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CARINAL ANGLE MEASUREMENT IN RESOURCE-CONSTRAINED SETTINGS USING SIMPLE POSTEROANTERIOR CHEST RADIOGRAPH

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ABSTRACT

Background: The carina is a ridge of cartilage in the trachea that occurs between the division of the two main bronchi. Determining the sub-carinal angle is of clinical importance as it serves as a guide in the diagnosis of some thoracic pathologies mostly related to the heart. However, advances in imaging modalities have made computed tomography more popular. Unfortunately, its cost and relative non-availability, still make planar radiography relevant especially in resource-limited communities.

Objectives: To determine the sub-carinal angle in the population and to assess if differences exist based on gender. To assess the relationship of Sub-carinal angle with age and height

Methodology: The sub-carinal angle (SCA) was measured on normally reported, high-quality plain PA-chest radiographs of 90 normal adults within the age range of 18-70 years (37 males and 53 females) that attended the Conventional Radiography Unit of the Radiology Department at Aminu Kano Teaching Hospital, Kano (AKTH) from July to August 2018.

Results: Overall mean ± SD sub-carinal angle was estimated at 58.31o ±10.57o. There was a statistically significant gender difference in SCA (p=0.01). A statistically significant difference also exists between the Left Sub Bronchial Angle (LSBA) among genders (p=0.01) only. A weak correlation exists between SCA with age. Height does not correlate with SCA (r= -0.14, p= 0.16).

Conclusion: Sub-carinal angle differs with gender. Age affects the SCA in some respects. Height reduces the angle although insignificant. Relevant health workers working in remote rural areas with limited diagnostic facilities now have a simple and cost-effective means of diagnosing mediastinal pathologies

Introduction

Sub-carinal angle (SCA) is the angle between the right and left main bronchi, also termed as tracheal bifurcation angle, or tracheobronchial angle [1]. The carina is a ridge of cartilage in the trachea that occurs between the division of the two main bronchi. This occurs at the lower end of the trachea usually at the level of the 4th thoracic vertebra, which is in line with the sternal angle, but may rise or descend up to two vertebrae higher or lower with breathing. This ridge lies to the left of the midline and runs anteroposteriorly [2,3]. The location of the lower end of the trachea varies with body posture, and with inspiration and expiration, and in deep inspiration the carinal may descend to the level of the sixth thoracic vertebra [4,5].

Determining SCA is of clinical importance because it serves as a guide in the diagnosis of some thoracic pathology more peculiar to the heart, according to Chunder, (2015) increase in the SCA is mentioned as an indirect sign of pathology in the heart or mediastinum such as left atrial enlargement, generalized cardiomegaly, lobar collapse, sub-carinal mass or pericardial effusion. An increased tracheal carinal angle had been reported as one indicator on chest radiography of left atrial enlargement [6,7,8].

Techniques of bronchial examinations are either invasive or non-invasive e.g. cadaveric dissection, bronchograms, virtual bronchoscopy, Computed Tomography (CT) scan, Magnetic Resonance Imaging (MRI) scan, and Chest Postero-anterior (PA) radiographs [9,10]. Reed et al (1996) reported direct examination by endoscopy provides excellent visualization of the intraluminal structures; however, overall orientation and angulation cannot be assessed endoscopically because of optical distortion and the limited field of view [6,9,10]. Additionally, manipulation of the airway to accommodate rigid instruments may result in stretching, pulling, or bending, potentially imparting inaccuracies to measurements. Similarly, cadaveric studies also are limited in application because of post-mortem changes and necessary tissue fixation techniques [6]. On the other hand, CT adds a 3-dimensional component to the understanding of tracheobronchial anatomy. It has proven to be an excellent technique for evaluating mediastinal structures and is an excellent method of displaying the cross-sectional anatomy of the trachea. Computed tomography causes little or no disturbance of tracheal anatomy [11]. However, its high doses of ionizing radiation, relative availability in urban areas, and cost highlight a drawback. An ideal PA chest radiograph provides diagnostic images of the bronchial tree, particularly the tracheal bifurcation, without distorting the tracheal anatomy [8]. This technique offers a safer, lower radiation dose examination and is readily available in resource-deprived rural areas of our communities. Additionally, it remains a cost-effective means of evaluating SCA [8, 12].

