

Original Article

Gross Morphological Variation of Luminal Diameter of the Trachea in Different Age and Sex Groups of Bangladeshi Cadavers

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Abstract

Background: The tracheobronchial tree is a branched distribution system that carries air from the trachea down to the acini which are the gas exchange units of the lung. In the trachea air speed is high and the airway is particularly vulnerable to obstruction by foreign bodies and tumors. The study of the morphological variations of luminal diameter of the trachea is of profound clinical importance as it may help the clinicians for smooth conduction of some maneuvers like endotracheal intubation and bronchoscopic procedure. It also helps the surgeons to deal with resection and reconstruction of the trachea. **Objective:** The present study was carried out to establish a Bangladeshi standard regarding the luminal diameter of the trachea and to minimize the dependency on foreign standards. **Materials and Methods:** This cross sectional descriptive study was performed on 70 post mortem human trachea (44 male and 26 female) to find out the difference in luminal diameter of the trachea of Bangladeshi people in relation to age and sex. The specimens were collected from the morgue in the department of Forensic Medicine, Mymensingh Medical College, Mymensingh by purposive sampling technique. All specimens were grouped into three groups according to age – Group A, B and C. Dissection was performed according to standard autopsy techniques. The trachea was cut horizontally through the upper border of the 5th tracheal ring and the luminal diameter was measured. The average diameter was expressed in centimeter. All data were recorded in the pre-designed data sheet and statistical analysis was done using computer based statistical package, SPSS to evaluate the significance of variance between the different findings. **Results:** In the present study the maximum luminal diameter of the trachea was 1.65 in Group A, 2.05 in Group B and 1.85 cm in Group C. The minimum luminal diameter of the trachea was 0.7 cm in Group A, 0.85 cm in Group B and in Group C 0.85 cm. The mean (\pm SD) luminal diameter of the trachea was 1.24 ± 0.3 , 1.39 ± 0.3 and 1.29 ± 0.23 cm in Group A, B and C respectively. The maximum mean luminal diameter of the trachea was in Group B (1.39 cm) and minimum was in Group A (1.24 cm). The mean difference of luminal diameter of the trachea between groups was statistically non significant at $p > 0.5$ level. The maximum mean (\pm SD) luminal diameter of the trachea was 1.50 ± 0.3 cm in male in Group B and minimum mean (\pm SD) luminal diameter of the trachea was 1.17 ± 0.26 cm in female in Group C. The mean luminal diameter of the male trachea was found to be greater than that of the female trachea among the age group. Mean difference between sexes in Group B was statistically highly significant at $p < 0.001$ level but not significant in Group A and C. **Conclusions:** The study would help to increase the information pool on the luminal diameter of the trachea of Bangladeshi people.

Key words: Trachea; Luminal diameter; Age; Sex; Bangladeshi people

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Introduction

Respiratory system is the basic prerequisite for living organisms to retain their life. This system has undergone various modifications and in multicellular organisms like man it developed into a system of branching network of bronchial tree.¹ The bronchial tree includes the trachea, right and left principal bronchi and their branching up to alveoli.

A common medical problem with the respiratory tract is acute respiratory tract infection (ARI). ARI is the leading killer of children under five. Data from developed and developing countries have shown that ARI is among the most important causes of death in all age groups and particularly in children under one year of age.² Except during the neonatal period, ARIs are the most common causes of both illness and mortality in children under five who suffer average three to six episodes of ARIs annually regardless of where they live or what their economic condition is. The World Health Organization (WHO) estimates that two million children under five die of pneumonia each year. Lower respiratory tract infections account for approximately 10% of the worldwide burden of morbidity and mortality. Seventy five percent of all antibiotics is for these diseases, despite the fact that they are mainly due to virus.³

The shape of the trachea is variable.⁴ The shape of the adult trachea varies even without disease. Some remain nearly circular rather than becoming ovoid. Knowing the size and shape of trachea has clinical implications. Endotracheal intubation and mechanical ventilation are indicated for treatment of established pulmonary failure or prior to general anesthesia. Endotracheal intubation is indicated in several clinical situations including acute hypoxemic or hypercapnic respiratory failure. This procedure is also used to protect the airway in conditions of upper airway obstruction either mechanical or from airway pathology. For proper endotracheal intubation the luminal diameter of the trachea as well as the anatomic differences among the infants, children and adults must be known. Because of anatomical differences there may be great difficulty in endotracheal intubation.⁵

There is a limitation of published work on morphological variations of the luminal diameter of the trachea of Bangladeshi people. We mainly depend on foreign text and literatures. However, we need our

own standard baseline from which we can compare the morphological parameter like luminal diameter of the trachea of our own population with those of Western and other Asian people. Therefore this study has been designed to study the luminal diameter of the trachea to see the variation with age and sex in Bangladeshi people.

