

# Tracheal Diverticulum: Incidence in Routine Chest Tomography and Its Relation with Smoking History

## Trakeal Divertikül: Rutin Göğüs Tomografisindeki Sıklığı ve Sigara Kullanımıyla İlişkisi

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Geliş Tarihi/Received: 25.01.2012  
Kabul Tarihi/Accepted: 21.06.2012

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**ABSTRACT Objective:** To investigate the incidence of tracheal diverticula in routine chest tomography and the relation between the presence and size of the tracheal diverticulum and smoking. **Material and Methods:** The study included 2270 consecutive patients who underwent a thoracic computed tomography (CT) exam with Dual Source Tomography due to distinct pathological signs. The size, localization and configurations of the diverticulum were reviewed and the smoking habits of the patients were questioned followed by the classification of the subjects in 5 groups. The correlation between the presence and the size of the diverticulum and smoking was investigated with non-parametric statistical tests. **Results:** The tracheal diverticulum was determined in 119 (5.2%) patients. The size of the diverticulum varied significantly between the groups. Of the 119 patients with diverticulum, only 22 were non-smokers; the remaining 97 patients (81.5%) were smokers. Statistical analyses revealed a clear correlation between smoking and diverticulum size. Diverticulum sizes increased in proportion with the severity of smoking. The largest diverticula were identified in the most intensive smoking group. **Conclusion:** This study suggests that the presence and size of the tracheal diverticulum increases proportionally with smoking and the size of the diverticula may be an indicator of smoking related damage.

**Key Words:** Trachea; diverticulum; tomography, X-Ray computed; smoking

**ÖZET Amaç:** Rutin göğüs tomografisinde trakeesel (trakeal divertikül) sıklığını araştırmak, trakeesel varlığı ve boyutu ile sigara kullanımı arasındaki ilişkiyi belirlemektir. **Gereç ve Yöntemler:** Farklı nedenlerle toraks bilgisayarlı tomografi (BT) taraması yapılan 2270 hasta çalışmaya katılmıştır. Trakeoselin yeri, boyutu ve konfigürasyonu değerlendirilmiş, divertiküllü hastalar retrospektif olarak sigara kullanımı yönünden sorgulanmıştır. Sigara alışkanlığına göre 5 gruba ayrılan hastalarda, gruplardaki divertikülün varlığı ve boyutu ile sigara kullanma arasındaki ilişki non-parametrik testler kullanılarak araştırılmıştır. **Bulgular:** Çalışma grubunu oluşturan 2270 hastanın 119 (%5,2)'unda divertikül saptanmıştır. Divertiküllü hastaların 97 (%81,5)'si sigara kullanmakta, yalnızca 22'si sigara içmemektedir. İstatistiksel analizler sonucunda divertikül varlığı ve boyutu ile sigara kullanma alışkanlığı arasında anlamlı bir bağlantı gözlenmiştir. Divertikül boyutu, sigara kullanma yoğunluğu ile doğru orantılı olarak artmaktadır. En büyük divertikül boyutları en yoğun sigara içen grupta saptanmıştır. **Sonuç:** Bu çalışmaya göre divertikülün varlığı ve boyutuyla sigara kullanımı arasında doğru orantılı bir ilişki mevcuttur. Dolayısıyla divertikül boyutu, sigara kullanımına bağlı hasarı saptamada belirleyici olabilir.

**Anahtar Kelimeler:** Trakea; divertikül; tomografi, X-Ray bilgisayarlı; sigara içme

Türkiye Klinikleri J Med Sci 2013;33(1):73-80

doi: 10.5336/medsci.2012-28466

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Türkiye Klinikleri J Med Sci 2013;33(1)

**T**racheal diverticulum is an air cyst commonly occurring along the right posterolateral tracheal aspect of the tracheal air column at the level of the thoracic inlet.<sup>1</sup> It can be uni- or multilocular and its size

