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ORIGINAL ARTICLE

Comparative Evaluation of Computed Tomography and Magnetic Resonance Imaging in Pulmonary Airspace Diseases

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Abstract

Background: Pulmonary diseases are broadly categorized into airspace & interstitial pattern with former being commoner and major cause of morbidity & mortality. Though chest radiograph has been the mainstay for screening these diseases, but it not only misses early disease but also fails to differentiate various patterns. Computed Tomography (CT) has become the gold-standard for diagnosis and determining the extent of various pulmonary diseases in modern-day medicine. Various limitations of CT especially radiation exposure & related cancer-risk have created the space for Magnetic Resonance Imaging (MRI) in thorax, which with its superior contrast resolution coupled with recent advancements is now preferred in variety of conditions. Hence, this study aims to evaluate the role of MRI in pulmonary airspace diseases. **Methods:** This study was performed on fifty patients of pulmonary airspace disease as detected on chest radiograph following Institutional Ethics Committee approval & written informed consent. All patients underwent contrast-enhanced CT thorax on 128-slice scanner & noncontrast MRI thorax on 1.5Tesla scanner on the same day and their findings were recorded in the predesigned proforma by a single radiologist in a single-blinded manner. All the recorded data was statistically evaluated using appropriate tools & methods. **Observations and Analysis:** Our study population had a mean age of 53.2years with male to female ratio of 4:1. In our study, CT diagnosed higher number of patients with ground glass opacity & lymph nodes than MRI. While nodule, atelectasis, pleural effusion & pleural involvement were detected in higher number of patients with MRI. Patients detected with consolidation or chest wall involvement were equal in number on both CT & MRI. MRI however, detected a greater number of patients with malignancy or tumor coexisting with consolidation than CT. MRI had least sensitivity for detection of pleural effusion, least specificity for ground glass opacity and least accuracy for lymph node detection. Sensitivity, specificity & accuracy of detection of chest wall involvement was highest with MRI being 100%. MRI revealed an overall accuracy of 94% in evaluating various parameters of pulmonary airspace disease. **Conclusions:** Though CT thorax is a gold standard imaging tool for evaluation of pulmonary airspace diseases, but MRI is equal or superior to it in depicting majority of morphological patterns. Noncontrast MRI thorax is especially useful in children & young patients, pregnant females, follow up patients, patients with deranged renal functions and those with hypersensitivity to iodinated contrast agents.

Keywords: Computed tomography, magnetic resonance imaging, pulmonary airspace

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Introduction

Pulmonary diseases are major causes of mortality and morbidity in general population. Though chest radiograph is the basic imaging modality but it not only fails to reveal small lesions but retrocardiac lung parenchyma and interstitial diseases are often inapparent [1]. An early and expeditious diagnosis of pulmonary diseases for early treatment represents the primary goal.

Cross-sectional imaging such as computed tomography (CT) and Magnetic Resonance Imaging (MRI) plays a vital role in evaluation of lung diseases in the modern medicine [2-4]. Despite major advantages of CT viz. high spatial resolution & three-dimensional visualization of pulmonary parenchyma, the major concern is ionizing radiation & high cumulative radiation exposure from repetitive examinations with its accompanying increased cancer risk, limiting utilization of CT in pediatric age groups, pregnant women, and immunocompromised patients. Also, CT has lower soft tissue contrast resolution to differentiate collapse from consolidation. Though CT is primary imaging modality to diagnose lung cancer, but it fails to differentiate tumor from consolidation when they coexist. Also, CT cannot depict extent of tumor invasion into vascular or bony structures as accurately as MRI [5].

Though MRI has lagged behind CT in imaging of thorax for a long time due to low signal/proton density from lung parenchyma, cardiac and respiratory motion artefacts impairing image quality and its longer acquisition time but recent technological advancements not only allow rapid scanning but also superior image quality [1,6,7]. However, role of MRI in pulmonary airspace disease is still under research investigation. Hence, this study was designed to find role of MRI in day-to-day clinical practice.

Aim

To compare the role of MRI and CT thorax in evaluating pulmonary airspace diseases.

Objectives

- To evaluate the role of MRI thorax in pulmonary airspace diseases.
- To compare the role of MRI with CT thorax in diagnosing pulmonary airspace diseases.

Material & Methods

This observational, cross-sectional & comparative study was conducted on fifty patients in the Department of Radiodiagnosis of our institution over a period of 15 months following approval from Institutional Ethics Committee and written informed consent from participants using the following criteria.

