ORIGINAL RESEARCH

# Tracheobronchial variations in Pneumoconiosis cases: multidetector computed tomography diagnosis

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## Abstract

**Background**

Tracheobronchial variations (TBVs) are more common than previously believed due to the increasing use of multi-detector computed tomography (MDCT). This study aimed to assess TBVs in cases of pneumoconiosis, one of the oldest occupational diseases that still poses a threat to public health.

**Methods**

This was a descriptive study that involved reviewing chest MDCT images of 34 cases of pneumoconiosis and 34 control cases retrospectively from January 2020 to April 2022. Variations in the trachea, right main bronchus, left main bronchus, lobar and segmental branches of the cases in the patient and control groups were evaluated according to Boyden's nomenclature.

**Results**

The frequency of TBV was 32.4% in pneumoconiosis cases. Although the frequency of TBV was higher in the patient group than in the control group, the difference was not statistically significant (p=0.086). Furthermore, there was no significant difference in terms of TBV classification between the patient and control groups (p=0.407). Additionally, the presence of TBV did not affect the distribution of International Labour Organization categories in pneumoconiosis cases (p=0.360).

**Conclusions**

Although our study provides initial insights into the occurrence of TBVs in pneumoconiosis cases, further research is needed to clarify the relationship between these variations and the disease.

**Key words:** Multi-detector computed tomography, occupational diseases, occupational medicine, pneumoconiosis, tracheobronchial variations

## Introduction

The tracheobronchial tree plays a crucial role in allowing the passage of air into the lungs for gas exchange. This system comprises the trachea, bronchi, and bronchioles, and its development begins in the fetal stage but does not fully mature until around eight years of age[1]. Variations in the tracheobronchial tree may occur at different levels, including the trachea, right and left main bronchi, and lobar branches. These variations may result from developmental defects, such as the development of an inappropriate number of lung buds or lung buds arising in atypical sites[2,3].

Over the years, several methods have been used to study the anatomy of the tracheobronchial tree, including anatomical dissections and bronchography. With the increasing use of diagnostic tools like fiberoptic bronchoscopy, multi-detector computed tomography (MDCT), and virtual bronchoscopy, tracheobronchial variations (TBVs) have been detected more frequently[2-5]. While the prevalence of TBV has been reported to be 1-12% in the literature[3,6], some studies have found different frequencies[7].

Although TBVs are often asymptomatic, they may cause chronic cough, hemoptysis, and recurrent respiratory infections in some cases. Recognizing TBVs is important for identifying the etiology in symptomatic patients and guiding clinicians before performing procedures like bronchoscopy and endotracheal intubation[8]. Previous studies have also linked acquired tracheobronchial diverticula (TD) with airway or parenchymal lung pathologies like lung fibrosis, bronchiectasis, and chronic obstructive pulmonary disease (COPD)[9,10].

This study aimed to evaluate TBVs in cases of pneumoconiosis, which is one of the oldest occupational diseases and still poses a threat to public health[11]. To the best of our knowledge, this study is one of the first to investigate the relationship between TBV and pneumoconiosis.

## Methods

### *Study design and participants*

This retrospective descriptive study examined data from the hospital information management system and the picture archiving and communication system records of a tertiary hospital. The study protocol was approved by the Clinical Researches Ethics Board of Samsun University (Decision Number: 2022/3/1).

The study included 34 cases diagnosed with pneumoconiosis and its sub-headings (ICD-10 code: J60, J61, J62, J62.0, J62.8, J63, J63.8, J64, J65) between January 2020 and April 2022, whose chest CT, High Resolution Computed Tomography (HRCT), and chest X-ray (CXR) images were accessible in the system of the Department of Radiology of Samsun Education and Research Hospital.



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**Table 1. Frequency of TBV in pneumoconiosis cases and control group**

| | Pneumoconiosis present n(%) | Pneumoconiosis absent n(%) | p† |
|---|---|---|---|
| TBV present | 11(32.35%) | 5(14.71%) | 0.086 |
| TBV absent | 23(67.65%) | 29(85.29%) | |
| Total | 34(100.00%) | 34(100.00%) | |

†Chi-square test.

TBV, tracheobronchial variations.

