ORIGINAL ARTICLE

The role of MR imaging with Half Fourier Acquired Single Shot Turbo Spin Echo sequence in the diagnosis of lung lesions in comparison with multislice CT

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Abstract

Objective: To compare the diagnostic values of magnetic resonance imaging using Half Fourier Acquired Single Shot Turbo Spin Echo sequence and multidetector computed tomography in patients with pathologically examined pulmonary lesions.

Methods: The retrospective, descriptive study was conducted at Radiology Department, Diskapi Research Hospital, Ankara, Turkey, and comprised records of patients with pathologically examined pulmonary lesions between May 2009 and March 2012. Patients were divided into three groups and examined by both multidedector computed tomography and magnetic resonance imaging. During the imaging, patients were not administered any intravenous contrast medium. Electrocardiogram gating and breath holding were not performed in echo sequence. Pulmonary lesions were evaluated on the basis of their dimensions, numbers, differentiation from atelectasis and consolidation, invasion to the thoracic wall-mediastinal structures and presence of lymphadenopathies.

Results: Sensitivity of all patients was 50% (p=0.214) and specificity of CT and MRI were 82.5% (p=0.134) for the detectability of submilimetric nodules . For differentiation of the mass from atelectasis and consolidation, the sensitivity of computed tomography was statistically more significant compared to magnetic resonance imaging (86.6%; p=0.035). For the invasion of the mass to the mediastinal structures and the thoracic wall, the sensitivity of magnetic resonance imaging was statistically more significant compared to tomography (86.6%; p=0.035).

Conclusion: HASTE sequence can be used to determine the invasion of the pulmonary mass to the mediastinal structures and the thoracic wall since it is more sensitive than computed tomography. It can also be used to detect submilimetric nodules. It has equal sensitivity and specificity compared to computed tomography. But computed tomography is superior for the differentiation of the mass from atelectasis and consolidation.

Keywords: MRI, Solitary pulmonary nodules, Pulmonary neoplasms, Pulmonary disease, Tomography. (JPMA 63: 1387; 2013)

Introduction

Computed tomography (CT) is the standard modality in the detection and followup of lung lesions. Magnetic Resonance Imaging (MRI) has some advantages such as soft tissue characterisation, multiplanar imaging, dynamic and functional analysis. MRI is not widely used in lung imaging due to limited spatial rezolution,[1,2] high contrast difference between pulmonary interstitium and airways, and pulmonary and cardiac motion artefacts.[3] CT has the advantage of imaging both alveolar and pulmonary interstitium without the use of intravenous (IV) contrast material.[4,5] On the other hand, CT has some disadvantages such us contrast medium-causes nephrotoxicity and radiation dose, especially in the followup lung lesions.[5,6] Since radiation has the risk of lung cancer formation itself, alternative imaging modalities are researched for the followup of lung lesions.[7]

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With the development of high-performance gradient systems, MRI-based pulmonary imaging has gained importance.[7-10] For this purpose, Half-fourier-Acquired Single-shot turbo Spin-echo (HASTE) sequence and gradient echo T1-weighted sequences have been mostly used. These sequences have short imaging time, and thus have few motion artefacts and can be done with breath-hold.

HASTE sequence enables the differantiation of neoplastic tissues with high T2 relaxivity from normal parenchyma with low signal. Pulmonary arteries and veins can be observed without the formation of high signal which shows advantage since small pulmonary lesions can give similar signal to vascular structures in CT.[8,9] HASTE sequence does not require IV contrast medium administration, potentially having no risk of allergy. Combined with the short imaging duration, pulmonary MRI imaging with HASTE sequence appears to be a modality with low cost.

The current study was designed to compare the diagnostic values of MRI using HASTE sequence and

multidetector CT in patients with pathologically examined pulmonary lesions.

Patients and Methods

Approved by the Instutional Ethics committee, the descriptive retrospective study comprised patients' records between May 2009 to March 2012. This research was conducted in Radiology Department, Diskapi Research Hospital, Ankara, Turkey. All the lesions had been sampled by thoracoscopy-guided biopsy or fine needle aspiration (FNA) biopsy and pathologically examined. All the patients had undergone CT which was accepted as 'Day 0'. Within 3 days all the patients underwent MRI examination.

