

Original Research Article

Determination of subcarinal angle of trachea using computed tomography

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ABSTRACT

Background: Change in tracheal bifurcation angle (subcarinal angle) is an indirect marker of various cardiac, pulmonary and mediastinal pathologies. Helical computed tomography (CT) allows acquisition of volumetric set of data of the chest and can be used for accurate measurements of subcarinal angle using reconstructed images on a workstation using minimum intensity projection (MinIP). The objective of this study was to estimate normal subcarinal angle (SCA) of trachea by computed tomography and to assess its relationship with gender.

Methods: This was an observational study comprising a study cohort of 552 patients comprising of 312 males and 240 females who were subjected to CT chest for various indications in our department. Patients with no underlying cardiac, mediastinal or pulmonary disease were included in the study. Spiral CT scan of chest was performed on 64-slice seimens CT SOMATOM and images were reconstructed with thickness of 1.5mm and the images were viewed in coronal reformatted minimum intensity projection (MinIP) for determination of subcarinal angle using the angle measuring tool provided in the workstation

Results: The mean subcarinal angle (SCA) in males was (67.60±14.55). The mean subcarinal angle (SCA) in females was (78.90±11.04). Females had a higher mean SCA compared to males with a statistically significant difference (p-value <0.05).

Conclusions: The mean SCA in females was higher compared to males with a statistically significant difference between the two. This study holds practical relevance with regard to the performance of invasive trachea-bronchial procedures like bronchoscopy and tracheal/bronchial intubation.

Keywords: Carina, Helical computed tomography, Minimum intensity projection, Multiplanar reconstruction, Subcarinal angle, Tracheal bifurcation

INTRODUCTION

The trachea is a cylindrical cartilaginous tube meant for passage of air between larynx and lungs and extends superiorly from cricoid cartilage and ends inferiorly at carina.^{1,2} It is about 10-11cm in length and extends from

the level of sixth cervical vertebra to the upper border of fifth thoracic vertebra.¹ It divides into right and left principal bronchi which enter the corresponding lungs and progressively branch off throughout the entire lung to form trachea-bronchial tree. Subcarinal angle (SCA) is an angle of divergence between the right and left main stem bronchi. Many diseases of heart or mediastinum lead to

an increase or decrease in the SCA and hence change in SCA is an indirect sign of pathology in the heart or mediastinum.³

The study of trachea-bronchial tree can be done by both invasive and non-invasive methods like bronchoscopy, bronchograms, computed tomography (CT) scan and magnetic resonance imaging (MRI) scan.^{1,2,4} Previously SCA was calculated on chest radiographs using a goniometer.^{5,6} Helical computed tomography (CT) allows acquisition of volumetric set of data of the chest and can be used for accurate measurements of SCA using reconstructed images on a workstation using minimum intensity projection (MinIP). MinIP is a data visualization process that allows detection of low-density structures (air in this case) in a given volume as the algorithm uses all the data in a volume of interest to generate a single two-dimensional image.⁷ This tool helps us to measure the SCA accurately as compared to coronal multiplanar reconstructed image.²

METHODS

This was an observational study conducted between June 2017 to January 2019. A total of 552 patients comprising of 312 males and 240 females who were referred to the department for chest CT were included in the study. Institutional ethical clearance was obtained for this study.

Patients with pulmonary and cardiovascular diseases such as COPD, tuberculosis, pulmonary fibrosis, emphysema, atelectasis, mediastinal mass or lymphadenopathy and pericardial or pleural effusion were excluded from the study.

All the CT scans were performed on 64-slice Seimens SOMATOM Multidetector CT with a single breath-hold using 64x0.625 collimation, 120kVp, and 120mAs. The rotation time and pitch of the scan were 0.5 and 1.2 respectively. The image was acquired in 5 mm thickness and reconstructed using reconstruction interval of 1mm into 1.5mm reformatted image. The images were viewed in MinIP in coronal plane at window width of 1600HU and centering of-600HU. The subcarinal angle (SCA) was measured using the angle measuring tool given in the workstation.

The collected data of the SCA was statistically analyzed using the statistical package for social science software (SPSS, version 16.0). Mean SCA, standard deviation (SD), maximum and minimum values and p-value were calculated. A probability value of p<0.05 was considered to be statistically significant using independent t-test.

RESULTS

A total of 552 chest CT scans were evaluated of which 312 (56.5%) were males and 240 (43.5%) were females. The mean age of males was 53 years±17.2 years with age range between 9 years to 80 years. The mean age of

females was 56 years±13.7 years with age range between 26 years to 85 years. The subcarinal angle (SCA) was measured in true coronal plane using the angle measuring tool given in the workstation (Figure 1).

