ASIAN JOURNAL OF PHARMACEUTICAL AND CLINICAL RESEARCH

INNOVARE ACADEMIC SCIENCES

Vol 11, Issue 4, 2018

Online - 2455-3891
Print - 0974-2441

Research Article

ESTIMATION OF SUBCARINAL ANGLE USING MINIMUM INTENSITY PROJECTION IN COMPUTED TOMOGRAPHY

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Received: 01 December 2017, Revised and Accepted: 23 Febuary 2018

ABSTRACT

Objectives: The main objective of the study was to determine the normal subcarinal angle (SCA) in an adult patient, to compare the relationship of SCA with patient gender and age, and to correlate the SCA with body mass index (BMI).

Methods: A total of 193 subjects (109 males and 85 females) in the age group of 20–60 years scheduled for computed tomography thorax at the Department of Radiodiagnosis and Imaging, Kasturba Hospital, Manipal, were included in the study. Plain images were reconstructed into 1.4 mm reformatted image and processed into minimum intensity projection, and measurement was taken using angle tool. Mean and standard deviation was used to determine normal SCA, and independent t-test was used to compare the relationship of SCA with patient's age and gender. "Pearson correlation" was used to correlate SCA with BMI.

Results- The mean SCA of the adult patient was 69.75±3.38°. The mean SCA in female was 69.90±4.07° and in male was 69.63±2.75°. In the age group of 20–40 years, the mean SCA was 70.38±3.85°, and in the age group of 41–60 years, it was 69.25±2.88°.

Conclusion: There was no relationship between SCA and patient's gender; however, the mean SCA of the age group 20–40 was found greater than that of 41–60 which was statistically significant. BMI has no significant correlation with SCA.

Keywords: Subcarinal angle, Computed tomography, Minimum intensity projection.

 DOI: http://dx.doi.org/10.22159/ajpcr.2018.v11i4.24041

INTRODUCTION

Cardiovascular diseases (CVDs) affect Indians at least a decade earlier in comparison with the people of European origin. CVD is responsible for a large number of death and disabilities world wide [1]. A study commissioned by the World Health Organization and the World Bank estimated the worldwide prevalence of chronic obstructive pulmonary disease (COPD) as 9.34/1000 in men and 7.33/1000 in women [2]. CVD complications have also become the fastest growing concern for diabetic patient worldwide [3].

The trachea is a limber cylindrical tube that facilitates the passage of air between the larynx and the lung. A ridge of cartilage that occurs between the divisions of the two main bronchi is called the carina. Subcarinal angle (SCA) is an angle of divergence of the right and left main stem bronchi. Increase or decrease in the SCA is mentioned as an indirect sign of pathology in the heart or mediastinum [4].

Most of the previous studies assessed the SCA on chest radiographs using a goniometer [4-6]. Helical computed tomography (CT) enables the acquisition of volumetric images of the chest and facilitates accurate measurements using reconstructed images on a workstation using minimum intensity projection (MinIP). MinIP is a data visualization process that allows detection of low-density structures in a given volume as the algorithm uses all the data in a volume of interest to generate a single bidimensional image [7]. This tool helps us to measure the SCA accurately as compared to coronal multiplaner reconstructed image.

METHODS

The study approval was attained by the Institutional Research Committee, School Of Allied Health Sciences and Ethics Committee, Kasturba Hospital, Manipal. The sample was collected from 194 individuals (109 males and 85 females) in the age group of 20–60 years scheduled for CT thorax at Kasturba Hospital, Manipal. The samples were collected by convenience sampling technique considering inclusion and exclusion criteria. Data collected from the male and female patients within the age range from 20 to 60 years were divided into two adult groups (20–40 and 41–60) free from pulmonary and CVDs such as COPD, tuberculosis, pulmonary fibrosis, emphysema, atelectasis, interthoracic mass or lymphadenopathy, and pericardial or pleural effusion, and coronary artery diseases were included in the study. Body mass index (BMI) of the patient was obtained and categorized into underweight (under 18.5 kg/m^2), normal weight (18.5–25), overweight (25–30), and obese (over 30). CT scan of the patient was performed as appointed by the physician for the CT thorax. All the CT scans were performed on 64-Slice Brilliance Multidetector CT Philips, Department of Radiodiagnosis and Imaging, Kasturba Hospital, Manipal, with a single breath-hold using 64×0.625 collimation, 120 kVp, and 123 mAs. The rotation time and pitch of the scan were 0.5 and 1.016, respectively. The image was acquired in 5 mm thickness and reconstructed into 1.4 mm reformatted image and transferred to extended brilliance workstation post-processed into MinIP, and the measurement was taken using angle tool (Fig. 1).