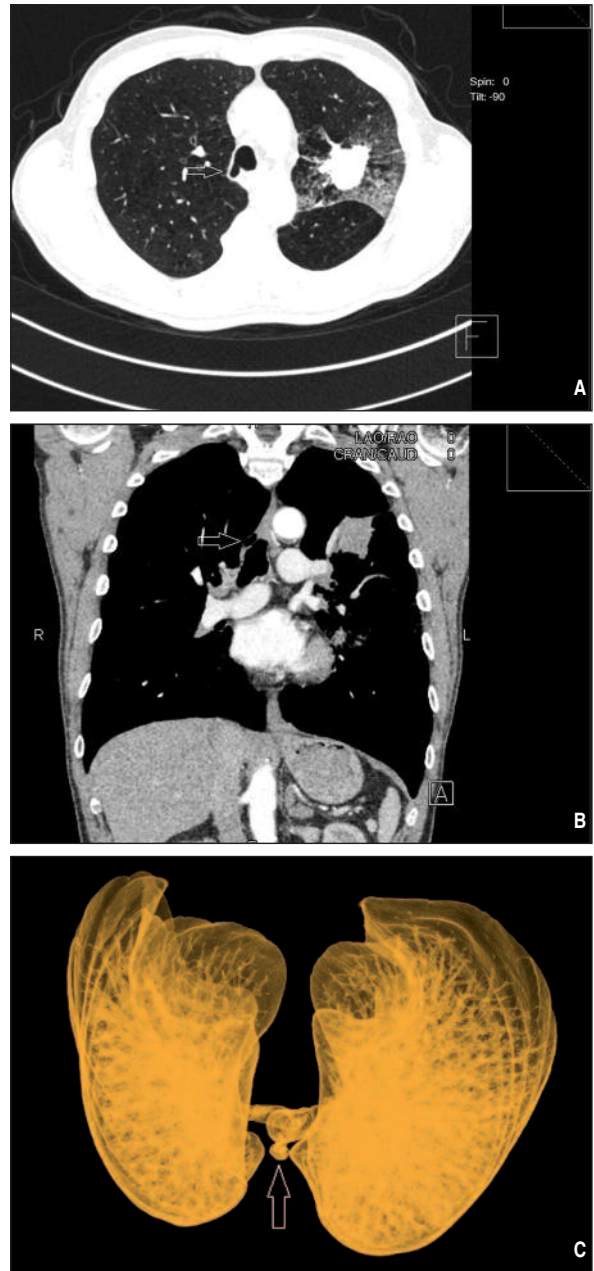
can vary between 1-2 mm and 4-5 cm. Thoracic and cervical computed tomography (CT) scans have increasingly demonstrated tracheal diverticula recently due to the routine use of multi-detector technology. Knowing the radiologic features of this condition, which is mostly asymptomatic and which rarely requires treatment, will allow us to distinguish it from other disorders such as the Zenker diverticulum and pneumothorax.<sup>2,3</sup> Tracheal diverticulum can easily go unnoticed due to its entrance into the trachea with a very thin orifice. Three-dimensional images performed through thin cross-section tomographic investigations expedite the diagnosis of diverticulum even without bronchoscopy.

The aim of our study was to investigate tracheal diverticula in routine chest tomography scans and to look for a correlation between the presence and size of the tracheal diverticulum and smoking.

## MATERIAL AND METHODS

Thoracic CT examinations of 2270 consecutive patients presenting to the İzmir Şifa Hospital between February 2010 and January 2011 were retrospectively investigated. Somatom Definition (Dual Source Technology, Siemens Medical Solutions, Germany) tomography device was used for radiologic examinations. Intravenous contrast media was used in 620 subjects. Eight patients underwent bronchoscopic examination.

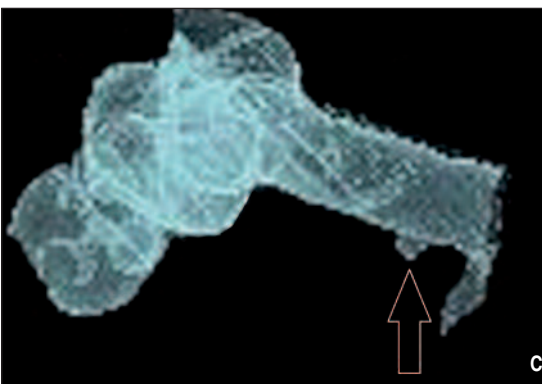
The CT images were reviewed in consensus by two radiologists (A.S., B.G.) experienced in thoracic radiology. Thin cross-sections obtained from the thoracic inlet to the level of the diaphragm were re-examined with sagittal and coronal reconstructions (Figure 1-3). The patients were placed in supine position and were scanned in craniocaudal direction using standardized scanning parameters (detector collimation, 2x32x0.6 mm 2x64x0.6 mm by means of a z flying focal spot; gantry rotation time, 330 milliseconds; tube current-time product, 350 mAs per rotation; tube potential, 120 kV.) Transverse images were reconstructed with 1-mm slice thickness (0.7-mm increment) using a soft-tissue kernel B20f (mean field of view, 345±40 mm;