**Table 2. The distribution of TBV detected in pneumoconiosis cases and control group**

| TBV | Pneumoconiosis present n(%) | Pneumoconiosis absent n(%) | p† |
|---|---|---|---|
| Suprasuperior bronchus | 5(45.45%) | 2(40.00%) | 0.407 |
| Tracheobronchial diverticula | 5(45.45%) | 1(20.00%) | |
| Tracheal bronchus | 1(9.10%) | 1(20.00%) | |
| Right preeparterial | 0(0.00%) | 1(20.00) | |
| Total | 11(100.00%) | 5(100.00%) | |

† Fisher-Freeman-Halton test.

TBV, tracheobronchial variations.

**Table 3. The distribution of ILO categories according to the presence of TBV in pneumoconiosis cases (n=34)**

| ILO classification | TBV present n(%) | TBV absent n(%) | p† |
|---|---|---|---|
| Category 1 | 2(18.18) | 3(13.04) | 0.360 |
| Category 2 | 2(18.18) | 11(47.83) | |
| Category 3 | 3(27.27) | 5(21.74) | |
| Large opacities | 4(36.37) | 4(17.39) | |
| Total | 11(100.00) | 23(100.00) | |

†Fisher-Freeman-Halton test.

ILO, International Labour Organization; TBV, tracheobronchial variations.

The study also included a control group of 34 cases selected randomly from the archive of chest CT/HRCT images in the relevant date range by matching their age and gender with the pneumoconiosis group. Exclusion criteria were a history of pneumonectomy/lobectomy or lung diseases (pneumonia, malignancy, interstitial diseases, etc.).

## *Imaging techniques and evaluation of images*

The imaging techniques used in the study included chest CT scans obtained without contrast in the supine position, in deep inspiration, using 16-detector (Toshiba aquilion), 64-detector (Philips, Brilliance, Netherlands), or 128-detector CT (GE Revolution EVO, USA). All images were processed with standard mediastinal and lung window settings, and axial, coronal, sagittal reformat images were structured with the 3D Slicer program. 3D volumetric images and minimum intensity projection (MinIP) images showing trachea, main bronchi, lobar and segmental bronchial branches were obtained from these images. The scanning parameters were; rotation time: 0.5-0.6 s., 120 kV, 50-500 mA, section thickness: 1.25 mm, section interval: 1.25 mm, pitch: 1.375-1.388.

CT images of the patient and control groups were evaluated again to note the TBV at three different times and were recorded by a radiologist with eight years of experience in thoracic radiology. CXRs of pneumoconiosis cases were classified according to the International Labour Organization (ILO) International Classification of Radiographs of Pneumoconioses[12] by an occupational diseases specialist who is a certified reader of pneumoconiosis.

## *Terminology and definitions*

Variations in the trachea, right main bronchus, left main bronchus, lobar and segmental branches of the cases in the patient and control groups were evaluated according to Boyden's nomenclature. A tracheal bronchus is a bronchus that abnormally arises directly from the trachea or the carina. The term right preeparterial bronchus refers to any bronchus directed towards the right upper lobe, originating abnormally from the right medial bronchus, above the level of the right upper lobe (eparterial bronchus). The suprasuperior bronchus is defined as a displaced subsegmental bronchus of the superior segment of the lower lobe, which originates from either the main or intermediate bronchus[13]. TD is defined as thin-walled air sacs covered with ciliary columnar

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epithelium, usually connected with the trachea, with congenital or acquired nature[14,15].

### *Statistical analysis*

The statistical analyses were performed using IBM SPSS for Windows v.24.0. In the statistical analyses, the compatibility of the variables with a normal distribution was examined using the Kolmogorov-Smirnov test. Continuous variables were presented as mean ± standard deviation because they were normally distributed, but number and percentage (%) for categorical variables. Categorical variables were compared using the chi-square test, and the Fisher-Freeman-Halton test was used if the assumptions regarding the chi-square test were not met. Independent groups under parametric conditions were compared using Student's t-test. For all comparisons, the statistical significance level was established as 0.05.

## Results

The study included 34 cases of pneumoconiosis and 34 control cases matched by age and gender. All patients were male, with a mean age of 44.32±7.02 years for the pneumoconiosis group and 46.21±8.37 years for the control group (p=0.188).

The frequency of TBV was 32.35% (n=11) in pneumoconiosis cases. Although the prevalence of TBV was higher in the patient group compared to the control group, the difference was not statistically significant (p=0.086) (Table 1).