Patients underwent routine thorax examination by Philips MX8000 multidetector (4 detectors) CT machine. The parametres were: slice thickness 6.5 mm, gap 5 mm, 150mAs, 120kV, IV contrast medium Ultravist 300/100cc (Schering), 8 seconds examination time, 3.5 miliseconds injection speed and 20 seconds delay.

MRI was 1.5 Tesla superconductive coil Siemens, Magnetom Vision plus VB33D model machine. HASTE sequence was used. The parametres were: TR 650, TE 43, FOV 263*350, matrix 192*256, 5 mm slice thickness, 38 seconds examination time. An area from lung apex to the diapragma was scanned in the axial plane. In addition, hiluses were scanned in coronal plane with 4mm slice thickness. IV contrast medium was not used. No ECG gating was used. Breath hold was not requested. Any patient with contraindications for MRI were excluded from the study.

CT and MRI images were interpreted by 2 radiologists who had a minimum of 5 years of thoracic radiology experience. There were no inter and intraobserver variability and the decision was made by concensus. Patients were divided into 3 groups. In the first group patients with multiple nodules were evaluated for detectability. In the second group the differentiation of the mass from atelectasis and consolidation was done. In the third group invasion of the mass to the mediastinal structures and the thoracic wall was evaluated. All data was interpreted by Pearson's Chi Square Test, and $p<0.05$ indicated significant statistical difference.

Results

The study sample comprised 34 patients; 25 (73.5%) male, and 9 (26.4%) female. Overall age range was 26-87 years, with a mean of 56±9 years. Pathological results were first compared with age and gender (Table).

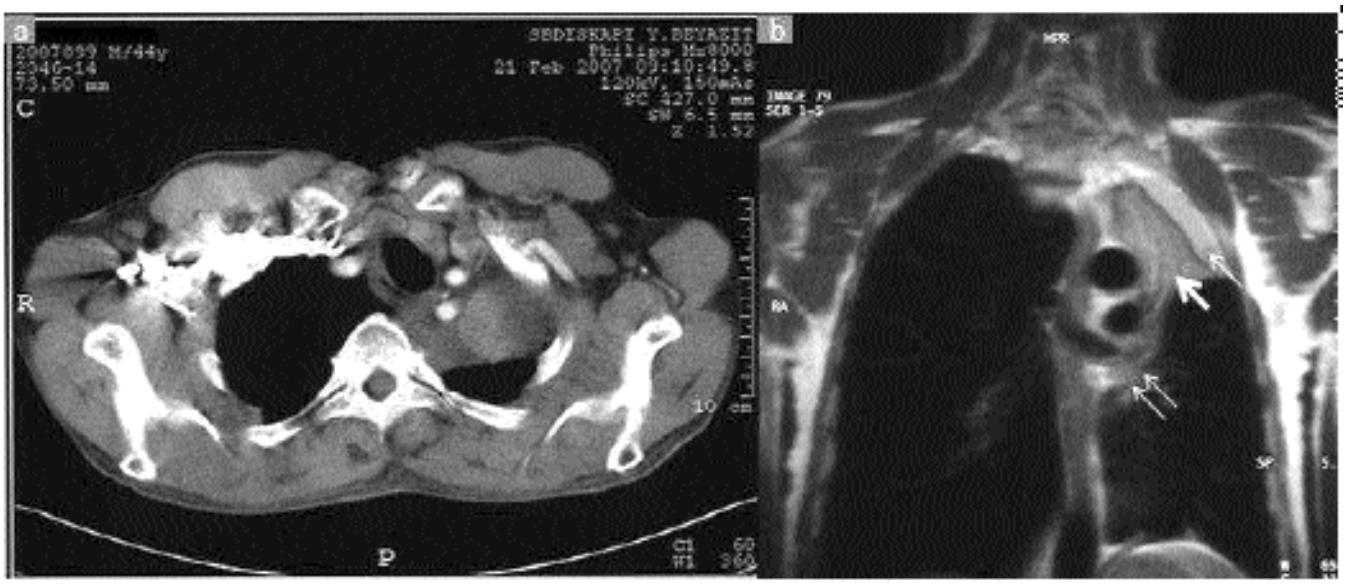
In the first group, 4 patients with multiple nodules were evaluated for the number of detectable nodules. Compared to the pathology results; sensitivity and specificity of both CT and MRI were 50%.

