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Case report

Domestic mixed-dust pneumoconiosis: A case report and literature review

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ABSTRACT

Background: Mixed-dust pneumoconiosis (MDP) is a controversial disease with respect to diagnostic criteria. Usually, it is regarded as an occupational disease, but cases due to domestic exposure have been reported. In domestic settings, different dust sources may contribute individually or collectively to the pathogenesis.
Case presentation: A 56-year-old woman presented with chest nodularity on chest X-ray examination that had not resolved after 6 months of tuberculosis (TB) treatment. Her history showed significant exposure to mixed dusts caused by grinding grains with stones and the use of biomass fuel.
Conclusion: In residential settings, sufficient exposure to a variety of dusts, primarily silica-based dusts as well as those containing other less-fibrogenic materials, such as carbon, silicates and iron, have been shown to cause mixed-dust pneumoconiosis. In settings where the incidence of TB is very high, such as South Africa, the diagnosis of MDP might be overlooked due to the similarities of both diseases in their radiological presentations, especially when a detailed history of domestic exposure is omitted.

1. Introduction

Pneumoconioses are usually associated with workplace exposure to dust in sand blasting, agriculture, mining, and other industrial settings. However, pneumoconiosis is also caused by environmental [1] and domestic exposure to mineral or organic dusts. One example is mixed-dust pneumoconiosis (MDP). MDP was first introduced in 1946 by a German Scientist, Von Uehlinger [2], who described soft "mixed-dust granulomas" that were softer than classic silicotic lesions and hypothesized that exposure to mixed dust modified the extensive fibrotic reaction associated with silica dust exposure. It was then used to describe pneumoconiosis in foundry workers who were exposed to both silica and other mineral dusts at the same time [3]. However, due to the lack of consensus on the definition of this pathology and due to varied pathological and radiological presentations, it has been described in the literature with different names and terms such as 'Transkei silicosis' by Palmer and Daynes [4], 'hut lung' by Grobbelaar and Bateman [5], and 'flour mill lung' by Sundaram et al. [6]. Other examples of terms used to describe a similar pathology are 'domestically acquired particulate lung disease' [7], 'anthracosiderosilicosis' [8], 'anthrasilicosis' [9–12], and 'anthracosilicosis' [13–17].

This article presents a case of MDP in a woman domestically exposed to mixed dust, followed by a review of the condition, including a discussion of its aetiology, clinical presentation, and investigations needed for diagnosis.

2. Case Presentation

The patient was a 56-year-old woman who was referred because of nodularity on chest radiograph examination that was not responding to tuberculosis (TB) medication. She complained of a dry cough for 10 months that was initially associated with mild haemoptysis but resolved shortly after TB medication was started. She complained of non-progressive shortness of breath over the same period. She denied any other respiratory symptoms, and the systematic examination was unremarkable. She was evaluated at a primary health care clinic 8 months previously, where she was started on TB medication despite the sputum culture and GeneXpert results being negative for TB.

She had reported never smoking. She practiced hand grinding maize using the traditional method involving large stones at home in the rural Eastern Cape for 40 years. Furthermore, she used biomass fuel for cooking inside her house for 40 years. She worked as a domestic worker for many years until 2000. Then, she worked as a farmer in a small farm in the Eastern Cape until 2014. She could not recall exposure to

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pesticides or any other chemicals.

On examination, she looked comfortable, presented no clubbing and had no lymphadenopathy, pallor, rash or cyanosis. Her pulse, respiratory rate, and oxygen saturation in room air were all within the normal limits. A respiratory examination revealed a central trachea, mild dullness and decreased breath sounds over the right upper and lower zones with no wheezing or crackles. Cardiovascular, abdominal and neurological examinations were unremarkable.

