Original article

A morphometric study of human subcarinal angle in different age groups in both sexes and its clinical implications

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Abstract:

Introduction: The subcarinal angle is the angle between the right and left main bronchus. Increase in the subcarinal angle is mentioned as an indirect sign of pathology in the heart or mediastimum such as left atrial enlargement, generalized cardiomegaly, lobar collapse, subcarinal mass or pericardial effusion.

Methods: A morphometric study of human subcarinal angle was undertaken in the Department of Anatomy, Institute of Post Graduate Medical Education and Research, Kolkata, West Bengal, India, on 60 specimens (34 male and 26 female) procured from relatively fresh disease free cadavers from Kolkata Police Morgue. Subcarinal angle was measured with a diagonal scale on the photograph of the specimen by tracing the medial borders of the right and left principal bronchi with the marker pen. The standard error (SE), standard deviation (SD) and test of significance were calculated using independent sample‘t’ test and multiple comparison test.

Observations: The present investigation revealed a wide variation in the subcarinal angle, in a same age group as well as in different age groups in both sexes. The mean subcarinal angle in male was 59.1 degrees and 53.1 degrees in females.

Conclusion: The study of these subcarinal angle variations is of profound clinical importance as it may help the clinicians to understand the etiology of several pulmonary and cardiac diseases and the surgeons to deal with resection and reconstruction of the tracheobronchial tree. This knowledge is also helpful for smooth conduction of some manoeuvres like endotracheal intubation and bronchoscopic procedures.

Key words: Morphometry, Principal bronchi, Sub-carinal angle, Cadaveric study

Introduction

The trachea extends from the lower border of the cricoid cartilage opposite C6 vertebra up to the upper border of T5 vertebra where it ends by dividing into right and left principal bronchi supplying the right and left lungs respectively. It lies approximately in sagittal plane, but its point of bifurcation is usually a little to the right.[1] In the adult, the tracheal bifurcation is at the level of second costal cartilage. The main bronchi are separated at their origin by a narrow ridge which, in view of its resemblance to the keel of an upturned boat, is called the carina. [2]

Several studies conducted on measuring the tracheobronchial angle showed apparent discrepancies in living subjects and post-mortem studies and explained in part by the vertical movement of the diaphragm.[3,4] The value of the subcarinal angle ranged from 35 degree-90.5 degree (mean, 60.8 degree; SD, 11 .8 degree). There was no relation of the bifurcation angle to age or gender. There was only a weak correlation between bifurcation angle

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and height or width of the thorax.[5] The width of the tracheal bifurcation angle may be of value in recognizing subcarinal masses, lobar collapse, left atrial enlargement, [6,7] generalized cardiomegaly and pericardial effusion.[8]

Aims and objectives

The present study was taken up to measure the subcarinal angle in different age groups of both sexes which might have bearing in the production of respiratory and cardiac diseases. An accurate anatomical knowledge of the same is of immense importance in problems of resection and reconstruction of the tracheobronchial tree. Last but not the least, these information have potential applications to studies in pulmonary physiology and anesthesiology as also to conduction of some maneuvers like endotracheal intubation and bronchoscopic procedures (diagnostic, therapeutic and combined) with skill and perfection .[9]

Materials and methods

A total number of 60 specimens were procured from 34 male and 26 female relatively disease free fresh cadavers from Kolkata Police Morgue. The specimens were grouped into five age groups (0-15years, 16-25years, 26-40years, 41-55years and >55years) for both sexes. Subsequent study utilizing these specimens was conducted in the Department of Anatomy, Institute of Post Graduate Medical Education and Research (IPGME&R), Kolkata, West Bengal, India.

First a photograph of the specimen was taken. Subsequently, the subcarinal angle which is referred to the angle between the two main bronchi, as measured along their inferior borders [3] was measured on the photograph of the specimen. The inferior borders of the right and left principal bronchi were traced with the marker pen and the two lines thus drawn were joined to get the subcarinal angle with the help of a diagonal scale (**Figure 1**).

All the measurements were recorded in a tabulated manner age wise (the different age groups in the present study being 0-15years, 16-25years, 26-40years, 41-55years and >55years) in both sexes. For each component of measurements, the standard error, standard deviation and test of significance were calculated using independent sample't' test and multiple comparison test and recorded in a tabular form. Graphical representations were also made. **(Figure 2)**

Observations and results

The mean subcarinal angles in the 0-15 years, 16-25 years, 26-40 years , 41-55 years and >55 years age groups in our study were 64.3 degrees, 56.4 degrees, 58.4 degrees, 57.1 degrees and 59.5 degrees in males and 61.4 degrees, 52.9 degrees, 49.2 degrees, 48.2 degrees and 54 degrees in females respectively.

