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ORIGINAL ARTICLE

Morphometry of Human Trachea in Male and Female using Computerized Tomography- A Comparative Study

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ABSTRACT

Background: The architecture of the trachea can help doctors choose the right size of the endotracheal tube for patients. Non-invasive procedures like cadaveric dissection (CD) and Computed Tomography (CT) scans can also be used in the investigation.

Objective: to describe the morphometry of a normal human trachea on CT scans and compare it to data from other studies

Methodology: The normal CT scan pictures of 110 patients (69 males and 41 females) were analyzed in this prospective investigation. A 64-slice CT scanner was used to do chest CT scans. DICOM, a program for digital imaging and communication in medicine, was used to collect the data. For each parameter, the research population's lowest and maximum values were established. The correlation between all research variables and height and weight was determined using Pearson's correlation method. Height and weight were used as predictors in a regression analysis of substantially correlated factors.

Results: In males, the AP and transverse diameters were substantially linked with height. The diameter of the AP and the CSA were found to be substantially linked with weight. A-P diameter, cross-sectional area, and volume were shown to be poorly predicted by weight. Weak predictors of length and transverse diameter were found to be height. In females, there was no association between height or weight with any of the research parameters. It was discovered that neither body mass index (BMI) nor height (or weight) could predict the dependent variables.

Conclusion: The data might be valuable in the setup and design of tracheostomy tubes and endotracheal tubes in the future.

Keywords: Trachea, diameters, Cross-sectional area, Volume, Computerized tomography.

INTRODUCTION

From a clinician's perspective, tracheal anatomy is crucial. Knowing about tracheal morphometry can help you choose the right endotracheal tube size.[1] The examination of the trachea is an important element of chest imaging. Invasive and non-invasive procedures such as cadaveric dissection, virtual bronchoscopy, computed tomography (CT) scan, and magnetic resonance imaging (MRI) scan can conduct the research.[2]

CT allows for the estimation of intraluminal volume and adds a 3-Dimensional component to the study of tracheobronchial anatomy. It allows for the first time in vivo measurement of tracheal diameters, cross-sectional area, length, and enclosed volume.[3] The diameter (anteroposterior, transverse), length, cross-sectional area, and volume of the human trachea was assessed on CT scans of individuals with no known respiratory illness or intra-thoracic pathology to define normal ranges in men and women.[4] The goal of this study was to describe the morphometry of a normal human trachea on CT scans and compare it to data from other studies.

MATERIAL AND METHODS

Normal chest CT scan pictures of 110 adults aged 10 to 70 years old (69 males and 41 females) were evaluated in an 18-month-long prospective investigation. Permission was obtained from the ethical committee of the Peoples University of Medical and Health Sciences for Women Shaheed Benazir Abad. It took 2-4 seconds to complete a chest CT scan on this group of patients using the GE light-speed VCT 64-Slice Multi-detector Spiral CT Scanner. Patient approval was gained for use of CT scan images in this investigation after complete information about the trial was presented to patients and signed informed consent was obtained. After full inspiration, and with arms completely extended above the head, the patients were asked to lie on their backs for the CT scans.[1,2]

Diameters (anteroposterior and transverse): A-P and transverse diameters of the airway lumen were obtained by using electronic measuring tools available as a part of Digital Imaging and Communications in Medicine (DICOM) software in the radio-diagnosis department and were determined from each axial section approximately at the level of the body of vertebrae C6-T4 and averaged. **(Fig. 1)**

Length of the trachea: The length of the trachea was measured from a sagittal reformatted image correlating the upper end as the level of the first axial slice below the level of the cricoid cartilage and the lower end as the axial slice showing the anteroposterior mucosal ridge of the carina **(Fig. 2).**

Cross-sectional area (CSA): was measured at 10 different axial slices craniocaudal along the length of the trachea and then averaged. The cross-sectional area of the airway (in square millimeters) was obtained by hand tracing the inner wall of the airway with an electronic tracing tool of the DICOM software **(Fig. 3)**.

Tracheal volume: was calculated by multiplying the length by the mean cross-sectional area. The mean corrected cross-sectional area, derived from all slices except those showing the lateral flare just above the tracheal bifurcation and those through the region of variable narrowing just below the cords, was multiplied by the corrected length of the trachea.[3]

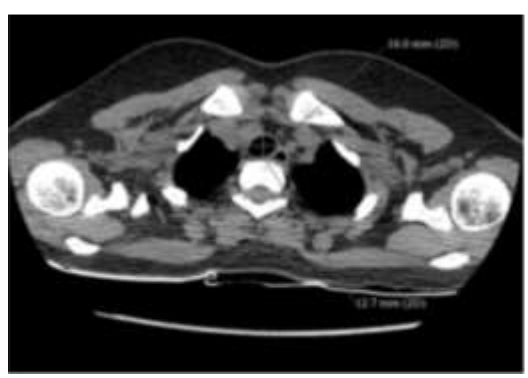

Fig. 1: Measurement of the A-P & transverse diameter

Fig. 2: Measurement of the length of the trachea

Statistical analysis: The mean of the quantitative variables was divided by the mean's two standard deviations (2SD). For each parameter, the research population's lowest and maximum values were established. A-P and transverse diameter of trachea, length of trachea, cross-sectional area, and volume of trachea were correlated with the height and weight of the patient using Pearson's correlation. For the regression analysis, we used height and weight as predictors for the substantially correlated variables. It was decided that a 'p-value of 0.05 was significant for R2 values. The 't-test was used to test the null hypothesis that there was no difference in any of the research parameters between the male and female populations. "p" values less than five percent were considered statistically significant. The statistical analysis was performed using SPSS 16 (Statistical Package for Social Sciences).