In the second group, 15 patients were included for differentiation of the mass from atelectasis and consolidation. With MRI in 9(60%) of the patients differentiation of the pulmonary mass from atelectasis was made better; in 2(13.3%) of the patients differentiation of the mass from consolidation was made better; and in 3(20%) of the patients differentiation of the mass from atelectasis and consolidation was made better. In 1(6.6%) of the patients, the atelectatic area was clearly seen both in MRI and CT. The sensitivity and specificity of CT were 86.6% and 13.3% respectively. The sensitivity and specificity of MRI were 13.3% and 86.6% respectively. The sensitivity of CT was statistically significant compared to

Table: Patients and pathology results.

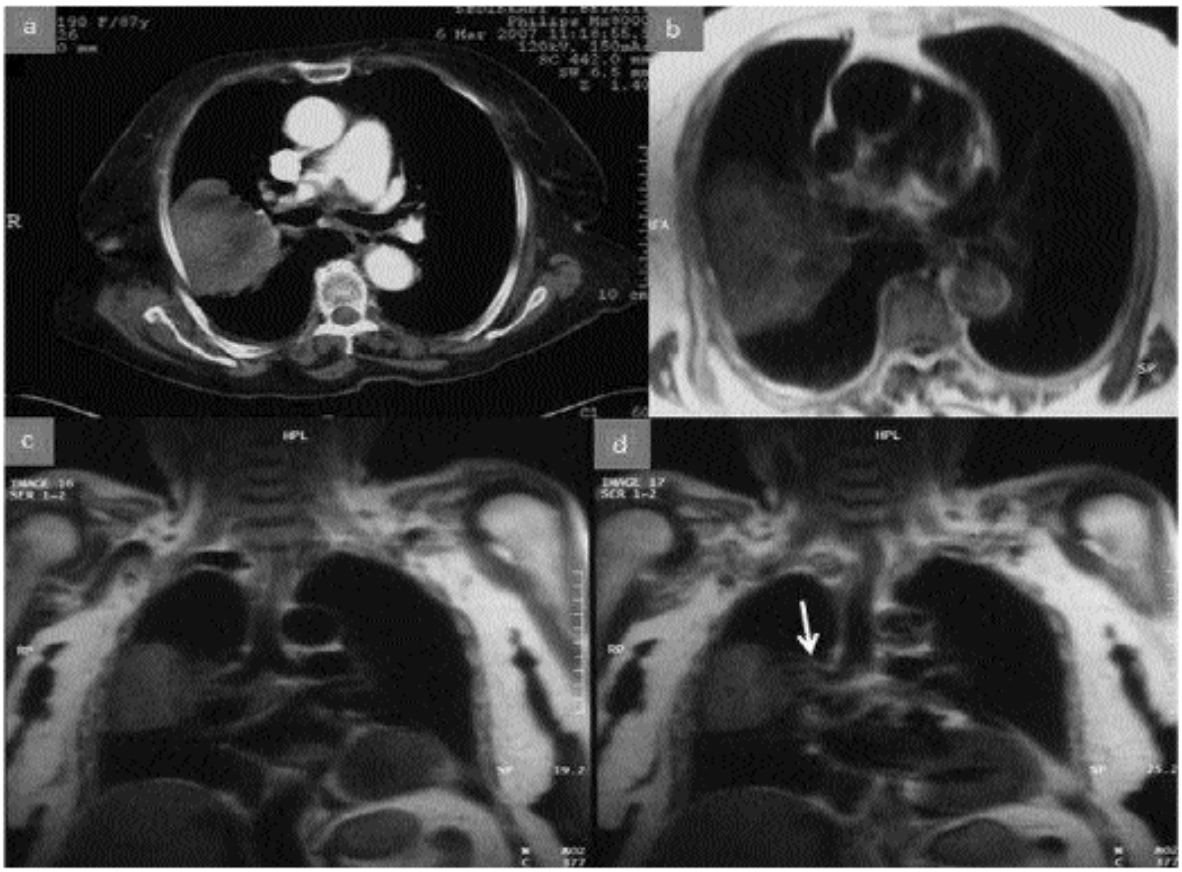
	Pathology Result	Age	Gender
1	Adenocarsinoma	78	M
2	Metastasis (Renal cell ca.)	57	M
3	Squamous cell ca.	43	M
4	Metastasis (Stomach)	84	F
5	Adenocarsinoma	52	F
6	Metastasis (Breast)	46	F
7	Squamous cell ca.	51	M
8	Non-small cell ca.	44	M
9	Metastasis (Malign Melanoma)	68	F
10	Squamous cell ca.	67	M
11	Epidermoid ca	74	M
12	Squamous cell ca.	76	M
13	Squamous cell ca.(necrotic)	51	M
14	Non-small cell ca.	73	M
15	Small cell ca.	73	M
16	Small cell ca.	62	M
17	Chronic infection-anthracosis	52	M
18	Non-small cell ca.	75	M
19	Non-small cell ca.	74	M
20	Hamartoma	50	F
21	Non-small cell ca.	70	M
22	Squamous cell ca.	65	M
23	Adenocarsinoma	70	M
24	Small cell ca.	67	M
25	Squamous cell ca.	54	M
26	Squamous cell ca.	76	M
27	Small cell ca.	47	M
28	Hytatic Cyst	26	F
29	Adenocarsinoma	61	F
30	Squamous cell ca.	47	M
31	Adenocarsinoma	75	M
32	Adenocarsinoma	87	F
33	Adenocarsinoma	60	M
34	Squamous cell ca.	63	F

