Exposure to Biomass Smoke and Anthracosis: Clinical, Radiological, Bronchoscopic and Histopathologic Findings

Biomass Maruziyeti ve Antrakozis: Klinik, Radyolojik, Bronkoskopik ve Histopatolojik Bulgular

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ABSTRACT Objective: Combustion of biomass fuel, is the primary source of exposure in developing countries. The description of the clinical picture of the possible pulmonary involvement in this form of indoor pollution is not well known. Our aim was to indoor air pollution determine the clinical and radiological characteristics of female patients exposed to biomass smoke, to show bronchoscopic findings and to determine the association of bronchoscopic findings with the duration of exposure. **Material and Methods:** The subjects of this study consisted of 20 non-smoking female patients with a history of using biomass fuel composed of animal dung who underwent bronchoscopic procedures for various diagnostic indications. The distinctive clinical features, radiological findings and nature of bronchoscopic lesions were analyzed retrospectively. The bronchoscopic findings were graded as grade I (anthracotic staining on overlying mucosa) and grade II (bronchial narrowing or obliteration due to anthracotic plaques). **Results:** Chief complaint was dyspnea on exertion (85%). The most frequent radiological finding on chest X-ray was reticular and/or reticulonodular infiltration (70%). The mean duration of biomass smoke exposure was 37.70 ± 19.53 years. Eleven patients were had grade I while 9 patients had grade II bronchoscopic findings. A statistically significant correlation was found between the exposure duration and bronchoscopic grade ($p< 0.005$). **Conclusion:** These findings suggest that long-standing domestic exposure to biomass smoke contributes not only to anthracotic staining on overlying mucosa, but also to bronchial narrowing or obliteration. To evaluate the role of bronchoscopic grade in different lung diseases that may be related with biomass fuel, prospective research is needed.

Key Words: Biomass; bronchoscopy; anthracosis

ÖZET Amaç: Gelişmekte olan ülkelerde ev içi hava kirliliğinin ana sebebi ısınma ve yemek yapma amaçlı olarak yakacak maddelerinin kullanılmasıdır. Yanma kaynaklı ev içi hava kirliliğinin pulmoner tutulumu ve klinik tablosu hakkında yeterli bilgi yoktur. Çalışmadaki amacımız; biomassa maruz kalan kadın olguların klinik ve radyolojik özelliklerini belirlemek ve bronkoskopik bulgularını değerlendirerek, bu bulgularla maruziyet süresi arasında ilişki olup olmadığını saptamaktır. **Gereç ve Yöntemler:** Değişik tanısal nedenlerle bronkoskopi uygulanmış ev içi biomass yakıt kullanımı öyküsü olan 20 sigara içmeyen kadın olgu çalışmaya alındı. Demografik, klinik ve radyolojik özellikleri, bronkoskopik bulguları retrospektif olarak incelendi. Bronkoskopik bulgular grade I (yüzeyel mukozada antrakotik boyanma) ve grade II (antrakotik plak nedeniyle bronşiyal daralma veya obliterasyon) olarak derecelendirildi. **Bulgular:** Esas şikayet (%85) eforla gelen nefes darlığı idi. PA akciğer grafisinde en sık izlenen bulgu (%70) retiküler ve/veya retikülonodüler infiltrasyondu. Biomass maruziyet süresi ortalama 37.70 ± 19.53 yıl idi. Bronkoskopik bulgular incelendiğinde 11 olgu grade I iken, 9 olgu grade II olarak saptandı. Bronkoskopik derecelendirme ile maruziyet süresi arasında istatistiksel olarak anlamlı ilişki bulundu ($p< 0.005$). **Sonuç:** Bulgularımz uzun süreli ev içi biomass maruziyetinin sadece yüzeyel mukozada antrakotik boyanmayla kalmayıp aynı zamanda bronşiyal daralma ve obliterasyona da neden olduğunu desteklemektedir. Biomass ile ilgili farklı akciğer hastalıklarında bronkoskopik derecelendirmenin rolünü değerlendirmek için prospektif araştırmalara ihtiyaç vardır.

