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Bronchial Wall Thickness in Toll Collectors

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Abstract: There is an increasing concern about the possible adverse effects of diesel exhaust particulates on human health. In a diesel exposed occupational group composed of 120 toll collectors, a cross-sectional study was performed to evaluate the chest radiographs and 40 toll collectors were selected for computed tomography examination according to hyperinflation and linear markings. The wall thicknesses and luminal diameters of trachea, main bronchi, and segmental bronchi of right apical and posterior basal segments were measured with manual tracing method. The walls of right upper bronchus in exsmoker toll collectors were significantly thicker than those of nonsmokers (p=0.011). A positive correlation was observed between age and the right upper bronchus wall thickness (r=0.577, p=0.000). An inverse correlation was found between the working duration and the diameter of right main bronchus (r=–0.366, p=0.020). A positive correlation was seen between smoking and the right upper bronchus wall thickness (r=0.457, p=0.005). Diesel exposure might have a role in increase of thickness of large airways wall and a decrease in the diameters of large airways. Studies in this area are needed to protect the population under the diesel exposure risk.

Key words: Toll collectors, Diesel exposure, Air pollution, Epidemiololgy

Introduction

There is an increasing concern about the possible adverse effects of diesel exhaust particulates (DEP) on human health. Diesel exhaust is one of the major contributors to particulate air pollution in cities. DEP air pollution is a mixture of solid particles and liquid droplets mainly included carbon monoxide, nitrogen dioxides and volatile organic compounds (VOCs)[1–3]. There are a considerable number of epidemiological studies demonstrating a significant relationship between road traffic pollution and an increase in asthma exacerbations and incidence of allergy in both adults and children[4–8]. Some associations between autovehicle traffic and lung function reduction, increased respiratory symptoms, increased mortality from respiratory diseases, reduced exercise tolerance were also reported previously[9].

Limited number of studies has focused on the radiographical changes related to the air pollution included diesel exhaust. Chest X-rays of children in Mexico City demonstrated bilateral hyperinflation (151/230) and increased linear markings (121/230). These findings were consistent with bronchiolar, peribronchiolar and/or alveolar duct inflammation, possibly caused by ozone, particulate matter (PM) and lipopolysaccharide exposure. Authors suggested that the epidemiological implications of these findings were important for children residing in polluted environments, because bronchiolar disease could lead to chronic pulmonary disease later in life[10].

Airway lumen and airway wall areas may be quantitatively assessed on CT images by using specific techniques that must be reproducible as well as accurate in order to compare the airways pre- and post-intervention (bronchoprovocation, bronchodilatation, therapeutic response) and to carry out longitudinal studies of airway remodeling[11]. Airway lumen and airway wall areas have been well investigated in asthmatic patients and in patients diagnosed as Chronic Obstructive Lung Disease (COPD). Few studies have focused on air pollution related changes

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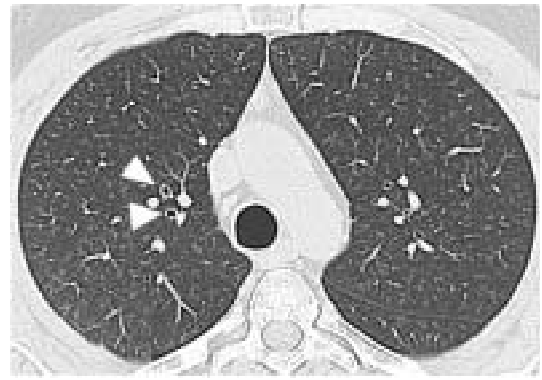
(a)



(b)

Fig. 1. The bronchi of two patients at right apical segments were shown.

in airway lumen and/or airway wall areas. Authors have found an association between chronic exposures to severe urban air pollution and a significant increase in abnormal chest x rays and lung CTs, suggestive of a bronchiolar, peribronchiolar and/or alveolar duct inflammatory process, in clinically healthy children with no risk factors for lung disease[12].

The aim of this cross-sectional study was to examine the relationship of the structurel changes in large and small airways in a diesel exposed occupational group, toll collectors quantified by high-resolution computed tomography (HRCT).