The independent samples test for subcarinal angle showed highly significant p value in all the age groups except >55 years age group which showed a significant p value**. (Table 1)**

As ANOVA test was highly significant ($p<0.001$) for subcarinal angles, multiple comparisons were done between all the five age groups for both males and females using Tukey's test. The results of multiple comparisons test in male and female subcarinal angles are furnished in **Table 2**.

Discussion

In our study, the mean subcarinal angle decreased from the value of 64.3 degree and 61.4 degree in male and female respectively in the 0-15 years to 56.4 degree and 52.9 degree in male and female in the 16-25 years age group. This might be due to the fact that in 0-15 years group, the lung grows more laterally than downwards as the lateral chest wall is more yielding (ossification of the ribs are in immature stage). In the 16-25 years age group, the chest wall becomes relatively rigid as ossification of the ribs are about to be complete and direct the more downward growth of the lung causing the subcarinal angle to be narrower.[10]

In Indian population the subcarinal angle was found considerably smaller, and averaged 53.54 degree in foetuses with CRL of 131–200 mm, 62.98 degree in neonates, 58.58 degree in children aged 1–10 years, and 54.56 degree in teenagers.[11]

Haskin et al measured the subcarinal angle of 100 autopsy specimens (47 men and 53 women of 21-80 years age). In their study, the mean subcarinal angle for males was 62.0 degree; SD = 11.97 degree and the mean subcarinal angle for females was 60.9 degree; SD = 10.99 degree.[5] The mean subcarinal angle in our study was 59.1 degree and 53.1 degree in males and females respectively.

Most published measurements have been obtained from cadavers or specimens of dissected tracheas. The bifurcation angles derived from nonliving specimens are of little value when applied to the patient in maximum inspiration, since the bifurcation angle decreases with inspiration.[12] In fact, the angle of tracheal bifurcation tends to decrease by up to 9º between inspiration and expiration.[13]

Alavi et al published one of the few studies in which values for the interbronchial angle were derived from erect chest radiographs of living patients (29 children and 58 adults). In 29 children (aged 3 weeks to 16 years), the bifurcation angle decreased with age. The formula y = (71 .91 5 - 0.71 x age in years) described the expected angle for children. In the 58 adults studied, the mean angle was about 57 degree, with a standard deviation of about 6 degree. Ninety-five percent of adult bifurcation angles were 45 degree - 69 degree.[14]

It has been suggested, but not proved, that the angle of bifurcation may vary with the patient's body habitus; that is, the asthenic patient should have a more acute angle than the stout patient. If indeed the angle does vary with the height, the width, or a height-to-width ratio of the thorax, perhaps the expected angle of bifurcation could be predicted for a given patient and a useful set of standards established that could be applied in clinical practice.[9]

According to Haskin et al, an angle of approximately 80 degree in the asthenic person is probably abnormal and the same approaching 40 degree in the stout person is also abnormal. They also stated that severe deviations from normal (>2 SD: <40 degree or >80 degree) should arouse the suspicion of abnormality and warrant additional investigation for cardiac, lung, or mediastinal abnormality.[5]

Several other clinical implications of the subcarinal angles have been studied. The angle of tracheal bifurcation may be reduced after pulmonary lobectomy and lobar collapse.[15] A significant positive correlation between subcarinal angles and LA volumes have been found which help in diagnosing several cardiac diseases.[7] A study by Chen et al reported the ability to follow the resolution of pericardial effusions by measuring the decrease in the carinal angle.[8]

Lastly, the limitation of this study lies in properly defining the angle of tracheal bifurcation. In most standard reference sources, figures cited in degree for the angle of bifurcation of trachea pertain to "**interbronchial angle**". Frequently, the figure for the two bronchi is given separately as "angle formed by the bronchus with the median plane". These angles are rarely further defined and their exact reference axes are seldom given. Figures related to such angles, therefore are ambiguous and have an unknown degree of reliability. Since the right and left bronchi usually diverge from the trachea at different levels, a midline interbronchial angle is normally not present between their central axes. A true interbronchial angle could be formed,