Inclusion Criteria

- Patients of all age groups and both sexes with clinical indication of CT thorax showing evidence of pulmonary airspace disease on chest radiograph.

Exclusion Criteria

- Patients with severe dyspnea.
- Patients with contraindications of CT thorax
- Patients with contraindications of MRI thorax

CT thorax preceded MRI thorax with both scans on same day followed by interpretation by radiologist in a single-blinded manner. All scans were done in supine position at full inspiration from lung apices to costophrenic angles.

CT thorax was performed on a 128 slice Philips Ingenuity CT scanner in helical mode with 5 mm slice thickness scans for final interpretation. Optimal amount of nonionic, iodinated, intravenous contrast agents was used to obtain the contrast-enhanced scans.

MRI Thorax (Non-Contrast) was performed on a 1.5 Tesla Siemens Avanto MR scanner using a body-coil without use of intravenous contrast agent. T1 & T2 weighted, non-fat & fat-suppressed, axial & coronal images; diffusion weighted axial images and T1GRE coronal images were taken in all patients. Sagittal images in any of the above image sequence were acquired, when needed.

Besides the demographic data, various imaging parameters (viz. nodule, ground glass opacity, consolidation, atelectasis, pleural effusion and lymph nodes) were recorded in a predesigned proforma.

The data thus acquired was interpreted and recorded on a predesigned proforma followed by appropriate statistical analysis using different tools and methods. P-value less than 0.05 was considered statistically significant.

Observations & Analysis *(Image 1-5)*

Our study included patients between 7-86 years of age with mean age of 53.2 years and 6th & 7th decades being the ones with maximum number of patients, 18 & 15 respectively. Males outnumbered females in our study in a ratio of 4:1.

Table 1 shows that higher number of nodules were detected by MRI than CT with statistically significant difference.

Table 2 shows that CT scored over MRI in detecting ground glass opacity with statistically significant difference.

Though consolidation & chest wall involvement was detected in equal number of patients with both CT & MRI, but atelectasis & pleural effusion was detected in 20 & 31 patients respectively with MRI against 19 & 29 respectively with CT.

Table 3 shows that CT was superior to MRI in lymph node detection in our study with statistically significant difference.

Table 4 shows MRI was superior to CT in detection of pleural involvement with statistically significant difference.

Table 5 & 6 shows that MRI was slightly better than CT in predicting malignancy or coexisting consolidation & tumor with statistically significant difference.

Table 7 shows the statistical performance of MRI compared to CT in evaluation of various characteristics in pulmonary airspace disease with clinical or histopathological correlation, latter especially in cases of tumors/malignancy. The table shows MRI has an overall accuracy of nearly 94% in evaluating various parameters of pulmonary airspace disease.

Table 1: Distribution of Nodule in CT & MRI

Nodule	CT		MRI		χ^2
	No. of Patients	%	No. of Patients	%	
Absent	21	42	19	38	p < 0.0001*
Present	29	58	31	62	
Total	50	100	50	100	

Table 2: Distribution of Ground Glass Opacity in CT & MRI

Ground Glass Opacity	CT		MRI		χ^2
	No. of Patients	%	No. of Patients	%	
Absent	37	74	45	90	p = 0.0041*
Present	13	26	5	10	
Total	50	100	50	100	

Table 3: Distribution of Lymph Nodes in CT & MRI

Lymph Nodes	CT		MRI		χ^2
	No. of Patients	%	No. of Patients	%	
Absent	4	8	16	32	p < 0.0001*
Present	46	92	34	68	
Total	50	100	50	100	

Table 4: Distribution of Pleural Involvement in CT & MRI

Pleural Involvement	CT		MRI		χ^2
	No. of Patients	%	No. of Patients	%	
Absent	34	68	30	60	p < 0.0001*
Present	16	32	20	40	
Total	50	100	50	100	

Table 5: Distribution of Prediction of Malignancy in CT & MRI

Prediction of Malignancy	CT		MRI		χ^2
	No. of Patients	%	No. of Patients	%	
Absent	28	56	27	54	p < 0.0001*
Present	22	44	23	46	
Total	50	100	50	100	

Table 6: Distribution of Coexisting Consolidation & Tumors in CT & MRI

Diagnosis	CT		MRI		χ^2
	No. of Patients	%	No. of Patients	%	
Infective	28	56	27	54	p < 0.0001*
Malignancy	22	44	23	46	
Total	50	100	50	100	