Pulmonary function tests could not be completed because of difficulty following the procedure due to language constraints. The chest radiograph showed borderline lung volumes and multiple round and irregular opacities occupying all lung zones (grade 2/2 q/t based on the International Labour Organization (ILO) classification [18]). The radiograph also showed peri-bronchial thickening and opacity in the right upper zone. There was no hilar lymphadenopathy or pleural effusion. There was no significant difference between the radiographs taken before and after the completion of the anti-TB medication course (Figs. 1 and 2).

At a joint pulmonology-radiology meeting, a diagnosis of mixed-dust pneumoconiosis was made based on the clinical presentation and exposure history. Computed tomography (CT) of the chest was not recommended, as it would not change the management plan. The patient was informed about the diagnosis and its prognosis, advised to stop any further exposure to biomass fuel and grinding, discharged from the clinic and advised to seek medical care in her home district as needed.

3. Discussion

3.1. Aetiology of mixed-dust pneumoconiosis

MDP is currently defined as "pneumoconiosis caused by concomitant exposure to silica and to less fibrogenic dusts such as iron, silicates, and carbon" [19]. Usually, it is an occupational disease that is reported in industries such as mining, quarrying, foundry work, and pottery and ceramics manufacturing [19,20]. However, MDP cases as a result of domestic exposure to mixed dust have also been reported. The classic history is exposure to mixed dust produced by biomass fuel burning and/or using stones to grind grain.

Exposure to low concentrations of crystalline silica dust is central to MDP pathogenesis. As the silica concentration increases, the histopathologic picture tends to mimic that of classical silicosis rather than

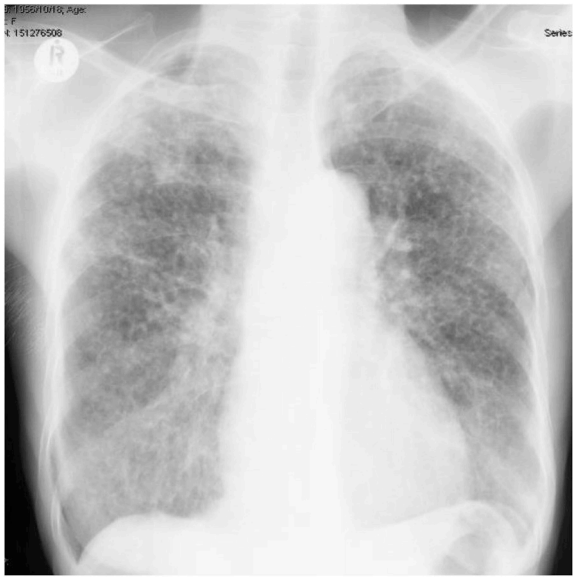

Fig. 1. Chest X-ray taken in May 2015 before the initiation of the anti-TB medications.

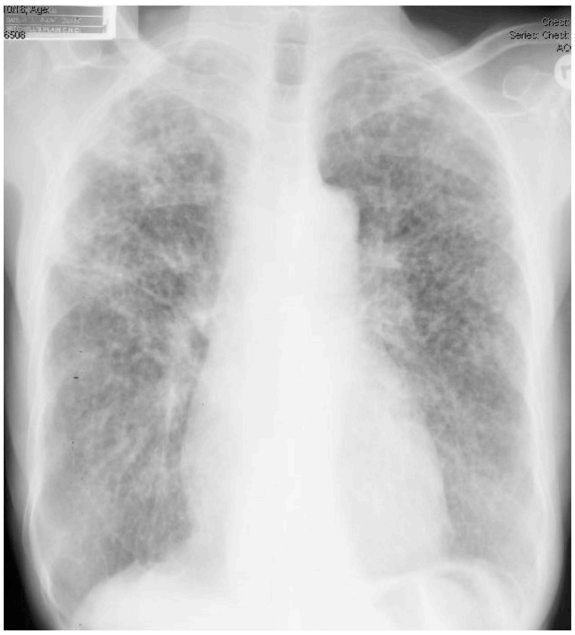

Fig. 2. Chest X-ray taken in November 2015 after the completion of 6 months of anti-TB medications.