The obtained data of the SCA were tabulated and statistically analyzed utilizing the *Statistical Package* for *Social Science* software (SPSS, version 16.0) where maximum and minimum values, range, means, standard deviation (SD), and 95% confidence interval of the mean were calculated. A probability value of *p<0.05 was considered to be statistically significant using independent t-test*. Mean and SD, with error bars, was used to determine normal SCA in an adult patient. The "independent t-test" was used to compare the relationship of SCA with patient's gender and age. "Pearson correlation" was used to correlate the SCA with BMI.

RESULTS

The investigated data to determine the normal SCA irrespective of genders are summarized in Table 1, where the mean was 69.75±3.38°. The reference range was measured using formula mean ± 2SD.

To compare the relationship of SCA with patient's gender, independent t-test was performed where the mean of SCA in female was found to be 69.90±4.07° which are slightly larger than the male with a mean of 69.63±2.75°. The difference between the mean of males and females was less, therefore, these differences are not statistically significant (p=0.589) (Table 2). Similarly, in the age group of 20–40 years, the mean was found to be 70.38±3.85 which is larger than the age group of 41–60 years with the mean of 69.25±2.88. Since the mean difference between these age groups was noted to be large, the differences were found to be statistically significant (p=0.02) (Table 3).

To correlate the SCA with BMI, Pearson correlation test was used and was found that SCA and BMI are not correlated (r=−0.053).

DISCUSSION

The carina is the apex of the bifurcation point of the trachea. The carinal angle occurs at the lower end of the trachea usually at the level of 4th thoracic vertebrae. Increase in the SCA is mentioned as an indirect sign of pathology in the mediastinum or heart. Determining the SCA helps the clinicians to interpret these changes [4,8]. This study was conducted to determine the normal SCA in adult patients using CT and also to compare the relationship of the SCA with patients' gender and age. While most of the previous studies conducted measured the SCA using a goniometer, we measured using MinIP and angle tool. MinIP allows detection of low-density structures in a given volume [9].

Since the carina is a dynamic structure, respiration phase may influence the carinal angle. It has been acknowledged that the carina is displaced downward during inspiration. Extension of the head and elongation of bronchial tree by inspiration will cause the carinal angle to become narrow. On the other hand, shortening of the bronchial tree widens the carinal angle [10]. In our study, all the CT scans of the thorax were only taken in inspiration phase without extension of the head.

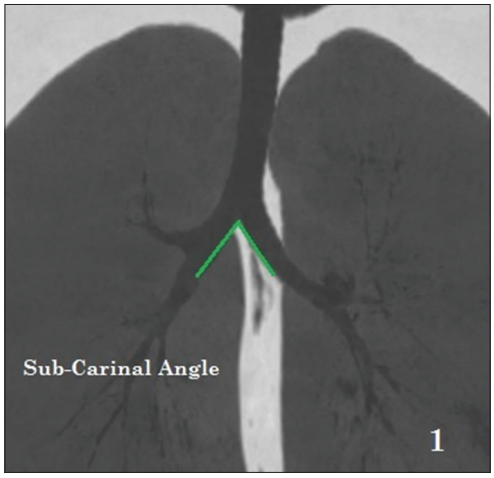

Fig. 1: The measurement of subcarinal angle in minimum intensity projection image

Table 1: Statistical analysis of the investigated measurement of SCAs

Parameter	*n*	Mean±SD	Min	Max	Reference range
SCA	193	69.75±3.38	60	87.50	66.37–73.13

SD: Standard deviation, SCA: Subcarinal angle

Radiologic evaluation of the trachea is done using plain chest posteroanterior radiographs, magnetic resonance imaging, and CT. CT has become an imaging modality of choice as it is of great value in assessing the spectrum of diseases that affect the trachea [11]. There are many studies performed to determine the SCA using cadavers and chest radiographs; however, there are limited studies reported using CT and no study reported using CT along with MinIP (Table 4). This volume rendering technique allows the examination of fine anatomical details which is hard to assess using axial sections [9].

In our study of 193 normal subjects, the mean SCA was about 69.75°. The SD was 3.38° with a minimum 60° and maximum 87.5° which is similar to the study conducted by Lin et al., in which the SCA measured on Picture Archive Communication System was about 66.9±11.1° [5]. In another cadaveric study by Mrudula and Krishnaiah, the bronchial tree was separated from the parenchyma and an outline was drawn on a paper. The SCA measured with the help of a protractor was about 77.58° [12].

