Background: Anthracosis is the black pigmentation of the mucosal lining of the tracheo‑bronchial tree. The significance of this finding is not known and often ignored. The aim of the present study is to find the association of anthracosis with demographic variables, biomass fuel and occupational exposure, respiratory diseases, radiological pattern and functional morbidity. Materials and Methods: Enrolment of the subjects for the study was done at SMS hospital, Jaipur. Patients with anthracosis evident on bronchoscopy were included as the cases. Patients without anthracosis on bronchoscopy, matched according to age, gender and smoking habits, were included in the control group. Subjects in both the arms completed a questionnaire and also underwent computed tomography (CT) of the chest and six minute walk test (6MWT). Results: Thirty cases and 53 controls were included in the study. The patients with anthracosis presented with symptoms ranging from cough (76.65%), hemoptysis (46.6%), fever (26.6%), dyspnea (90%) and malaise (73.3%). Biomass fuel exposure for the cases was 35.13 ± 55.86 hours in a year and for the controls was 28.15 ± 40.09 hours in a year (P > 0.05). Stone mining was significantly associated with anthracosis (P < 0.05). CT chest revealed fibrosis (43.3%), consolidation (33.3%), cavitation (16.6%) and mass (46.6%) in the cases. Sixty percent of cases and 15% of controls were diagnosed to have either old or active pulmonary tuberculosis (P < 0.05). Conclusions: Anthracosis is associated with pulmonary tuberculosis. Biomass exposure is not significantly associated with anthracosis. Post tubercular fibrosis is more common on CT chest of patients with anthracosis.

Key Words: Anthracofibrosis, anthracosis, biomass smoke, bronchoscopy, lung cancer, tuberculosis

INTRODUCTION

Black pigmentation with or without narrowing of the tracheobronchial tree is often observed during routine bronchoscopies. The most common cause of this finding is deposition of carbon, silica and other inhaled pollutants and is called as anthracosis.[1] Occasionally, narrowing of the bronchi may accompany the pigmentation and is called as anthracofibrosis.[1] In 1951 it was described by Abraham et al.[2] and in 1998 the term anthracofibrosis was coined by Chung et al.[3] There have been various synonyms for the same entity including anthracotic bronchitis,[4] anthracostenosis,[5] and bronchial anthracosis.[1]

The significance of anthracosis and anthracofibrosis is not well understood. It has been reported in 3-21% of all patients undergoing bronchoscopy.[1,6] There have been various hypotheses to explain the occurrence of this elusive entity but no etiological agent has been singled out yet.

The present study aimed to find out the association of anthracosis with pulmonary diseases, occupational and biomass smoke exposure. Inclusion of a comparison group has increased the strength of our study as most of the earlier studies on the subject did not include a control group to assess the clinical and radiological factors of anthracosis. The demographical variables, clinical symptoms, radiological pattern and functional morbidity of the patients were also studied.

MATERIALS AND METHODS

This was an observational study conducted at SMS Hospital, Jaipur, India. This study was conducted in accordance with the amended Declaration of Helsinki. The study was approved by institutional research review
board, SMS Medical College, Jaipur (51/EC/2011, Dated: 29/12/2011). Patients with ages between 20 and 85 years were included in the study after taking informed consent. Seriously ill patients and refusal to give informed consent were the exclusion criterion for the study. All patients with black patch evident on bronchoscopy during 13 months of study period were included in the control group of our study. Similarly, patients matched according to age, gender and smoking habits, without black patches on bronchoscopy, were included in the control group during the same period. The demographic data, clinical, and radiographic finding of patients in both the groups were recorded. Questionnaire including the personal data, place of residence, present symptoms, smoking history, exposure history, occupation and past history of tuberculosis in the patient and their family, was completed for each patient. Chest x-ray (CXR), computerized tomography (CT) and sputum examinations were also obtained. Six minute walk test (6MWT) was performed by all patients who were fit to do the same.

