from three regions of the same appendix, therefore,  $3 \times 6 = 18$  slides were made for histological study from each group. Accordingly,  $5 \times 18 = 90$  slides were prepared from five age groups. The sections were processed following standard histological procedures and were stained with routine hematoxylin and eosin stain. For the measurement of the wall thickness and luminal diameter, the entire section of each slide was focused under low magnification (10X) of microscope.

### 2.1. Measurement of the Wall Thickness

A piece of transparent plastic sheet (about the size of a cover slip) was divided photographically into four equal quadrants by drawing two straight lines at right angles (Figure 1). Then it was placed over a histological slide properly in such a way that the crossing point of the two

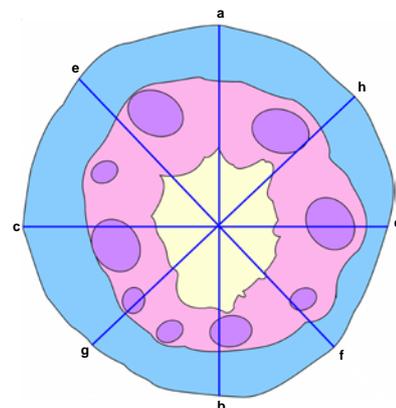
straight lines was placed at the center of lumen of the appendix. Thus, the appendix was divided into four more or less equal parts. A point was marked at the outer margin of the vermiform appendix in every quadrant on the 4-quadrant plastic sheet. The thickness of the wall in each quadrant was measured from that pre-fixed point with the help of ocular micrometer. The actual measurement in millimeters was then calculated by multiplying the ocular micrometer reading by 0.0125. Then the average value of the four wall thickness values was taken as the 'wall thickness' of the particular region (base, middle or tip) of the specific vermiform appendix. The mean value ( $\pm$  SD) of the six slides of each group was then calculated for each region. Another average was calculated for each group-the average of the mean wall thickness at the three regions.



**Figure 1.** Procedure of measuring wall thickness of a section of the appendix

### 2.2. Measurement of the Luminal Diameter

For each histological section, the measurement of the luminal diameter was taken four times using the ocular micrometer (Figure 2). One of this was taken along the maximum visible diameter and the other one along a line perpendicular to the first one. The next two measurements were taken in between first two measurements. The arithmetic mean of these four values was taken as the 'luminal diameter' of the base/middle/tip of the specific vermiform appendix. Further calculations were done as before.



**Figure 2.** Procedure of measuring luminal diameter of a section of the appendix

**Table 2. Wall thickness of vermiform appendix at the base, middle, tip and average in different study groups**

Wall thickness of vermiform appendix in mm					
Groups	n	Base Mean±SD	Middle Mean±SD	Tip Mean±SD	Average Mean±SD
A	6	2.77±0.06 (2.70-2.84)	3.15±0.07 (3.06-3.25)	1.65±0.13 (1.52-1.85)	2.53±0.01 (2.51-2.55)
B	6	2.51±0.05 (2.45-2.58)	2.95±0.17 (2.65-3.10)	2.12±0.06 (2.03-2.18)	2.53±0.04 (2.44-2.55)
C	6	2.36±0.08 (2.25-3.46)	2.48±0.08 (2.39-2.58)	2.28±0.06 (2.19-2.36)	2.37±0.04 (2.33-2.43)
D	6	2.29±0.06 (2.18-2.34)	2.34±0.06 (2.26-2.40)	2.37±0.05 (2.30-2.43)	2.33±0.04 (2.25-2.38)
E	6	2.19±0.16 (2.03-2.36)	2.26±0.14 (2.15-2.43)	2.33±0.14 (2.15-2.50)	2.26±0.07 (2.38-3.10)
Groups compared	Significance of difference (p)				
	Base	Middle	Tip	Average	
A vs. B	<0.001***	<0.05*	<0.001***	>0.05 <sup>ns</sup>	
A vs. C	<0.001***	<0.001***	<0.001***	<0.001***	
A vs. D	<0.001***	<0.001***	<0.001***	<0.001***	
A vs. E	<0.001***	<0.001***	<0.001***	<0.01**	
B vs. C	>0.05 <sup>ns</sup>	<0.001***	<0.01**	<0.001***	
B vs. D	<0.001***	<0.001***	<0.001***	<0.001***	
B vs. E	<0.001***	<0.001***	<0.01**	<0.01**	
C vs. D	>0.05 <sup>ns</sup>	<0.01**	<0.05*	>0.05 <sup>ns</sup>	
C vs. E	<0.05*	<0.05*	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	
D vs. E	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	