Materials and Methods

The specimens comprising of the trachea up to principal bronchus, larynx including thyroid gland and part of the esophagus were collected from Bangladeshi cadavers aged 6–60 years, from autopsy laboratory of the Department of Forensic Medicine of Mymensingh Medical College, Mymensingh from July 2014 to June 2015. Dissection was performed according to standard autopsy techniques. The arch of the cricoid cartilage was carefully cleaned and defined. With the help of sharp scalpel the trachea was freed posteriorly from the esophagus and anteriorly from thyroid and parathyroid gland. The specimens were washed thoroughly with normal saline water to remove the clotted blood from the specimens. Each specimen was examined externally to detect any abnormalities. Then the trachea was cleaned gently with precaution not to damage any part. The specimens were preserved in formol saline. All the collected specimens of cadavers were from medico-legal cases (unnatural death). Only fresh specimens from persons who died within the preceding 12 hours were chosen. Each specimen was duly tagged by a piece of waxed cloth which bore an identification number representing individual serial number. The collected specimens were divided into three groups according to age — Group A (up to 20 years), Group B (21–40 years) and Group C (41–60 years). Each group was again subdivided into male and female groups.

Excess water or formol saline was soaked with blotting paper and the trachea was cut horizontally through the upper border of the 5th tracheal ring and the luminal diameter was measured with a point divider by placing the points of the divider at first on the inner edge of the trachea transversely and then by placing at right angle to the previous position. The divider was placed on an ordinary metric scale each time. The average diameter was expressed in centimeter (cm). All data were recorded in the predesigned data sheet and analyzed by SPSS program (version 21.0, 2012).



Fig 1: Photograph showing the procedure of measurement of luminal diameter of the trachea. A, anterior; P, posterior

Results

Table I shows mean luminal diameter of the trachea in different age groups and Table II shows the comparison of luminal diameter of the trachea among the age groups. The maximum luminal diameter of the trachea was 1.65, 2.05 and 1.85 cm in Group A, B and C respectively. The minimum luminal diameter of the trachea was 0.7 cm in Group A, 0.85 cm in Group B and 0.85 cm in Group C.

The mean luminal diameter of the trachea was 1.24 ± 0.3 , 1.39 ± 0.3 and 1.29 ± 0.23 cm in Group A, B and C respectively. The maximum mean luminal diameter of the trachea was 1.39 cm in Group B and minimum was in Group A (1.24 cm). The mean difference of luminal diameter of the trachea between groups was statistically nonsignificant at $P > 0.5$ level.

Table III shows the mean luminal diameter of the trachea in male and female and table IV shows comparison of mean luminal diameter of the trachea between male and female. Maximum mean (\pm SD)

luminal diameter of the trachea was 1.5 ± 0.3 cm in male in Group B and minimum mean (\pm SD) luminal diameter of the trachea was 1.17 ± 0.26 cm in female in Group C. The mean luminal diameter of the male trachea was found to be greater than that of the female trachea. Mean difference between male and female in Group B was statistically highly significant ($P < 0.001$) but not significant in Group A and C.

Table I: Mean luminal diameter of the trachea in different age groups

Groups	Number of specimen	Mean \pm SD (Range)
Group A	17	1.24 ± 0.3 (0.7–1.65)
Group B	35	1.39 ± 0.3 (0.85–2.05)
Group C	18	1.29 ± 0.23 (0.85–1.85)

Table II: Comparison of luminal diameter of the trachea among the age groups

Comparison between groups	Mean difference	Standard error	p	Level of significance
A versus B	-0.15	0.09	0.101	Nonsignificant
B versus C	0.094	0.082	0.255	Nonsignificant
C versus A	0.056	0.091	0.543	Nonsignificant

$p < 0.001$ is considered as highly significant; $p < 0.05$ is considered as significant; $p \geq 0.05$ is considered as nonsignificant

Table III: Mean luminal diameter of the trachea in male and female

Groups	Sex	Number of specimens	Mean diameter in cm	± SD
Group A	Male	10	1.23	0.29
	Female	7	1.25	0.35
Group B	Male	21	1.5	0.3
	Female	14	1.23	0.24
Group C	Male	13	1.34	0.21
	Female	5	1.17	0.26

Table IV: Comparison of mean luminal diameter of the trachea between male and female

Group	Mean difference	Standard error difference	t	p	Level of significance
Group A	-0.02	0.15511	-0.129	0.899	Non significant
Group B	0.27262	0.09527	2.861	0.007	Highly significant
Group C	0.17231	0.11857	1.453	0.165	Non significant

Discussion

In the present study the maximum luminal diameters of the trachea were 1.65, 2.05 and 1.85 cm in Groups A, B and C respectively. The minimum luminal diameter of the trachea was in 0.7 cm in Group A, 0.85 cm in Group B and in Group C 0.85 cm.

