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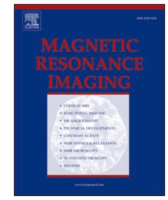

Case Report

High-performance low field MRI enables visualization of persistent pulmonary damage after COVID-19

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A B S T R A C T

The outbreak of coronavirus disease 2019 (COVID-19) with the origin of the spread assumed to be located in Wuhan, China, began in December 2019, and is continuing until now. With the COVID-19 pandemic showing a progressive spread throughout the countries of the world, there is emerging interest for the potential long-term consequences of suffering from a COVID-19 pneumonia. Imaging plays a central role in the diagnosis and management of COVID-19 pneumonia, with chest X-ray examinations and computed tomography (CT) being undoubtedly the modalities most widely used, allowing for a fast and sensitive detection of infiltration patterns associated with COVID-19 pneumonia. For a better understanding of underlying pathomechanisms of pulmonary damage, longitudinal imaging series are warranted, for which CT is of limited usability due to repeated exposure of X-rays. Recent advances in MRI suggested that high-performance low-field MRI might represent a valuable method for pulmonary imaging without the need of radiation exposure. However, so far, low-field MRI has not been applied to study pulmonary damage after COVID-19 pneumonia. We present a case report of a patient who suffered from COVID-19 pneumonia using 0.55 T MRI for follow-up examinations three months after initial infection. Low-field MRI enables a precise visualization of persistent pulmonary changes including ground-glass opacities, which are consistent with CT performed on the same day. Low-field MRI seems to be feasible in the detection of pulmonary involvement in patients with COVID-19 pneumonia and may have the potential for repetitive lung examinations in monitoring the reconvalescence after pulmonary infections.

1. Case

We report of a man in his early 60s who suffered from a COVID-19 infection. Diagnosis was confirmed by polymerase-chain-reaction assays (PCR) and non-enhanced chest computed tomography (CT) demonstrating typical peripheral, multilobar areas of ground-glass opacity (GGO) consistent with COVID-19 pneumonia [1,2]. During hospitalization of less than a week, no oxygen inhalation or other specific treatment was necessary. Three months after discharge, he still presented a limited capability to moderate exercise, triggering the indication for chest CT (Somatom go.Top, Siemens Healthcare, Erlangen). The examination demonstrated residual pulmonary changes with patchy, peripheral GGOs and consolidations (Fig. 1). An additional MRI scan (Siemens Healthcare, Erlangen, Germany) was performed on the same day with a morphologic BLADE respiratory triggered sequence (5 mm slice thickness, 36 slices, 2 concatenations, TE 43 ms, TR 5335 ms, Matrix 334, Inplane Resolution 1.13 × 1.13 mm, acquisition time: 2 × 4 min 28 s). This sequence has an intermediate contrast weighting between proton density and T2 weighting. A low field (0.55 T) prototype MRI system was used. It consists of a closed-bore superconductive magnet, as well as state-of-the-art radiofrequency coil technology and MRI pulse sequences. In the following, the system is called high-performance low field MRI to distinguish it from older-generation low field systems.

The imaging findings of the 0.55 T MRI are well consistent with the findings of the performed chest CT identifying GGOs in all pulmonary lobes (Fig. 1). A short-time follow-up MRI was performed two weeks later demonstrating vastly unchanged imaging findings (Fig. 2).

2. Discussion

As the COVID-19 pandemic is still progressing, understanding the course and outcome of recovery from COVID-19 pneumonia is of increasing interest [3,4].

The greatest severity of pulmonary changes have been described about 10 days after the start of symptoms [3] with ground glass opacities (GGOs) being the most frequent pattern in up to 75% of the patients suffering from COVID-19 pneumonia. Significant lung impairment as

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visible abnormal findings however have been found to persist in to the early recovery phase in up to 54.4% of the patients suffering from COVID-19 pneumonia with a higher rate of patients showing persistent patterns of pulmonary damage after severe disease [4]. However, long-term imaging studies with serial assessment in patients with COVID-19 pneumonia are lacking. Chest CT, as expanding the diagnostic capabilities beyond those of standard chest X-ray examinations, has shown tremendous clinical potential for screening and diagnosis of COVID-19, but repeated application is limited due to the potential risks associated with repetitive radiation exposure [3]. Pulmonary MRI may have the potential to address the drawbacks of CT, but is intrinsically limited at air-tissue interfaces and therefore not routinely performed for lung imaging. Low field MRI might overcome some of the important limitations mentioned: First, as implied by the technique, it is a radiation-free imaging method, thus concerns about repetitive examinations using CT can be resolved. Second reduced susceptibility effects at air-tissue interfaces at low field MRI result in a higher signal intensity of lung parenchyma, which might significantly improve lung imaging in MRI as compared to higher field strengths [5,6]. Further, which might be considered one of the most important advantages of using MRI for pulmonary imaging is the capability to provide tissue characterization beyond the limits of the CT. This includes as well the potential to provide a regional functional information, e.g. perfusion and ventilation properties, be means of non-invasive imaging. Thus MRI might allow both assessing morphology and function in a single examination without the need to apply intravenous contrast agents (not performed as part of this case report) [7,8].

