Original Article

Measurement of the Sub-carinal Angle on the Normal Chest Radiograph of Adult at BPKIHS, Dharan, Nepal

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Abstract

Background: The sub-carinal angle is an angle formed between the main right bronchus and left bronchus clearly seen in adequately exposed chest radiograph, normally at the level of 5th thoracic vertebrae.

Objective: To measure sub-carinal angle in relationship to different age, sex and body mass index in the adult.

Methods: A cross-sectional study was carried out in the Department of Radiodiagnosis and Imaging at BPKIHS, Dharan from 27th April to 6th August 2017. Sub-carinal angle was measured on the normal chest radiograph in 392 adult patients. The data were analyzed using SPSS Version 11.5 and descriptive statistics percentage, Mean, Standard Deviation were calculated. For inferential statistics, Independent 't' test and Pearson's correlation were applied.

Results: The sub-carinal angle ranged from 39°- 81.1° with mean value 60.17°±7.81°. The mean sub-carinal angle for the male was 59.17°±8.19° and for female was 60.62°±7.49°. The mean sub-carinal angle was wider in female than male in our study; however, the difference in sub-carinal angle between male and female was statistically not significant (p> 0.05). There was negative correlation between sub-carinal angle and age (r= -0.168, p <0.01). The sub-carinal angle was positively correlated with BMI (r= 0.100, p< 0.05).

Conclusion: In our study, the mean sub-carinal angle was 60.17° ± 7.81°. The mean sub-carinal angle difference between male and female was statistically non-significant. There was negative correlation of sub-carinal angle with age and positive correlation with BMI. The reference value obtained from this study will be helpful to diagnose abnormal sub-carinal angle due to various pathologies.

Key words: Bronchi, chest X-ray, sub-carinal angle.

Introduction

The sub-carinal angle (SCA) is an angle formed between the right and the left main bronchus which is clearly seen in adequately exposed chest radiograph at level of 5th Thoracic vertebrae. Chest radiography is the most important imaging tests used to evaluate respiratory and cardiac disease. There are various references of normal value of SCA in the literature from previous studies that were measured on the chest radiograph. Alavi et al found in their study, the mean value of SCA of the patient over 16 years age was 57.16° ±6.06°. In patients over 16 years of age, mean values of SCA was 56.40° ±5.664° for male and 57.73°± 6.375° for female. The normal angle of tracheal bifurcation on standard chest film from 41.5° to 72.8° and the mean value was 57.2°.[1] Murray et al found in their study, the mean value of SCA for male 61.2° ±13.1° and for female 63.6° ±5.9° and total mean value of SCA was 62.6° ±14.8°.[2] Haskin et al found the mean value of SCA 60.8° ±11.80° in their study.[3] In their study, Choorat et al found the mean value of SCA of the Thai

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population 62° ±12.62°. The value of SCA ranges from 31°- 95°. The mean SCAs for Thai males and females were 60.42° and 63.46° respectively.[4]
The angle of tracheal bifurcation may be widened due to cardiac disease and mediastinal abnormalities. Despite this, it has long been accepted as a manifestation of left arterial enlargement.[5] Widening of the SCA is associated with trachea, bronchus, lung and mediastinal pathologies such as: left arterial enlargement, cardiomegaly, lobar collapse, sub-carinal mass or pericardial effusion, lymph node enlargement, upper lobe atelectasis. All previous studies measured SCA on the postero-anterior chest radiograph and coronal reformatted chest CT in respect to age, gender, thoracic index patient habitus and body mass index.[1-10]
Previous studies have shown that SCA varies in relation to various independent factors like age, sex and patient habitus. The reference value mentioned by previous studies may not be extrapolated in our population. Hence, this descriptive study was conducted to measure SCA on normal chest radiograph of adult patients in respect to age, sex and body mass index.