Group A: Age 0-20 years.  
 Group B: Age 21-30 years.  
 Group C: Age 31-40 years.  
 Group D: Age 41-50 years.  
 Group E: Age >50 years.

Figures in the parentheses indicate range. Statistical analysis was done by ANOVA (multiple comparison), ns ≡ not significant, \* = significant, \*\* = very significant, \*\*\* = highly significant.

**Table 3. Luminal diameter of vermiform appendix at the base, middle, tip and average in different study groups**

Luminal diameter of vermiform appendix in mm					
Groups	n	Base Mean±SD	Middle Mean±SD	Tip Mean±SD	Average Mean±SD
A	6	2.36±0.13 (2.12-2.48)	2.23±0.13 (2.03-2.42)	1.52±0.15 (1.35-1.80)	2.04±0.45 (2.01-2.23)
B	6	2.54±0.20 (2.32-2.76)	2.39±0.25 (2.13-2.67)	1.51±0.23 (1.23-1.78)	2.15±0.56 (1.90-2.70)
C	6	2.78±0.33 (2.32-3.14)	2.53±0.33 (2.24-3.10)	1.65±0.37 (1.14-2.27)	2.23±0.59 (2.04-2.84)
D	6	3.03±0.17 (2.84-3.20)	2.99±0.23 (2.60-2.94)	2.03±0.54 (1.54-2.78)	2.68±0.57 (2.38-2.96)
E	6	3.20±0.38 (2.82-3.68)	2.51±0.28 (2.21-2.82)	1.26±0.10 (1.10-1.37)	2.32±0.98 (2.10-2.56)
Groups compared	Significance of difference (p)				
	Base	Middle	Tip	Average	
A vs. B	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	
A vs. C	<0.05*	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	<0.05*	
A vs. D	<0.001***	<0.001***	>0.05 <sup>ns</sup>	<0.001***	
A vs. E	<0.001***	<0.05*	<0.01**	<0.05*	
B vs. C	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	
B vs. D	<0.01**	<0.01**	>0.05 <sup>ns</sup>	<0.05*	
B vs. E	<0.01**	>0.05 <sup>ns</sup>	<0.05*	>0.05 <sup>ns</sup>	
C vs. D	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	
C vs. E	>0.05 <sup>ns</sup>	>0.05 <sup>ns</sup>	<0.05*	>0.05 <sup>ns</sup>	
D vs. E	>0.05 <sup>ns</sup>	<0.05*	<0.01**	>0.05 <sup>ns</sup>	

Group A: Age 0-20 years.  
 Group B: Age 21-30 years.  
 Group C: Age 31-40 years.  
 Group D: Age 41-50 years.  
 Group E: Age >50 years.

Figures in the parentheses indicate range. Statistical analysis was done by ANOVA (multiple comparison), ns ≡ not significant, \* = significant, \*\* = very significant, \*\*\* = highly significant.

### 3. Results

#### 3.1. Wall Thickness of the Vermiform Appendix

Table 2 and Figure 3 show the mean wall thickness of vermiform appendix per histological section in different study groups of the present study. In the present study, average wall thickness of the vermiform appendix ranged from 2.25 mm to 3.10 mm. The average wall thickness was highest in group A ( $2.53 \pm 0.01$  mm), which gradually decreased through group B, C, D and the lowest value was in group E ( $2.26 \pm 0.07$  mm).

