



ORIGINAL RESEARCH

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## Anatomical and radiologic approach to tracheal diverticula

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### Abstract

Tracheal diverticula (TD) are benign conditions characterized by single or multiple outpouchings from the tracheal wall. Different series which demonstrate tracheal diverticula on autopsy series, fiber optic bronchoscope examinations, and CT images are found in the literature. Treatment options for TD are surgical resection, endoscopic cauterization with laser or electrocoagulation and conservative management. Surgery is the treatment choice for young patients, while conservative treatment is recommended for elderly patients. We performed a retrospective study on 2271 patients who underwent thoracic CT examination for different reasons. Presence, number, anatomical location, level, diameter, cystic component, and accompanying variations were assessed and recorded. A total of 2271 patients were evaluated in the present study. 73 patients (38 females, 35 males) with TD were detected. The prevalence of TD was found to be 3.2%. It was found more frequently in women (52.1%) than in men (47.9%). The mean diameter of the diverticula was 4.5 mm (range 1-15 mm) in females and 5mm (1-14) in males. There was no difference between gender groups according diameter median values ( $p=0.811$ ). TD was solitary in 71 (97.2%) patients and doubled (2.7%) in two patients. In conclusion our data showed a female predilection of prevalence, but no statistically significant difference between gender and other parameters (diameter, side, and level) was indicated. Patients with paratracheal air cysts that have no connection with the tracheal lumen were also analyzed in this study, and cystic group's diameter values were found to be higher than the non-cystic group. This difference was found to be statistically significant.

**Keywords:** Tracheal diverticula, computed tomography, air cyst, variation

### Introduction

Tracheal diverticula (TD) are benign conditions characterized by single or multiple outpouchings from the tracheal wall [1,2]. They are relatively rare, congenital or acquired entities [3,4]. A defect in the endodermal differentiation during the development of the posterior wall of trachea leads congenital diverticulum [5]. Acquired diverticula are formed by outpouching of mucous membrane through a weak point of tracheal wall due to increased intraluminal pressure [4,6]. Congenital TD is defined as true diverticula because they contain all layers of tracheal wall. Acquired TD is lack of smooth muscle and cartilage, but they are lined with respiratory type ciliated columnar epithelium [2].

Different series which demonstrate tracheal diverticula on autopsy series, fiber optic bronchoscope examinations and CT images are found in the literature [1]. The prevalence of TD was suggested 1% in autopsy series by Mac Kinnon [2]. However higher prevalence of TD (3.7% to 9.5%) was indicated by the aid of multi-detector computed tomography (MDCT) [7]. Besides there are studies in the literature suggesting that TD is more prevalent in men whereas

some authors report higher prevalence among women. A similar prevalence for both genders is also suggested in literature [2].

Most cases with diverticula are asymptomatic and incidentally discovered entities [2]. Symptomatic patients may suffer from chronic cough, dyspnea, stridor, hemoptysis, dysphagia, hiccups episodes. It may act as a reservoir for secretions, which may lead recurrent respiratory infections and paratracheal abscess [8,9]. Especially patients with cystic fibrosis and advanced pulmonary disease are more prone to develop TD which act as a bacterial reservoir [10]. Large TD may cause dysphonia due to compression on the recurrent laryngeal nerve. Difficulties in endotracheal intubation of patients with TD are also reported in the literature [8]. TD may be perforated during the intubation and may cause pneumomediastinum [9].

Treatment options for TD are surgical resection, endoscopic cauterization with laser or electrocoagulation, and conservative management. Surgery is the treatment choice for young patients, while conservative treatment is recommended for elderly patients [9,11].

### Material and Methods

Ethics committee approval was received from the TOBB ETU Faculty of Medicine Clinical Research Ethics Committee (number:

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KAEK-118/053).