MDP [19]. A component in the mixture of 10% free silica was first suggested as a threshold for the development of MDP [21]; this threshold was later revised to 18% [22].

Biomass fuels are derived from organic materials, such as grass, corn cobs, crop residues, dung, and wood. Approximately half of the world's population and 90% of rural households in developing countries use biomass fuel for cooking and heating [23]. It has been estimated that indoor biomass fuel use was responsible for approximately 4.3 million deaths in 2012, mostly in lower- and middle-income countries [24]. In South Africa, approximately 33% of households were still using biomass fuel for cooking and heating in 2000 [25]. The emissions from biomass fuel may contain up to 200 chemical substances along with inhalable particulates (PM_{10}) and respirable particulates ($PM_{2.5}$), including silica and silicates that exceed environmental guideline levels for such chemicals and particulates in some settings [26,27]. Mineralogical examinations of 3 patients who were exposed to biomass fuel and were diagnosed with MDP showed silica in the lung tissue [28–30]. Two of the three patients reported no history suggestive of the source of silica, while the third patient reported a history of grinding grain using stones. The ash produced by the combustion of some types of biomass fuel might be more hazardous than the airborne emissions produced during the combustion process with regard to silica composition. The proportion of silica in post-combustion dry ash ranges from 91% for rice hulls to 2% for willow wood [27]. Silica is found more frequently in the ash of grain waste, such as rice hulls, rice straw and wheat straw [27]. Therefore, the manual cleaning of such ash might have a role in the pathogenesis of MDP. As the silica and other chemical compositions differ between different types of biomass fuel [27,31], the lung histopathological patterns of those exposed to biomass fuels may vary.

Grobbelaar and Bateman [5] described three pathological patterns in 25 patients: simple anthracosis, anthracosis with macule formation and mixed-dust fibrosis (MDF). Anthracosis is defined as black plaques on the bronchial mucosa due to exposure to carbon or soot particles [32]. It is mainly carbon particle deposition, but it can be caused by the deposition of other elements such as silica, iron and hydrocarbon complexes [33–35]. In the advanced form of this pathology, anthracosis can cause stenosis of the airways, termed anthracofibrosis [36]. Although anthracofibrosis has been linked to exposure to biomass fuel [36], the development of this pathology without such exposure has been reported

[32,37]. Specifically, cases of anthracofibrosis due to exposure to mixed dust have been reported [38]. However, the disease favours the airways, and whether it should be included under the definition of MDP remains uncertain.

Although many factors affect grain dust composition, it comprises organic grain particles, pollen, fungi, mites, animal dander, and insect fragments and might be contaminated by endotoxins, pesticides, and excreta and faeces of rodents and birds [39,40]. Furthermore, it may contain up to 15% silica, with a large proportion of this dust in the respirable size range [39,40]. Cases of pneumoconiosis in grain handlers have been reported in the past, but not without controversy [41–43]. While most of the literature addresses occupational exposure to grain dust, domestic grinding of grain results in a significant exposure to grain dust, considering the duration of the exposure. In Palmer and Daynes [4], the activity of grinding maize between stones was observed to have been carried out on a daily basis for at least 30 and 60 minutes by women and girls over 9 years of age. Although Palmer and Daynes attributed the source of silica to the stones used for grinding, the silica composition of the grain might have played a role in the pathogenesis of MDP in their study population.

Generally, although the composition of agricultural dust differs according to soil composition, the weather and the type of job or task performed, exposure to respirable silica and silicate particulate during farming activities may be substantial [44]. In South Africa, studies have demonstrated a potential overexposure to silica in individuals engaging in farming [45,46]. MDP and other types of pneumoconioses have been reported in farmers and attributed to the exposure to silica and silicates in agricultural dust [47–54]. Agricultural dust may therefore have a role in the pathogenesis of MDP in rural areas where traditional methods of farming are still practiced.