The statistical difference between the mean wall thickness of per histological section of vermiform appendix was significant between group A and C, A and D, A and E, B and D, B and E at all levels including average value, between group A and B at base middle and tip, between group B and C at middle, tip and average value, between group C and D at middle and tip, between group C and E at base, middle.

Figure 4 shows the correlation between age and average wall thickness. The regression line shows negative correlation between age and average wall thickness, which reached the level of significance ( $p < 0.001^{***}$ ).

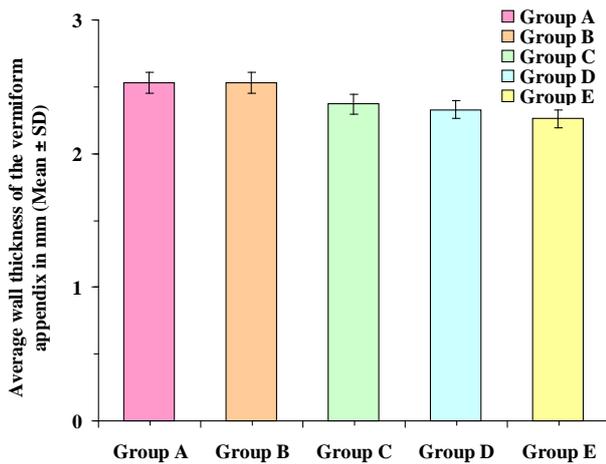


Figure 3. Average wall thickness of the vermiform appendix in mm in different study groups

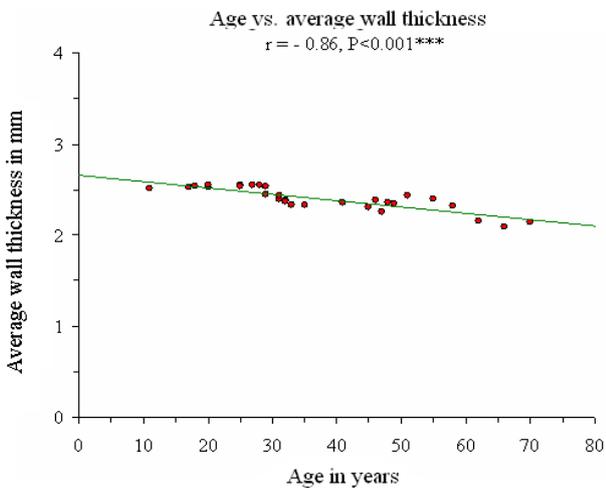


Figure 4. Relationship between age of the subject and wall thickness of the vermiform appendix

#### 3.2. Luminal Diameter of the Vermiform Appendix

Table 3 and Figure 5 show the mean luminal diameter of vermiform appendix per histological section in different study groups of present study. In the present study, average luminal diameter ranged from 1.90 mm to 2.96 mm. Average luminal diameter was lowest in group A ( $2.04 \pm 0.45$  mm) and highest in group D ( $2.68 \pm 0.57$  mm). In group E, the value ( $2.32 \pm 0.98$  mm) was higher than that of group D.

The statistical difference between average luminal diameter of vermiform appendix was significant between group A and C at base and average value, between group A and D at base, middle and average value, between group A and E at all levels, between group B and E at base, middle and average value, between group B and E at base and tip, between group C and E at tip, between group D and E at middle and tip.

Figure 6 shows the correlation between age and average luminal diameter of vermiform appendix. The regression line shows positive correlation between age and average luminal diameter, which reached the level of significance ( $p < 0.001$ ).