Anahtar Kelimeler: Biomass; bronkoskopi; antrakoz

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In industrialized countries, the most common sources of non-tobacco-related inhaled pollutants are industrial air pollution and dust inhalation from mining.[1,2] Conversely, indoor air pollution, derived from the combustion of biomass fuel, is the primary source of exposure in developing countries. Biomass fuel is any material derived from plants or animals that is deliberately burned by humans. Wood is the most common example, but in areas with little forestation corn husks, straw, and animal dung are frequently used alternatives.[3] Many of the substances in biomass smoke can be detrimental to health.[4,5] Although there is consistent evidence that chronic exposure to biomass smoke is implicated as the leading cause of chronic bronchitis among non-smokers in rural countries and increases the risk for pulmonary tuberculosis and lung cancer, the description of the clinical picture of the possible pulmonary involvement in this form of indoor pollution is not well known.[6,7]

The purpose of this study was to evaluate the clinical, radiological and bronchoscopic characteristics of non-smoking female patients with a history of using biomass fuel composed of animal dung. Particular emphasis was given to the relation between exposure duration and bronchoscopic findings in these patients.

MATERIAL AND METHODS

A total of 9000 patients underwent bronchoscopy in Atatürk Chest Disease and Chest Surgery Center during a period of four years. Of these, only 20 non-smoking female patients with a history of using biomass fuel composed of animal dung and bronchoscopic findings of anthracotic pigmentation on overlying mucosa with or without bronchial obliteration and/or narrowing were included in the study. Male patients and smokers with any history of exposure to coal dusts or other soot particles were excluded. Finally, although our study was conducted in Ankara, since all of our patients lived in rural areas, the possible role of atmospheric air pollution in large cities could be reasonably excluded.

We retrospectively reviewed the medical records of all patients for basic demographic data, history of smoking and exposure to biomass fuel composed of animal dung and detailed medical history including tuberculosis and other infections. Biomass smoke exposure length was defined as cumulative years. Plain chest X-ray and thoracic computed tomography (CT) findings at presentation were analyzed retrospectively by a radiologist and final decision on the findings was reached by consensus. Bronchoscopic records were evaluated retrospectively and findings were graded as grade I (anthracotic staining on overlying mucosa) and grade II (bronchial narrowing or obliteration due to anthracotic plaques). These findings are seen in Figures 1 and 2. Results of bacteriologic and cytopathologic examinations of bronchial washing fluid and biopsy specimens were analyzed retrospectively and then final diagnoses were given. The current study received institutional review board approval.

STATISTICAL ANALYSIS

Means and standard errors of measurements (SEM) were determined for continuous variables and percentages were calculated for categorical variables. The differences between two groups were analyzed using Mann-Whitney U test. All statistical analyses were carried out using statistical software (SPSS, version 11.0 for Windows; Chicago IL, USA). Differences were considered significant when $p< 0.05$.

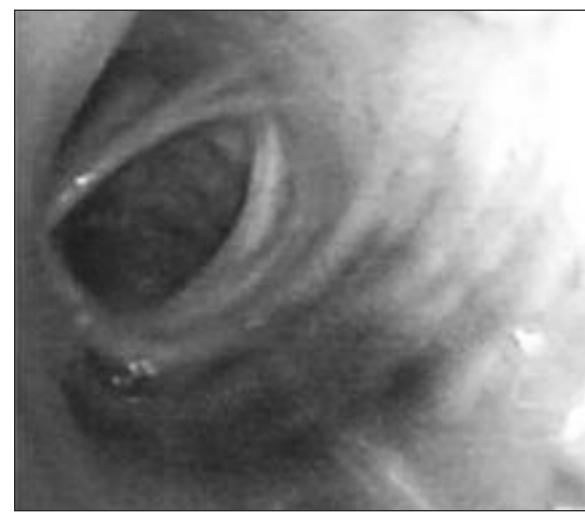


FIGURE 1: Bronchoscopic examination shows anthracotic staining on overlying mucosa of left main bronchus (grade I).