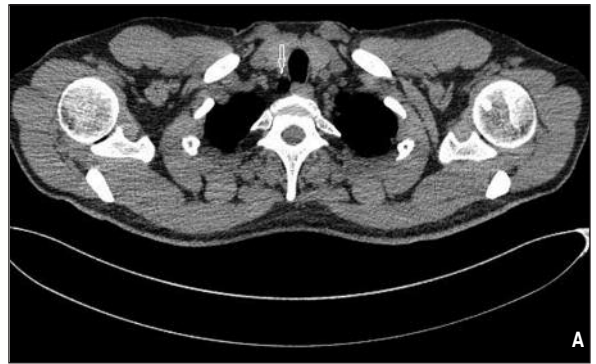
**FIGURE 1A-C:** Axial (A), coronal (B) section chest tomography, 3 dimensional volume rendered image (C). The patient with malignant tumor mass lesion in the left lung and lymphatic spread to neighbour tissues. Diverticulum is located on the intrathoracic segment of the trachea (arrows). The connection point with the trachea is wide and easily seen.

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image matrix, 512x512). All data sets were transferred to a dedicated workstation (Leonardo, Syngo Multimodality Workplace, Siemens Healthcare) to create multiplanar reformatted images and for image analysis. The size of the diverticulum was



**FIGURE 2A-C:** Axial computed tomography section shows multilocular lesion at the right paratracheal location (**A**), it is observed as 3D volume rendering technology (**B, C**) arrows show left bronchial diverticula.



**FIGURE 3A-C:** Same patient has multiple tracheal diverticula and subcarinal air cyst in trachea in consecutive tomographic sections. Lesion is observed as 3D volume rendering examination.  
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measured according to the longest sizes in two different planes.

Complaints of the patients were noted and classified (Table 1). The location, size and shape of the paratracheal air cysts were determined. Parenchymal and mediastinal findings accompa-

nying the diverticulum were investigated. The presence of infiltrations indicating chronic obstructive pulmonary disease, findings of primary and/or secondary malignancy, bronchiectasis, healed tuberculosis parenchymal findings, pneumonic consolidation, and healed non-specific infectious changes were noted separately for each subject (Table 2).

Smoking history was recorded from the electronic patient record system (EPR-PACS, Picture Archiving and Communication System of Siemens) of the hospital. The history of each patient was reviewed and they were classified according to the amount and duration of smoking. The patients who did not smoke at all and the ones who smoked less than one in a day for more than 1 year were included in the group called the non-smoking group. The previously smoking

group included the subjects who were smoking regularly but had stopped smoking for the last 6 months or shorter or who were still smoking regularly. These patients were subdivided into three categories separated by those who smoked under 10 packs per year, 10-25 packs per year and 25 packs per year or more.

In the statistical analysis, variables (diverticular sizes) were controlled with the Shapiro-Wilk test according to the compliance of the normal distribution. There was significant deviation from normality in the smoking group with 25 packs per year or more; thus, non-parametric tests were preferred. The Kruskal Wallis test was used to compare the difference between the smoking groups. Mann Whitney tests were used for further exploration of between-group differences (Table 3). A p value of <0.05 was considered statistically significant.

This retrospective study was approved by our institutional review board, and informed consent was waived.

## RESULTS

Overall, 119 patients had paratracheal cysts (43 female and 76 male). The mean age was 52.7 years (SD 11.8, range 14-84 years). Eighteen subjects had no respiratory complaints (15%). The remaining 101 patients had one or more complaints summarized in Table 1.

The widest diameters of the diverticulum in axial sections were measured as 26 mm. The widest vertical diameter reached 49 mm in the coronal images. Twenty-nine patients (24%) had a single unilocular diverticulum not exceeding 2 mm; in 56 subjects, the diverticula were multilocular (45%). The connection point or channel with the trachea was visible in 74 subjects (61%) (Figure 1). More than one connection was present in two multilocular diverticula (Figure 2A, B). The diverticulum was located in the right paratracheal region at the T2-T3 vertebral levels in 116 patients (97%), in both the posterior and right paratracheal region in one patient, and at the intrathoracic segments of the trachea in two subjects.

**TABLE 1:** Distribution of the subjects according to complaints.

n	Complaints
42	Productive cough
23	Non-productive cough
36	Chest pain
38	Hemoptysis

**TABLE 2:** Radiological findings accompanying to diverticulum.

n	Findings
55	Parenchymal changes of chronic obstructive respiratory disease, low grade or mild emphysema, findings of chronic bronchitis
39	Healed specific infection findings: calcified lymph nodes, apical pleural thickening, parenchymal fibrotic changes
36	Previous non-specific infection findings, multiple fibrotic changes, subsegmental atelectasis, peribronchial and subpleural septal thickenings
22	Bronchiectatic cavities
15	Metastatic pulmonary nodules
13	Bronchopneumonic infiltration or consolidation compatible with active infection
21	No abnormal finding
41	Subcarinal air cyst
3	Bronchial diverticula



