

RESEARCH ARTICLE

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Morphometric Examination of The Tracheobronchial Tree in Cases with Foreign Body Aspiration

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Abstract

Objective: Recently, few studies have evaluated bronchial morphometric parameters focusing on bronchial length, diameter, or angles. These parameters can be an important indicator in various pathological processes and are essential for simulating the flow of aspiration and inspired particle transport. The aim of this study is to determine the trachea, the diameters of the right and left main bronchus, the angle of the carina and the angulations of the right and left main bronchus; To investigate the extent to its affects the foreign body aspiration localization.

Methods: In this study, pediatric patients under the age of 18 who came with a history of foreign body aspiration and underwent computerized tomography between 2017 and 2020 were included in the study. The patients were evaluated in terms of age, gender, anatomical localization of the aspirated foreign body, diameter of trachea, right main bronchus, left main bronchus, carina angle, branching angles of right and left main bronchus on CT.

Results: Of the cases in this study, 13 (56.5%) were female and 10 (43.5%) were male, It was observed that the aspirated foreign body was on the left side in 12 (52.2%) children, and on the right side in 11 (47.8%) children. The mean age of the patients was 5.52 ± 4.86 . The right bronchial angle (RBA) mean of the children with the foreign body on the left side was 39.04 ± 6.68 , with a significantly wider angle compared to the mean RBA in the children with the foreign body on the right side ($p=0.013$).

Conclusion: The factor affecting the localization of the foreign body is the branching angle of the right main bronchus. According to the results of our study, it has been observed that if this angle is less than 37, the object will be on the right side, and if it is 37 degrees and above, the object will turn to the left.

Key Words: Tracheobronchial tree, Foreign body aspiration, Carina angle

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INTRODUCTION

The escape of any foreign body into the tracheobronchial system is defined as foreign body aspiration. Approximately 60-90% of foreign body aspirations occur in children and it is responsible for 7% of deaths in 1-3 years age group. Aspirated foreign bodies can lead to death in a short time, and if this acute period is unnoticed and remains in the tracheobronchial tree for a long time, it can cause progressive lung problems such as recurrent pneumonia, lung abscess and bronchiectasis. Therefore, early diagnosis and treatment is very important in foreign body aspirations. Half of the patients can be diagnosed within the first 24 hours, 30% within a week, and the remaining 20% within weeks or years(1,2). Although not as prominent as in adults, right bronchial tree in children is shorter, perpendicular, and its angle with the trachea is narrower than the left main bronchus. Due to this structure of the tracheobronchial tree, it has been shown in many studies that aspirated foreign bodies mostly escape to the right lung(3,4).

Recently, few studies have evaluated bronchial morphometric parameters focusing on bronchial length, diameter, or angles. These parameters can be an important indicator in various pathological processes and are essential for simulating the flow of aspiration and inspired particle transport (5,6).

To the best our knowledge, our study is one of the first studies in the literature to examine

the bronchial tree morphometrically according to the foreign body location side in cases with foreign body aspiration.

The purpose of this study is to determine the trachea, the diameters of the right and left main bronchus, the angle of the carina and the angulations of the right and left main bronchus; To investigate the extent to its affects the foreign body aspiration localization.

METHODS

Patients

In this study, pediatric patients under the age of 18 who came with a anamnesis of foreign body aspiration and underwent computerized tomography between 2017 and 2020 were included in the study, with the approval of the ethics committee dated 16.01.2020 and decision numbered 19.

Patients who underwent radiography with the suspicion of foreign body, but who had no direct or indirect radiographic findings and who had CT examination (to avoid unnecessary bronchoscopy) because of the continuing clinical suspicion were included in the study. The patients were evaluated in terms of gender, age, anatomical localization of the aspirated foreign body, diameter of trachea, left and right main bronchus, carina angle, branching angles of left and right main bronchus on CT.

Patients older than 18 years of age and did not have an optimal quality radiological image, and who received emergency bronchospy due to poor general condition were excluded from

the study.