3.2. Clinical presentation

MDP tends to progress slowly, and most patients with incidental X-ray findings tend to be asymptomatic [5,20]. Moreover, the clinical presentation of MDP in symptomatic patients is non-specific [20]. Therefore, the diagnosis depends mainly on a thorough history of the patient's occupational, domestic and environmental dust exposure. Pulmonary function findings also tend to be non-specific and may be normal or show a restrictive, obstructive or mixed pattern [5,6,20]. Overall, pulmonary function seems to be less affected in MDP than in other types of pneumoconiosis [55,56].

3.3. Investigations needed for diagnosis

3.3.1. Imaging

The classic chest X-ray pattern of MDP is a bilateral mixture of irregular or reticular opacities with small rounded nodules, as defined by the ILO classification [6,20,57]. However, the findings depend on the component proportions of the mixed dust and the cumulative exposure history. Chest X-ray results may appear normal, show pure nodular opacities, show early reticulation and irregular opacities only, or show a mixed pattern with progressive massive fibrosis (PMF) in the early stages and show hilar lymphadenopathy and calcification in the late stages [4–6,29,57,58]. Moreover, emphysema may also be present [4,19,20,58]. CT of the chest may show a reticular, reticulonodular or nodular pattern with emphysema and honeycombing [6,20,59].

3.3.2. Histopathology

There are three histopathological patterns that may be present in MDP patients [20], as shown in Fig. 3. MDP has been pathologically defined as a pneumoconiosis with "a combination of macules and MDF lesions, with or without silicotic nodules or PMF, in an individual with a history of exposure to mixed dust" [20]. According to the definition of Honma et al. [20], patients with MDF must show more than silicotic nodules to pathologically classify MDP; otherwise, silicosis is the appropriate diagnosis. Alternatively, it has been suggested that an exclusively macular pattern may represent the early stages of MDP if the patient has an appropriate exposure history. In the absence of verified typical exposure, mineralogical examinations of the lung tissue or the domestic or workplace environment can supplement the pathological and radiological findings to support an MDP diagnosis [20,30,60].

3.3.3. Differential diagnosis

Because the clinical and radiological presentations are not specific, it is important to take a detailed history to rule out other possible pathologies. Differential diagnoses includes sarcoidosis, respiratory bronchiolitis-associated interstitial lung disease, pulmonary Langerhans cell histiocytosis, pulmonary TB, usual interstitial pneumonia, eosinophilic granuloma, and other types of pneumoconiosis, such as silicosis, welder pneumoconiosis, asbestosis, coal workers' pneumoconiosis, berylliosis and silicate pneumoconiosis [28,30,55,61,62].

In South Africa, the incidence of pulmonary TB is very high, making it essential to rule out this disease before establishing the diagnosis of MDP. At the same time, a detailed history of domestic and occupational exposures is important to prevent unnecessary TB treatment. This would include those with negative sputum analysis who come from rural areas where exposure to indoor biomass fuel and dust from grinding maize is common. In our case, the patient was started on TB medication even though she had a typical history suggestive of MDP and her sputum analysis was negative. Similar to our case, a case published by Gold et al. [7] reported pulmonary TB as a primary diagnosis despite a negative sputum TB analysis and histopathological findings suggestive of pneumoconiosis. A subsequent detailed history of domestic and environmental exposure confirmed that the patient had experienced significant exposure to indoor biomass fuel. As a result, a diagnosis of MDP was