Material and Methods

Study population

Postero-anterior chest radiographs of 120 toll collectors residing in Duzce were examined as a general screening. High-resolution CT was performed in 40 toll collectors whose plain radiographs showed hyperinflation and linear markings. A questionnaire including demographic factors (age, residence, occupation, etc.), occupational history, past diseases, medications, respiratory symptoms (dyspnea, cough, sputum, chest thightness), smoking habits was performed to subjects. An informed consent was obtained from all subjects and the study was approved by Duzce University Faculty of Medicine Ethics Committee. The patients were separated into three groups according to age, smoking habits and working duration.

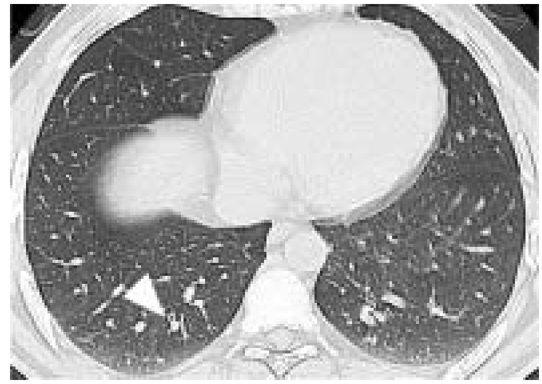
Measurement of airway dimension

A helical CT scanner (Toshiba Astheion, Tokyo, Japan) was used for conventional 10-mm thick contiguous scanning for screening of chest. High-resolution CT scans were obtained using a thin-section (1.5 mm collimation) technique, and because of the great natural contrast between the airways and their environment, low kilovoltage (120 kVp) and milliamperage (175 mA) with 1 s scanning time was used[11].

In the apical segment and the posterior basal segment, we obtained three CT sections at 10-mm intervals from 1 cm below the superior margin of the aortic arch, and an additional three sections were obtained from 4 cm above the top of the diaphragm, which resulted in six sections per subject. Images containing segmental and subsegmental bronchi with internal diameters of 2 mm or larger seen in a cross-section of the right apical and right posterior basal segments were selected (Figs. 1 and 2). These sites were chosen because they are more convenient for obtaining a tangential view of the bronchus and artery.

Scans were evaluated for bronchial wall thickenings. A window width of 1,500 HU was chosen because narrower widths cause less than-optimal visualization of anatomic landmarks at the –450 HU level[13]. Only the bronchi that were seen as end-on slices were selected, while those at an angle were excluded from analysis if the longest diameter exceeded the shortest diameter by a factor of >1.2.

The wall thicknesses and luminal diameters of trachea, main bronchi, segmental bronchi of right apical and posterior basal segments, magnified 1.5–1.8 times, were measured with manual tracing method, using the DicomWorks v1.3.5 software. Regions of interest are traced manually using a mouse at the workstation. Measurements were made by a single observer in a blinded fashion. All mea-



(a) (b)

Fig. 2. The bronchi of two patients at right posterior basal segments were shown.

Table 1. Past diseases, smoking status and respiratory complaints of toll collectors

	Toll collectors n=40	%
Past diseases		
Pneumonia	1	2.5
Asthma	2	5.0
Respiratory complaints		
Cough	16	40.0
Sputum	16	40.0
Wheezing	10	25.0
Chest thightness	8	20.0
Dyspnea	5	12.5
Smoking status		
Smoker	26	65.0
Exsmoker	8	20.0
Nonsmoker	6	15.0

surements were done three times and the mean values were recorded.

Statistical analysis

Statistical analysis was carried out using the Statistical Package for Social Science (SPSS)/PC 12.0 (SPSS INC., Chicago, IL). Comparison of measured airway dimensions and wall thicknesses among the three groups classified by working duration and smoking status was performed using a one-way analysis of variance. Linear regression analysis was used to evaluate the relationship between age, working duration and smoking with calculated values. The relationship between age, smoking, working duration, the airway dimensions and airway wall thicknesses were assessed using Spearman's correlation.