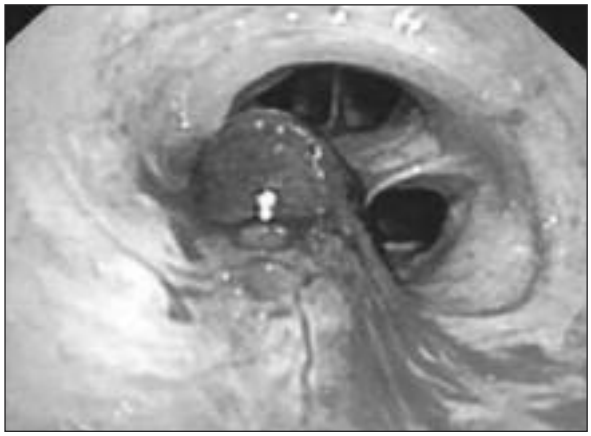


FIGURE 2: Bronchoscopic examination shows bronchial obliteration of right lower lobe due to anthracotic plague (grade II).

RESULTS

The mean age of the patients was 69.05 ± 9.48 years and the mean duration of exposure was 37.70 ± 19.53 years. Age, exposure duration to biomass smoke, bronchoscopic grade and the final diagnoses of the study group are given in Table 1. The clinical features as well as the plain chest radiographs and thoracic CT findings are shown in Table 2. Dyspnea and productive cough were the main complaints. Radiographic findings of the plain chest radiographs at presentation were variable, as follows: reticular and/or reticulonodular lesions (70%) (Figure3), consolidation (30%), segmental or subsegmental atelectasis (15%) (Figure 4a, b), hyperinflation (15%), hilar enlargement (25%) and mass lesion (10%). On thoracic CT, reticular and/or reticulonodular pattern (55%), mass lesion (35%), consolidation (30%), atelectasis (20%) and hyperinflation (20%) were the most frequent findings. The principal finding on bronchoscopy was anthracotic pigmentation of bronchial mucosa and/or bronchial luminal narrowing or obliteration with anthracotic plaques. According to the bronchoscopic grading system used in this study, 11 patients were determined as grade I while 9 patients revealed grade II bronchoscopic findings (Table 1).

TABLE 1: Ages, exposure duration to biomass smoke, bronchoscopic grade and the final diagnosis of the study group.

Age	Exposure duration of biomass smoke (years)	Bronchoscopic grade	Final diagnosis
72	69	2	DAPLD
66	40	2	Lung cancer, CB
66	50	2	Pulmonary tuberculosis, DAPLD
73	15	1	DAPLD
75	40	1	Lung cancer
68	30	1	Lung cancer, CB
78	60	1	DAPLD, bronchiectasis
69	66	2	DAPLD
77	47	2	DAPLD
55	25	1	Chronic fibrinous pleuritis, DAPLD
64	35	2	DAPLD, pneumonia
71	65	2	DAPLD, pneumonia
85	18	1	CB
57	20	1	DAPLD
64	12	1	Lung cancer, CB
65	22	1	DAPLD, CB
82	15	1	DAPLD, pneumonia
77	55	2	DAPLD, pneumonia
72	55	2	DAPLD, CB
45	15	1	DAPLD, pulmonary tuberculosis

DAPLD: Domestically acquired particulate lung disease.

CB: Chronic bronchitis.

TABLE 2: Clinical features, plain chest radiograph and thoracic computed tomography findings.

Clinical Features	(n)	Plain Chest Radiographs	(n)	Thoracic Computed Tomography	(n)
Dyspnea	17	Linear or reticular opacity	14	Hyperlucency	5
Cough	5	Volume loss	3	Pulmonary hypertension	3
Sputum production	9	Hyperlucency	3	Cardiac enlargement	1
Hemoptysis	2	Cardiac enlargement	4	Atelectasis	4
Fever	1	Cavity	2	Consolidation	6
Weight loss	5	Mass	2	Mass	7
Chest pain	6	Consolidation	6	Mediastinal lymphadenomegaly	2
		Pleural effusion	6	Bronchiectasis	4
		Hilum enlargement	5	Linear or reticular opacity	11
		Mediastinum enlargement	2	Pleural effusion	6
				Cavity	1

