

MRI Findings in Covid-19 Patients with Lung Involvement Before and After the Treatment: Comparative Study

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KEYWORDS

Chest MRI, Covid-19, Pneumonia, Viral infections

ABSTRACT

Objectives: Advancements in Magnetic Resonance Imaging technology have positioned it as a viable alternative to other imaging techniques, such as Computed Tomography scans. Given the high incidence of lung involvement in viral infections, particularly coronavirus, this study evaluated MRI's effectiveness in diagnosing lung involvement in COVID-19 patients before and after treatment.

Methods and materials: This cross-sectional study involved 20 patients with a mean age of 49 ± 12.14 years, suspected of having COVID-19, who were admitted to Shahid Rahnamoun Hospital in Yazd, Iran. All participants underwent thorax MRI scans before and 2 weeks after treatment. Two highly experienced radiologists with over a decade of clinical and academic expertise analysed the MRI images. The number of lobes affected, number of lobes containing Ground Glass Opacities and consolidation, number of nodules, distribution of lesions, fibrosis, and the presence of pleural effusion were recorded. A comparative analysis was conducted to assess the proportion of patients with lesions on T2-weighted imaging and diffusion-weighted imaging before and after treatment, based on the McNamara criteria. The statistical significance threshold was set at $p < 0.05$ for all criteria.

Results: The results of this study demonstrated a statistically significant decrease in the percentage of pulmonary involvement in the right lower lobe (RLL), right middle lobe (RML), left middle lobe (LML), and left upper lobe (LUL) of patients after treatment ($P < 0.05$). Before treatment, 55% of patients (11 cases) exhibited lung involvement above 25% in MRI scans, while only 25% (5 cases) showed this level of involvement post-treatment. McNemar's statistical test confirmed the significant reduction in pulmonary involvement in MRI after treatment ($P < 0.05$). Further analysis using McNemar's test revealed a significant difference in the number of Ground Glass Opacities (GGO) reported in MRI scans before and after treatment. However, the differences observed in consolidation, atelectasis, and fibrosis were not statistically significant ($P > 0.05$).

Conclusion: These findings provide valuable insights into the diagnostic capabilities of MRI in assessing COVID-19 lung involvement and the impact of treatment on pulmonary conditions. Although thorax CT is widely used in the imaging of COVID-19 infection, due to its advantages, MRI can also be used as an alternative diagnostic tool.

1. Introduction

Since the emergence of the COVID-19 pandemic in December 2019, healthcare professionals have faced significant challenges in accurately diagnosing and monitoring the progression of this disease. While chest computed tomography and digital radiography have played crucial roles in the diagnosis and management of COVID-19 patients, the potential of magnetic resonance imaging in this context has not been fully explored.

The COVID-19 pandemic has highlighted the need for efficient and accurate diagnostic tools to assess the extent of lung involvement and monitor the progression of the disease. While thorax CT has been widely used for imaging COVID-19 patients, MRI can also serve as a valuable alternative (1). The findings presented in this paper provide valuable insights into the diagnostic capabilities of MRI in evaluating COVID-19-related pulmonary conditions and the impact of treatment on these conditions.

Computed tomography of the thorax has been shown to play an important role in diagnosing and tracking the progress of COVID-19 in comparison to other methods, such as monitoring of temperature/respiratory symptoms and molecular testing using sputum or nasopharyngeal swabs. Several countries have even opted to use CT as a primary imaging modality, from the initial diagnosis through the entire treatment process. However, MRI can also be a viable alternative, as it offers advantages over CT, such as the absence of ionizing radiation and the ability to provide detailed information about the lungs and other thoracic structures (2,3).

A multinational consensus statement on the role of chest imaging in patient management during the COVID-19 pandemic has provided recommendations on the use of CXR and CT in the management of the disease.

Chest CT and CXR have demonstrated high sensitivity in detecting lung involvement in COVID-19 patients, but they have limitations in terms of specificity and in identifying false-negative cases. Furthermore, the inadequate diagnosis of COVID-19 patients has been a major obstacle in controlling the pandemic. In this context, exploring alternative diagnostic methods, such as magnetic resonance imaging, could provide valuable insights and potentially improve the overall management of COVID-19 patients (4,5).