All patients were premedicated with nebulized form of lignocaine, lignocaine gargles and topical lignocaine in the nostril prior to flexible bronchoscopy. Apprehensive patients were intravenously sedated with a short acting benzodiazepine. Continuous blood pressure and pulse oximeter monitoring were done during the procedure. Patients with oxygen saturation of <90% measured by pulse oximeter were provided with supplemental oxygen.

Characteristics of the black patches in the form of number, site and extent were noted. Concomitant bronchoscopic findings were also noted. Bronchoalveolar lavage (BAL) was obtained and sent for testing of acid fast bacilli (AFB), mycobacterium tuberculosis PCR and cytopathology. Bronchial biopsies were taken from endobronchial growths and sent for histopathological examination. Brush smear and trans-bronchial needle aspiration (TBNA) were performed when indicated.

Radiographic findings (CXR and CT films) were analyzed by chest physician and radiologist, after which a consensual diagnosis was made. The medical records of all the patients were reviewed.

Statistics
The data were summarized as percentage and were compared using the Chi-square test. Continuous data of interval and ratio scale were summarized as mean and standard deviation. These were compared by the unpaired t test. Odds ratio was calculated to assess risk following exposure. A P value of less than 0.05 was considered significant. All calculations were done using Medcalc 2.0.0 version.

RESULTS
During the study period, a total of 379 bronchoscopies were done in our hospital; among these 51 were females while 328 were males [Table 1]. 30 cases (with anthracosis) and 53 matched controls (without anthracosis) were included in our study keeping a ratio of approximately 1:2. The mean age was 59.4 ± 12.7 years and 57.7 ± 10.75 years for cases and controls, respectively. The anthracosis group had 22 males and 8 females.

The patients with anthracosis presented with symptoms of cough (76.65%), hemoptysis (46.6%), fever (26.6%), dyspnea (90%), loss of weight (46.6%) and malaise (73.3%). Fever was significantly less prevalent in the cases than in the controls (P < 0.05). However, there was no significant difference in the prevalence of other symptoms amongst the cases and controls [Table 2]. Family history of tuberculosis was present in 26.7% of the cases and 5.7% of controls and this difference was significant (P < 0.05).

Biomass exposure for the cases was 35.13 ± 55.86 hours in a year and for the controls was 28.15 ± 40.09 hours in a year. However, this difference was not statistically significant. Among the occupational exposure [Table 3], stone mining was significantly associated with anthracosis (P < 0.05).

The computed tomography (CT) of the chest [Table 4] among the cases revealed fibrosis (43.3%), consolidation (33.3%), cavitation (16.6%) and mass (46.6%). Fibrosis was significantly more prevalent in the cases as compared to the controls (P < 0.05).

Pulmonary functions were more depressed in controls as compared to cases. The mean FEV1 was 1.62 ± 0.74 L in cases and 1.30 ± 0.61 L in controls with a P value of 0.07 while FVC was more significantly affected with a value

### Table 1: Demographic variable in the cases and controls

| Variable | Cases (n=30) | Control (n=53) | P Value |
|----------|-------------|---------------|---------|
| Age (years) | 59.4±12.7 | 57.7±10.75 | 0.519* |
| Gender | | | |
| Males (%) | 22 (73.3%) | 38 (71.7%) | 0.924** |
| Females (%) | 8 (26.7%) | 15 (28.3%) | |

