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Original Research Article

An analytical comparative evaluation of ultrashort TE lung MRI and HRCT lungs for detection of pulmonary nodules in oncology patients

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Abstract
Aim: The purpose of this study was to evaluate the detection rate of pulmonary nodules in ultrashort echo time (UTE) lung magnetic resonance imaging (MRI) and to compare it with computed tomography (CT) in oncology patients.
Methods: The study was performed at department of radiology. Approval of the thesis was taken by the Institutional Ethical Committee and the study was performed according to standard protocols. In this study of comparison of UTE lung MRI and HRCT lungs for detection of pulmonary nodules in oncology patients, 50 patients were subjected to HRCT lungs and UTE lung MRI using the sequence Fl3d_spiralvibe cor 1.25mm iso.
Results: 50 patients who underwent both a spiral 3D UTE examination of the lungs and thin-section chest CT were included (35 men and 15 women; mean age, 62.2 years; range, 30–79 years). The mean duration between chest CT and MRI was 22.4 days (range, 0–30 days). Among the total number of nodules detected in both lungs of all patients, nodules detected by CT were 241, and nodules detected by MRI were 212. The nodule detection rate by MRI was 87.96%.
Conclusion: Our study results indicate that lung MRI had a near-complete detection rate for nodules equal to or more than 5 mm in size. Hence, in oncology patients who are undergoing regular follow-up of the lung nodules, lung MRI using UTE can replace low-dose CT, which in turn reduces the radiation dose to the patient.

Keywords: pulmonary nodules, ultrashort TE lung MRI, oncology, HRCT lungs

Introduction

The applications of lung magnetic resonance imaging (MRI) have of lung tissue and by physiological motions including respiration and cardiac pulsation of the thorax. On the contrary, computed tomography (CT) has excellent spatial resolution and image contrast and is the modality of choice for most pulmonary diseases. However, inevitable ionizing radiation exposure and its potential carcinogenic risks are major drawbacks of CT examinations, especially for oncology patients who are in need of repeated imaging workups for the evaluation of tumor recurrence or metastasis.

With recent improvements in MRI, new techniques such as an ultrashort echo time (UTE) have enabled the clinical application of lung MRI [1-5]. Considering the exceedingly short T2 and T2* values of the lungs, a short echo time is a critical factor in obtaining a diagnostic lung MRI examination [6,7]. Moreover, recent studies on a combination of a UTE and a radial acquisition technique, such as the pointwise encoding time reduction with radial acquisition (PETRA) sequence, have proven the feasibility of lung MRI for the evaluation of various pathologies including pulmonary masses or nodules, cystic fibrosis, and pulmonary embolisms [1-5, 8].

Magnetic resonance imaging (MRI) is a promising technique for the longitudinal evaluation of pulmonary diseases and functions andmay provide an alternative to low-dose CT (LDCT)

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for lung cancer patients. However, a major issue with lung MRI is its susceptibility to the effects of respiratory motion. Therefore, respiratory gating or a breath-hold maneuver is performed during image acquisition to minimize the impact of respiratory motion. Besides respiration motion, structural lung MRI has been limited historically because of the low proton density of the lung parenchyma and short T2* values at the air–tissue interface requiring rapid data sampling after pin excitation and maximizing kspace coverage while minimizing acquisition time. The recently developed MRI ultrashort echo time (UTE) technique allows an echo time (TE) shorter than 200 μs, which improves the evaluation of pulmonary disease and pulmonary malignancies. UTE MRI has demonstrated acceptable diagnostic image quality and high interreader agreement for pulmonary nodule detection, making it a potential alternative to LDCT in lung cancer screening. A feasibility study conducted in oncology patients suggested that the high sensitivity, shorter scan duration, and satisfactory image quality of free-breathing spiral three-dimensional (3D) UTE improved detection of pulmonary nodules.2 More sensitive detection of small nodules sized 4 to 8mm was achieved with freebreathing. 2 Additional studies are needed to evaluate UTE MRI in cancer patients with very small nodules.

The purpose of this study was to evaluate the detection rate of pulmonary nodules in ultrashort echo time (UTE) lung magnetic resonance imaging (MRI) and to compare it with computed tomography (CT) in oncology patients.

Materials and Methods

The study was performed at department of radiology. Approval of the thesis was taken by the Institutional Ethical Committee and the study was performed according to standard protocols. In this study of comparison of UTE lung MRI and HRCT lungs for detection of pulmonary nodules in oncology patients, 50 patients were subjected to HRCT lungs and UTE lung MRI using the sequence Fl3d_spiralvibe cor 1.25mm iso.

- All oncology patients who were coming for screening of pulmonary nodules for a 1-year period.
- MRI technique: Imaging was performed on a 3T Siemens Skyra scanner. MRI sequence and parameters used
- CT Technique: ImagingwasperformedwithGE Bright speed 16 slice CT scanner. Parameters included are: helical scan type, kV ranges 120 to 140, tube rotation time 0.8 second, detector configuration 161.25mm, collimation 0.625 to 10mm, pitch 1.75, and mAS ranges from 100 to 350.

Inclusion Criteria

All individuals undergoing radiotherapy/chemotherapy/regular follow-up or visiting the oncology department and referred to the radiology department for nodule detection were included in this study.