Table 2. Mean cross-sectional airway measurements, age and working duration in toll collectors

	Mean	Minimum	Maximum	SD
Age	36.85	23	61	7.84
TD	1.96	1.18	2.69	0.30
TWT	0.16	0.06	0.25	0.03
DRMB	1.28	0.81	1.75	0.19
TRMB	0.15	0.08	0.23	0.03
DRAB	0.19	0.06	0.31	0.06
TRAB	0.08	0.05	0.19	0.03
DRPB	0.24	0.09	0.44	0.08
TRPB	0.10	0.02	0.11	0.02
DLMB	1.16	0.88	1.44	0.13
TLMB	0.14	0.09	0.20	0.03
WD	11.93	1	30	5.91

*The mean values of airway diameters and the wall thicknesses are expressed as cm (centimeter).
TD: Tracheal diameter, TWT: Tracheal wall thickness, DRMB: Diameter of right main bronchus, TRMB: Wall thickness of right main bronchus, DRAB: Diameter of right apical bronchus, TRAB: Wall thickness of right upper bronchus, DRPB: Diameter of right posterobasal bronchus, TRPB: Wall thickness of right posterobasal bronchus, DLMB: Diameter of left main bronchus, TLMB: Wall thickness of left main bronchus, WD: Working duration.

Results

Information about the past diseases, smoking status, respiratory complaints of 40 toll collectors has been shown in Table 1. Cough and sputum were the most common complaints in toll collectors. The ratio of smokers was as high as 65.0%.

Mean values of wall thicknesses (in cm), mean age and working duration in toll collectors are shown in Table 2.

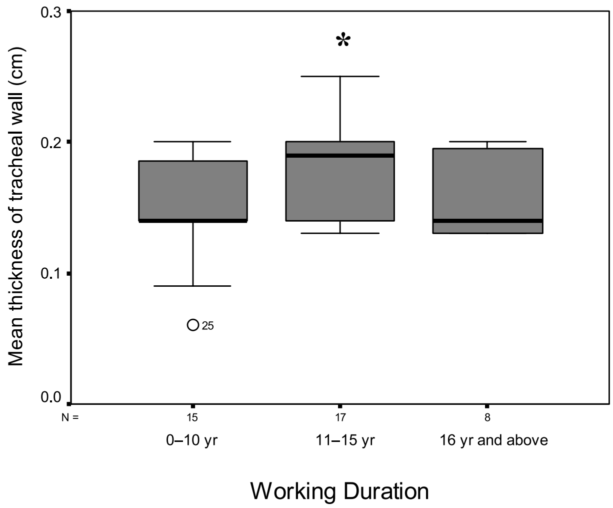


Fig. 3. Mean tracheal wall thickness in toll collectors according to the working duration.

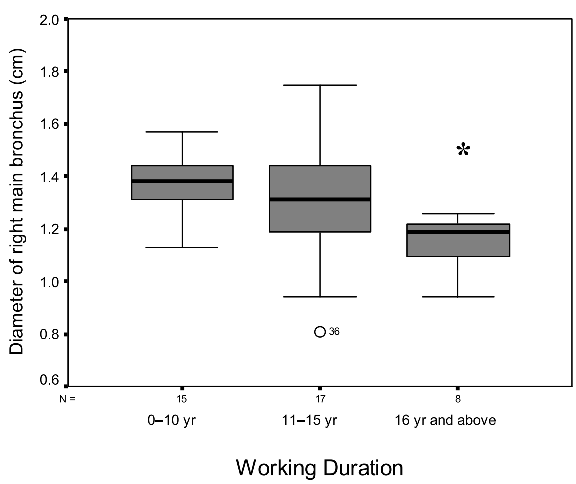


Fig. 4. Mean diameter of right main bronchus in toll collectors according to the working duration.

There were 15 workers with a working duration for 0–10 yr, 17 toll collectors were working for 11–15 yr and 8 were working for 16 yr and above. The mean values of the diameters of airways and the wall thicknesses according to the working durations were compared and significant results were shown in figures respectively. The tracheal walls of toll collectors working for 11–15 yr were thicker than those of working for 0–10 yr (Fig. 3, p=0.048).