We performed a retrospective study on 2271 patients who underwent thoracic CT examination for different reasons between September 2014 and February 2019. Patients had no history of thoracic trauma or surgery. 73 patients with TD were reported. The ages of the patients were between 19-84 years (mean age: 54 years).

The CT images of the cases were obtained from the archive system of TOBB ETU University. CT examinations were obtained with a Philips Ingenuity 128 slice computed tomography (CT device) device (Philips Medical Systems, Cleveland, OH, USA). Patient dose parameters were adjusted automatically for the lung parenchyma by the device. A 1 mm slice thickness and a pitch value of 1 were used at thorax CT scans. All thoracic CT scans include the entire thoracic area to view tracheobronchial tree clearly. CT scans were made either with or without an intravenous contrast media. Axial reformat images (thickness of 2-3mm) were performed. All images and calculations were made with the same magnification level whenever diverticula diagnosed.

Presence, number, anatomical location, level, diameter, cystic component, and accompanying variations were assessed and recorded.

### Statistical Method

Descriptive statistics were given as frequency, and percent for categorical variables and median (min-max) values were used for continuous ones. To compare diameter values between independent groups Mann-Whitney U test or Kruskal Wallis test was used according to group number because diameter is not normal distributed within each group. Spearman-rho correlation coefficient was used to calculate the correlation between age and diameter. Chi-square test statistics were used to evaluate the relation between gender and RLM. But at the crosstab created had some empty cells. So, the p values for related crosstabs were calculated by MCMC simulation with 10.000 repeats. The type-I error rate was taken as 0.05 to test statistical hypotheses. SPSS 20.0 was used to run statistical analyses (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.)

### Results

A total of 2271 patients were evaluated in the present study. 73 patients (38 females, 35 males) with TD were detected. The prevalence of TD was found to be 3.2%. It was found more frequently in women (52.1%) than in men (47.9%). (Table 1)

The mean diameter of the diverticula was 4.5 mm (range 1-15 mm) in females and 5mm (1-14) in males. There was no difference between gender groups according to diameter median values ( $p=0.811$ ) (Table 2) (Fig 1a, Fig1b)

TD was solitary in 71 (97.2%) patients and doubled (2.7%) in two patients. (Fig 2a, Fig 2b)

The mean patient age was 54 (range 19-84 years). There was no correlation between age and diameter (Spearman rho=-0.028;  $p=0.811$ )

According to the location, patients were classified in R (Right), L (left) and M (median) groups. 60 among 72 patients (82.2%) had right-sided TD. The relationship between size and R-L-M groups was also analyzed. There was no significant relationship between RLM groups according to diameter median values ( $p=0.939$ ) (Table 1, Table 2).

Based on the level indicated by thoracic vertebrae, patients were classified into five groups. The majority of the TD (58.9%) were at a level between T2 and T3 vertebrae. Mean diameter values for each level group were analyzed. There was no relationship between level groups according to diameter median values ( $p=0.519$ ) (Table 2).

Based on the communication between tracheal lumen and diverticula, patients were classified into two groups; cystic and non-cystic. The relationship between diameter and cystic and non-cystic groups was statistically analyzed. There was a statistically significant difference between cystic and non-cystic groups according to diameter median values ( $p<0.001$ ). The cystic group's diameter median value is higher from non-cystic group. (Table 2) (Fig 3a, Fig 3b)

The relation between gender and RLM was not statistically significant ( $p=0.082$ ) (Table 1).

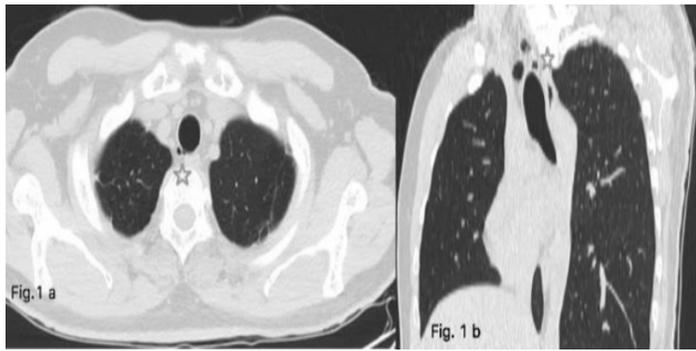
The relation between cystic / non-cystic parameters and RLM was not statistically significant ( $p=0.027$ ).