Screening protocol

CT scans were performed on the 64-slice Toshiba Aquilion (Toshiba Medical System Corporation, Otawara-Shi, Japan, Model TSX-101A, 5 mm section thickness) unit. CT images were acquired in the supine position. CT scans were performed at low dose for the pediatric age group and without any contrast agent. A lung window image array with a slice thickness of 3 mm was used for measurements.

Image Analysis

A single radiologist with 11 years of experience were analyzed CT images of the patients Anteroposterior (Tr-AP) and transvers (Tr-T) diameters of trachea were measured on axial images. Tracheal diameter measurements were made at the midclavicular level at the level of the thoracic inlet, due to its easy identification. Right bronchial angle (RBA) and left bronchial angle (LBA) measurements were made from coronal images. A vertical line was drawn through the middle of the carina in the coronal images and the angles between this line and the imaginary lines parallel to the lumen of the bronchi and passing through the middle of the bronchial lumen were measured (Figure 1). In addition, carinal angle (CA) and main bronchus diameters were measured from the coronal series.

Statistical Analysis

The normal distribution of the data to the was examined using the Shaphiro Wilk test.

Variance homogenite was examined Levene test. Mean differences between two independent groups with normally distributed will be compared by Student's t-test, whereas the Mann–Whitney U test will be applied for comparisons of the not normally. In addition, the relationship between right-sided foreign body aspiration with RBA angle was examined by receiver operating characteristic (ROC). For numerical variables, mean±standard deviation are given and , number and percentage values for categorical variables are given. SPSS (Statistical Package for the Social Sciences, SPSS Inc., Chicago, IL, USA) Windows version 22.0 program was used and $p < 0.05$ was considered statistically significant.

RESULTS

Of the cases in this study, 10 (43.5%) were male and 13 (56.5%) female, It was observed that the aspirated foreign body was on the left side in 12 (52.2%) children, and on the right side in 11 (47.8%) children. The mean age of the patients was 5.52 ± 4.86 . On the aspiration side, atelectasis was observed in 2 children (8.7%), and consolidation was observed in 6 children (26.1%) (Table 1).

Table 1. General descriptive features of the cases

	n (%)	
Sex	female	13 (56,5)
	male	10 (43,5)
Age(standard deviation)	5,52±4,86	
side	left	12 (52,2)
	right	11 (47,8)
atelectasis	+	2 (8,7)
	-	21 (91,3)
consolidation	+	6 (26,1)
	-	17 (73,9)

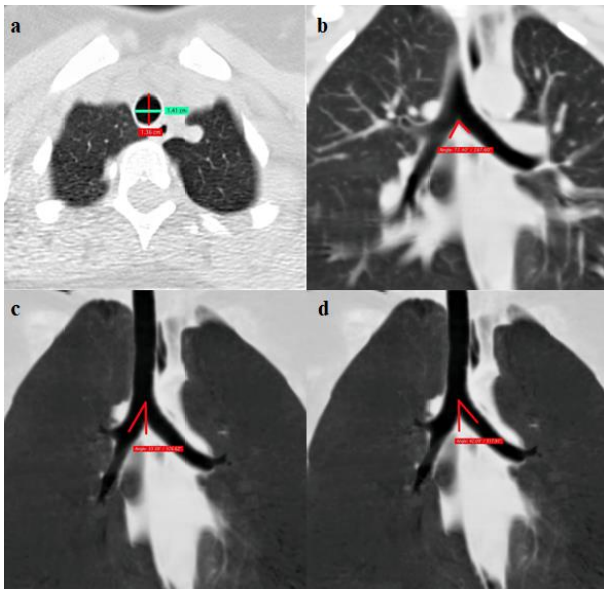


Figure 1: a. Measurement of anteroposterior and transverse diameter of the trachea. b. Measurement of carinal angle. c and d. Measurement of right and left bronchial angle.