Correlations with height and weight in the male population: If there was any relationship between study variables and cases' heights or weights, Pearson's correlation coefficient (r) was computed for each one. An alpha level of 0.05 was significant. An association between height and A-P diameter (r=0.397, p=0.01) as well as transverse diameter (r=0.344, p=0.05) could be found. Only the AP diameter ('r' =0.376, p=0.01) was substantially linked with weight, not the transverse diameter. 'r' = 0.275, 'p' 0.05) and weight ("r" = 0.277, "p" 0.05) showed a modest connection between tracheal length and height. Weight and tracheal volume had a significant ('r' =0.330, 'p'0.01) association. Height and volume were unrelated. In the cross-sectional area, there was no correlation between height and cross-sectional area, but the correlation between weight and the cross-sectional area was considerable.

Linear regression with height and weight in Male population: ('p' 0.05) The correlation between weight and A-P diameter (R^2=0.141), cross-sectional area (R^2=0.104), and volume (R2=0.109) was determined to be modest. A weak correlation was established between height and length (R^2=0.063) and transverse diameter (R^2=0.105; 'p' 0.05).

Correlations with height and weight in the Female population: There was no association between any of the research parameters and either height or weight.

Linear regression with height and weight in the Female population: It was revealed that neither height nor weight predicted the dependent variables in the female population.

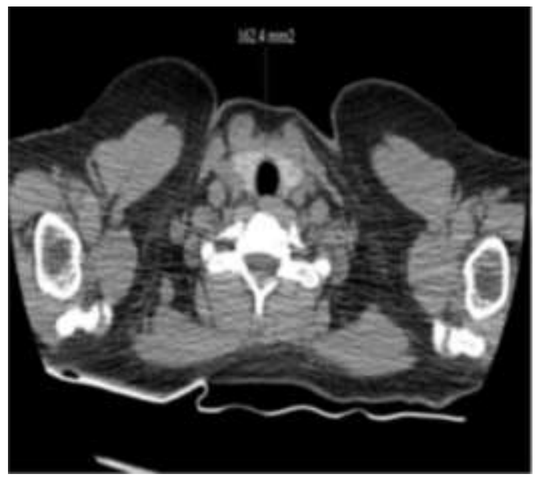
Fig. 3: Measurement of the cross-sectional area of the trachea

Parameters	Mean		S.D.		Minimum		Maximum	
	Male	Female	Male	Female	Male	Female	Male	Female
A-P Diameter (mm)	18.82	13.25	2.37	1.68	10.15	10.72	22.92	17.25
Transverse Diameter	16.30	14.92	1.65	1.50	11.02	10.57	19.98	17.22
(mm)								
Length(mm)	116.21	105.67	9.99	5.34	73.1	92.90	118.9	121.30
CSA(mm^2)	288.42	175.54	50.20	40.16	100.36	127.34	367.59	270.27
Volume (cm^3)	33.70	18.54	6.88	4.30	7.34	13.78	43.71	28.32
Height (mtr)	1.65	1.59	0.052	0.040	1.35	1.50	1.74	1.66
Weight (Kg)	67.11	57.12	8.74	8.97	25	42	87	75

Table 2: Statistical analysis of differences between male and female population

Parameters	Mean difference	95% C.I.	‘p-value
A-P Diameter (mm)	5.57	4.73 to 6.41	<0.01
Transverse Diameter (mm)	1.37	0.75 to 2.0	<0.01
Length(mm)	10.53	7.18 to13.89	<0.01
CSA(mm2)	112.87	94.61to131.14	<0.01
Volume (cm3)	15.16	12.79 to 17.52	<0.01

DISCUSSION

The trachea of the human being is a dynamic, distensible organ whose size and shape are constantly changing. To correctly estimate the endotracheal tube's size, it is necessary to take standard measurements of several tracheobronchial tree characteristics. Tracheal blockage may be showed and quantified using CT area computation, which can also pinpoint the location of the lesion.