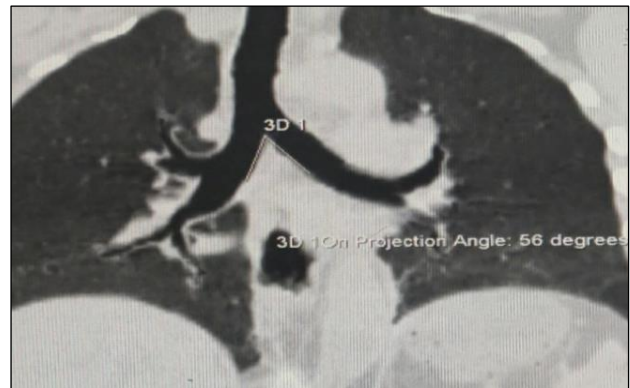


Figure 1: True mid- coronal MinIP image of chest revealing measurement of SCA by the angle measuring tool.

The highest SCA noted was 104° in a female aged 65 years whereas the lowest SCA (41°) was observed in a male aged 30 years (Figure 2).

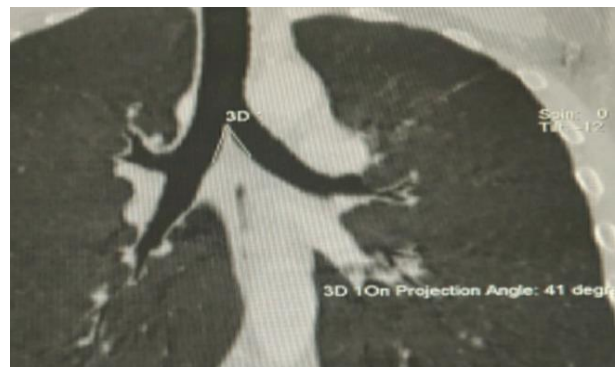


Figure 2: Coronal MinIP images of thorax showing minimum SCA (41°) in a 30-year old male.

The lowest SCA in females was 58° (Figure 3).

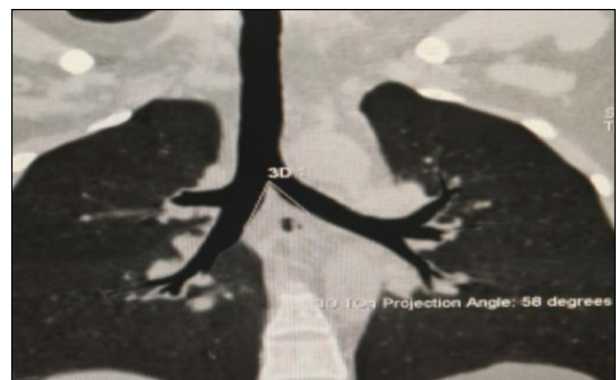


Figure 3: Coronal MinIP image showing minimum SCA of 58° in a 39- year old female.

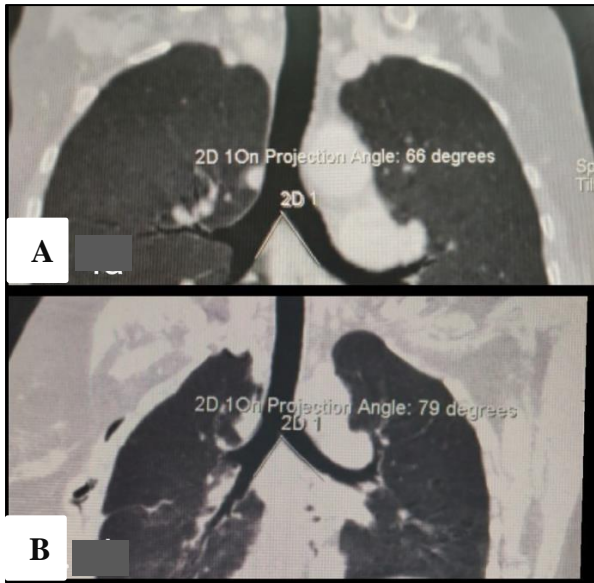


Figure 4: Coronal MinIP image showing mean SCA in males (4A) and females (4B).

The highest SCA noted in men was 96°. The mean SCA in males was 67.60±14.55 (Figure 4A) with range of 41-96°. The mean SCA was higher in females 78.90±11.04 (Figure 4B) with range of 58-104° (Table 1).

Table 1: Mean subcarinal angle with SD in males and females.