The imaging findings of our case, in a patient suffering from persistent limited capability to perform moderate exercise 3 months after COVID-19 infection, are well consistent with the findings of the chest CT performed. Herein the patchy GGOs were well to be identified both in the CT and MRI examination with predominantly peripheral localization and near the interlobular septa. GGOs were found bi-pulmonal and in all pulmonary lobes, without visually demonstrating clinically significant differences in the percentage of pulmonary tissue involved in between the two imaging modalities. No pleural effusions were observed. A consecutive short-time follow-up MRI was performed two weeks later demonstrating vastly unchanged imaging findings and the feasibility of using MRI for repetitive and reproducible monitoring of morphological alterations in COVID-19 patients.

Fig. 2. Repetition of the MRI scan two weeks later revealed no significant changes of the presentation of GGOs using the PD BLADE MRI (FoV 379x379mm^2, TE 43 ms, TR 5335 ms. Slice Thickness 5 mm) sequence.

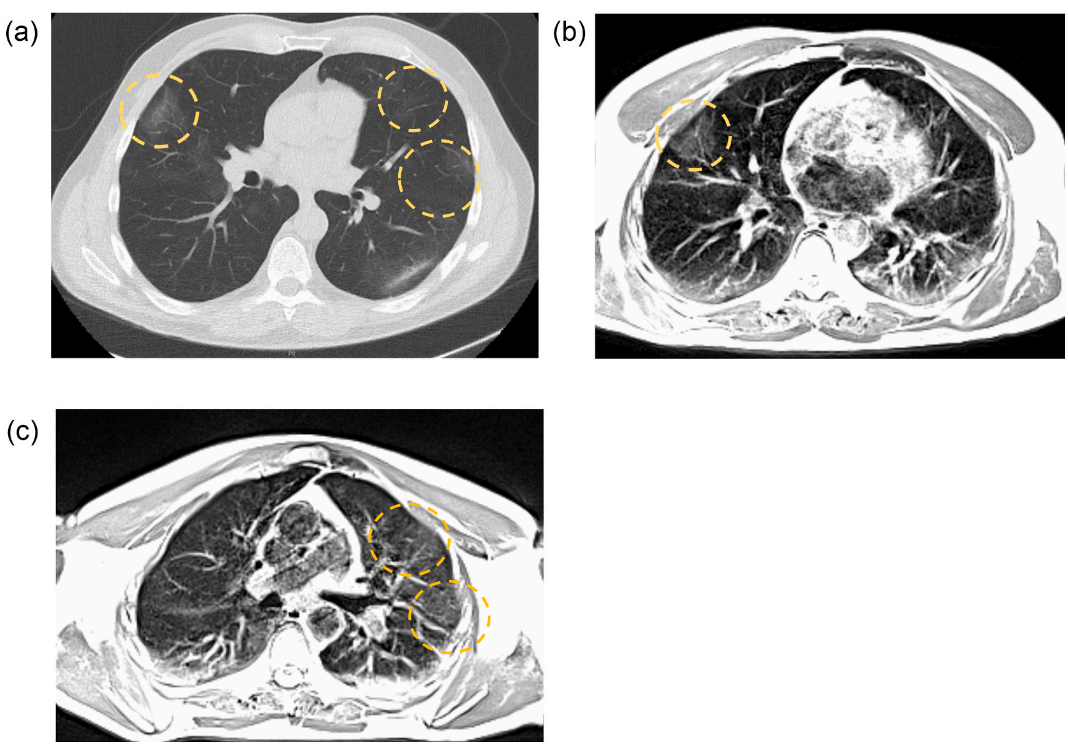

Fig. 1. a) Chest computed tomography (CT) demonstrating patchy GGOs with a peripheral distribution 3 months after COVID-19 infection in a patient in his early 60s. b) Adjacent MRI images of the patient using a high-performance low-field MRI at 0.55 T with an intermediate-weighted BLADE sequence (FoV 379x379mm^2, TE 43 ms, TR 5335 ms. Slice Thickness 5 mm) demonstrating corresponding patchy GGO in accordance to the chest CT. MRI images and CT differ in some kind due to the breathing mobility, as CT was acquired in inspiration and respectively the MRI in expiration. Image acquisition in expiration and longer scanning times explain the dystelectases in the lower lobes, which partially unmark findings in the dorsal lung parts. c) Adjacent MRI images of the patient using a high-performance low-field MRI at 0.55 T with an intermediate-weighted BLADE sequence (FoV 379x379mm^2, TE 43 ms, TR 5335 ms. Slice Thickness 5 mm) demonstrating corresponding patchy GGO in accordance to the chest CT. MRI images and CT differ in some kind due to the breathing mobility, as CT was acquired in inspiration and respectively the MRI in expiration. Image acquisition in expiration and longer scanning times explain the dystelectases in the lower lobes, which partially unmark findings in the dorsal lung parts.

Taking the advantages of lung imaging at lower field strengths resulting in higher signal intensity of lung parenchyma, low-field MRI might provide the necessary serial imaging studies for a better patho-physiological understanding of the novel COVID-19 pneumonia [5].

3. Conclusion

High-performance low-field MRI seems to be feasible in the detection of pulmonary involvement in patients with COVID-19 infection and may have the potential to be an adequate alternative imaging modality to radiation-based methods such as CT, especially if repetitive examinations/monitoring are anticipated in pulmonary diseases.

Declaration of Competing Interest

D.G. and W.H. are employees of Siemens Healthcare GmbH. The other authors have nothing to declare.

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