This study utilizes high-quality PA chest radiographs of normal human subjects to determine the SCA in the population. It aims to assess the existence of gender differences and explore the relationship between SCA, age, and height. This will be of value to Radiologists, Radiographers, pulmonologists, and even medical officers working in remote settings with limited diagnostic options a readily, cheap, safe, convenient, and objective method of evaluating the mediastinal and cardiac pathologies.

Materials and Method

This was a prospective cross-sectional study that was carried out in the Conventional Radiography unit of the Department of Radiology, Aminu Kano Teaching Hospital (AKTH), and was approved by the Human Research and Ethics Committee of the College of Health Science Bayero University, Kano. Only normal PA chest radiographs were recruited. Their age ranged from 18 to 70 years. This was from a pool of patients referred for PA Chest x-ray. Recruitment was by convenient sampling technique considering only those with a normal finding were admitted into the study. The height of patients was measured using a calibrated and graduated Stadiometer (MI20, manufactured by IndiaMART; 2014 in India). The ages of participants were obtained through oral interviews and confirmed on each patient's medical folder.

The Sub-Carinal Angle (SCA) was measured on the Postero-Anterior (PA) chest radiographs by first drawing a straight vertical reference line down the middle of the trachea, ensuring it intersected the carina at a right angle. Next, two straight lines were drawn along the longitudinal axis of the medial borders of the right and left bronchi, intersecting the carina in the midline. These lines formed different angles with the vertical reference line. A graduated protractor was placed on the reference line to

measure each bronchial angle. The angles formed between the reference line and the lines along the medial walls of the right and left bronchi were recorded as the right and left sub-bronchial angles, respectively. Similarly, the SCA for the participants was the sum of the determined right and left bronchial angles. Following normality test using KS-test data was expressed in terms of mean±SD. Gender differences were assessed using an independent samples t-test and Pearson's correlation was used to assess for relationship between SCA and height. The level of statistical significance was set at 0.05. Analysis was done using SPSS version 20.0.

Results

A total of 90 normal reported PA chest radiographs comprising 37 (41%) males and 53 (58.9%) females were recruited. Their age ranged from 18 to 70 years with mean age of 35.08 ±13years. Their mean height was (1.63 ±0.97m). The mean Sub-Carinal Angle (SCA) for the entire population was 58.31° ± 10.57°. When analyzed by gender, the mean SCA was 54.95° ± 9.20° for males and 60.66° ± 10.91° for females. Additionally, the overall mean right SCA was 27.76° ± 8.04°, while the overall mean left SCA was 30.78° ± 5.68°. A statistically significant difference was observed between the determined SCA among genders (p=0.01) as seen in Table 1.

Table 1: Gender difference in Sub carina angle

Variable	n	mean	SD	df	tcal	p value
Male	37	54.95º	9.20 º			
				88	2.60	0.01
Female	53	60.66 º	10.91 º			

However, when analyzing the Right Sub-Bronchial Angle (RSBA) based on gender, no statistically significant difference was found (p=0.66), as shown in Table 2. The Left sub carina angle (LSCA) showed statistically significant difference among gender (p=0.003) (Table 3).

Table 2: Gender difference in Right Sub-bronchial angle

Variable	n	mean	SD	df	tcal	p value
Male	37	27.43 º	4.60 º			
				88	-0.45	0.66
Female	53	27.98 º	6.36 º			

Table 3: Gender difference in Left Sub-bronchial angle

Variable	n	mean	SD	df	tcal	p value
Male	37	27.38 º	7.25 º			
				88	-3.06	0.003
Female	53	32.87 º	8.07 º			

A statistically significant but weak positive correlation was found between SCA and age (r=0.21, p=0.005). Conversely, a weak negative correlation was observed between SCA and height, though this was not statistically significant (r=-0.15, p=0.16).