The radiological parameters of children with a foreign body on the right side and those with a foreign body on the left side were compared (Table 2). It was observed that the right bronchial angle mean of the children with the foreign body on the left side was 39.04 ± 6.68 , with a significantly wider angle compared to the mean RBA in the children with the foreign body on the right side ($p=0.013$). It was showed that there was no statistically difference in terms of transverse and anteroposterior diameters of the trachea, carina angle, and diameters of the left and right main bronchi in children with objects on the left and right sides ($p>0.05$).

The RBA parameter was analyzed by ROC (Receiver operating characteristic) analysis to estimate the foreign body side. It was observed that the Area Under of the Curve value in

determining the side of the RBA parameter was statistically significant (AUC 0.807: $p=0.013$) (Figure 2). It was predicted that if the RBA angle was less than 37, the object would be on the right side, and if it was 37 angle and above, the object would tend to the left (Table 3, Figure 3).

Table 2. Comparison of parameters

Variables	Left (n=12) mean±sd	Right (n=11) mean±sd	Test statisti cs	P
Anteroposterior tracheal diameter	7,65 ± 1,72	7,67 ± 1,17	z=-0,67	0,498
Transvers tracheal diameter	7,63 ± 2,27	7,14 ± 1,3	z=-0,19	0,853
RBA	39,04 ± 6,68	32,84 ± 3,72	t=2,71	0,013
LBA	40,33 ± 4,58	37,15 ± 8,42	t=1,14	0,267
CA	81,37 ± 9,97	75,66 ± 15,62	t=1,05	0,304
Right main bronchus diameter	6,2 ± 2,32	5,83 ± 1,64	z=-0,06	0,951
Left main bronchus diameter	5,67 ± 2,17	5,29 ± 1,28	z=-0,46	0,644

t value was obtained from Student t test, z value was obtained from Mann Whitney U test. sd:Standard deviation

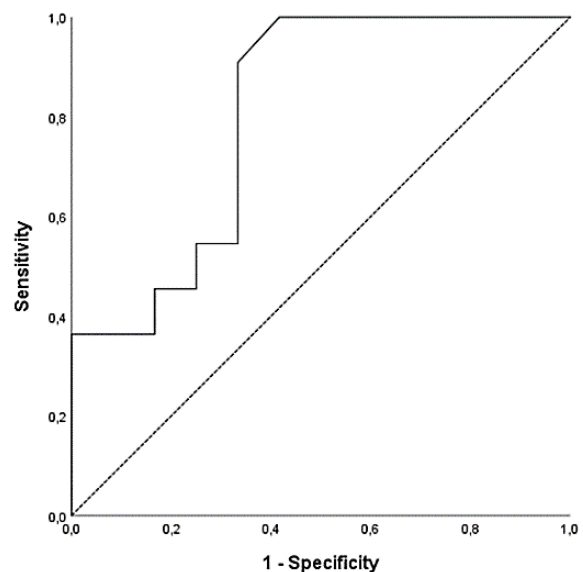


Figure 2. Roc curve of the relationship between the side of the foreign body and the RBA angle

Table 3. Determination of the relationship between the side of the foreign body and the RBA angle by Roc analysis

Cut-off	RBA<37,71
AUC (%95 CI)	0,807 (0,624 0,989)
Sensitivity	0,999
Specificity	0,583
P value	0,013

CI: confidence interval

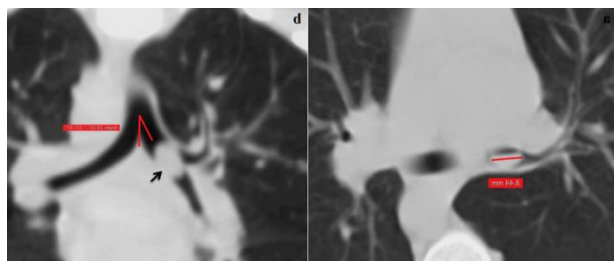


Figure 3. a and b. The right bronchial angle was measured as 28 degrees in a 9-year-old male patient with an 8.4 mm diameter foreign body (black arrow) in the right main bronchus.