The mean diameter of right main bronchus decreased significantly in toll collectors working for 16 yr and above (Fig. 4, p=0.016).

The walls of right main bronchus in toll collectors working for 11–15 yr were significantly thicker than those of working 16 yr and above (Fig. 5, p=0.027).

The mean diameter of right lower bronchus in toll collectors working for 16 yr and above was significantly less than that of working for 11–15 yr (Fig. 6, p=0.033).

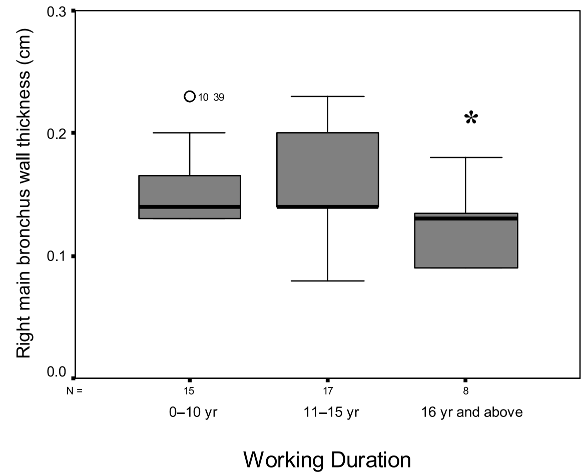


Fig. 5. Right main bronchus wall thickness in toll collectors according to the working duration.

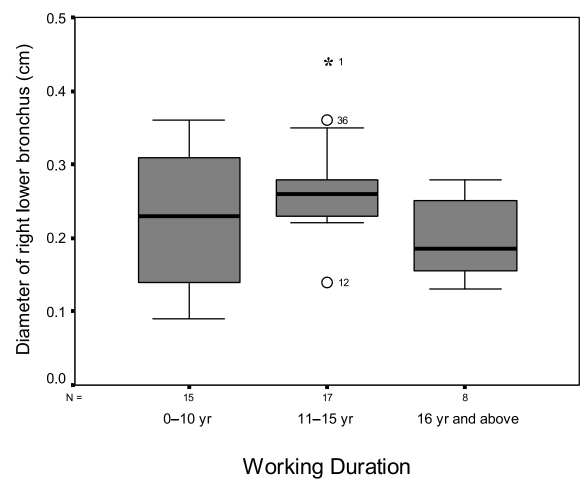


Fig. 6. Mean diameter of right lower bronchus in toll collectors according to the working duration.

The mean diameter of left main bronchus in toll collectors working for 16 yr and above was significantly less than that of working for 0–10 yr (Fig. 7, p=0.039).

Seven workers were nonsmoker, whereas 25 toll collectors were smoker and 8 subjects were exsmoker.

The walls of right upper bronchus in exsmoker toll collectors were significantly thicker than those of nonsmokers (Fig. 8, p=0.011). A positive correlation was observed between age and the right upper bronchus wall thickness (r=0.577, p=0.000). An inverse correlation was found between the working duration and the diameter of right main bronchus (r=–0.366, p=0.020). A positive correlation was seen between smoking and the right upper bronchus wall thickness (r=0.457, p=0.005).

The linear regression analysis on the relations between

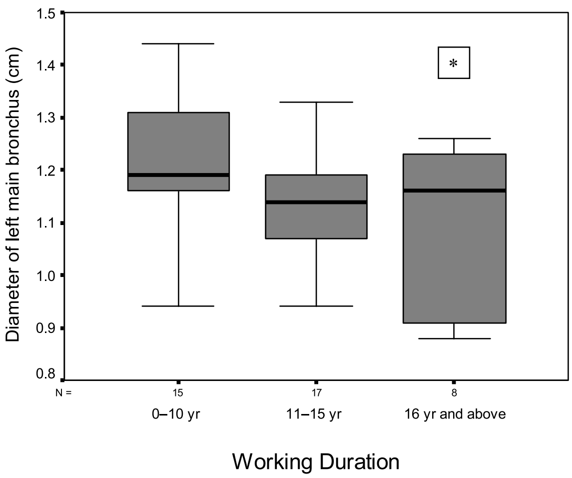


Fig. 7. Diameter of left main bronchus in toll collectors according to the working duration.