All TBVs detected in the study were right-sided, with the most frequent TBVs in pneumoconiosis cases being TD (45.45%; n=5) and suprasuperior bronchus (45.45%; n=5), and in the control group was the suprasuperior bronchus (40.00%; n=2). However, no significant difference was found in TBV classification between the two groups (p=0.407) (Table 2).

The distribution of ILO categories according to the presence of TBV in the pneumoconiosis cases did not show a significant difference (p=0.360) (Table 3).

## Discussion

Previous studies on the frequency of TBVs have yielded varying results both in Turkey and around the world[3,16]. It is believed that the disparities in outcomes may be attributable to factors such as different studied populations, the use of distinct diagnostic tools, the distinction between congenital and acquired variations in some studies, and individual factors related to the diagnosing specialists. This study discovered TBVs in roughly one-third of pneumoconiosis cases, which is higher than the TBV prevalence obtained from population studies in the literature[7].

In this study, the TBVs detected in pneumoconiosis cases were the suprasuperior bronchus, TD, and tracheal bronchus. The frequency of suprasuperior bronchus was found to be higher in our study than that reported in the existing literature[16,17]. However, the prevalence of tracheal bronchus aligns closely with the percentages reported in previous studies[18.] TD, one of the variations within TBV, is defined in the paratracheal air cyst (PAC) lesion group[14]. In previous studies, almost all of the TD/PAC variations were found on the right side[15,19]. The current study revealed a higher frequency of TD in pneumoconiosis cases than in previous studies[15,20] with all instances being localized on the right side. It is suggested that this right-sided preference may be related to weakness of the right side compared to the left side, which is supported by the esophagus[14].

The relationship between TD/PAC and various airway and lung pathologies has been the focus of several studies in the literature, but a consistent result has not yet been reached[9,10,14,15,19,20]. Some studies have suggested a link between weakened tracheal musculature due to recurrent respiratory infections and long-standing increased intraluminal pressure with TD formation, particularly in cases of COPD[21,22]. In addition, the presence of PAC may indicate obstructive pulmonary disease and radiological evidence of emphysema[22]. Other studies have reported associations between PACs and upper lung fibrosis and bronchiectasis[9]. However, some studies have found no significant relationship between COPD and the presence of TD[15]. Other studies have reported that the relationship between COPD and PACs was statistically significant, but no relationship was found between primary or metastatic malignancies, pneumonia and other lung diseases and PACs[10]. In this study, although the frequency of TD in pneumoconiosis cases was higher than that in the control group, the difference was not statistically significant. The relationship between TD and diseases with pathological processes similar to pneumoconiosis such as chronic pulmonary inflammation or fibrosis[11] was discussed earlier. However, since there have been no specific studies on pneumoconiosis, a comparison could not be made.

Two recent studies have proposed a new hypothesis regarding the direction of the causal relationship between bronchial variations and COPD. In a multicenter prospective cohort study, bronchial branching variations were associated with increased susceptibility to COPD. In the study, which suggested that these variants could be used as biomarkers, a relationship was also established between the variants and the fibroblast growth factor (Fgf10) gene[23]. Sun et al. reported that bronchial variations contribute to the development of COPD by providing deposition sites for inhaled particles, impairing mucociliary clearance and promoting chronic airway inflammation[24]. Because of the descriptive nature of this study, causality inferences could not be made. However, it is thought that future studies are required to reveal possible relationships. Understanding the mechanisms underlying these associations may contribute to identifying high-risk patients.

As far as we know, this study is the first to evaluate the potential relationship between pneumoconiosis and TBV; however, caution is advised when interpreting the results because of the relatively small sample size and the fact that the study was conducted in a tertiary hospital, which may not be representative of the general population. Additionally, bronchoscopic or histopathological examinations were not performed during diagnosis. The ongoing Coronavirus disease (COVID-19) pandemic during the research period and underreporting of occupational diseases as a global problem may have affected the number of cases included in this study.

## Conclusions

In conclusion, TBV was detected in approximately one-third of the pneumoconiosis cases in this study, and all cases were localized on the right side. Clinicians should be aware of the possibility of TBV in patients and consider it in their diagnostic and management approaches. In this study, no significant association was observed between TBV and pneumoconiosis. However, future studies with larger sample sizes including clinical evaluations may clarify the relationship between these variations and pneumoconiosis.

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