DISCUSSION

Most of the morphometric studies of the bronchial tree have been performed with only posteroanterior chest radiography. There are various studies measuring the diameter, length and angles of the trachea and main bronchi at different levels and planes by computed tomography (7,8). In a morphometric study by Oliver et al. with thoracic CT, it was reported that transverse diameter of the trachea the was smaller than anterior-posterior diameter, but this difference was statistically significant only in males(9). It has been reported that the intrathoracic trachea is usually circular or oval, sometimes oblong or horseshoe-shaped; and its shape may vary according to its level. Gamsu et al. reported that the trachea can have different shapes. According to this study, it was reported that the trachea had a different shape in 22 out of 50 patients. Horseshoe-shaped

trachea was present in 12 patients (24%), inverted pear-shaped trachea in 6 patients (12%), and rectangular trachea in 2 patients (4%) (10,11). In our study, there was no significant difference between the anteroposterior and transverse diameters of the trachea.

Revealed in a retrospective study that angles of tracheal bifurcation (IBA, RBA and SCA) in children younger than 18 years showed differences in different age groups. However, this difference is significant just between children over the age of 10 and under the age of 10. IBAs and SCAs expanded under age of 10. They measured mean SCA values above 80° and IBA values above 85° for children under the age of 10. In our study, almost all of our patients were under the age of 10. The mean carina angles were 81.37 ± 9.97 in cases aspirated into the right main bronchus, and 75.66 ± 15.62 in cases aspirated into the left main bronchus.

When the studies analyzing the subcarinal angle in adults and children are examined, it is showed that the subcarinal angle is higher in adults than in children (Tables III and IV). Ulusoy et al. reported that the subcarinal angle was higher in adults (12). Jit et al. and Chunder et al. study found that the subcarinal angle was higher in children (13,14). Farrukhabad et al. reported that as age progresses, chest wall and ribs ossifications is about to be completed, they become relatively stiff and direct the

undergrowth of the lungs, causing a narrowing of the subcarinal angle (15). Although different subcarinal angle values have been reported in the literature in adults and children, in our study, no statistically significant effect was found on the aspiration of the foreign body in the right or left main bronchus in the pediatric age group. However, in some studies, it has been stated that the enlargement of mediastinal structures or lung diseases can change the subcarinal angle dramatically and this can cause a change in the right main bronchus angle (16). In our study, a statistically significant relationship was found between the branching angle of the right main bronchus and the aspiration localization of the foreign body.

In a study conducted by Kubota et al., it was reported that the mean right bronchial angle was $31^{\circ} \pm 5^{\circ}$ and the mean left bronchial angle was $49^{\circ} \pm 7^{\circ}$ (17). No statistically significant difference was observed in the mean left bronchial angle values compared to the foreign body location side in our examination using CT images according to the side of the foreign body aspiration in cases of foreign body aspiration. However, the mean right bronchial angle was found to be 39.04 ± 6.68 in cases with aspiration to the left bronchial tree and 32.84 ± 3.72 in cases with aspiration to the right bronchial tree, which was statistically significant ($p:0.013$)

CONCLUSION

As a result; as far as we know, this study is

the first study in the literature to examine the bronchial tree morphometrically according to the foreign body location side in cases with foreign body aspiration. Our findings showed that; the factor affecting the localization of the foreign body is the branching angle of the right main bronchus. According to the results of our study, it has been observed that if this angle is less than 37, the object will be on the right side, and if it is 37 degrees and above, the object will turn to the left. In our opinion, considering the branching angle of the right main bronchus in cases of non-opaque foreign body aspiration may be helpful in bronchoscopy.

Ethics Committee Approval: Ethics committee approval was received for this study from Hatay Mustafa Kemal University Clinical Research Ethics Committee (ethics committee date and no: 16.01.2020 and 19)

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