Original

MRI Patterns of Progressive Massive Fibrosis in Coal Workers with Pneumoconiosis

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Abstract

Introduction: Pneumoconiosis progresses from simple to complicated with progressive massive fibrosis (PMF). The usefulness of T2-weighted images (WIs) with low signal intensity (SI) in differentiating lung cancer from PMF has been reported. Meanwhile, cases of necrotic PMF consisting of liquefied materials showed high SI on T2-weighted MRI. From this background, studies on the frequencies and patterns of SI on MRI for PMF involving larger subjects are necessary.

Objective: We examined the frequencies and patterns of SI on T2-WI of PMF in coal workers' with pneumoconiosis (CWPs).

Subjects: Forty-nine CWP with PMF.

Methods: Two experienced thoracic radiologists reviewed the CT and MRI images in concensus. They evaluated the SI patterns of the PMF on T2-WIs. Furthermore, when areas of high SI were observed for PMF on T2-WIs, the internal high SIs were classified into three: diffuse, localized, and scattered.

Results: In total, 133 PMF lesions were identified. Ninety-two (69%) of them showed very low SI on T2-WIs. The remaining forty-one (31%) PMF lesions showed 3 patterns of internal high SI: diffuse in 13 lesions, localized in 24 lesions, and scattered in 4 lesions.

Conclusion: Most PMF lesions typically have a very low SI on T2-WIs, but apporoximately 30% of PMF lesions have high internal SIs of various degrees, which indicate liquefactive necrosis. These findings should be considered in the evaluation of MRI in for CWPs.

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—Key words—
silicosis, necrosis, lung cancer

Introduction

Pneumoconiosis is a pulmonary disease, characterized by fibroproliferative lesions and mainly caused by the inhalation of mineral dust. During disease progression, nodular lesions agglomerate into progressive mas-

sive fibrosis (PMF). Kimura et al. reported that 31% of pneumoconiosis patients with a few nodular lesions (fusion rate 1 in ILO classification) developed PMF in their lungs within 10 years, even after staying away from dusty environments[1]. Lung cancer can be a complication of pneumoconiosis. Therefore, a differential diagnosis of lung cancer from PMF is needed. However, it is difficult for positron emission tomography (PET) to distinguish between PMF and lung cancer because both lesions have high standardized uptake values (SUVs)[2].

Recently, Ogihara et al. reported that PMF, on T2-weighted MRI (T2-wMRI) showed a low signal intensity, while lung cancer showed a high signal intensity with 100% sensitivity and 94% specificity, which enables the differentiation between the two lesions[3]. Zhang et al. also reported the value of MRI in differentiating lung cancer from PMF[4]. On the other hand, in pneumoconiosis, especially in coal workers, it has been reported that a cavitation of PMF with vascular obliteration and ischemic necrosis may occur. Liquefied materials within these cavities have the appearance of Indian ink[5]. Matsumoto et al. reported that 46% of 13 PMF lesion in 6 silicosis patients and 38% of 21 PMF lesions of 11 silicotuberculosis patients with internal high SI areas on T2-wMRI[6]. MRI of pneumoconiosis patients with PMF may not differentiate lung cancer from PMF based on high SIs on T2-wMRI. To understand the MRI findings of PMF, we planned to reexamine the frequencies and patterns of SI for PMF on T2-wMRI using a larger sample of PMF lesions in coal workers with pneumoconiosis (CWPs)[3][6][7].

Participants

Fifty CWPs associated with PMF in our institution were recruited with written permission, but one patient withdrew his consent. After exclusion of this patient, 49 patients were included in this present study. PMF was diagnosed according to the Bergin's criteria: a mass lesion with an irregular border in the upper and middle lung fields with surrounding emphysematous change on CT[8]. There were no cases of complicated lung cancer or tuberculosis in these 49 patients.

Methods

MRI was performed using a Siemens Magnetom Avanto 1.5T machine (Siemens Healthcare Co., Ltd, Germany). The scanning parameters were as follows: slice thickness of T1- and T2-weighted imaging=3–4 mm and field of view (FOV)=320 mm. If PMFs were in both lung fields or a participant had a large frame, the FOV was set to 360 mm. In addition to axial images, coronal sections of T2-weighted images were also obtained.