*Unpaired ‘t’ test, **Chi-square test

### Table 2: Clinical variables amongst cases and controls

| Variable | Cases (n=30) (%) | Control (n=53) (%) | Odds ratio (confidence interval) |
|----------|-----------------|-------------------|---------------------------------|
| Dyspnea | 27 (90) | 48 (90.5) | 0.938 (0.208-4.231) |
| Cough | 23 (76.65) | 46 (86.7) | 0.500 (0.157-1.597) |
| Hemoptysis | 14 (46.6) | 22 (41.5) | 1.233 (0.500-3.038) |
| Fever | 8 (26.6)* | 31 (58.4)* | 0.258 (0.097-0.685) |
| Loss of weight | 14 (46.6) | 33 (62.2) | 0.530 (0.214-1.314) |
| Malaise | 22 (73.3) | 44 (83) | 0.562 (0.191-1.658) |
| Wheeze | 9 (30) | 15 (28.3) | 1.086 (0.406-2.903) |
| Clubbing | 2 (6.6) | 5 (9.4) | 0.686 (0.125-3.772) |
| Pallor | 6 (20) | 10 (18.8) | 1.075 (0.348-3.323) |
| Lymphadenopathy | 3 (10) | 10 (18.8) | 0.478 (0.121-1.894) |
| Tachypnea | 24 (80) | 34 (64.1) | 2.235 (0.777-6.427) |
| Tachycardia | 11 (36.6) | 10 (18.8) | 2.489 (0.905-6.851) |
| Rhonchii | 4 (16.6) | 4 (7.5) | 1.885 (0.435-8.158) |
| Crepitations | 2 (6.6) | 5 (9.4) | 0.686 (0.125-3.772) |

*P<0.05
of 2.082 ± 0.89 L in cases and 1.621 ± 0.64 L in controls and a \( P \) value of 0.02. However, airflow obstruction was comparable in both groups as it was seen 22.22% of cases and 25.71% of controls with a \( P \) value of 0.34.

There was no significant difference between the cases and controls in terms of the distance covered during 6MWT. Significant fall (>5%) in oxygen saturation (SpO\(_2\)) measured by pulse oximeter during 6MWT was seen in 3.3% cases and 9.4% controls (\( P > 0.05 \)).

The black patches were distributed predominantly in the upper lobes in the cases with 26.4% on the right and 24.5% on the left side predominantly. Other involved lobes included right middle lobe (13.2%), right lower lobe (5.6%), right intermediate bronchus (15.1%), lingula (3.7%) and left lower lobe (11.3%). Single black patch was found in fifteen cases while remaining fifteen cases had more than one black patch. Concomitant endobronchial growth was found in four patients and endobronchial narrowing was seen in two cases (6.67%).

On microbiological and histopathological work up, 60% of the cases and 15% of controls had tuberculosis (\( P < 0.05 \)). Table 5 also reveals that malignancy was less frequent in the cases (\( P < 0.05 \)).

**DISCUSSION**

In the present study, the patients with anthracosis were middle aged to elderly adults presenting with non-specific symptoms such as cough, dyspnea, malaise and hemoptysis. Fever was less common in the cases as compared to controls.

In our study, number of males was higher than females in the cases (22 males and 8 females). However, previous studies have shown a preponderance of this disease in females.\(^{[7,8]}\) This divergence could be due to the fact that majority of patients undergoing bronchoscopies at our center are males. Amongst the total number of bronchoscopies, 6.7% of the males and 15% of the females had anthracosis, which again suggests a female predominance of the disease.

The age of the patients ranged from 36 to 85 years (mean age = 59.4 ± 12.7 years). Majority of the affected patients were in the older age group which was concordant with the previous data (mean age ranging from 59 to 76).\(^{[3]}\) The most common symptoms in patients with anthracosis were dyspnea (90%) and cough (76.65%). Hemoptysis was present in 46.6% of the patients. This percentage of hemoptysis was higher than previous studies with prevalence ranging from 9% to 30%.\(^{[10-11]}\) Chung et al.\(^{[3]}\) reported cough (71.42%) and dyspnea on exertion (60.71%) as the predominant symptoms. Similarly, Mirsadree et al.\(^{[12]}\) stated dyspnea in 95% and cough in 86% cases of anthracosis. Other previous studies have also revealed similar findings.\(^{[3]}\)