**TABLE 3:** This table shows patient numbers of groups (n), median, minimum (min), and maximum (max) sizes (millimeters) of the diverticula, and pairwise comparisons. P value shows significant relationship between smoking and the size of the diverticulum (py: packs per year).

	n	Median	Min	Max	p	Pairwise comparison
Never smoker	22	2,2	1	4	0,041	Never smoker-Ex smoker <0.001
Ex smoker	18	4,5	1	6		Never smoker-Under 10 py <0.001
Under 10 py	14	4	3	6		Never smoker-10-25 py <0.001
10-25 py	18	6	3	9		Never smoker-25 py <0.001
25 py	47	11	3	49		Ex smoker-Under 10 py 0.460
						Ex smoker-10-25 py 0.037
						Ex smoker-25 py <0.001
						Under 10 py-10-25 py 0.030
						Under 10 py-25 py <0.001
						10-25 py-25 py 0.002

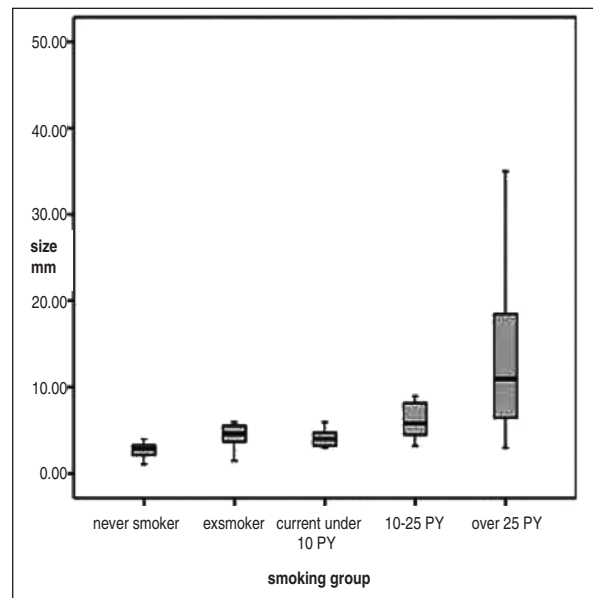
Bronchial diverticulum accompanying the right paratracheal diverticulum was determined in three subjects (0.25%) (Figure 2C) and subcarinal air cyst was seen in 41 subjects (34%) (Figure 3). The parenchymal findings of the subjects were summarized in Table 2.

No parenchymal and mediastinal pathological finding was determined in eighteen non-smoking subjects with diverticulum (81%) and in 3 subjects from the remaining groups (0.3%). Although the presence and the size of the diverticulum were noted in the tomography report, the diverticulum orifice was not determined in eight patients with pre-diagnosed malignancy who underwent fiberoptic-bronchoscopy. Diverticular orifices could not be identified on CT exam either except for one patient with left lung tumor (Figure 1).

A statistically significant correlation between the presence of diverticulum and smoking was shown (Table 3). The size of the diverticulum increased in the groups where the intensity of smoking was increased ( $p=0.0416$ ). Box plot graphic table demonstrated that the severity of smoking increased the size of the diverticulum proportionally. This finding was most striking in the smoker group with 25 packs per year or more (Figure 4).

## DISCUSSION

Tracheal diverticulum can be congenital or acquired. The congenital type is typically small and



**FIGURE 4:** Box plot graphic table illustrates that the severity of smoking increases with the size of diverticulum.

rarer compared to the acquired type. In addition, the congenital type is typically located 4-5 cm below the vocal cords. The acquired types typically have repeated infections and insufficient intubations in their etiology.<sup>4,5</sup> Various studies have reported the frequency of tracheal diverticulum described initially by Rokitansky in 1838. McKinnon et al. found a 1% incidence of tracheal diverticulum in 867 routine autopsy series for disorders. A 0.3% incidence was reported in children aged over 10 years using a fiberoptic bronchoscopy.<sup>1</sup> The

incidence of diverticulum was reported as 3.7% in a study by Buterbaugh et al. who reported use of 2 and 5 mm sections.<sup>6</sup> In our study, tracheal diverticulum was present in 5.2%; which is the highest reported rate to date. This may be attributed to the differences in scanning and reconstruction parameters of CT used in this study. However, only eighteen subjects presented in this study did not have respiratory complaints. Therefore, this result may not reflect the real incidence of diverticulum in the population.