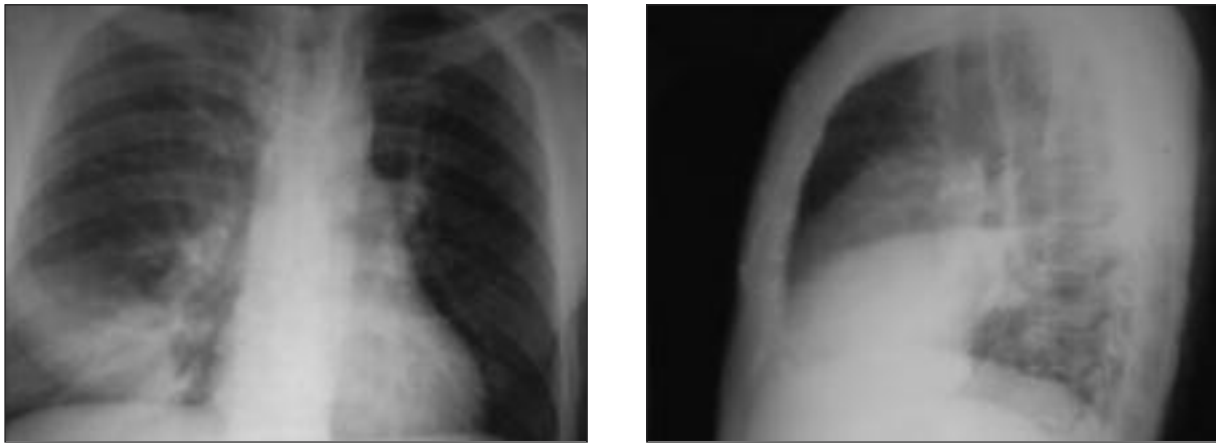
The mean exposure duration in grade I was found as 24.72 ± 14.23 years versus 53.55 ± 11.79 years in grade II, and a statistically significant difference was found between the exposure duration and bronchoscopic grade ($p< 0.005$). Bronchoscopic mucosa biopsy was performed in nine patients and transbronchial biopsy in two patients. Pathologic examination of the bronchial mucosa biopsy specimens showed acute and chronic inflammatory infiltration of the submucosa with deposition of anthracotic material. Among the nine patients, biopsy specimens of two patients also showed hyperplasia and squamous metaplasia of the bronchial epithelium. Pathologic examination of the specimens obtained by transbronchial biopsy revealed severe anthracosis of the lung parenchyma with thickening of the alveolar septa.

Four patients were diagnosed as lung cancer (adenocarcinoma); one was diagnosed after lobectomy and two were diagnosed after obtaining a biopsy from endobronchial lesions during bronchoscopy, and the last was diagnosed through a pleural biopsy. Pulmonary tuberculosis was diagnosed in two patients. In one patient, right upper lobectomy was performed because of the possibility of malignancy on thoracic CT, and resected specimen showed granulomatous inflammation with caseating necrosis and anthracosis. Bacteriologic examination of bronchial lavage for acid-fast bacilli was positive in the other patient. Final diagnoses of the patients based on clinical, radiologic and pathological findings are given in Table 1.

FIGURE 3: Posterior-anterior chest radiograph showing reticular infiltration in lung bases.

DISCUSSION

Biomass fuel is any material derived from plants or animals that is deliberately burned by humans. Wood is the most common example, but the use of animal dung and crop residues is also commen.[8] Many of the substances in biomass smoke can be detrimental to health. The most important are particles : carbon monoxide, nitrous oxides, sulphur oxides, formaldehydes, and polycyclic organic matters including carcinogens such as benzo(a)pyrene.[9,10] There is *in vitro* evidence that many of these compounds are mutagenic, and contain irritants and coagulating agents that can compromise respiratory system defenses and increase the risk of acute and chronic lung infections.[10,11]



a b

FIGURE 4a, b: Posterior-anterior and lateral radiographs of the chest demonstrates middle lobe atelectasis.