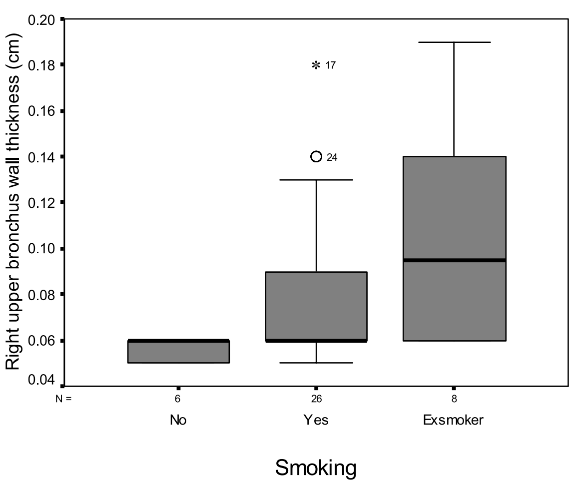


Fig. 8. Right upper bronchus wall thickness in toll collectors according to the smoking status.

the airway diameters and wall thicknesses and age, smoking, working duration is shown in Table 3. Working duration had an independent effect on the diameter of right main bronchus (t=–2.076, p=0.046). Age was found to have an independent effect on the thickness of right apical bronchus wall (t=2.471, p=0.019).

Discussion

In the present study the relation between the airways and various parameters such as age, working duration, and smoking were investigated in a diesel-exposed occupational group, toll collectors. Longer working duration was associated with an increase in thickness of large airways walls. On the other hand, an inverse correlation was found between the working duration and the diameters of large airways. The right upper bronchus wall thickness

Table 3. The relations between the airway diameters and wall thicknesses and age, smoking, working duration

	Standardized coefficients	*t*	*p*
TD			
Age	0.248	0.923	0.362
Smoking	–0.133	–0.734	0.468
WD	–0.071	–0.276	0.785
TWT			
Age	0.254	0.958	0.345
Smoking	0.113	0.634	0.530
WD	–0.090	–0.355	0.725
DRMB			
Age	0.166	0.660	0.514
Smoking	0.101	0.594	0.556
WD	–0.502	–2.076	**0.046**
TRMB			
Age	–0.424	–1.686	0.101
Smoking	0.327	1.925	0.063
WD	0.098	0.407	0.687
DRAB			
Age	0.090	0.334	0.740
Smoking	0.047	0.257	0.799
WD	–0.258	–1.000	0.325
TRAB			
Age	0.556	2.471	**0.019**
Smoking	0.288	1.896	0.067
WD	–0.250	–1.155	0.256
DRPB			
Age	0.179	0.594	0.567
Smoking	0.003	0.006	0.482
WD	–0.038	–0.148	0.529
TRPB			
Age	0.107	0.415	0.980
Smoking	0.864	2.367	0.322
WD	0.146	0.671	0.447
DLMB			
Age	–0.125	–0.487	0.777
Smoking	–0.227	–0.626	0.445
WD	–0.537	–2.471	0.076
TLMB			
Age	–0.097	–0.319	0.935
Smoking	–0.258	–0.600	0.626
WD	0.135	0.523	0.958

TD: Tracheal diameter, TWT: Tracheal wall thickness, DRMB: Diameter of right main bronchus, TRMB: Wall thickness of right main bronchus, TMB: Wall thickness of left main bronchus, DRAB: Diameter of right apical bronchus, TRAB: Wall thickness of right upper bronchus, DRPB: Diameter of right posterobasal bronchus, TRPB: Wall thickness of right posterobasal bronchus, DLMB: Diameter of left main bronchus, TLMB: Wall thickness of left main bronchus, WD: Working duration.

correlated positively with the age and smoking status in toll collectors. Using HRCT techniques, investigators have assesssed airway dimensions in humans either with asthma or chronic obstructive pulmonary disease (COPD). Boulet *et al.* have found a significant reverse relation between the thickness of large airways and the provocative dose of methacholine causing a 20% fall in FEV_1 (Forced Vital Volume In One Second)[14].