ca: carcinoma



CT: Computed Tomography. HASTE: Half-fourier-Acquired Single-shot Turbo Spin-Echo.

Figure-1: A 44-year-old man with non-small cell carcinoma of the left lung. Axial CT image shows the mass and atelectasis beside the mass (a). In coronal plane with HASTE sequence, the mass (broad arrow), atelectatic area (arrow) and another mass under the left main bronchus (double arrow) is shown.



CT: Computed Tomography. HASTE: Half-fourier-Acquired Single-shot Turbo Spin-Echo.

Figure-2: A 84 year old woman with adenocarcinoma of stomach. CT image in axial plane (a), HASTE sequence in axial plane (b), HASTE sequence in coronal plane (c) shows the metastatic mass in the right lung. The right main broncheal obstruction is easily depicted by HASTE (arrow) (d).

MRI (p=0.035) (Figure 1 and 2).

In the third group, 15 patients were evaluated for the invasion of the mass to the mediastinal structures and the thoracic wall. With MRI the inner structure of the lesion was more clearly defined in 7(46.6%) of the patients; mediastinal invasion was better evaluated in 2(13.3%) patients; presence of lymphadenopathies were better detected in 2(13.3%) patients, pericard invasion was more precisely evaluated in 2(13.3%) patients. In 2(13.3%) patients thoracic wall invasion was only evaluated in MRI. The sensitivity and specificity of CT were 13.3% and 90% respectively. The sensitivity and specificity of MRI were 86.6% and 13.3% respectively. The sensitivity of MRI was statistically significant compared to CT(p=0.035) (Figure 2).

With total evaluation of all patients in all groups, sensitivity of CT and MRI were 50% (p=0,214) and specificity of CT and MRI were 82,5% (p=0,134).

Discussion

Lung cancer is the most common cancer type seen worldwide.[10] It is responsible for 12.8% of cancer cases seen worlwide and 17.8% of the deaths from cancer.[11] For the diagnosis of lung tumours, several imaging modalities, including chest radiography, CT and MRI, are being used and transthoracic biopsy is the worldwide reference standard.[6-8] Both MRI and CT have proven significant accuracy than conventional chest radiography.[12,13] Thoracic region, especially the lungs, exploits lots of advantages inherent to CT; density differences between the pulmonary interstitium and air-filled alveoli should easily allow the depiction and discrimination of pulmonary masses even without IV contrast agent administration. Benign calcified lesions are also readily diagnosed by CT.[6,7,12] With the advancement of technology in CT, especially with the increase in number of slices and detectors, CT is believed to be the gold standard regarding the detection and characterisation of pulmonary masses.[12-14] On the other hand, CT, especially multidedector type (MDCT), is closely associated with radiation exposure and potential nephrotoxicity risks when contrast agents are applied and these important limitations could easily ignore the benefits of CT in the visualisation of lung masses.[5-8,13] Nowadays MRI is being performed for thoracic imaging due to its optimised imaging sequences, without exposure to radiation and high-quality receiver coils although the scan time is longer and the spatial resolution is lower than CT.[9-12,15,16]