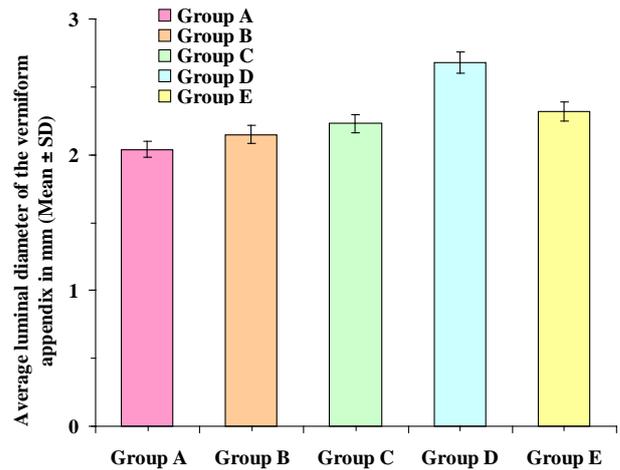


Figure 5. Average luminal diameter of the vermiform appendix in mm in different study groups

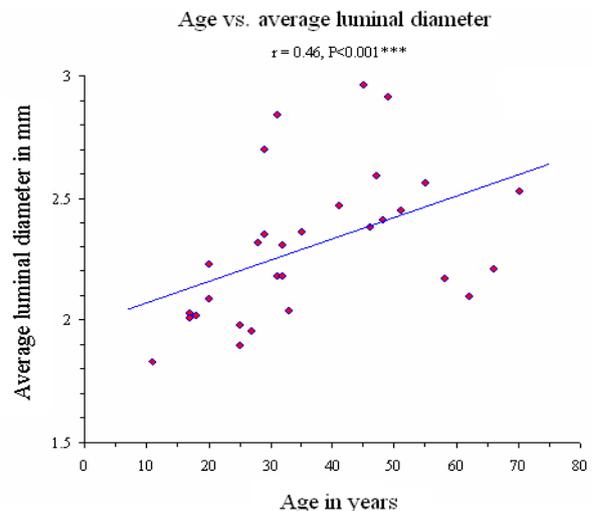


Figure 6. Relationship between age of the subject and average luminal diameter of vermiform appendix

## 4. Discussion

### 4.1. Wall Thickness of the Vermiform Appendix

Though Simonovský [12], Ferri *et al* [13], Tamburrini *et al* [14] and Huwart *et al* [15] studied wall thickness of the vermiform appendix through various imaging techniques, there were very few published data available regarding wall thickness of the cadaveric vermiform appendix. Bockman [16] studied the functional histology of the vermiform appendix and reported that average thickness of the wall of the appendix was 3.2 mm. Wangenstein *et al* [6] in USA studied adult cadaveric vermiform appendices and reported that the wall thickness of the appendix was 1.0-2.5 mm. The wall thickness of the present study matched with results of Bockman [16]. The result of the present study did not match with that of Wangenstein *et al* [6].

### 4.2. Luminal Diameter of the Vermiform Appendix

Luminal diameter of the vermiform appendix depends on the number and diameter of lymphoid follicles within its wall as well as on its wall thickness. The number and diameter of lymphoid follicles reduces gradually with advancing age. As a result, the wall thickness of vermiform appendix decreases. Ultimately luminal diameter increases with advancing age. Wangenstein *et al* [6] in USA reported that the average diameter of the lumen was 1-3 mm. The luminal diameter of the present study was similar to the findings of Wangenstein *et al* [6].

## 5. Conclusion

On the background of the availability of the data, regarding histological study on human vermiform appendix supplied by various standard textbooks and journals, it is found that very few research works have been performed on Bangladeshi people. The observations and results of the present study are expected to provide an idea about the histological changes of the vermiform appendix in relation to age of Bangladeshi people and

these findings will standardize the various measurements obtained by other observers in this country. Finally, it may be concluded that the wall thickness decreased and luminal diameter increased gradually with increased age. Due to limitation of time, sample size was small but if the sample size was large, then the results might be more specific. Further studies with larger sample size covering wider age group and covering both sexes of same age group are recommended for future study.

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