The mean (\pm SD) luminal diameter of the trachea was 1.24 ± 0.3 , 1.39 ± 0.3 and 1.29 ± 0.23 cm in Groups A, B and C respectively. The maximum mean luminal diameter of the trachea was in Group B (1.39 cm) and minimum was in Group A (1.24 cm). The mean difference of luminal diameter of the trachea between groups was statistically nonsignificant ($p > 0.5$). The maximum mean (\pm SD) luminal diameter of the trachea was 1.50 ± 0.3 cm in male in group B and minimum mean (\pm SD) luminal diameter of the trachea was 1.17 ± 0.26 cm in female in Group C. The mean luminal diameter of the male trachea was found greater than that of the female trachea. Mean difference between male and female in Group B was statistically highly significant ($p < 0.001$) but not significant in Groups A and C.

According to Datta⁶, the internal measurement of trachea is 12 mm in adult. The author also commented that in newborn it is 3 mm in breadth which persists up to 3rd year of life; thereafter the lumen increases by 1 mm each year up to 12th year after which it remains

fairly constant. Campos⁷, based on the flexible fiberoptic bronchoscopic technique, observed that the average diameter in a normal trachea is 22 mm in men and 19 mm in women. According to Stranding et al⁸ the internal transverse diameter is 12 mm (1.2 cm) in live adults although this increases after death due to relaxation in the smooth muscles at its posterior aspect. In the study of Chunder et al⁹ the average internal transverse diameters of upper trachea were 1.24 cm and 1.22 cm and of lower trachea were 1.2 cm and 1.1 cm in adult males and females respectively. Stark¹⁰ observed that the normal transverse internal diameter of the trachea ranges between 15 and 25 mm which increases by 10% with inspiration and can decrease by 30% with coughing.

According to Engel¹¹ the average values of internal anteroposterior diameter of the trachea were 5.7 cm at 0–1 months, 6.5 cm at 1–3 months, 7.6 cm at 3–6 months, 7.0 cm at 6–12 months, 9.4 cm at 1–2 years, 10.8 cm at 2–3 years, 9.1 cm at 3–4 years, 10.4 cm at 6–8 years, 9.3 cm at 10–12 years, 13.7 cm at 14–16 years and 16.5 cm in adults. The average values of internal transverse diameter were 6.0 cm at 0–1 month, 6.8 cm at 1–3 months, 7.2 cm at 3–6 months, 7.8 cm at 6–12 months, 8.8 cm at 1–2 years, 9.4 cm at 2–3 years, 11.2 cm at 3–4 years, 11.0 cm at 6–8 years, 12.4 cm at 10–12 years, 13.5 cm at 14–16 years and 14.4 cm in adults.

Yousuf¹² studied on 40 post-mortem human tracheobronchial trees and observed that the luminal transverse diameter of the trachea ranged from 0.9 to 2.2 cm and the mean value was 1.51 (\pm 0.27) cm. He found that in most cases (65%) the diameter was 1.5 cm or less and the luminal anteroposterior diameter of the trachea ranged from 0.9 to 1.8 cm. The mean value was 1.39 (\pm 0.21) cm and in most cases (82.5%) the diameter was 1.5 cm or less. In his study it was found that the average luminal diameter of the trachea ranged from 0.9 to 1.75 cm and the mean value was 1.45 (\pm 0.19) cm and in most cases (67.5%) the average luminal diameter of the trachea was 1.5 cm or less.

The findings of the present study were nearly similar to that of Datta⁶ and Standring et al⁸, but less than the findings of other authors. In addition, most of the authors describe the transverse and anteroposterior luminal diameters of the trachea separately and in most cases the life status of the subject was not mentioned. In some case there was no mention about the sex of the subject. So it was difficult to make comparison with each other.

From the present study, it may be concluded that the maximum mean luminal diameter (1.39 cm) of the trachea was in 21–40 year group and minimum (1.24 cm) was in up to 20 years group. The mean difference of luminal diameter of the trachea between groups was statistically nonsignificant. The maximum mean (\pm SD) luminal diameter of the trachea was 1.50 \pm 0.3 cm in male in age group between 21–40 year and minimum mean (\pm SD) luminal diameter of the trachea was 1.17 \pm 0.26 cm in female in age group between 41–60 years. The mean luminal diameter of the male trachea was found greater than that of the female trachea among the age group. Mean difference between male and female in age group between 21–40 years was statistically highly significant but nonsignificant in age groups up to 20 years and between 41–60 years.

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