Tracheal diverticulum can be congenital or acquired. Histologically congenital diverticulum, which is much rarer, contains all layers of the bronchial wall and is considered a malformed bronchus. Acquired diverticulum develops from the pressure caused by intratracheal compression due to chronic cough, which weakens the bronchial wall because of repeated infections. Acquired diverticulum can be at any localization along the trachea. Typically, acquired forms have a much bigger size compared to the congenital forms and they do not include cartilaginous or muscular layers.<sup>7-11</sup>

The cyst was smaller than 4 mm (mean 2.2 mm diameter) with right paratracheal localization in 22 patients in our study and there was no paranchymal pathology in nineteen of those patients (81%). The diverticulum in this group of patients, whose mean age was 26.7 years, was thought to be congenital. There was no history of smoking in those subjects.

It is easier to differentiate tracheal diverticulum from other conditions such as lung parenchyma herniation, pneumothorax, and Zenker diverticulum by using multiplanar images in thin-sectioned tomographies. It is much easier to show the connection between the diverticulum and the trachea with the thin section examinations.<sup>12,13</sup> We also showed the connection with the trachea in 74 of the 119 subjects. The connection channels between the trachea and the diverticulum can be very thin and they can go unnoticed because they may collapse during tomographic examination.<sup>1,13</sup> Therefore, it was thought that there was diverticulum due

to typical localization and the view in the lesions without visualized typical tracheal communication.

Lesions can be unnoticed in bronchoscopy due to small lesion orifice, covering of the orifice with secretion, growing and shrinking of diverticulum air cysts between inspiration and expiration. Goo et al. stated that they did not visualize the diverticulum during bronchoscopy before the operation even in the subjects in whom diverticulum was determined as surgical; however, they determined diverticulum on CT in 4 patients who were completely normal in bronchoscopy.<sup>7</sup> Similarly in the present study, diverticulum was not seen in all patients who underwent bronchoscopy.

Tracheal diverticula mostly develop at the right posterolateral region due to the supporting effect of the esophagus on the left side. The intrathoracic passing zone of the trachea is anatomically the weakest region.<sup>14</sup> When the intrathoracic pressure increases evaginations occur from the low resistance region to the right posterolateral region. These evaginations rarely come along with intrathoracic vascular or non-vascular congenital abnormalities.<sup>15-17</sup> There are numerous studies in the literature showing the presence of diverticulum in patients with repeated cough, persistent lung infections and hemoptysis.<sup>18-22</sup> Diverticulum was located in the right paratracheal region at the T2-T3 vertebral levels in 116 out of 119 patients in our study. Higuchi et al. stated that there was subcarinal air collection in a thorax CT series in 61 out of 200 patients who had no history of pulmonary disease. However, they could not find any relationship between smoking and this anomaly, which is common in the healthy population without respiratory complaints.<sup>23</sup> In our study, air cysts were seen in 41 subjects of the patients.

It is well known that emphysema develops with the inhalation of toxic substances like nicotine over a long time. To lead to emphysema it is important to smoke at least 4 months continually. The destructive response of the lung parenchyma to chronic smoking can vary between individuals and might be independent of the dose. Sometimes, long-term and high-dose smoking can be limited

with moderate degrees of emphysematous changes. However, animal studies have suggested that smoking even for several hours increases the risk of exposure to infectious agents with mucociliary inhibition.<sup>24</sup> Thus, exposure to repeated barotrauma at high-pressure attacks with coughing results in frequently repeating upper airway infections. Experimental studies have shown that smoking cigarettes for less than 14 days causes the release of cytokines, which bring together lymphocytes and macrophages on the bronchial wall and initiate a series of inflammatory reactions. Eventually, tracheal mucosa becomes even weaker due to the inflammation caused by smoking for as short as several days and diverticulum will easily occur with coughing.<sup>9,12,24</sup> Sverzellati et al. studied the correlation between smoking and the size and the wall thickness of bronchial diverticula. In their study, they reported that the size and wall thickness of the diverticulum increased as the severity of smoking increased. Bronchial diverticulum was

present in patients who smoked (45%).<sup>25</sup> In our study, 81.5% of the patients with tracheal diverticulum had a history of smoking. The number of cigarettes smoked and the size of the diverticulum were directly proportional in both studies.

Our study had several possible limitations. Firstly, this was not a population-based study because the patients were selected from those undergoing CT scans rather than a random sample. The other limitation was the questioning of smoking history only in patients with diverticulum.

In conclusion, there was a significant relationship between cigarette consumption and tracheal diverticulum as shown from the statistical analysis mentioned above. The presence and size of the tracheal diverticulum increases proportionally with smoking and the size of the diverticula may be an indicator of smoking-related damage. We believe that this study will shed light on this subject for further studies.

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