Discussion

The mediastinum is a dynamic region that is mostly affected by respiration as even a subtle change in the respiratory phase may affect the carinal angle. It is known that the carina is displaced downward during inspiration. Extension of the head and elongation of the bronchial tree by inspiration do cause the carinal angle to become narrow [8]. On the other hand, the shortening of the bronchial tree widens the carinal angle [1,2,4,5]. Despite these apparent variations, a change in the SCA is considered an indirect indicator of pathological assessment in the mediastinum or heart [2,6,7,8]. Establishing the normal range of the SCA using the simple method described in this study will assist radiologists, radiographers, clinicians, and medical officers—particularly those in remote and rural health settings with limited access to advanced medical imaging—in making prompt, evidence-based decisions for patients suspected of having mediastinal pathologies.

In the present study, the overall mean Sub-Carinal Angle (SCA) was found to be 58.31° ± 10.57. This is consistent with a similar study conducted by Alavi et al. (1970) in Aurangabad, India, which determined the SCA using PA chest radiographs and reported a mean SCA of 57.16° ± 6.01. A similar study conducted by Khade et al., (2016) in India determined the SCA using CT, they reported a mean SCA of 79.92o ±11.60[6]. The disparity with the present study could be as a result of methodology differences among the studies. While the present study and that of Alavi et al., (1970) utilized plain PA chest radiographs in determining the SCAs, Khade et al., (2016) utilized CT-generated images. It is worth noting that plain radiographs demarcate only the intraluminal air interface since the walls of the bronchi is poorly appreciated. Whereas CT images have clear densities for both the bronchial wall and lumen. This may perhaps create room for additional margin and might explain why Khade et al., (2016) reported a wider SCA.

Based on gender, the present study determined the male and female SCA as 54.95 o ±9.2 o and 60.66o ±10.91 respectively. Alavi et al., (1970) in India conducted a similar study and reported an SCA of 56.4o±5.66o in males and 57.73o ±6.37o in females [13]. A similar pattern was observed in the present study whereby females had wider SCA than males. Although with a slight margin which could be due to anatomical and/or geographic variation. Furthermore, this could be attributed to the participant's age distribution as females had a higher mean age than their male counterparts. The age variation among genders could account for higher values as observed. A statistically significant difference between SCA of males and females was established in the present study($p<0.005$). The reason for this could be attributed to body habitus. The study population largely has men being hypersthenic-sthenic individuals as against their female counterparts who are broader and shorter (sthenic-asthenic) body up.

On symmetrical sides, the present study estimated the RSBA and LSBA to be 27.76o±4.60 and 30.78o ±7.25 respectively. A similar finding for the RSBA was obtained by in Poland who reported 26.9 o ±7.0 while the LSBA was reported as 46.2o±8.09[14]. A study by in Andhra Pradesh, India using cadaver reported RSBA and LSBA were estimated to be 39.68o and LSCA was found to be 43.34o[9]. Here, all cited studies reported LSBA having a wider angle than the RSBA due to the obvious presence of the apex of the heart (basis cordis). The convexity of the left atria, pulmonary trunk, and coronary sulcus (posterior part) may account for a pressure effect on the left bronchus which is evident on the wider angle [1,5,15]. This, further explains why there was a statistically significant gender difference in LSBA but not obtained in the RSBA.

Similarly, the present study established a relationship between SCA with age. This may be due to muscle tone and ligament integrity in the mediastinum. With age, these structures tend to lose their tone and laxity [3]. No correlation was established between SCA and height, thus height is of no clinical significance.

Conclusion

The SCA of normal adults for the study population was estimated using a reproducible and easy

method. Gender differences also exist. Also, a relationship exists between the SCA and age. However, its relationship with height was negative and weak.

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