Table 7: Statistical Performance of MRI compared to CT in Pulmonary Airspace Diseases

Characteristic	Sensitivity in %	Specificity in %	Accuracy in %
Nodule	90.5	100	96
Consolidation	87.5	97.6	96
Ground Glass Opacity	97.3	30.8	80
Atelectasis	96.8	100	98
Pleural effusion	76.2	89.7	84
Lymph Nodes	100	75	76.9
Pleural Involvement	88.2	100	92
Chest Wall Involvement	100	100	100
Prediction of Malignancy	96.4	100	98
Final Diagnosis	**92.7**	**95.5**	**94**

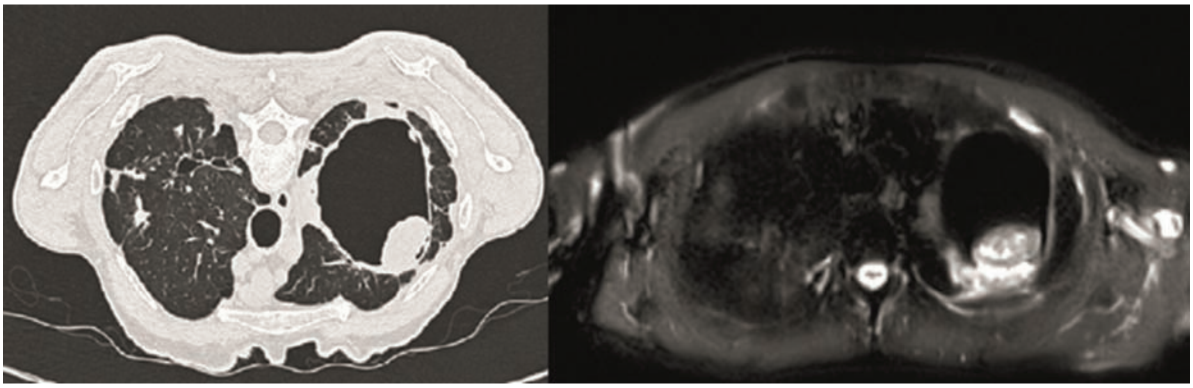

Image 1: Axial CT image (lung window) in prone position (left) & axial fat-suppressed T2W MRI image (right) showing fungal ball in cavitary lesion of left upper lobe

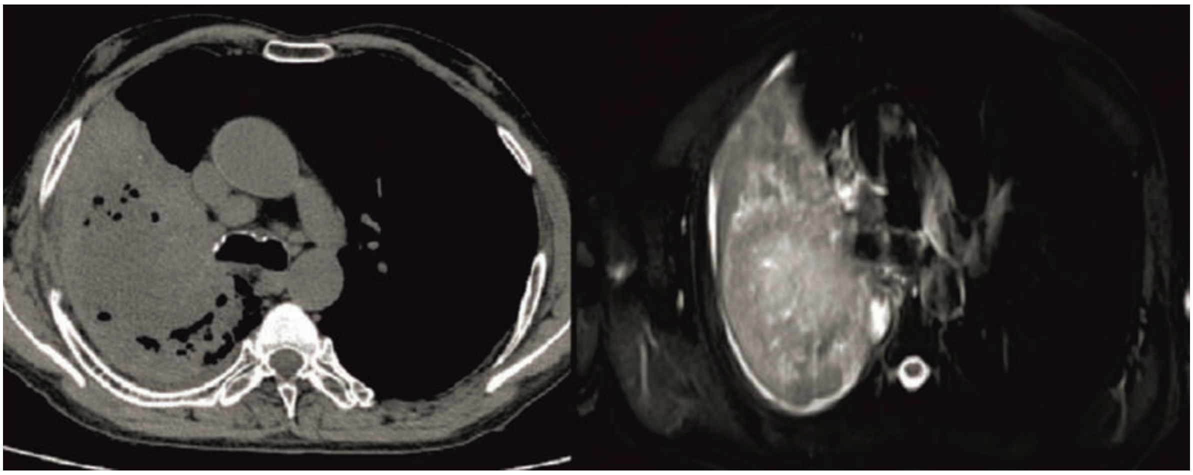

Image 2: Axial NECT image (mediastinal window) (left) & axial fat-suppressed T2W MRI image (right) showing central tumor with surrounding consolidation