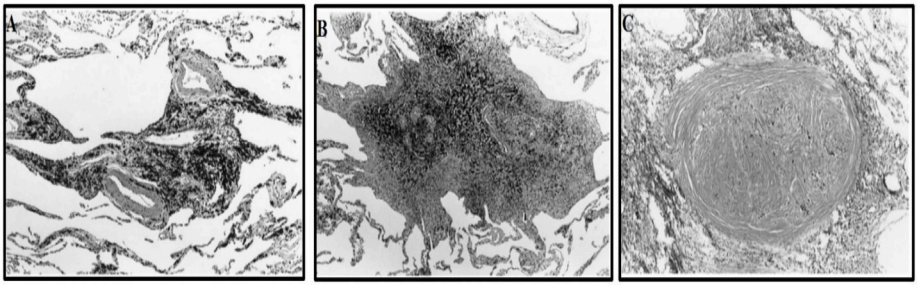

Fig. 3. The three types of histopathology patterns that can present in MDP. Picture A shows a macule presenting as a non-palpable lesion consisting of interstitial accumulations of dust-laden macrophages. Typically, peribronchiolar or perivascular distribution is associated with a delicate meshwork of reticulin fibers without obvious collagenisation. Picture B shows MDF presenting as a palpable, irregularly contoured, stellate-shaped lesion with varying degrees of collagenisation. Picture C shows a Silicotic nodule comprising well-delineated, firm, almost acellular fibrotic nodules composed of whorled hyalinized collagen. Generally, as the proportion of free silica increases in the total respirable dust, the number of silicotic nodules increases in proportion to the mixed-dust nodules. Reprinted from Ref. [20], Copyright (2004), with permission from Elsevier.

made, sparing the patient of unnecessary TB treatment.

3.4. Management and prognosis

Although the prognosis of MDP is generally favourable, MDP can progress to extensive fatal fibrosis [20], and there is no specific treatment. The most important step is to remove the patient from further exposure to the causative respirable dust. However, in domestic settings, public health authorities are responsible for preventing the disease by limiting exposure to respirable domestic and/or occupational dust that contributes to MDP or any other lung pathology. For instance, public health authorities should educate rural dwellers, particularly women, about the risk of using indoor biomass fuel or grinding maize with stones. Additionally, they must motivate them to use modern, less-hazardous methods for cooking and grinding maize.

4. Conclusion

In industrial and residential settings, sufficient exposure to a variety of dusts, primarily silica-based dusts as well as those containing other less-fibrogenic material, such as carbon, silicates and iron, has been shown to cause mixed-dust pneumoconiosis. The condition has been identified among people living in rural areas who use biomass fuel as a source of fuel for cooking and use silica containing stones for indoor grain grinding and among farmers exposed to agricultural dust. In our case, the patient had been exposed to all of these sources that might have contributed individually or collectively to the development of her condition. Mixed-dust pneumoconiosis has been described in very different settings and with multiple nosologic terms. It seems that the disease has a presentation spectrum, and the picture might differ according to the type and duration of exposure and the time of presentation. Given that the symptoms and signs of the disease are non-specific, a detailed history of potential occupational and domestic exposures is the basis of the diagnosis. In settings where TB, which mimics the radiological findings of MDP, is common, TB should be a prominent part of the differential diagnosis. A high index of suspicion for MDP is required for patients who come from rural areas and who report a suggestive domestic exposure, especially when they have a negative sputum analysis. Histopathologic examination of the lung is the gold standard for diagnosing MDP. Finally, international expert consensus is needed to define standard criteria for the diagnosis of MDP to achieve universal agreement on this topic.

Authors' contributions

Faisal M Al Badri contributed in the clinical examination of the patient, carried out the literature searches, wrote the manuscript and he is the main author. Shahieda Adams was involved with editing and revising the paper.

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Availability of data and materials

Not applicable.

Ethics approval and consent to participate

Unfortunately, all my attempts to contact the patient has failed because her contact number had been unreachable for months. Therefore, I couldn't get a consent from her. However, the case report does not include any personal information or any image that could breach the confidentiality of the patient. Moreover, the study received ethical approval from the Research Ethics Committee of the University of Cape Town (reference no. 471/2019).

Consent for publication

All authors approved the manuscript and this submission.

Declaration of competing interest

The authors declare they have no competing interests.

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Abbreviations

MDP	Mixed-dust pneumoconiosis
TB	Tuberculosis
CT	Computed tomography
MDF	Mixed-Dust Fibrosis
ILO	International Labour Organization
PMF	Progressive Massive Fibrosis

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.rmcr.2019.100985.

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