Now, the purpose of this research was to compare the findings of MRI modality in patients, admitted to Shahid Rahmonun Hospital in Yazd between April and September 2019, suspected of covid-19 before and after treatment. It should be mentioned that we initially formulated solutions about the procedure and necessary preventive and protective measures for MRI examination of COVID-19 patients for peer reference, with the help of infection-control experts at our hospital department.

2. Material and Methods

Study Design

This cross-sectional study was approved by the Ethics Committee with specific approval number for the Protection of Human Subjects of Yazd University of Medical Sciences. The costs of this research project were funded by the Research Committee of Yazd University of Medical Sciences and the Vice-Chancellor of Research.

This study included 20 cases, suspected of COVID-19 admitted to Shahid Rahnemoun Hospital in Yazd and underwent Chest MRI. All the included patients were CT-scan imaging confirmed Covid-19 disease in addition to clinical findings. It is necessary to mention that all the patients were stable with respect to respiratory, cardiac and medical status. All of the study steps were clarified for each patient prior to be enrolled in the study. Age of patients ranged from 32 to 70 years, i.e., the average age was 49 ± 12.14 years (Table 1.)

Table 1- Determining the frequency of patients by gender

<i>Gender</i>	<i>Number</i>	<i>percent</i>
male	15	75
female	5	25
Total patients	20	100

MRI Protocol

MRI of the study was conducted on 3 T scanner (AVENTO 1/5 TESLA) in the supine position using the abdominal and spinal radiofrequency coils. MRI protocol included: Axial T2 Haste (T2 half Fourier single shot turbo spin echo), Sagittal: T2 Haste, Transverse: T2 Haste fat suppression; T2 true FISP.

MRI protocol was conducted based on TR: 800, TE: 350, Flip angle: 150, for phase: 100%, slice thickness: 4.5 mm. To minimize dynamic artefacts associated with respiratory movements; single shut with respiratory gating was used. All the protocols were implemented for each patient about a total cycle time of 12–15 min (6).

It is good and also necessary to mention that all the safety measures were in accordance with the prior WHO guidelines for COVID-19.

Safety

During the examination of patients suspected or confirmed COVID-19, all safety measures were taken, namely: all department personnel had to use personal protective equipments and FFP2 respirators, and patients were wearing surgical masks. In addition, all parts of the scanner that came into contact with patients were covered by disposable covers, which were disposed immediately after each scan, and were disinfected with hospital designed medical equipment's sanitizer. After the completion of the study, the scanner's surfaces were disinfected. MRI was carried out again after two weeks of treatment.

Radiologic Assessment

All the information of patient's radiologic images (MRI before and after treatment) were studied and analyzed by 2 experienced accurate radiologists with more than 10 years of clinical and academic experience.

All the findings of the MRI were classified and reported according to the European Society of radiology-European Society of thoracic imaging (ESR-ESIT) in five grades as follows; grade I: less than 10 percent; grade II: 25 percent, grade III: 25-50 percent, grade IV: 51-74 percent and grade V: more than 75 percent.

During preparation of the findings reports of the radiology study, we paid a very accurate attention to the poly-segmented sections with isointense signal which were reflecting GGO. Images were also evaluated for the presence of areas of homogeneous hyper-intense signal corresponding to pulmonary consolidation on CT scans, as well as for 'crazy-paving' sign corresponding to combination of GGO and pronounced thickening of interlobular septa. Researcher-designed checklist was reviewed and completed by two radiologists, who were not aware of the MRI results. After two weeks of treatment, MRI was performed again for the follow-up. The MRI was reported by the two radiologists, who reported the initial MRI.

Statistical analysis

Statistical analysis was performed to compare the findings of MRI modality in suspected patients of COVID-19. A proportion of patients with the presence of lesions on T2WI and on DWI was compared according to the McNemar test. The significance level for all criteria was set to $p < 0.05$.

3. Results

In this study, various parts of the lungs showed varying degrees of involvement both before and after treatment. The most affected area before treatment was the Right Lower Lobe (RLL) in 85% of patients, which decreased to 60% after treatment. The Left Lower Lobe (LLL) showed similar trends, with 80% involvement before treatment and 60% after. The Right Middle Lobe (RML) also showed a significant decrease in involvement, from 70% before treatment to 25% after. The Left Middle Lobe (LML) and Right Upper Lobe (RUL) both showed decreases of 55% to 25% and 35%. LUL pulmonary lobe involvement was reported before treatment in 12 patients (60%) and after treatment in 6 patients (30%).