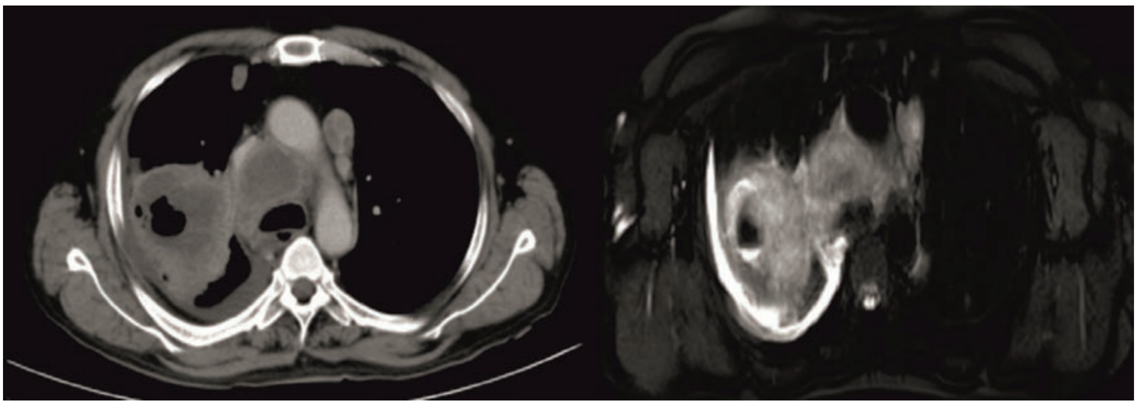

Image 3: Axial CECT image (mediastinal window) (left) & axial fat-suppressed T2W MRI image (right) showing tumor with internal necrosis, necrotic mediastinal adenopathy and right sided pleural effusion

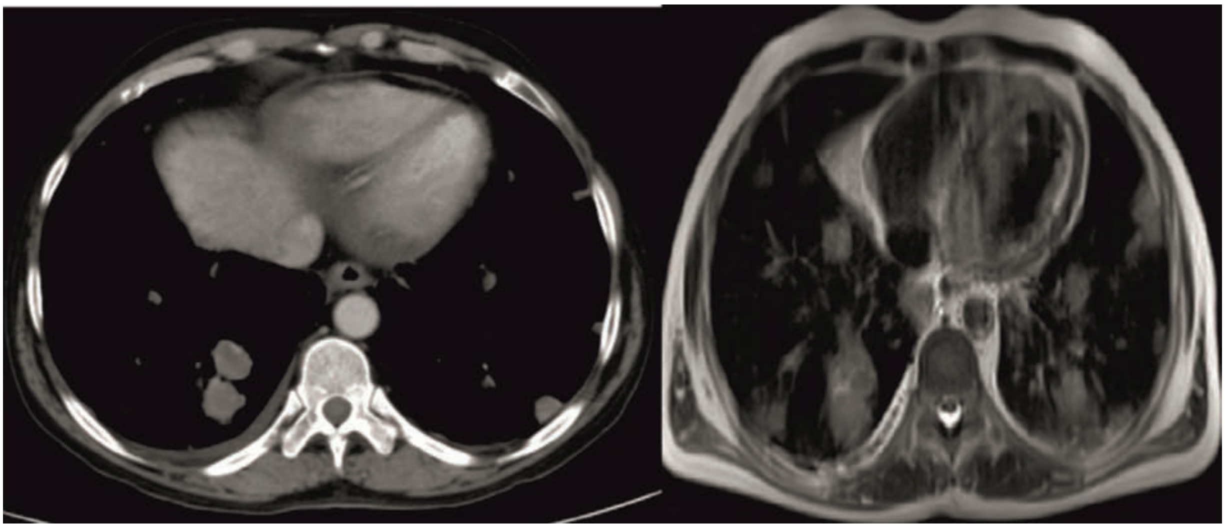

Image 4: Axial CECT image (mediastinal window) (left) & axial non-fat-suppressed T2W MRI image (right) showing multiple tumor nodules in bilateral lower lobes