**Table 1.** Descriptive and morphologic characteristics

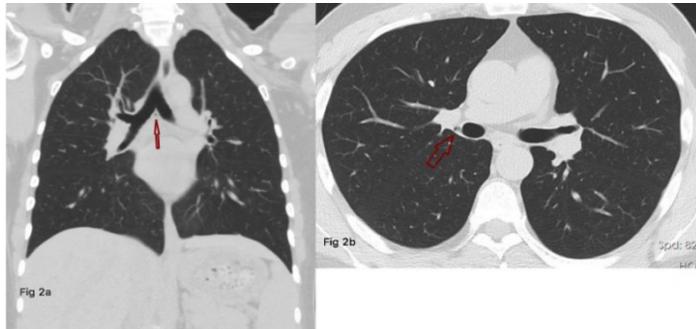
	CARINA	L MAIN	M	R	R MAIN
<b>FEMALE, n</b>	2	2	3	31	0
<b>%</b>	5.3%	5.3%	7.9%	81.6%	0%
<b>MALE, n</b>	0	1	3	29	2
<b>%</b>	0%	2.9%	8.6%	82.9%	5.7%
<b>NON-CYSTIC, n</b>	0	0	1	32	0
<b>%</b>	0%	0%	3%	97%	0%
<b>CYSTIC, n</b>	2	3	5	28	2
<b>%</b>	5%	7.5%	12.5%	70%	5%

**Table 2.** Location, level, cystic form and diameter relationship

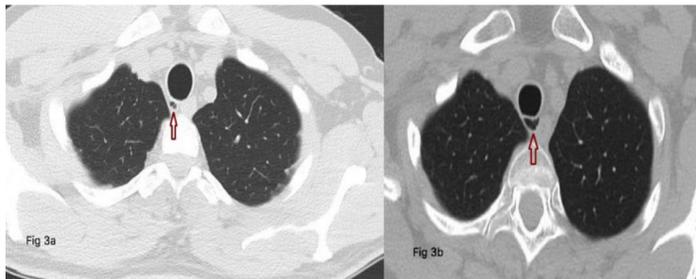
	DIAMETER	p
<b>GENDER</b>	Median (min-max)	
<b>Female</b>	4.5 (1-15)	
<b>Male</b>	5 (1-14)	0.811
<b>LEVEL</b>	Median (min-max)	p
<b>R main</b>	4 (4-4)	
<b>TH1-2</b>	6.5 (1-15)	
<b>TH2-3</b>	5 (1-14)	0.519
<b>TH3-4</b>	4 (1-7)	
<b>TH6-7</b>	6 (3-7)	
<b>RLM</b>	Median (min-max)	p
<b>Carina</b>	4.5 (3-6)	
<b>L main</b>	6 (3-6)	0.939
<b>M</b>	5.5 (2-11)	
<b>R</b>	4.5 (1-15)	



**Figure 1a, 1b.** Axial and sagittal view of a 6 mm diverticula (grey stars)



**Figure 2a, 2b.** There were two diverticula; at the level of sub carinal level (2a), and at the right main bronchus (2b)



**Figure 3a, 3b.** Cystic type tracheal diverticula at the posterior side of the trachea in two different patient

## Discussion

Tracheal diverticula are incidentally diagnosed, asymptomatic single, or multiple outpouchings of tracheal wall [1, 2,12].