McNemar's statistical test showed that the difference in reporting the percentage of pulmonary involvement in MRI of patients in RLL, RML, LML and LUL lobes is statistically significant ($P < 0.05$) (Table-2).

Table 2- Comparison of the involved lung lobe in MRI of patients before and after treatment

Variable	before treatment		After treatment		P value	
	number	percent	number	percent		
Location of lung involvement	RLL	17	85	12	60	0.06
	LLL	16	80	12	60	0.12
	RML	14	70	5	25	0.004
	LML	11	55	5	25	0.03
	RUL	11	55	7	35	0.12
	LUL	12	60	6	30	0.03

Pulmonary involvement in MRI of patients before treatment was less than 10% in 3 patients (15%), between 10 and 25% in 6 patients (30%), between 25 and 50% in 10 patients (50%) and in 1 patient (5%) more than 50% was reported.

Pulmonary involvement in MRI of patients after treatment was reported in 10 patients (50%) less than 10%, in 5 patients (25%) between 10 and 25% and in 5 patients (25%) between 25 and 50%. (Table-3).

Table 3- Prevalence of lung involvement in MRI of patients before and after treatment

variable	Before treatment		After treatment		
	number	percent	number	percent	
Location of lung involvement	<10%	3	15	10	50
	10-25%	6	30	5	25
	25-50%	10	50	5	25
	50-75%	1	5	-	-
	>75%	-	-	-	-

According to Table 5, the percentage of patients with lung involvement above 25% in MRI before treatment was reported in 11 cases (55%) and after treatment in 5 cases (25%). McNemar's statistical test showed that the percentage of pulmonary involvement in the MRI of patients after treatment has significantly decreased ($P < 0.05$) (Table-4).

Table 4- Comparison of the frequency of pulmonary involvement above 25% in MRI of patients before and after treatment

Variable	Before treatment				After treatment				P value
	Has		Does not		Has		Does not		
	number	percent	Number	percent	number	percent	number	percent	
Pulmonary	11	55	9	45	5	25	15	75	0.03

involvement
above 25%

In examining the pathological MRI findings of patients before treatment, GGO was reported in 19 patients (95%); Consolidation in 11 (55%) patients, atelectasis in 5 (25%) patients and 1 patient (5%) was reported to show fibrosis.

In examining the pathological MRI findings of patients after treatment, in 12 patients (60%) was; consolidation was reported in 9 (45%) of patients and only 1 (5%) of patients showed atelectasis and fibrosis.

McNemar's test showed that there is a significant difference only in the number of GGO reported in the MRI of patients before and after treatment, but in the case of Consolidation, Atelectasis and Fibrosis, this difference was not significant ($P > 0.05$).

Lymphadenopathy, pleural effusion, pulmonary nodule, emphysema, lineal opacity, reverse halo sign, cavitation, crazy paving, peri bronchial thickening and mosaic attenuation were not reported in any of the patients (Table-5).

Table 5-Comparison of MRI pathological findings of patients before and after treatment

Pathological finding	Before treatment				After treatment				P value
	Has		Does not		Has		Does not		
	number	percent	number	percent	number	percent	number	percent	
Ground glass (GGO)	19	95	1	5	12	60	8	40	0.01
Consolidation	11	55	9	45	9	45	11	55	0.62
Atelectasis	5	25	15	75	1	5	10	95	0.12
Fibrosis	1	5	19	95	1	5	19	95	1

4. Discussion

According to the statistical health information, most of the infected cases of SARS-Cov2 (Covid-19) virus experienced mild to moderate symptoms, and were managed with good prognosis. However, a subset of cases experienced moderate to severe pulmonary involvement, leading to prolonged disease courses.

This study aimed to navigate the power of MRI scan as an imaging modality in diagnosis of pulmonary involvements, especially by viral causes to present an approach providing highly informative chest MRI as an alternative of non-ionizing method for patients with Covid-19 under the condition of limited availability of computed tomography or other situations, as a contraindication to CT-scan use.

It is well-known that CT scan is the most sensitive among all imaging modalities for detection of changes in pulmonary parenchyma, and in time it became the gold standard imaging modality in diagnosis of pulmonary involvement during the pandemic of Covid-19. On the other hand, the use of thorax MRI has been increasing in recent years. Since there is no radiation risk, MRI allows multiple examinations to be performed on the same patient, and it can provide additional information to CT during patient follow-up (7).