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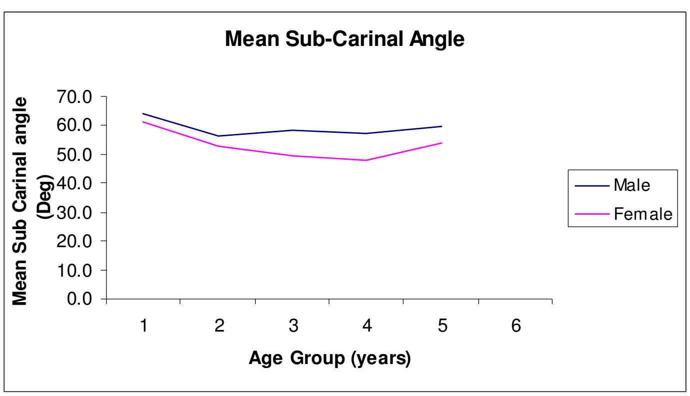
in most cases, by extending the line drawn through the central axes of bronchi to a point of intersection of the midline. In some other instances, the term interbronchial angle has been constructed to refer to the angle between the two main bronchi, as measured along their inferior border (**subcarinal angle**) as in our study. Mean values of the right and left subcarinal angles are quite different from those of right and left main axes angles and ambiguity again results from failure to define the geometry specifically. Even in those cases where the values are given for right and left bronchus separately, the angle formed by bronchi with the median plane (presumably the tracheal) is vague and could refer to either subcarinal angle or main axes angle.[16]

Figure 1:
Showing the measurement of the subcarinal angle by tracing the inferior borders of the right and left principal bronchi with a marker pen and measuring the angle with a diagonal scale at the meeting point of the two lines in a 22 year old female (Specimen no. 19) R: Right side of specimen. Subcarinal angle: 55



Graphical representation of the Mean Subcarinal Angle in different age groups in both sexes.
Age group signifies: **1**. 0-15years, **2**. 16-25 years, **3**. 26-40 years, **4**. 41-55 years, **5**. More than 55 years.

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Table 1

Statistical constants of the Sub Carinal Angle in different age groups in male and female including test of significance using independent sample test

	Age group (in years)	Mean Sub-Carinal Angle (in degree)	Standard deviation	Standard Error	p value	Significance
M	0-15	64.3	5.123	2.562	_	_
A	16-25	56.4	4.771	1.509	<0.001	HS
L	26-40	58.4	3.233	0.975	<0.001	HS
E	41-55	57.1	3.442	0.861	<0.001	HS
	>55	59.5	3.957	1.251	<0.05	IS
F	0-15	61.4	0.707	0.500	_	_
E	16-25	52.9	5.615	1.872	<0.001	HS
M	26-40	49.2	4.868	1.623	<0.001	HS
A	41-55	48.2	3.824	1.209	<0.001	HS
L	>55	54.0	4.243	1.732	<0.05	IS
E						

HS: Highly significant , IS: Insignificant.

Table 2

Multiple comparisions of Sub Carinal angle in males & females using Tukey's Test

Age Group	Age Code	Male p value for SCA	Significance	Female p value for SCA	Significance
Age code 1	2	0.848	IS	0.313	IS
(0-15	3	0.093	IS	0.690	IS
years)	4	0.017	Sg	0.839	IS
	5	0.848	IS	0.035	Sg
Age code 2	1	0.848	IS	0.313	IS
(16-25	3	0.253	IS	0.820	IS
years)	4	0.032	Sg	0.522	IS
	5	1.000	IS	0.380	IS
Age code 3	1	0.093	IS	0.690	IS
(26-40	2	0.253	IS	0.820	IS
years)	4	0.927	IS	0.989	IS
	5	0.253	IS	0.065	IS

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Age code 4	1	0.017	Sg	0.839	IS
(41-55	2	0.032	Sg	0.522	IS
years)	3	0.927	IS	0.989	IS
	5	0.032	Sg	0.021	Sg
Age code 5	1	0.848	IS	0.035	Sg
(>55	2	1.000	IS	0.380	IS
years)	3	0.253	IS	0.065	IS
	4	0.032	Sg	0.021	Sg

Conclusion

The subcarinal angle decreased markedly from 0-15 years age group to 16-25 years age group in both the sexes. This might be due to the yielding and unyielding character of the chest wall in those age groups respectively both in male and female. But in other age groups, the subcarinal angle difference in both the sexes showed mild to moderate degree of variation. The knowledge of the subcarinal angle is of clinical importance due to the following reason:-

1. Bronchoscopy is easier in adults than neonates and children and it requires more skill to introduce the bronchoscope particularly on the left side where the primary bronchus makes a smaller angle with the trachea. Lack of this knowledge might give a wrong interpretation of bronchial obstruction on failing to introduce the bronchoscope.[17]
2. The growth in the mediastinal structures or any pathology of the lung or pleura (example: fibrosis, collapse, pleural effusion) or cardiac diseases (pericardial effusion, left atrial enlargement) may alter the subcarinal angle considerably.
3. The subcarinal angle contributed by the right bronchus is small, as it is more or less in the same line with the trachea. So lodgement of foreign body is more in right bronchus. [18]

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