There are different series of TD in the literature that have been demonstrated on autopsy series, fiber optic bronchoscopy examinations and CT images [1]. TD should have communication with the lumen of trachea. Orifice between trachea and diverticula is sometimes small to visualize, and it is often not visible in bronchoscopy [2,3]. CT provides information on location, size, and origin of this structure and enables to visualize communication with tracheal lumen. It also enables to distinguish congenital TD from the acquired ones depending on the presence of the cartilage [1,11]. Differential diagnosis of TD consists of the clinical conditions like pharyngocele, laryngocele, Zenker's diverticulum, apical lung herniation, apical paraseptal blebs, bullae, and pneumomediastinum. Similar to TD, these entities present as paratracheal air images. Findings on CT images serve clear information when differentiating TD from these entities [2,8]. We herein analyzed morphologic features of TD on CT images.

Gayer and Hurdado et al. suggested that different studies in the literature indicated TD prevalence in a range from 1% to 8% [2,11,12]. While the previously published studies on autopsy series in the past decades suggest lower prevalence, CT studies documented higher rates [13]. The prevalence of TD was 8.1% in the study of Bae et al. [13]. By the advent of the higher spatial resolution and thinner slices of the advanced CT technology they indicated higher prevalence than the previous studies. Different from the study of Bae et al., including 854 patients we found 3.2% prevalence on 2271 patients in the present study. We think larger patient number is an added value for our study. The difference between prevalence of the studies may depend on the characteristics of the population. Further studies with more extensive patient series in different countries may enlighten this point.

Several studies report higher prevalence of TD in men, whereas some other studies indicate higher rates in women. Besides there are studies suggesting similar prevalence in both genders [2]. It was found more frequently in women (52.1%) than in men (47.9%) in our study. To our knowledge, different from the studies in the literature we also analyzed the relationship between gender and diameter of TD. No difference between gender groups according diameter median values was found ( $p=0.811$ ). This is another different value of the present study.

Most of the TD are asymptomatic. Symptomatic cases commonly present with respiratory symptoms [8-11,14]. Anatomical structures neighboring to trachea along its course are many in number. A tracheal diverticula may cause oppression on any of these structures and present with nonspecific and irrelevant symptoms [7, 8]. Dysphonia caused by compression of recurrent laryngeal nerve and dizziness caused by oppression of common carotid artery is striking examples of these irrelevant symptoms [7,8,12]. Hence anatomical relations of trachea should be well known when evaluating such patients. In the present study levels of TD were analyzed. TD was found to be located at a level between T2 and T3 vertebrae in 58.9% of the cases, and this is the most common location in our series. The least common location for TD was at a level between T6 and T7 vertebrae. Besides 82.2% of the patients had right-sided TD. Detailed data for anatomical location of TD presented in this study will enlighten physicians when evaluating symptoms caused by oppression. The present study will contribute to literature with respect to these data.

TD was almost always defined on the right side of trachea in the previous studies. In concordance with the literature we indicated right-sided dominance in the present study. Pace et al. explained this dominance by the weak wall of the right side of trachea. The left side of trachea is supported by arch of aorta and esophagus. Therefore conditions increasing pressure in the trachea such as chronic cough and obstructive pulmonary disease more likely to cause TD on the right side [15].

## Conclusion

Our data showed a female predilection of prevalence, but no statistically significant difference between gender and other parameters (diameter, side, and level) was indicated. The anatomical location of TD in terms of level and side was analyzed for each patient and no relationship between diameter, and anatomical location was found. Patients with paratracheal air

cysts that have no connection with the tracheal lumen were also analyzed in this study, and cystic group's diameter values were found to be higher than the non-cystic group. This difference was found to be statistically significant.

Regardless of congenital or acquired origin, clinical presentation, and treatment options, this study provides anatomical morphological data to the literature.

#### Conflict of interest

*The authors declare that there are no conflicts of interest.*

#### Financial Disclosure

*All authors declare no financial support.*

#### Ethical approval

*This study has been approved by the Ethical Committee of TOBB University Faculty of Medicine Number: KAEK-118/053.*

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