MRI as a method of investigation of the pulmonary tissue has though some disadvantages. As we know pulmonary structure is filled with high volume of air, i.e., less volume of water molecules, which consequently form a signal that negatively affects the signal-to-noise ratio, a reduced ratio which

means images with a poorer quality. Moreover, there are other conditions that affect the final detected signal, such as respiratory process and accompanied movements of the chest that may cause artefacts in the final resolution (8,9).

Nevertheless, it should be mentioned that MRI has the potential of visualizing the changes in the pulmonary tissue due to the fast progression in the high technology of the devices such as MRI scanners, which leads to more accurate and processed images. Also, MRI with high magnetic field demonstrated a higher signal to noise ratio during lung imaging (9).

It has recently shown that lung MRI is as efficient and accurate as chest CT imaging in providing fine details of the lung parenchyma and pleural abnormalities in patients with lower respiratory tract infection. Hence, various radiologic manifestations of Covid-19 pneumonia, such as GGO, consolidations and ill-defined reticulations, can be easily distinguished with lung MRI. Nevertheless, the main question is to what degree the detected findings on MRI scans of Covid-19 patients correlate with the radiological changes detected by CT scan. This needs further research results (10).

In a study conducted by Ates et al., 31 patients with covid-19 diagnosis were enrolled, and after 24 hours of performing the initial diagnostic CT-scan, patients underwent chest MRI. After the results were examined, it was clear that MRI can be used in diagnosis of COVID-19. In this study, all 31 patients had evidences of lung involvement in their MRI, consistent with CT findings, and our results revealed the same findings (11).

In a study by Vasilev et al., 15 patients with covid-19 diagnosis were enrolled, and after 24 hours of performing the initial diagnostic CT-scan, patients underwent chest MRI. The results showed that in case of CT is not available, it is advisable to conduct a chest MRI for patients with suspected or confirmed COVID-19. It is important that in contrast to planar imaging methods, MRI allows us to assess the extent of the lesion and monitor the disease dynamics. It should be noted that the formations on MRI do not look like GGO, therefore in that work they called them “cloudy sky sign” (12).

Ekinçi et al. came to the similar results compatible with this study that: all MRI sequences were almost perfectly consistent with detected on CT scans areas of consolidations and local increase in lung density. They believe that MRI can be used, particularly in cases where dynamic monitoring of patients is required in order to avoid ionizing radiation exposure (13).

5. Conclusion

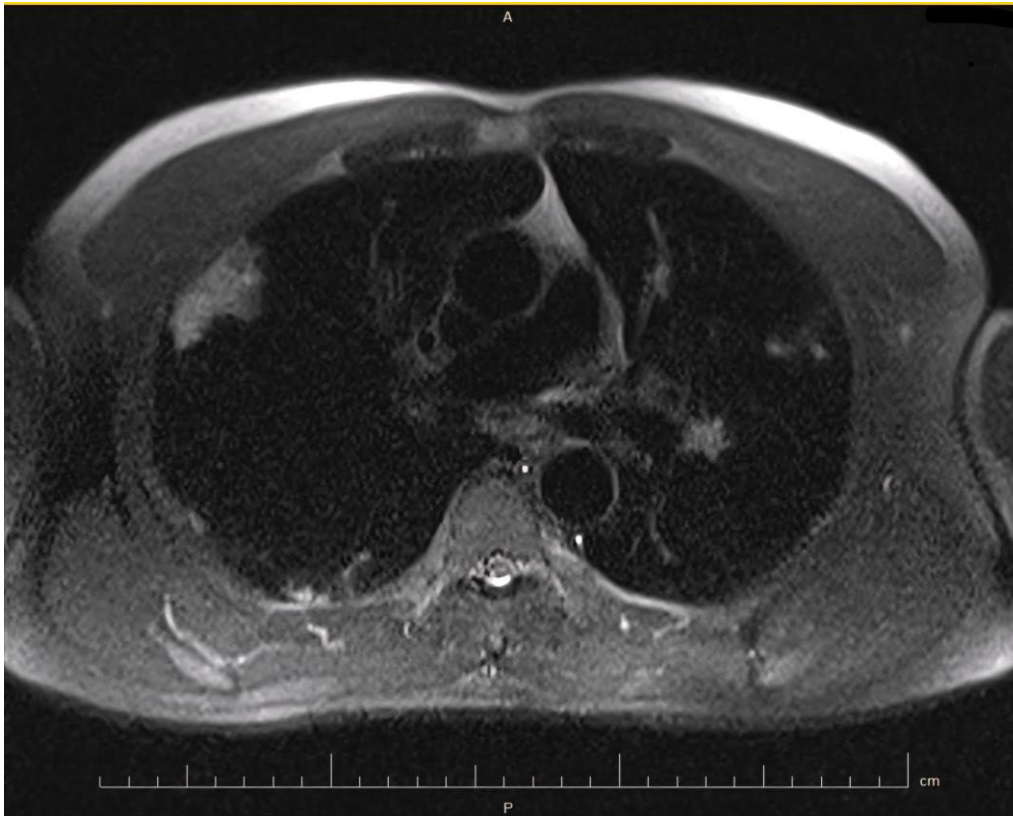
In contrast to previous studies emphasizing CT imaging, our findings indicate that MRI can effectively monitor disease progression and resolution, while mitigating radiation exposure concerns associated with CT scans. Additional research is warranted to confirm the integration of MRI within COVID-19 diagnostic protocols and evaluate its usefulness in tracking disease course and response to treatment over time. By exploring the potential of MRI, healthcare professionals may gain a valuable tool for safer, more comprehensive patient care.