Non-contrast-enhanced CT examination was performed using the GE Light Speed VCT machine (GE Health care Japan, Tokyo, Japan). The scanning parameters were as follows: tube voltage=120 kVp, automatic tube current modulation (AUTO (SD10)), slice thickness=5 mm, slice interval=5 mm, rotation time=0.4 s, and helical pitch=0.984:1 (mm/rotation). All images were reconstructed with a slice thickness of 1.25 mm with the same increment. CT images were taken within 2 months of the MRI study.

Two experienced thoracic radiologists reviewed the CT and MRI images in concensus. All the CT images were assessed using both lung (level, −700 HU; width, 1,500 HU) and mediastinal (level, 45 HU; width, 300 HU) settings. The radiologists evaluated the signal intensity (SI) patterns of PMF on T2-weighted images. Furthermore, when areas of high SI were observed in the PMF on T2-weighted images, the radiologists classified the internal high SIs into three: diffuse (50% or greater area), localized (less than 50% area), and scattered. We also evaluated the areas of high SI in the corresponding CT images.

Results

All 49 patients were male, with a mean age of 81.6 ± 5.4 (SD) years. The mean duration of dusty occupational history was 26.3 ± 8.8 (SD) years. All patients had a history of coal mining. Four people had additional occupational histories: two had tunneling history for one year and 6 years, respectively; one had an electric welding history for 9 months; and one had a cement factory history for 6 months. The proportion of smokers, including past smokers, was 85%. The smoking index was 32.5 ± 20.5 (SD) pack years.

A total of 133 PMF lesions were identified on CT and MRI images. The SIs of all the PMF lesions on T2-weighted images are provided in Table 1. Ninety-two (69%) of the 133 PMF lesions showed very low SI on T2-

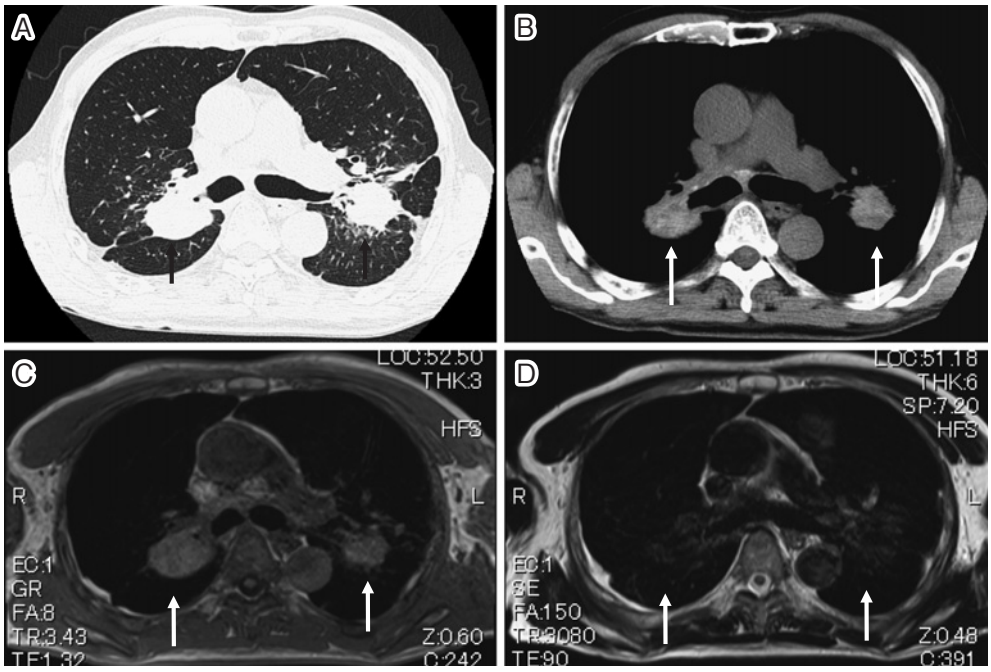

Fig. 1 A 56-year-old man with a 30.9-year history of working with coal

A, B: Chest CT images showing PMF lesions (arrows) in the bilateral upper lobes. Emphysematous changes can be observed in the surroundings PMF lesions.

