Normal dimensions of trachea and two main bronchi in the Iranian population

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Summary

Background: The purpose of this study was to determine the normal diameters of larger airways in the Persian population, since these demographic variables are essential for interpretation of chest CTs and/or plain X-rays.

Material/Methods: During a 6-month period, sagittal and coronal diameters of tracheas of all cases admitted for a chest CT to the radiology department of the National Research Institute of Tuberculosis and Lung Disease (NRITLD) were measured. The patients had to accept to take part in the study and had to fulfill the inclusion and exclusion criteria of the study.

Ninety-nine percent confidence intervals (99% CI) were used to define the upper and lower limits of normal.

Results: Two hundred subjects, including 132 men and 68 women aged 20–85 years, were studied.

Coronal and sagittal diameters of tracheas in the upper part were as follows: 1.8±0.24 and 2.06±0.27 cm for men, and 1.48±0.20 and 1.49±0.24 cm for women, respectively. For the lower part that was: 1.8±0.23, 1.86±0.27, 1.51±0.18, and 1.46±0.23, respectively. For the right and left main-stem bronchi the values were as follows: 1.16±0.17 and 1.02±0.22 for men and 0.93±0.13 and 0.81±0.13 for women, respectively.

Conclusions: The values determined by us had a narrower range of normality than the ones found in the previous reports, so they will stay more friendly for interpretation of individual cases.

Key words: anatomy • trachea • bronchi • normal • CT

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Background

Anthropometric variables are individual characteristics and their range of normality differs between races and even ethnic groups in the same race [1].

Dimensions of the trachea and other large airways are anthropometric variables that have not received adequate attention for the past decades. Most of the published measurements are either based on post-mortem studies [2,3] in which the tracheas can significantly differ from the ones in living organisms, or on plain chest X-rays obtained decades ago by means of old-fashioned machines and poor-quality techniques [4,5]. Reports on computed tomography (CT) have focused on the growing trachea or its one particular dimension.

The most recent, few CT-based publications do not provide adequate information which could be generalized to all local populations. This lack of knowledge can result in...
misinterpretations while looking for diseases that affect tracheal caliber. Some pathologies, such as congenital anomalies, or prolonged intubation make the trachea narrower. On the other hand, tracheobronchomegaly, tracheobronchomalacia etc. result in an abnormal dilation of the central airways. Furthermore, in operating rooms, when intubation of a patient is mandatory, choosing a tube with an appropriate size is essential for the anesthesiologist to manage the situation and avoid untoward complications.

Tracheal dimensions of Iranian populations had never been published before.

The purpose of this study was to present the dimensions of the upper and lower trachea in a representative sample of Persian adults of both sexes.

Material and Methods

Institutional review board had accepted the research protocol and the methodology.

In a prospective cross-sectional descriptive 6-month study we measured the anteroposterior (AP) and transverse diameters of tracheas of all consecutive cases admitted for a chest CT to the radiology department of the “National Research Institute of Tuberculosis and Lung Disease” (NRITLD), if they accepted to participate and fulfilled the inclusion and exclusion criteria of the study.

Inclusion criteria:
• Consent to take part in the study,
• Age of 20 years or more.

Exclusion criteria:
• Any musculoskeletal deformity,
• Kyphoscoliosis,
• Destructive lung pathologies including fibrosis, bullas, retractions,
• Meditacional and/or extra-bronchial masses compressing large airways,
• Tracheo-bronchomegaly,
• Tracheomalacia,
• Bronchiectasis,
• Chronic tuberculosis,
• Any history of laryngotracheal intubation for more than 3 days.

Measurements were performed with a Siemens Somatom, Emotion Series CT scanner.

All the measurement were performed by the same resident of radiology and verified by two attending radiologists.

Tracheal dimensions were measured with breath-hold at full inspiration, at two levels: right below the notch of the sternal manubrium and right below the lower aspect of the aortic arch.

The diameters of two main-stem bronchi were measured on images where they appeared the roundest.