Method

A cross-sectional study was carried out in the department of Radiodiagnosis and Imaging at B. P. Koirala Institute of Health science, Dharan, Nepal from 27th April to 6th August 2017.
SCA was measured on the normal chest radiograph of 392 adult patient (≥ 18years) referred to the Department for chest x-ray. Postero-anterior chest projection in full inspiration was performed on indirect flat panel detector system 'Digital Diagnost' (Philips). The patient was positioned and horizontal beam centered at the eighth thoracic vertebrae (T8) level which was coincident with the mid-level of the lung field.[11] The exposure was done under technical adequacy. Technical parameters such as High kVp technique and AEC (Automatic exposure control) mode with large film focal distance (FFD) 180 cm, large focal spot were used in chest PA projection examination. The obtained chest radiograph was compared with ideal chest PA radiograph.[11]
The chest radiograph having essential image characteristics was reported by radiologist. After chest x-ray reporting, patient was included for this study as per inclusion criteria. Selected patient was given detailed information about the study and written informed consent was obtained from patient after their permission. Patient's age, sex, weight and height were taken. BMI (weight/ height^2) was calculated and were categorized as per the WHO classification.[12] SCA was identified by the consensus of the two radiologist separately as defined by Turner.[13] SCA was measured at point of tracheal bifurcation along inferior boarders of the right and left main bronchi on chest PA inspiratory image displayed over work-station medical grade monitor by means of electronic angle measurement tool (open angle tool) available in the work-station system (Digital Diagnost). The measured value of the SCA entered in semi-structured proforma for analysis.
The data were entered in MS Excel 2007 and then, exported into statistical package for social science software (SPSS) version 11.5 for statistical analysis. Descriptive statistics percentage, mean and standard deviation were calculated. For inferential statistics, independent 't' test, and Pearson's correlation was applied to find out significance of variables. P-value less than 0.05 was considered to be statistically significant.

Result

Table 1: Number of patients by age and sex

Age group	Sex		Total (n)	Percentage
	Male	Female		
18- 27	54	66	120	30.6
28- 37	34	51	85	21.7
38- 47	33	52	85	21.7
48- 57	20	30	50	12.8
58- 67	16	16	32	8.2
68- 77	9	8	17	4.3
78- 87	3	0	3	0.8
Total	169	223	392	100

A total of 392 adult patients' normal chest radiographs were used to measure SCA. There were 169 (43.1%) male and 223 (66.9%) female patients. The age ranged from 18- 83 years. The mean age of the patients was 38.36 ±15.12 years. Age distribution of the patient and its frequency is summarized in Table 1**.**

Table 2: Patient's calculated BMI as per WHO classification

Classification	BMI (kg/m^2)	Frequency (n= 392)	Percentage (%)
Underweight	< 18.5	58	14.8%
Normal weight	18.5- 24.9	231	59.9%
Pre-obese	25- 29.9	88	22.4%
Obese class- 1	30- 34.9	15	3.8%
Obese class- 2	35- 39.9	0	0

The value of BMI of the patients ranged from 13.17- 33.30 kg/m^2 and the mean value was 22.55±3.92 kg/m^2 (Table 2).

The mean SCA was 60.17º ± 7.81º (range 39°- 81.1 °)**.** The mean SCA in various age distribution of patient's is summarized in Table 3.

Table 3: Mean Sub-cranial Angle in different age groups

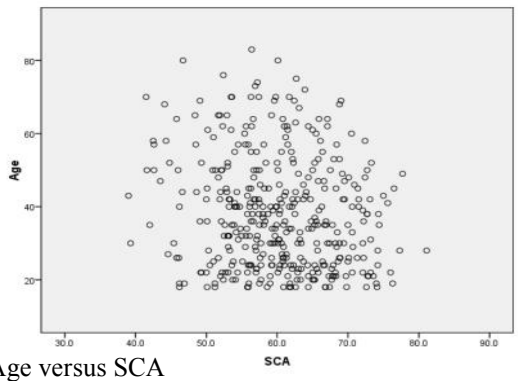
Age (years)	Frequency (n= 392)	Mean	SD
18- 27	120	61.53º	7.83º
28- 37	85	60.49º	7.17º
38- 47	85	60.45º	7.78º
48- 57	50	58.75º	8.60º
58- 67	32	58.22º	7.73º
68- 77	17	56.52º	7.05º
78- 87	3	54.40º	6.92º
Total	392	60.17º	7.81º

The mean SCA for the male was 59.17° ±8.19° and for female was 60.62° ±7.49°**.** The SCA was wider in female than male. The mean SCA of male and female is summarized in Table 4.

Table 4: Mean sub-cranial angle in male and female

Sex	Frequency (n= 392)	Percentage (%)	Mean± sd	P-value	Remarks
Male	169	43.1	59.591 °±8.198°	0.196	Non-significant
Female	223	56.9	60.622 °±7.441°		

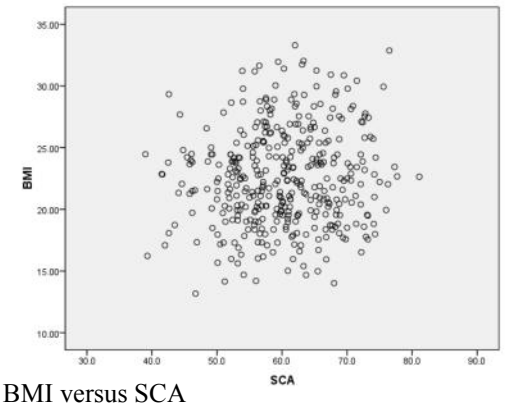
The difference between mean SCA in male and female was not statistically significant (P> 0.05). The Pearson's correlation test was applied between sub-carinal angle and age and it was found statistically significant (p< 0.01) with negative correlation (Pearson's r=-0.168, n= 392) (Figure 1).