Acknowledgement:

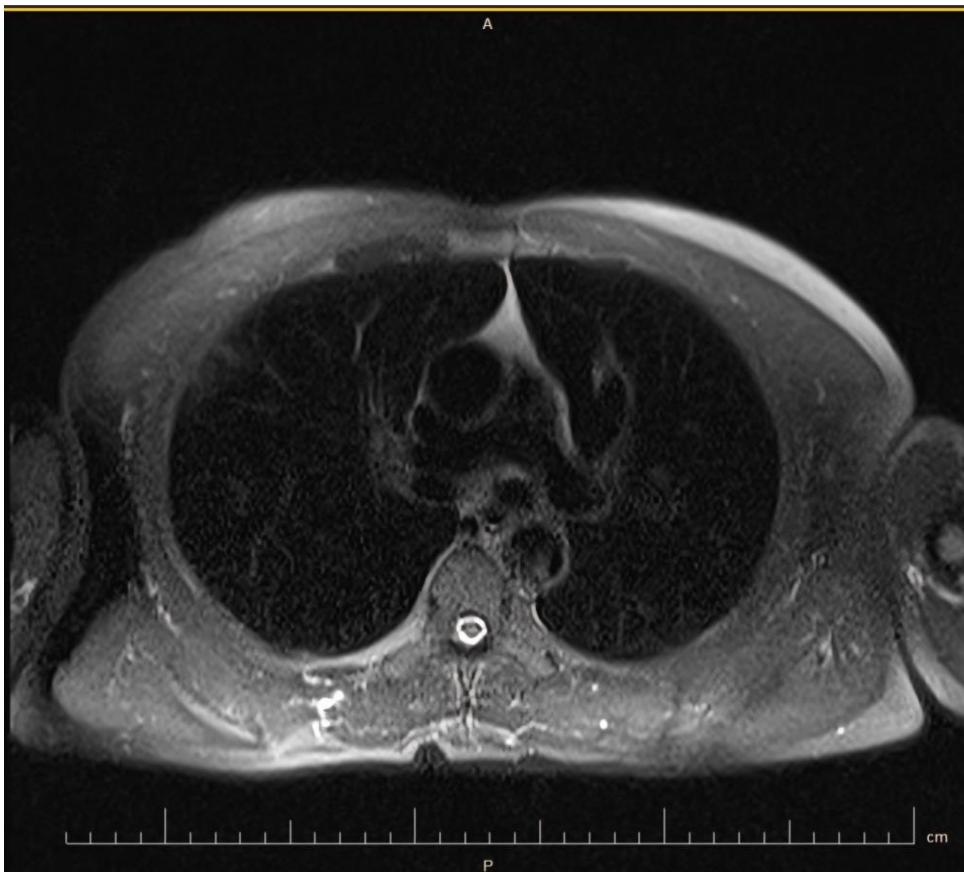
Not applicable in this section.

MRI Images (before and after treatment)

Before treatment



After treatment



Before treatment



After treatment



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