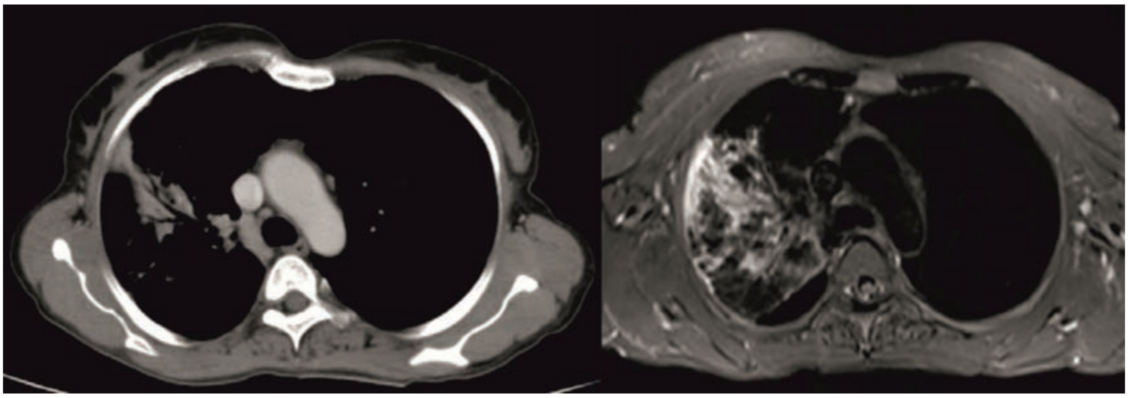

Image 5: Axial CECT image (mediastinal window) (left) & axial fat-suppressed T2W MRI image (right) showing consolidation in a patient with Koch's chest

Discussion

In our study, though MRI detected greater number of nodules than CT (31 vs 29), but ground glass opacity was missed in 8 cases by MRI resulting in sensitivity & specificity of 90.5% & 100% respectively for nodule detection and 97.3% & 30.8% respectively for ground glass opacity. These differences were observed because of the lower spatial resolution of MRI. End-inspiratory, breath-hold MRI scan without fat-suppression allows better visualization of pulmonary parenchyma, thus helping to overcome these limitations partially [8].

Consolidation was detected in equal number of patients by both MRI and CT in our study with MRI showing sensitivity & specificity of 87.5% & 97.6% respectively. Eibel et. al. in a similar study using single shot T2 FSE sequences have compared nodular infiltrates, ground glass opacities and consolidations on 1.5T MRI [9]. Detection rate of pulmonary nodules in their study was 72%.

The assessment of pleural involvement was better delineated by MRI. MRI detected pleural effusion & pleural involvement in a higher percentage of patient than CT (58% vs 62% & 32% vs 40%) with sensitivity of 76.2% & specificity of 89.7% for detection of pleural effusion and sensitivity of 88.2% with specificity of 100% for detection of pleural involvement. Similar findings were reported Rizzi et.al. who reported higher percentage in MRI than CT (35% vs. 17%) among patient populations of pulmonary tuberculosis [10].

The observation rates for CT vs MRI for atelectasis (58% vs 62%), lymph nodes (92% vs 68%), chest wall involvement (12% vs 12%), prediction of malignancy (44% vs 46%) and final diagnosis (44% vs 46%) had a sensitivity & specificity of 96.77% & 100%, 100% & 75%, 100% & 100%, 96.4% & 100% and 92.9% & 95.5% respectively. Ozcan et. al. also reported similar observations when comparing MRI and multidetector CT findings of pulmonary abnormalities in immunocompromised children [11]. These results indicate a high potential of MRI in evaluation of pulmonary airspace diseases. To conclude, pulmonary MRI can detect all clinically relevant morphological changes in lung when compared to CT in pulmonary airspace diseases.

Limitations of the Study

- Small sample of 50 patients (larger sample would be more informative).
- Contrast MRI was not included in our study
- 1.5T MR (3T MR would be superior)

Summary

CT has been established as the current "Gold Standard" for assessing the lung morphology. As the life expectancy increases, the cumulative radiation dose also increases from the life-long repeated scans following the annual follow-ups. Clearly, no amount of low radiation dose will nullify the risks associated with the ionizing imaging when similar or superior information can be achieved without any ionizing radiation.

Magnetic resonance imaging (MRI) has been at par with CT for detection of most morphological changes seen in the pulmonary airspace diseases especially tumors coexisting with consolidation. However, MRI appears to be less sensitive for detecting any small airway disease. MRI could replace CT in assessing various pulmonary airway diseases in certain subsets of patients such as young patients, children, pregnant women and follow-up patients. MRI can be employed as an alternative for contrast CT patients with deranged renal functions and those with hypersensitivity to iodinated contrast agents.

Conflict of Interest:	All authors declare no COI
Ethics:	There is no ethical violation as it is based on voluntary anonymous interviews
Funding:	No external funding
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