Age versus SCA
r= -0.168, p= 0.001(p< 0.01)

Figure 1: Scatter plot of age vs. sub-carinal angle

The Pearson's correlation test was applied between sub-carinal angle and patient's BMI found statistically significant ($p< 0.05$) with positive correlation (Pearson's $r= 0.100$, $n= 392$ (Figure 2).



BMI versus SCA
$r= 0.100$, $p= 0.47(p< 0.05)$

Figure 2: Scatter plot of BMI vs. sub-carinal angle

Discussion

In this study, we measured sub-carinal angle on normal chest radiograph of adult patients in respect to age, sex and body mass index. The normal SCA ranged from 60º- 75º.[14] The mean value of SCA was 60.17º ± 7.81˚ in our study which was comparable to previous studies. Alavi et al found that the mean SCA was 57.16º ± 6.06˚.[1] Similarly, Haskin et al found the value to be 60.8º±SD11.8º.[3] Choorat et al had reported the mean SCA to be 62˚±12.62˚.[4]

In our study, the value of SCA ranged from 39º to 81.1º. The standard deviation was about 8º indicating that 95% of SCA ranges from 44º-76º. Similar results were also reported in other studies. Ninety five percent of normal values were in range of 45.28^0 to 67.50^0 by Alavi et al, 40º - 80º by Haskin et al and 36º- 88º by Choorat et al.[1,3,4]

Our study found that the mean SCA was 59.17º ± 8.19º in male and 60.62º ±7.49º in female. The mean SCA was wider in female than male. Similar results was also reported by Alavi et al, Karabult et al, Choorat et al and Salahuddin et al in their studies.[1,4,6,7] We found that the difference of mean SCA in male and female was not significant statistically ($p= 0.196$).

Our study found that age have influenced over SCA. There was weak negative correlation ($r= -0.168$ $p< 0.05$, $n= 392$) between SCA and age. In contrast to our study, according to others' age did not have influence over SCA.[1,3,4] The reason behind this may be rigid chest wall as ossification of ribs occurs in older age and downward growth of the lung also causes SCA to be narrower.[15] The bifurcation angle also decrease with inspiration. The airways are dynamic structure, and their position varies with respiration. The carina descends by 9- 15º between inspiration and expiration. The angle of tracheal bifurcation tends to decrease by up to 9º between inspiration and expiration.[10,16-18] Calcification of the cartilage rings of the trachea is the common finding after age 40 years, increasing in frequency with age which may be one reason of decreasing SCA with increasing age.[19] The SCA was positively correlated with BMI ($r= 0.100$, $p< 0.05$). The angle of bifurcation may vary with patient's habitus i.e. the asthenic patient should have a more acute angle than hypersthenic patient.[18]

Our study found that there was positive correlation ($r= 0.100$, $p< 0.05$, $n= 392$) between mean SCA and BMI. Similar finding was also reported by Salahuddin et al in their study.[7] In contrast to our finding, Karabulut et al reported that body mass index did not show significant correlation with SCA.[6]

Murray et al correlated the widening of the tracheal bifurcation angle on chest radiograph with echocardiographically determined left atrial size and found that widening of the

tracheal bifurcation angle on chest radiographs was an insensitive and nonspecific sign of left atrial enlargement. A sub-carinal angle of 65.4^o was the best discriminators between patient with normal and those enlarged left atrial dimension.[2] The upper limit of the SCA in our study was 81^o where the upper limit of the SCA was 88^o in the study by Choorat et al and about 84^o in the study by Haskin et al.[3,4] The greater value cause concern of abnormality. Taskin et al in his study concluded a carinal angle greater than 100^o was an easy, inexpensive, reliable method of predicting left atrial enlargement.[5]

Conclusion

The mean sub-carinal angle was 60.178^o $\pm$7.813**°** in our study**.** The mean SCA difference between male and female was statistically non-significant. There was negative correlation between SCA and age and positively correlated with BMI. The reference value obtained from this study will be helpful to diagnose abnormal SCA due to various pathologies. It is highly suggested to carry out the similar study on the patients having history of left atrial enlargement for predicting the abnormal sub-carinal angle.

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