### Table 3: Distribution of cases and controls according to occupational dust exposure

| Occupational dust exposure | Case (n=30) (%) | Control (n=53) (%) | Odds ratio (confidence interval) |
|---------------------------|----------------|------------------|----------------------------------|
| Organic                   |                |                  |                                  |
| Farming                   | 14 (46.7)      | 35 (66.1)        | 0.450 (0.180-1.124)              |
| Flour mill                | 1 (3.3)        | 2 (3.8)          | 0.897 (0.078-10.318)             |
| Inorganic                 |                |                  |                                  |
| Stone mining              | 6 (20.0)       | 1 (1.9)          | 13 (1.482-114.039)*              |
| Cement                    | 1 (3.3)        | 4 (7.5)          | 0.422 (0.045-3.964)              |
| Copper mining             | 0              | 2 (3.8)          | 0                                |
| No occupational exposure  | 8 (26.7)       | 9 (17.0)         |                                  |

\*\( P<0.05 \)

### Table 4: Radiological findings in patients with and without anthracosis

| CT findings                  | Case (n=30) (%) | Control (n=53) (%) | Total (n=83) |
|------------------------------|----------------|--------------------|--------------|
| Normal                       | 1 (3.3)        | 2 (3.7)            | 3            |
| Abnormal                     | 29 (96.6)      | 51 (96.2)          | 80           |
| Consolidation                | 10 (33.3)      | 15 (28.3)          | 25           |
| Cavity                       | 5 (16.6)       | 9 (16.8)           | 14           |
| Fibrosis*                    | 13 (43.3)      | 4 (7.5)            | 17           |
| Nodules                      | 14 (46.67)     | 34 (64.15)         | 48           |
| Collapse                     | 7 (23.3)       | 12 (22.6)          | 19           |
| Pleural effusion             | 4 (13.3)       | 8 (15.1)           | 12           |
| Pleural thickening           | 2 (6.6)        | 1 (1.8)            | 3            |
| Miliary shadows              | 3 (10)         | 2 (3.7)            | 5            |
| Mass                         | 14 (46.6)      | 33 (62.2)          | 47           |
| Mediastinal lymphadenopathy  | 16 (53.3)      | 26 (49)            | 42           |
| Air trapping                 | 5 (10)         | 10 (18.8)          | 13           |

\*\( P<0.05 \), CT: Computed tomography

### Table 5: Associated conditions in patients with anthracosis by logistic regression multivariate analysis

| Risk factor                  | Odds ratio | 95% C.I. | S.E. | \( P \) Value |
|------------------------------|------------|----------|------|--------------|
| Tuberculosis                 | 7.3428     | 1.92-28.09| 0.68 | 0.004        |
| Biomass fuel exposure        | 0.5714     | 0.19-1.74 | 0.57 | 0.32         |
| Malignancy                   | 0.6334     | 0.17-2.39 | 0.68 | 0.50         |

CI: Confidence interval, SE: Standard error

On examination, the common findings were tachypnea (80%) and tachycardia (36.6%). There was no significant difference between cases and control in terms of other clinical signs like generalized lymphadenopathy and crepitations. Previous studies have suggested a higher percentage of rhonchi and crepitations;\(^{[12]}\) however, we had lesser number of patients with findings on auscultation (rhonchi in 16.6% and crepitations in 6.6% cases).

Anthracosis has been previously documented in patients with chronic exposure to biomass fuel smoke.\(^{[10-11,13,14]}\) Grobbelaar et al.\(^{[15]}\) found that anthracosis was evident in patients with chronic exposure to biomass smoke and coined the term “Hut Lung” for this entity. However, none of the previous studies had a control group. Though, exposure to biomass fuel smoke was present in the cases in our study, there was no significant difference from the comparison group.
We also found that stone mining was significantly associated with anthracosis. This may be due to the fact that stone mining is associated with silicosis and subsequently tuberculosis. Silica alters the macrophage function and thus, the clearing of the inhaled particles is also compromised. This may lead to deposition of the pigments and black discoloration of the mucosa. Sigari et al. found that 7.5% of their patients with anthracosis were miners. In our study 20% of the cases were involved in stone mining and cutting which was significantly higher than the controls (P < 0.05).