Likewise, chronic exposure to biomass smoke is implicated as the leading cause of chronic bronchitis among non-smokers in rural countries.[12,13] With continued exposure, individuals may develop both physiological and radiological abnormalities of the lung.[14] Though there is still lack of a standard definition, domestically acquired particulate lung disease (DAPLD) is used to describe this syndrome.[9] DAPLD is potentially the largest environmentally attributable disorder in the world, with an estimated three billion people at risk.

Clinically, DAPLD manifests a broad range of disorders from dyspnea and chronic bronchitis to advanced interstitial lung disease and malignancy.[1] Unfortunately, the wide range of reported results makes impossible to know the true prevalence of this disorder.[15] The prevalence of this syndrome in Turkey has not been completely established either. The majority of women living in rural areas in Turkey use biomass fuels for domestic energy and are exposed to high levels of indoor air pollution in their daily lives. Ekici et al. studied the presence of chronic airway diseases (CAD) in non-smoking women in Kırıkkale and found that CAD attributed to biomass smoke exposure was found in 23.1%.[16]

In our study, 20 non-smoking female patients with a history of using biomass fuel composed of animal dung were evaluated retrospectively. The length of exposure was defined in years. The mean duration of exposure was found as 37.70 ± 19.53 years. The length and intensity of biomass smoke exposure required for development of lung disease as well as the complete clinical spectrum of the pulmonary involvement remain to be fully defined. However, all mentioned studies have pointed out that length of exposure in years as well as intensity of exposure might be, important determinants among others.[8] Acute symptoms during exposure to biomass smoke are important predictors for the presence of DAPLD. The most common manifestations of DAPLD in adults are cough-related complaints, especially chronic bronchitis.[17,18] With a good environmental history, there is often little difficulty in making the diagnosis of DAPLD in a non-smoker presenting with chronic bronchitis and a normal chest radiograph. However, as mentioned in the report of Gold et al., the differential diagnosis of patients with significant parenchymal disease is more diverse.[1]

The chief complaints of our patients were dyspnea on exertion (85%) and productive cough (45%). All of the patients in this study underwent a bronchoscopic evaluation for various diagnostic indications. None of them had a normal chest radiograph. The most frequent radiological finding on chest X-ray was reticular and/or reticulonodular infiltration (70%). On thoracic CT, reticular and/or reticulonodular pattern (55%) and a mass lesion (35%) were the most frequent findings.

On bronchoscopy, the presence of grossly visible anthracotic plaques, usually seen at the bifurcation of a lobar bronchus, has been shown to be a frequent finding in biomass smoke exposure.[19] To our knowledge, there is no study grading the bronchoscopic findings of DAPLD patients and evaluating the relation of these findings with the exposure duration.

The analysis of the bronchoscopic findings in 20 non-smoking female patients in our study revealed not only an anthracotic staining on overlying mucosa (grade I) but also bronchial narrowing and/or obliteration due to anthracotic plaques (grade II). Eleven patients had grade I and nine patients had grade II bronchoscopic findings. A statistically significant difference was found between the two grades with respect to the mean exposure duration ($p< 0.005$). On bronchoscopy, dark anthracotic pigmentation was not only seen in biomass smoke exposure but also in heavy smokers, miners and rarely in city dwellers.[20] Dark anthracotic pigmentation in conjunction with bronchial narrowing or obliteration has also been reported in patients with pulmonary tuberculosis.[21] In our country, tuberculosis is still the most important infectious disease so the possibility of active or old tuberculosis should always be considered in a patient with bronchial stenosis due to anthracofibrosis.