C, D: The bilateral PMF lesions are observed as slightly high SI area on T1-weighted images (arrows, C) and as diffuse and very low SI area on T2-weighted images (arrows, D).

Table 1 Signal intensity patterns of 133 PMF lesions on T2-weighted image

Signal intensity patterns of PMF lesions	Number of PMF (%)			
	this study	Matsumoto et al.	Jung et al.	Ogihara et al.
Low	92 (69)	15 (44)	11 (61)	24 (100)
High	41 (31)	19 (56)	7 (39)	0 (0)
Diffuse	13 (10)		0 (0)	
Localized	24 (18)		2 (11)	
Scattered	4 (3)		5 (28)	
Total	133 (100)	34 (100)	18 (100)	24 (100)

weighted images for most of the lesions (Fig. 1), which has been previously reported to be a typical MRI finding for PMF[3]. Forty-one (31%) of the 133 PMF lesions showed three patterns of internal high SI: diffuse in 13 lesions (Fig. 2), localized in 24 lesions, and scattered in 4 lesions (Fig. 2, Table 1).

Discussion

This study showed that 69% of PMF lesions showed very low SI on T2-weighted images in larger participants. PMF lesions with internal high SIs show several patterns on T2-weighted images, which can be categorized into scattered, localized, and diffuse.

This study emphasized the typical SI pattern of PMF on MRI without necrotic degeneration showing low SI, as described by previous studies[6][7] (Table 1). Although the proportions of necrotic lesions of PMF have been reported in several studies, it was not clear whether they were frequent or infrequent because of the involvement of participants with a particular body frame. Matsumoto et al. reported the MRI findings of 46% of 13 PMF lesion in 6 silicosis patients with internal high SI areas on T2-weighted images[6]. Hirakata reported that 41% of 12 PMFs in five patients showed hypodense areas on HRCT, some of which were histologically correlated with necrotic cavities in PMF[9]. In this study, we showed the relative frequency ratio (approximately 30%) for internal high SI on T2-weighted images for 133 PMF lesions of 49 participants. As in the case of Matsumoto

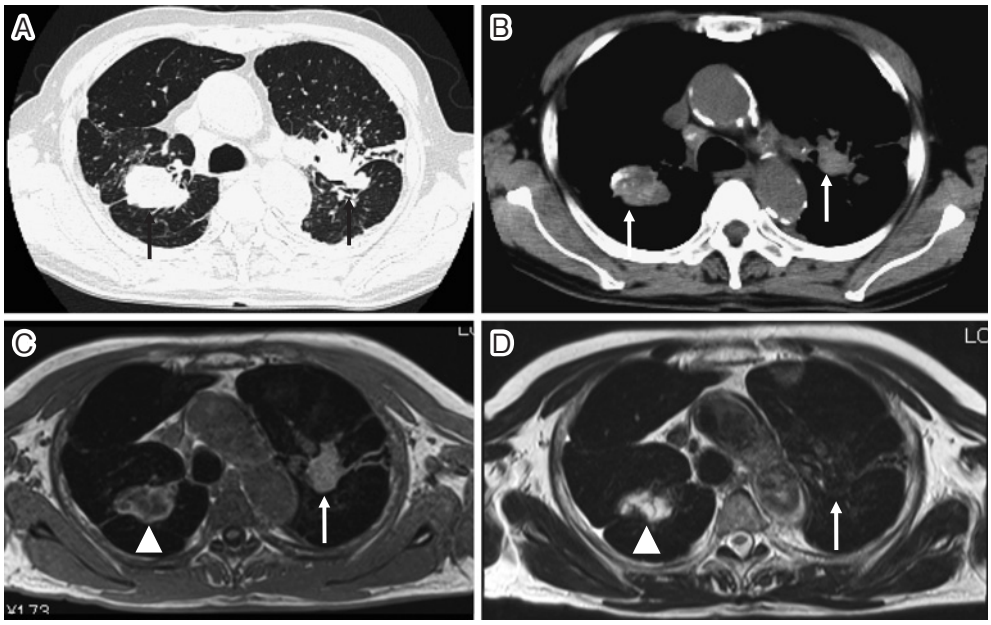

Fig. 2 A 55-year-old man with a 12.5-year history of working with coal
A, B: Chest CT images showing PMF lesions (arrows) in the bilateral upper lobes.
C, D: The PMF lesion in the left upper lobe is observed as a slightly high SI area on a T1-weighted image (arrow, C) and a very low SI area associated with scattered high SI areas on T2-weighted images (arrow, D). The PMF lesion in the right upper lobe is observed as a low SI area on T1-weighted images (arrowhead, C) and a diffuse area with very high SI on T2-weighted images (arrowhead, D).