Gender	N	Mean age±SD	Mean SCA±SD	Range of SCA
Male	312	53±17.2 years	67.6°±14.55	41-96°
Females	240	56±13.7 years	78.9°±11.04	58-104°

Statistical analysis revealed significant difference in the subcarinal angle (SCA) between males and females with higher angles noted in females (p-value<0.05).

DISCUSSION

Trachea is a cartilaginous tube which serves as the conduit for conveyance of air required for gaseous exchange from and to lungs. It measures approximately 10-11cm in length.¹ It is composed of 16-22 horse-shoe shaped hyaline cartilaginous incomplete rings antero-laterally. The incomplete posterior parts of these cartilaginous rings are joined by a fibromuscular band known as posterior tracheal membrane. Trachea bifurcates into two principal bronchi at the level of 4th thoracic vertebra. The point of bifurcation of trachea is called carina. The angle subtended by the divergence of two principal bronchi is called subcarinal angle (SCA). SCA can increase or decrease in a wide array of cardiac, mediastinal or pulmonary ailments thus serving as an indirect indicator of an underlying disease within the chest.^{2,3}

This study was conducted to determine the normal SCA in patients using CT and its variation with patient’s gender. Authors used MinIP reformation technique in computed tomography to measure the SCA. In MinIP reformation technique the window centering is done at the low-density structure (air in this case). SCA varies with the phase of respiration being narrow in inspiration due to downward displacement of lungs in inspiration whereas in expiration SCA increases due to elevation of lungs. Similarly, elongation of head or neck will narrow the carinal angle. All our CT scans were performed in inspiration to avoid any technical bias. Radiologic evaluation of the trachea is done using plain chest postero-anterior radiograph, CT or magnetic resonance imaging. CT has attained the status of first modality for the evaluation of array of diseases affecting trachea-bronchial tree.^{1,2}

Many studies have been performed to determine the SCA using cadavers, chest radiographs and CT scan, however, only one study has been performed using CT with MinIP technique for evaluation of SCA.^{1-3,5-6,8-14}

Table 2: Comparison of mean subcarinal angle in males and females given in literature.

Author (year)	Method	Sample size	SCA in males Mean±SD	SCA in females Mean±SD	Total SCA Mean±SD
Alavi S.M.et al ⁸	R	87	56.4±5.66	57.73±6.37	57.16±6.06
Haskin PH et al, and Goodman LR et al ¹¹	R	100			60.8±11.80
Chen JTT et al ¹⁵	R	54			62.3±8.6
Murray JG et al ⁶	R	108	61.2±13.1	63.6±15.9	62.6±14.8
Coppola V et al ¹²	R	500			79.7(37-105)
Karabulut N et al ⁹	CT	120	70±16	77±14	
Kamel KS et al ¹⁰	CT	60	76±20	81±20	78±20
Khade B et al ¹	CT	110	80±12.53	79.7±9.99	79.9±11.60
Fernandes SF et al ²	CT	193	69.63±2.75	69.90±4.07	69.75±3.38
Present study	CT	552	67.60±14.55	78.90±11.04	

In present study 552 patients were evaluated for measurement of SCA including 312 males and 240 females. The highest SCA noted was 104° in a female aged 65 years whereas the lowest SCA (41°) was observed in a male aged 30 years. The lowest SCA in females was 58°. The mean SCA in males was 67.6°±14.55 with range of 41-96°. The mean SCA was higher in females 78.9°±11.04 with range of 58-104°.

Statistical analysis revealed significant difference in the SCA between males and females with a p-value of <0.05. Authors drew a comparison with the previous studies done in this regard (Table 2). Many studies did not find a statistically significant difference in subcarinal angle (SCA) between males and females.^{1,2,6,8} However, two studies have demonstrated a statistically significant difference in subcarinal angle (SCA) between males and females.^{9,10} Karalbulut N et al, evaluated a total of 120 patients (65 males and 55 females) (17-85 years) using CT.⁹ The mean subcarinal angle was 70±16 degrees and 77±14 degrees in males and females respectively. The angle was wider in females than males. Similar results were concluded by Kamel KS et al, who studied tracheal morphology using CT and cadaveric dissection.¹⁰ The mean subcarinal angle using CT in 60 subjects was 76±20 in males and 81±200 in females. The subcarinal angle was greater in females than males.

CONCLUSION

Subcarinal angle (SCA) can increase or decrease in a plethora of cardiac, mediastinal or pulmonary diseases. However, SCA physiologically exhibits a wide range of variability in normal individuals. The mean SCA in females was higher (78.90±11.04) compared to males (67.60±14.55) with a statistically significant difference between the two. This study holds practical relevance with regard to the performance of invasive trachea-bronchial procedures like bronchoscopy and tracheal/bronchial intubation.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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