In our study, pulmonary tuberculosis was diagnosed in two patients (grades I and II bronchoscopic findings). Though it is impossible to know which is the leading cause of anthracotic staining, tuberculosis and/or biomass smoke exposure, it is important to know that exposure to biomass smoke may be an additional risk factor for tuberculosis.[4] Four of the patients included in this study had radiological evidence of malignancy in the form of central airway obstruction and collapse of a lobe or segment on plain chest X-rays. Their thoracic CT showed bronchial narrowing and/or collapse-consolidation. On bronchoscopy, they revealed grade II findings, and there was no evidence of malignancy in either bronchial lavage fluid or histopathological specimens. These radiological and bronchoscopic findings might be explained by the extremely long periods of exposure in these patients. Thus, it will be important to keep in mind that radiological findings of biomass exposure may mimic lung cancer. Biomass smoke, however, contains a wide range of chemicals that are known or suspected human carcinogens. The presence of high levels of carcinogen benzo(a)pyrene, often in excess of 4000 ng/m^3 during cooking over biomass stoves (a level comparable to smoking one pack of cigarettes in 24 hours), has led many to investigate the role of biomass smoke in the development of malignancy.[1] Indoor pollution due to domestic fuels has been recently implicated as a causative agent in lung cancer. Behera et al. showed that adenocarcinoma was the predominant histological type of malignancy in the non-smoking females who were exposed to various cooking fuels.[22]

In our study, four patients were diagnosed as pulmonary adenocarcinoma. All were non-smokers and were exposed to biomass smoke for most of their lives. Bronchoscopy showed grade II findings in only one patient. In contrast to our finding, Hou et al. reported a relationship between the degree of background anthracosis and the differentiation of pulmonary adenocarcinoma, using data from autopsy cases.[23] Wang et al. studied used surgically resected cases and they concluded that relatively advanced and less differentiated adenocarcinomas tended to develop in severely anthracotic lungs or that adenocarcinomas that developed in severely anthracotic lungs progressed more readily to advanced tumors.[24] In developing countries, previous lung disease attributable to tuberculosis and other lung infections could contribute to lung cancer development in persons who have never smoked.[4]

Chronic exposure to biomass smoke is implicated as the leading cause of chronic bronchitis among non-smokers in rural communities.[7,12,13,16] Although there are currently no longitudinal studies, subjects may progress to pulmonary fibrosis with significant hypoxemia and cor pulmonale.[8,14]

Domestic smoke pollution, particularly due to biomass fuel, is a contributing factor in the prevalence of chronic bronchitis in rural women.[25] Kiraz et al. found that chronic bronchitis and COPD

were more prevalent among rural than urban women ($p< 0.03, 0.05$). Although the pulmonary function tests were within normal limits, forced expiratory volume in 1 sec (FEV_1) values in rural women were found to be relatively low compared to those of urban women ($p< 0.05$).[26]

In the present study, six patients were diagnosed as chronic bronchitis according to the current standard definition (daily cough with sputum production for three consecutive months for at least two years) and bronchoscopic findings. However, upon retrospective review, we consider that two of these six patients also had DAPLD. Their bronchoscopic findings were anthracotic staining on overlying mucosa in addition to the finding of chronic bronchitic changes. Histopathological examination of the bronchial mucosa biopsies revealed acute and chronic inflammatory infiltration of the submucosa with deposition of anthracotic material, hyperplasia of mucous glands, and hyperplasia and squamous metaplasia of the bronchial epithelium. Transbronchial biopsy performed in two patients revealed severe anthracosis of the lung parenchyma with thickening of the alveolar septa. We could not obtain pulmonary function test results.

The final diagnosis in four patients in this study was pneumonia while one patient was diagnosed as bronchiectasis according to the physical examination and radiologic findings. We thought that the term DAPLD should be used in these diagnoses as well. The bronchoscopic findings of three patients with pneumonia revealed a grade II pattern while others showed grade I pattern. Chronic exposure to biomass smoke has been shown to interfere with mucociliary defenses of the lungs and to decrease several antibacterial properties of lung macrophages.[20,27] It is possible that bronchial narrowing and/or obliteration due to anthracotic plaques impair the clearance of mucoid secretions from the distal lung and predispose pneumonia in the affected segment or lobe. A predisposition for the development of bronchiectasis due to repeated infections should also be taken into consideration.

We all know that smoking, air pollution, occupational exposures and infections, especially active or old tuberculosis, are associated with anthracotic pigmentation with or without bronchial obliteration. This study also showed that long-standing domestic exposure to biomass smoke composed of animal dung contributes not only caused anthracotic staining on overlying mucosa but also bronchial narrowing and/or obliteration. Prospective studies are needed to assess the role of bronchoscopic grade and exposure duration in different lung diseases that may be related to biomass fuel.

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