Internal air column was the target for all measurements, and was expressed in centimeters.

Results

Two hundred subjects were studied. Their age ranged from 20 to 85 years. The number of male subjects was almost two-fold higher than of women, with women being minimally younger than men. However, the mean age was not statistically different between the two groups ($P=0.31$).

Demography of the population is summarized in Table 1.

Mean values ($\pm$SD) of the measured diameters, as well as the upper and lower limits of normality as defined by ninety-nine percent confidence intervals, are presented in Table 2.
The tracheas seem slightly narrower in our series than in the literature. This difference can be explained by technical reasons, i.e. past measurements based on plain chest radiographs.

The tracheal diameters were significantly associated with gender but showed poor correlation with other anthropometric characteristics of the population, except for the arm span (Figure 1) that reveals a loose association with coronal diameters of the trachea ($P=0.05$).

Table 3 compares our measurements with values available in major textbooks.

When tested with chi-square, the mean values of most of the measured parameters showed a statistically significant correlation with: gender, age, arm span and BMI (but not with height). However, in multivariate analysis, when the findings were corrected for sex and arm span, the association with age and BMI was lost and the only strong predictor of tracheal dimensions was gender; a loose association also persisted between the arm span and the upper tracheal transverse diameter as well as the diameter of the right main bronchus.

Regression analysis was used to build mathematical equations to predict the diameters for individual subjects when necessary, but such equations failed to present a strong predictive power and showed the coefficient of determination ($r^2$) lower than 0.05, so we omitted the calculated regression equations.

**Table 2. Tracheal diameters.**

|                      | Sex | N   | Mean | 99% confidence interval | Std. deviation | Std. error | P-value |
|----------------------|-----|-----|------|-------------------------|----------------|------------|---------|
|                      |     |     |      | Lower limit | Upper limit | Mean     |         |
| Sagittal upper       | M   | 132 | 2.06 | 1.97        | 2.15         | 0.27      | 0.02371 | 0.000   |
|                      | F   | 68  | 1.491| 1.41        | 1.57         | 0.23783   | 0.02884 |         |
| Coronal upper        | M   | 132 | 1.80 | 1.72        | 1.84         | 0.24713   | 0.02151 | 0.000   |
|                      | F   | 68  | 1.479| 1.42        | 1.54         | 0.19792   | 0.02400 |         |
| Sagittal lower       | M   | 132 | 1.86 | 1.79        | 1.92         | 0.27414   | 0.02386 | 0.000   |
|                      | F   | 68  | 1.464| 1.39        | 1.54         | 0.22768   | 0.02761 |         |
| Coronal lower        | M   | 132 | 1.80 | 1.74        | 1.84         | 0.22568   | 0.01964 | 0.000   |
|                      | F   | 68  | 1.514| 1.45        | 1.57         | 0.18773   | 0.02277 |         |
| R_m_b*               | M   | 132 | 1.16 | 1.12        | 1.20         | 0.17976   | 0.01565 | 0.000   |
|                      | F   | 68  | 0.931| 0.89        | 0.97         | 0.13022   | 0.01579 |         |
| L_m_Bb**             | M   | 132 | 1.02 | 0.97        | 1.07         | 0.22754   | 0.01980 | 0.000   |
|                      | F   | 68  | 0.808| 0.76        | 0.85         | 0.13869   | 0.01682 |         |
| Upper area***        | M   | 132 | 2.90 | 2.73        | 3.1          | 0.61980   | 0.05395 | 0.000   |
|                      | F   | 68  | 1.7398| 1.61       | 1.87         | 0.40400   | 0.04899 |         |
| Lower area#          | M   | 132 | 2.63 | 2.50        | 2.77         | 0.62441   | 0.05435 | 0.000   |
|                      | F   | 68  | 1.757| 1.61        | 1.90         | 0.43722   | 0.05302 |         |

* Right main-stem bronchus; ** Left main-stem bronchus; *** Tracheal cross-sectional area at the upper aspect; # Tracheal cross-sectional area at the lower aspect. All diameters are expressed in centimeters. All areas are expressed in square centimeters.