CT provides high accuracy in measurements. For the diagnosis of tracheal anomalies, issues in respiratory physiology, and endotracheal intubation, endoscopy, and tracheostomy, these measures might be useful

According to the findings of the MRI study conducted by Reed J.M. et al. (1996),[4] which looked at the tracheal diameter, the data from this study might apply to the development of tracheostomy tubes. Direct assessment of tracheal width, according to Brodsky J.B. et al. (1996),[5] can forecast which left double-lumen tube (DLT) is best for each patient. Medical understanding of archaeometry is critical, according to Randstad A. and colleagues (2000).[6] Endotracheal tubes should be selected based on tracheal diameter (TD) measurements, according to Sakuraba S. et al. (2010).[7] For mediastinal tumours, non-invasive CT area estimate may be beneficial, according to Vock P. et al. (1984).[8] Children with anterior mediastinal masses can be managed surgically and anesthetically with the aid of cross-sectional area, according to Shamberger R.S. et al (1991).[9]

Comparison of mean values of the study parameters with that of previous studies:

Table 3: A-P diameter of the trachea(mm)

S. No	Author (year)	Method	n	A-P diameter(mm)	
				Male	Female
1	Oon C.L. (1964)	R	150	19.2±1.8	14.5±1.3
2	Greene R. (1978)	R	60	22.5± 2.4	-
3	Breatnach E. et al. (1984)	R	808	10-27	10-23
4	Olivier P. et al. (2006)	CT	206	19.7± 3.7	16.0± 2.2
5	Kamel K.S. et al. (2009)	CT	60	22.6±2.9	19.2±2.6
		CD	10	20.8±2.9	15.5±1.1
6	Present study (2011)	CT	110	18.82±2.37	13.25±1.68

R= radiograph, CT= Computed tomography CD= cadaveric dissection, n= study sample

Table 4: Transverse diameter of trachea (mm)

Sr. No	Author (year)	Method	n	Transverse diameter(mm)	
				Male	Female
1	Greene R.(1978)	R	60	19.7± 2.0	-
2	Breatnach E.et al. (1984)	R	808	13 –25	13 -21
3	Olivier P.et al. (2006)	CT	206	17.1±3.6	15.7±2.1
4	Kamel K.S.et al. (2009)	CT	60	27.1±3.4	22.9±2.6
		CD	10	21.4±1.6	17.8±1.5
5	Sakuraba S.et al (2010)	CT	146	17.4± 1.7	14.8±1.8
		R	146	17.7± 2.0	15.8±1.8
6	Munguía-Canales D.A. et al (2011)	CD	44	19± 2	17±3
7	Present study(2011)	CT	110	16.30±1.65	14.92±1.50

R= radiograph, CT= Computed tomography, CD= cadaveric dissection, n= study sample

Table 5: Length of trachea (mm)

Sr. No	Author (year)	Method	n	Length of trachea (mm)	
				Male	Female
1	Kamel K.S.et al. (2009)	CT	60	105.1±9.8	98.3±8.7
		CD	10	103	96
2	Munguia-Canales D.A. et al (2011)	CD	44	91± 9	86± 5
3	Present study(2011)	CT	110	116.21±9.99	105.67±5.34

CT= Computed tomography, CD= cadaveric dissection, n= study sample

Males had a larger A-P diameter than females. In this investigation, the A-P tracheal diaphragm diameters were like those found by Oon C.L. (1964), Griscom N T et al. (1986), Leader J K and co-workers (2004, 2006), Oliver P and co-workers (2006), and Boiselle PM and co-workers (1986). (2009). The present study's results were lower than those reported by Kamel K.S. et al. (2009), suggesting that race played a role in the measurements. It was because of the age distribution of the research sample that Reed J.M. et al. (1996) gave lower results than our current study.

The mean transverse diameter measured in this study was less than that measured in prior investigations that relied on CT imaging. Although the transverse diameter of the trachea was found to correspond with height and weight (Sakuraba S. and colleagues (2010),[7] this was not the case here. There was a poor link between height and transverse diameter in this study (R^2=0.105) and a strong correlation (R^2=0.5928) between height and transverse diameter in Al Mazrou et al (2009).[10] (moderate association). Tables 3 and 4 show that the A-P diameter was larger than the transverse diameter in earlier studies.[2,11–14] This was likewise true in the male group, with mean A-P diameters (18.82±2.37 mm) and mean transverse diameters (16.30±1.65 mm) being greater than the mean transverse diameter (15.79±1.73 mm) when considering the entire research population (n=110). Females, on the other hand, had a larger mean transverse diameter (14.92±1.50 mm) than males (13.25±1.68mm).

Males had a longer trachea than females. According to Kamel K.S. et al. (2009), the length of the trachea is the same as the figures supplied (CT). According to the results of this investigation, the trachea length was larger than previously reported.[15] Using multiple techniques of investigation and comparing living participants and cadavers revealed that the differences may be attributable to the difference in values.

Males had a larger tracheal cross-sectional area than females. The cross-sectional area measurements made in this investigation are quite similar to those made by Vock P. et al (1984).

Males had a larger tracheal volume than females. Our study's average tracheal volume fell within the range established by Kamel K.S. and colleagues (2009)

CONCLUSION

The goal of this study was to use a standardized computed tomography approach to identify the typical range of tracheal diameters. Measurements of the research parameters' mean values were made by computed tomography (CT).

Tracheostomy tubes, endotracheal tubes, and procedures such as tracheal intubation, endoscopy, and organ transplantation can all benefit from the practical use of these facts.

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