Awadh *et al.* have showed that the degree of the thickening of large airway wall depended on the severity of asthma[15]. The present study that included 40 healthy toll collectors showed an increased large airway wall thickness (tracheal wall thickness in this case) related to the working duration. Similar to the results of the present study, in animal models exposure to SO_2 (the most important air pollutant) caused hypertrophy of tracheal submucosal glands, and airway epithelial mucous cell hyperplasia and metaplasia[16, 17].

Deveci *et al*. compared the airway wall thickness and bronchial wall area in patients with COPD, healthy smokers and nonsmokers. They reported that moderate and severe COPD patients had greater airway wall thickening than healthy current smokers and healthy non-smokers as assessed by HRCT scanning; airway wall thickness is increased in healthy smokers who had normal spirometric values compared with normal controls. Wall thickness is inversely related to the degree of airflow obstruction, and positively related to cumulative smoking history[18]. Nakano *et al*. reported a smaller airway lumen and an increased wall thickness in patients with COPD[19]. In the large airways the obstructive component may be due to enlargement of the mucous glands, increased mucous secretion with mucous plugging, and loss of support of the large airways due to cartilage atrophy or inflammation. The relationship between the increase in bronchial gland size in segmental airways and its effect on airway resistance for airways of different diameters was shown. When mucous gland enlargement was severe, airway resistance increased two to four times[20]. The inverse correlation between the working duration and the diameters of large airways in toll collectors might be explained by those data mentioned above. The decrease in the diameters of large airways in accordance with the working duration was interesting. In a study by Matsuoka *et al*., the morphometric changes associated with aging were not clearly seen on measurements of bronchial wall thickness. However, in elderly smokers bronchial wall thickening was found even in the absence of respiratory symptoms[21]. Conversely, Nakano *et al.* have reported that the wall thickness of bronchi were higher in smokers. This controversy can be attributed to the difference in the study groups i.e. Matsouka *et al.* have studied with a healthy group. Berger *et al*. have also demonstrated that *in vivo* normalized airway wall thickness was larger in smokers with COPD than it was in smokers or nonsmokers without COPD[22]. Therefore age and smoking should be taken into consideration in case of measurement of bronchus wall in larger series due to the controversies in previous studies.

The right upper bronchus wall thickness correlated positively with the age and smoking status in toll collectors in this study. We believe that measurement of wall thickness of right upper bronchus might be sufficient in the evaluation of inflammatory changes in bronchus wall for future studies.

Our study has several limitations. If the present study would include a bigger sample size and air trapping would be calculated precisely, the decrease in the diameters of large airways might be evaluated more appropriately. An elongation in large airways due to the underlying air trapping and/or emphysema and associated decrease in the diameters of large airways might be a possible explanation in this case. Another limitation of the present study was that all airway measurements were conducted by a single observer in a blind fashion. Intra-observer variability was tested by this observer independently repeating the measurements after an interval of several days. Interobserver variability was not assessed by having other observers conduct the same measurements independently. We did not perform pulmonary function tests on our subjects. Although pulmonary function declines with age, individual variability cannot be disregarded. The possibility that some subjects did not have age-appropriate pulmonary function cannot be excluded. The appropriate bronchi can be selected by longest diameter-shortest dimeter ratio. However, the measurement of the wall thickness with manual tracing method is somewhat difficult because the measured thickness is very small.

Conclusions

In the light of the previous reports the large airway dimensions have been evaluated in a diesel exposed group in the present study. Diesel exposure might have a role in increase of thickness of large airways wall and a decrease in the diameters of large airways due to inflammatory processes. Studies in this area are needed to protect the population under the diesel exposure risk.

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