In this research; the diagnostic performance of CT and MRI based on HASTE sequence were compared for the evaluation of biopsy proven lung lesions, classified in three groups. Except for one hydatid cyst case, all the pulmonary lesions were verified by transthoracic biopsy.

In the first group with patients who had multiple nodules sensitivity and specificity of CT and MRI were equal in the detectability of submilimetric nodules (50%). Patients who had more than four nodules were defined as multiple nodules and included in this subgroup. The number of patients in this group was low and most of these nodules were greater than 1 cm in size. These factors might be the reason why our results showed equal sensitivity and specifity for CT and HASTE sequence.

Schroeder et al[13] studied pulmonary nodules of 30 patients with HASTE MRI and CT, and presented 73% sensitivity with MRI for lesions less than 5mm, 95% sensitivity for lesions between 6-10 mm and 100% sensitivity for lesions larger than 1 cm. They recommended HASTE-MRI sequence for pulmonary lesions bigger than 5 mm, and CT for the suspicious lesions smaller than 5 mm. Their sensitivity for both CT and HASTE MRI were higher than our results. Vogt et al.[12] investigated the efficacy of ECG-triggered HASTE MRI for the metastatic nodules of 64 patients by using MDCT as standard reference.They predicted 95% sensitivity with MRI for nodules between 5-10 mm in diametre and 100% sensitivity for lesions exceeding 3 cm in size. They did not include lesions smaller than 5mm and suggested the application of HASTE MRI for pulmonary nodules exceeding 5 mm in diametre. Their sensitivity was also higher than our results. Schafer et al[14] detected pulmonary nodules of 30 patients with HASTE MRI and 3D-Gradient echo sequence (GRE). They showed that 3D-GRE sequence was superior to the HASTE sequence due to the reduced false-positive findings and sensitivity of MRI was only acceptable in the detection of lung nodules larger than 4 mm (85% sensitivity for HASTE MRI, 65% sensitivity for lesions smaller than 4mm in size). They had also higher sensitivity than our research findings.

In our second group, CT was superior to the MRI for the differentiation of pulmonary masses from atelectasis and consolidation with 86.6% sensitivity. MRI depicted atelectasis in 60% of the cases, but presented only 13.3% success in the discrimination of masses from consolidation. Bourgounin et al,[15] Kono et al[16] and Webb et al[17] predicted MRI superiority over CT in the differentiation of lung masses from atelectasis and consolidation. On the other hand, Tobbler et al[18] presented contrast-enhanced CT dominancy over MRI in the differentiation of pulmonary masses from atelectasis similar to our results. Bourgounin et al[15] studied the differentiation of pneumonitis from tumour in 12 patients

with MRI. In 10 patients MR imaging was succesful (83.5% sensitivity). Kono et al[16] suggested the use of Gd-DTPA(Gadolinium-diethylenetriaminepenta- acetic) enhanced MRI instead of CT in order to differentiate between malignant and benign pulmonary masses, hilar lung cancer and peripheral postobstructive atelectasis or pneumonia, determine therapeutic effect after radiation therapy, and differentiate recurrent or residual tumour and radiation pneumonitis. Webb et al[17] presented the exact differentiation of hilar tumour from pneumonia with MRI in 3 of 4 patients (75% sensitivity). Tobbler et al[18] studied 18 patients with proximal bronchogenic carcinoma and postobstructive lobar collapse. CT was more successful than MRI in differentiating tumour mass from collapsed lung (80% sensitivity).