**Figure 1.** A minimal increment in the tracheal transverse diameter with increasing arm span.

**Discussion**

When trying to repair an injured trachea, or planning to perform a single- or double-lung transplantation, the knowledge of the tracheal diameters is essential for choosing appropriate stents or lung to be transplanted. Furthermore, the radiologist often faces a problem of a possible tracheal narrowing by compression or stricture.
or tracheal dilation due to conditions like Munier-Cohn or William-Campbell and so on. In such conditions, it is important to know the range of normality for a given individual.

Unfortunately, the said values vary considerably in major imaging textbooks, i.e. from 25 to 27 mm for men and from 21 to 23 for women [7–10] with some discrepancies referable to different methodologies. However, the range of normality in these texts is so large that it is difficult to make a precise decision in a given subject.

Adding ethnic differences between various populations to the problem makes a reliable interpretation really difficult for the radiologist.

We tried to minimize the range of normality by using a 99% confidence interval instead of 2 or 3 SDs, as in the former studies. This means that 99% of daily cases will fit in the values presented by us. The wider range of normality in the textbooks can explain narrower tracheas in our series.

**Conclusions**

In conclusion, Persian people have tracheal dimensions close to the European ones.

Now it is possible for us to label cases as abnormal with more certainty than before, because of our narrower range of normality.

**Conflict-of-interest disclosure**

The authors declare no conflict of interest.

**References:**

1. Giles E, Klepinger LL: Confidence intervals for estimates based on linear regression in forensic anthropology. J Forensic Sci, 1988; 33: 1218–22
2. Kamel KS, Lau G, Stringer MD: In vivo and in vitro morphometry of the human trachea. Clin Anat, 2009; 22: 571–79
3. Seymour AH: The relationship between the diameters of the adult cricoid ring and main tracheobronchial tree: a cadaver study to investigate the basis for double-lumen tube selection. J. Cardiothorac. Vasc Anesth, 2003; 17: 299–301
4. Breatnach E, Abbott GC, Fraser RG: Dimensions of the normal human trachea. Am J Roentgenol, 1984; 142: 903–6
5. Zhevnov VN, Bodnarchik LV: Dimensions of the larynx and trachea in young children. Vestn Khir Im I I Grek, 1969; 103: 116–17
6. Van SJ, Joos G, Pauwels R: Tracheobronchomegaly – the Mounier-Kuhn syndrome: report of two cases and review of the literature. Eur. Respir. J, 1991; 4: 1303–6
7. Padle S, MacDonald S LS: The central airways. In: Adam: Grainger & Allison’s ed. diagnostic radiology, 5th ed. China; Churchill Livingstone, electronic ed. An Imprint of Elsevier, 2008; 12
8. Miro S, Klein JS: Methods of examination, normal anatomy, and radiographic findings of chest disease, (In): Brant WE, Helms CA. Fundamentals of diagnostic radiology, 3rd ed. Lippincott Williams & Wilkins, 2007; 336–89
9. Muffitt J, Robinson PJA, Whitehouse RW et al: The normal chest: methods of investigation and differential diagnosis, in David Sutton Ed. Textbook of radiology and imaging, 7th Ed. Churchill Livingstone, 2003; 1–56
10. Collins J: Trachea, Normal anatomy; in Paul & Juhl’s Essentials of radiologic imaging. 7th ed, Ebook; Lippincott Williams & Wilkins, 1998; 937–38

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**Table 3. Comparison of the diameters measured in this series with 3 major textbooks*.**

| Sex   | Current series | Grainger | Brant | Sutton |
|-------|---------------|----------|-------|--------|
| trach_u_ap | M 2.06 | 1.82 | 2.5 | 2.5 |
|       | F 1.4909 | | | |
| trachea_u_t | M 1.80 | 1.52 | 2.1 | 2.1 |
|       | F 1.4787 | | | |

*The reported textbooks do not follow a similar methodology. All diameters are expressed in centimeters.