et al.[6], these findings emphasized frequent complications of necrosis of PMF in CWPs.

We also examined the patterns of high SIs for PMF on T2-weighted images. There were three patterns of internal high SI area for PMF lesions, including diffuse, localized, and scattered. For the scattered and localized cases, it is possible to diagnose the lesion as PMF with necrosis in CWPs. For diffuse cases, a very high intensity of T2-weighted images suggests marked liquefaction, and necrosis may be more presumptive with additional CT findings and T1-weighted imaging findings. For internal high SI on T2-weighted images, pattern recognition of the internal high SI in mass lesion and the reference findings of other modalities can facilitate the differential diagnosis of PMF from lung cancer.

The present study has some limitations. First, the pathological findings of PMF were not obtained for any of the cases. Therefore, associations between the MRI features and pathological findings of PMF were not assessed. However, according to a previously reported study[9], the internal high SIs of PMF lesions on T2-weighted images reflect necrosis, which is consistent with corresponding CTfindings. The CT images showed hypodensity, and they were consistent with those showing necrotic cavities reported by Hirakata[9]. Second, we did not study MRI images of lung cancer. To evaluate the usefulness of T2-wMRI in the diagnosis of lung cancer in CWPs, further study are necessary to analyze T2-wMRI for CWPs with lung cancer and those with necrosis in PMF. Jung et al. reported that PMF showed marked post-infusion enhancement and a gradual time enhancement curve, which provides diagnostic potential in differentiating PMF from lung cancer[7].

The strength of this study is that relatively larger PMF lesions are examined in this study than in previous reports. The high frequency of necrotic PMF, especially in CWPs, should be taken into consideration in MRI examination.

In conclusion, most of PMF lesions with fibrosis show a low SI on T2-weighted images, but approximately 30% of PMF lesions in CWPs show internal high SI with several patterns, including scattered, localized, and diffuse. These findings should be considered in the evaluation of MRI for CWPs.

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炭鉱夫じん肺における進行型塊状線維巣の MRI 画像による検討

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―キーワード―
珪肺，壊死，肺癌

【はじめに】じん肺は単純型から進行型塊状線維巣（PMF）を伴い複合型に進展する．近年 MRI 検査の T2 強調画像における PMF の低信号が肺癌との鑑別に有用と報告されている．その一方で壊死した PMF が液状化し T2 強調画像にて高信号を呈する症例が報告されている．このような背景をもとに PMF の信号の頻度やパターンを今までの 1 けたの対象を基にした報告よりも多い対象者を基にしてその実態を明らかにする研究が必要である．

【目的】炭坑夫肺症例に見られた PMF の T2 強調画像の信号の頻度，パターンを調べる．

【対象】PMF を有する炭坑夫肺症 49 名．

【方法】呼吸領域の放射線専門医 2 名が CT と MRI 画像を相互協議のもとにレビューし診断した．T2 強調画像で高信号を PMF 内に確認した際にはそのパターンも検討し，びまん型，局在型，散布型に分類した．

【結果】133 の PMF 病変を認めた．92 病変（69%）の PMF においては T2 強調画像で低信号であった．残りの 41 病変（31%）の PMF で内部に高信号を認め，13 病変がびまん型，24 病変が局在型，4 病変が散布型を示した．

【結論】大部分の PMF は，T2 強調画像で典型的な低信号を示すが，約 30% は内部に液状化した壊死を反映して様々な程度に高信号を示した．炭坑夫肺の MRI 検査ではこれらを考慮に入れて読影する必要がある．

［COI 開示］本論文に関して開示すべき COI 状態はない

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