In our third group, HASTE-MRI sequence had superiority over CT with 86.6% sensitivity for the detection of mediastinal and thoracic invasion. Lyphadenopathies were also seen more clearly with the HASTE sequence compared to CT. Mayr et al found that mediastinal invasion was evaluated better with CT compared to MRI.[19] Rapoport et al, Bonomo et al, Heelan et al showed that MRI was superior to CT in detection of the thoracic wall and mediastinal invasion of the lesion.[20-22] Webb et al, Boiselle et al found MRI superior to CT in detection of the lymph nodes.[23,24]

Overall, both CT and MRI detected 17 pulmonary nodules and masses for all the three groups; both imaging modalities had 50% sensitivity and 82.5% specificity. Our results confirmed the data of previous studies with lesser sensitivity and higher specificity. This might be due to the small number of cases, poor general conditions of some patients and lower spatial resolution of both modalities due to some technical failures. We believe that large number of cases with advanced technical facilities used for both imaging techniques could give more beneficial data with higher sensitivitiy and specificity.

In previous studies, limited spatial resolution, high susceptibility differences between air spaces and the pulmonary interstitium, presence of respiratory and cardiac motion, long acquisition time, dark appereance of calcified nodules making them almost undistinguishable from the surrounding parenchyma were presented as the limitations of pulmonary MRI. To overcome these limitations, they recommended the use of breath-holding and ECG-triggering to eliminate respiration and motion artefacts, implementation of parallel imaging techniques plus usage of latest hardware and software to increase the spatial resolution and image quality plus contrast properties of MRI.[12,13,18-22,25] The abilitiy to detect most of the pulmonary lesions exceeding 5 mm in diametre, lack of exposure to radiation and reliable distiction between benign and malignant noncalcified nodules were presented as the advantages of pulmonary MRI to CT.[12,20,25] Higher spatial resolution over MRI, depiction of pulmonary nodules with sizes less than 5 mm, shorter imaging time and more accurate diagnosis of calcified nodules were the advantages of CT over MRI with a serious disadvantage of exposure to ionising radiation.[8,13,14]

There was no calcified nodule or pulmonary mass in our research so we didn't have such a limitation Small number of cases with patients who have poor general condition might be responsible for the worse image quality and lower spatial resolution which were the main limitations of our research. Absence of parallel acquisition implementation, ECG-gating and breath-hold sequences due to technical failures were the second major limitation. Four-slice CT usage due to lower technical facilities correlated to MDCT might be another limitation and, evaluation of the results by two readers with consensus without any intra and interobserver variability might introduce less effective data compared to literature.

Conclusion

CT is superior to MRI HASTE sequence for the differentiation of the mass from atelectasis and consolidation. HASTE sequence can be used to determine the invasion of the pulmonary mass to the mediastinal structures and thoracic wall since it is more sensitive than CT. It can also be used to detect submilimetric nodules, as it has equal sensitivity and specificity compared to CT. To understand the real diagnostic value of HASTE sequence, research with a larger patient group and the application of breath-hold and ECG gating techniques are needed. Still it is an alternative in the diagnosis and followup of pulmonary lesions in patients with high radiation load as well as in patients who have failure in renal function tests and cannot tolarate the usage of IV contrast medium.

References

1. Kauczor HU, Kreitner KF. MRI of the pulmonary parenchyma. Eur Radiol 1999; 9:1755-1764.
2. Hatabu H, Chen Q, Stock KW, Gefter WB, Itoh H. Fast magnetic resonance imaging of the lung. Eur J Radiol 1999; 29: 114-32.
3. Thompson BH, Stanford W. MR imaging of pulmonary and mediastinal malignancies. Magn Reson Imaging Clin N Am 2000; 8: 729-39.
4. Schwickert HC, Thelen M, Schwedwn F, Kauczor HU, Kersjes W, Triebel HJ. CT and MRI in pneumology. Pneumologie 1994; 48: 1-11.
5. Müler NL. Computed tomography and magnetic resonance imaging: past, present and future. Eur Respir J 2002; 35(Suppl): 3S-12S.
6. Collins J. CT screening for lung cancer: are we ready yet? WMJ 2002; 101: 31-4.
7. Diederich S, Wormanns D, Semik M, Thomas M, Lenzen H, Roos N,