When it came to considering gender, Alavi *et al*. conducted a study which included 87 subjects. In the study, a straight line was drawn in the middle of each bronchus and parallel to each wall, and a reference point was employed. This angle of intersection was considered as the SCA. The mean value of the SCA was found to be 56.4±5.66° in males and 57.73±6.37° in females [13]. Murray *et al*. stated larger IBA and SCA values in female patients but did not assess its statistical significance [6], whereas in our present study, the mean SCA of males was found to be 69.63±2.75° and that of females was 69.90±4.07°. The difference between the mean SCA of male and female was less (p=0.589); therefore, it was concluded that there was no relationship between the SCA with patients gender.

In our study, we considered two adult age groups that are 20–40 (85 subjects) and 41–60 (108 subjects). When age was taken into consideration, we found that the SCA was higher in the age group 20–40 than 41–60. We found that in the age group 20–40, the SCA was 70.38±3.85°, and in 41–60, the angle measured 69.25±2.88°. Chunder and Guha [14] study found that the mean SCAs in the 0–15 years, 16–25 years, 26–40 years, 41–55 years, and >55 years age groups were 61.4°, 52.9°,49.2°, 48.2°, and 54° in females and 64.3°, 56.4°, 58.4°, 57.1°, and 59.5° in males. It concluded that in the adult group there was a decrease in the SCA with an increase in the age which was similar to the study conducted by Khade *et al*. [10], who also demonstrated a decrease in the SCA with an increase in the age group which is similar to our study.

In the present study, we performed Pearson correlation test to find the correlation between SCA and BMI where we found that there was no correlation between BMI and SCA, which is similar to the study

Table 2: Investigated measurement of SCAs in relation to gender

Parameter	Mean±SD		MGD	p
	Males (no. 109)	Females (no. 84)		
SCA	69.63±2.75	69.90±4.07	0.27	0.589^{ns}

MGD: Mean group difference, SD: Standard deviation, SCAs: Subcarinal angles. ns: Not significant. p<0.05 is considered to be statistically significant

Table 3: Investigated measurement of SCAs in relation to age group

Parameter	Mean±SD		MGD	p
	20–40 years (no. 85)	41–60 years (no. 108)		
SCA	70.38±3.85	69.25±2.88	1.13	0.02^{s}

MGD: Mean group difference, SD: Standard deviation, SCAs: Subcarinal angles, s: Significant. p<0.05 is considered to be statistically significant

Table 4: Comparison of SCA according to different studies

S. No.	Author	Method	SCA		
			Male	Female	Total
1	Alavi *et al.*	R	56.4±5.66	57.73±6.37	57.16±6.06
2	Haskin and Goodman	R	-	-	60.8±11.80
3	Chen *et al.*	R	-	-	62.3±8.6
4	Murray *et al.*	R	61.2±13.1	63.6±15.9	*62.*6±14.8
5	Lin et al.	R	-	-	66.9±11.1
6	Saowanit Choorat	R	-	-	62±12.62
7	Chunder and Guha	CD	59.1	53.1	-
8	Mrudula and Krishnaiah	CD	-	-	77.58 (50-130)
9	Karabulut	CT	70±16	77±14	73±16
10	Khade *et al.*	CT	80±12.53	79.7±9.99	79.9±11.60
11	Present study	CT	69.63±2.75	69.90±4.07	69.75±3.38

CT: Computed tomography, SCA: Subcarinal angle

conducted by Karabulut, who concluded that BMI did not show a significant correlation with SCA [15].

CONCLUSION

There is a wide range of SCA. The mean SCA for the normal adult was 69.75. There was no relationship between the SCA and patient's gender; however, the mean of the SCA of the age group of 20–40 was found to be greater than that of 41–60 with p=0.02 which was found to be statistically significant. We also found that BMI has no significant correlation with SCA.

ACKNOWLEDGMENT

We would like to thank Department of Radiodiagnosis and Imaging, Kasturba Hospital, Manipal, for allowing us to collect data for the thesis.

AUTHORS' CONTRIBUTIONS

Salome Francia Fernandes: Design, Literature search, Data Acquisition, Data Analysis, Manuscript Preparation, and Editing. Abhimanyu Pradhan: Concept, Design, Literature search, Data Analysis, Statistical Analysis, Manuscript Editing, and review.

CONFLICT OF INTEREST

There is no conflict of interest.

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