Computed tomography revealed mediastinal lymphadenopathy (53.3%), fibrosis (43.3%), nodules (46.67%), consolidation (33.3%) and collapse (23.3%). However, fibrosis was the only finding that was significantly more common in the cases as compared to the controls. This further emphasizes the association of anthracofibrosis with tuberculosis. A previous study done by Kim et al. revealed that CT can diagnose anthracofibrosis based on bronchial narrowing. Similarly, Chung et al. had also done a study on 28 patients with anthracofibrosis and studied their radiological pattern on CT. They found that 82.14% patients had nodules, 42.86% had mediastinal lymphadenopathy and 46.43% had consolidation. The occurrence of mediastinal lymphadenopathy was similar but nodules were not as frequent in our study.

We found that pulmonary tuberculosis (old healed and active) was more common in patients with anthracosis as compared to patients without anthracosis. Anthracosis has been found to be associated with tuberculosis previously also. Various hypotheses have been proposed to explain the same. Silica containing pigmentation has been associated with altered immune mechanisms in the lungs, thereby predisposing to Mycobacterium tuberculosis infection. Another hypothesis proposes that subjects with heavy exposure to air pollutants, cigarette smoke and biomass fuel smoke have carbon and silica deposited in their lymph nodes. When these lymph nodes are infected with M. tuberculosis, they rupture into the adjoining trachea-bronchial tree, leading to black pigmentation and subsequently inflammation and fibrosis. Some authors have tried to look into the histopathologic alterations and pathogenesis of subsequent malignant transformation. On biopsy of lesion chronic mucosal inflammation, carbon particle deposition, and fibrosis can be demonstrated. Similarly, molecular alterations in the anthracotic lesion have been proposed to be responsible for malignant transformation in lungs. However, detailed pathogenesis of such transformation is yet be explored.

Malignancy was less common in cases than control but it needs further exploration in view of its presence in 23% cases. Bronchopneumonia was also less common in patients with anthracosis (6.7%). Association of anthracosis with pneumonia is not clear. Few authors opine that bronchial narrowing due to anthracofibrosis leads to poor drainage of secretions and predisposes to recurrent infections. However, we did not find a significant association between bronchopneumonia and anthracosis.

Bronchoscopy revealed an upper lobe predominance of the disease in our study. This further strengthens the association of anthracosis with pulmonary tuberculosis as the latter also has upper lobe predominance. Torun et al. had postulated that anthracosis develops at sites of turbulence and friction such as branching points of bronchi. Similarly few authors deduce right middle lobe as the most common site and some as the upper lobes. A single black patch was present in 50% cases and multiple in 50% cases in our study. Kim et al. found that 26/54 (48%) patients had single site involvement and 28/54 (52%) had multiple site involvement. We found bronchial narrowing in 2/30 (6.67%) cases, whereas it was more common in the previous studies. This could be due to the fact that anthracosis and anthracofibrosis are probably spectrum of the same disease and represent mild and severe disease respectively, rather being separate entities. A longitudinal follow up of lesion would be of significant help in defining importance of such lesions.

Even though we have tried to evaluate the association of anthracofibrosis with the clinical, radiological and bronchoscopic features, there are many unanswered questions. What is the exact nature of anthracofibrosis? What is the pathogenesis? What is the natural history of disease? What is the best management strategy? Larger prospective studies with more number of cases, follow-up bronchoscopy and involvement of healthy volunteers are required to answer some of these questions.

**CONCLUSIONS**

In summary, we found that anthracosis affects adults in the range of 36-85 years and predominantly involves the upper lobes. Patients with anthracosis were found to have pulmonary tuberculosis more frequently. Post tubercular fibrosis is more common on CT chest of patients with anthracosis as compared to the patients without anthracosis.

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