Exclusion Criteria

- General contraindications for MRI.
- Patient not willing to give consent.
- Suboptimal image quality due to patient movement during image acquisition.
- The HRCT and MRI images were analyzed 1 week apart to remove observer bias. The images were assessed by a board certified radiologist with 15 years of experience in cross-sectional imaging. The number and size of lung nodules in each lobe of both lungs were evaluated, and data were collected in MS Office Excel 2010.

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Results

Table 1: Patient characteristics

Variables	
Age (years)	62.2 ± 11.96 (range, 30–79)
Sex, male: female	35:15
Primary malignancy	
Hepatobiliary carcinoma	20
Stomach carcinoma	2
Colorectal carcinoma	20
Pancreas carcinoma	2
Breast carcinoma	2
Non-small cell lung carcinoma	2
Renal cell carcinoma	1
Adrenal cortical carcinoma	1

50 patients who underwent both a spiral 3D UTE examination of the lungs and thin-section chest CT were included (35 men and 15 women; mean age, 62.2 years; range, 30–79 years). The mean duration between chest CT and MRI was 22.4 days (range, 0–30 days).

Table 2: Comparison of nodule detection rate between CT and MRI

Size of the nodules	No. of nodules in CT	No. of nodules in MRI	Nodule detection rate by MRI
≥3 mm to <4 mm	32	8	25%
≥4 mm to <5 mm	16	12	75%
≥5 mm to <7 mm	58	57	98.3%
≥7 mm to < 10 mm	50	50	100%
≥ 10 mm	85	85	100%
Overall nodules	241	212	87.9%

Among the total number of nodules detected in both lungs of all patients, nodules detected by CT were 241, and nodules detected by MRI were 212. The nodule detection rate by MRI was 87.96%.

Discussion

Although computed tomography (CT) is currently considered the preferred method for the detection of lung nodules, however, because MRI images are usually acquired slowly and repeatedly, breathing and cardiac movements have a greater impact on image quality, lung tissue has relatively little soft tissue or water component, and lung tissue and air have a poor pair comparison, This often results in a low signal-to-noise ratio (SNR) in lung MRIand the use of MRI is greatly limited. Lung magnetic resonance imaging, as an imaging tool for the diagnosis and characterization of lung lesions, has attracted extensive attention in recent years. Recent studies have shown that Lung lesions can also be detected by MRI, Because of its higher intrinsic soft tissue contrast, MRI provides even more information about the heterogeneity of lung nodules than CT. However, the role of MRI, such as diffusion weighted imaging (DWI), in the evaluation of nodules is still unclear, and some studies have shown conflicting results.

Ultra-short echo time MRI (UTE-MRI) is not easily disturbed by rapid T2* attenuation and respiratory motion, which has shown its utility in pulmonary applications. UTE technology is characterized by the TE time can be reduced to the microsecond level (32μs), and the signal is collected at the early stage of proton magnetic resonance signal attenuation. It is especially

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suitable for magnetic resonance imaging of organs with low proton content and heterogeneous magnetic field (such as lung tissue).Ohno *et al*. concluded that UTE-MRI can be used to display GGO, consolidation, etc., in high agreement with CT [11].

Our study demonstrates the feasibility of spiral 3D UTE of the lung with 1.5-mm isotropic spatial resolution for pulmonary nodule detection in oncology patients. In our study, the overall nodule detection rate on spiral 3D UTE images was as high as 87.9%. There was a 100% detection rate for nodules 7 mm or larger on spiral 3D UTE images, which outperformed prior studies [12, 13]. Moreover, the detection rate for4-5 mm nodules was 76%. This result far exceeds the detection rate reported by Burris *et al*.; only 17% of nodules smaller than 4mm were detected on UTE images based on a radial k-space trajectory [12]. Furthermore, a recent study by Ohno *et al*. that evaluated the nodule detection capability of UTE images by radial acquisition alone included pulmonary nodules larger than 4mm [11]. We suggest that use of the 3D stack-of-spirals method with respiratory gating for lung MRI has resulted in substantial progress in the detection of nodules < 5mm in diameter, which is essential for a pulmonary metastasis workup.

For nodules less than 5 mm, and equal to or more than 4 mm, MRI showed a comparable detection rate of 75%, while for nodules less than 4 mm, the detection rate was only 25%. It was worth noting that the risk of cancer in nodules smaller than 5 mm is extremely low, ranging between 0 and 1% [14, 15]. The prevalence of lung cancer among the patients with 4 to 6 mm nodules was also extremely low in the NLST: 0.49% (18 out of 3,668 patients) at baseline, 0.3% (12 out of 3,882 patients) in the first screening round, and 0.7% (15 out of 2,023 patients) in second phase of screening [16].

In our study, the nodule detection rate for nodules less than 5 mm is 50%. However, according to Fleischner Society and BTS recommendation guidelines, the probability of nodules less than 5 mm turning malignant is less. Hence, the lesser detection rate of nodules less than 5 mm in our study is not going to significantly affect the prognosis. According to Fleischner Society guidelines, the nodules are managed according to their density, size, number of nodules (single or multiple), and the patient's cancer risk. CT follow-up in 3 months is recommended for solid nodules less than 8 mm. Positron emission tomography-CT or tissue sampling is recommended for nodules greater than 8 mm. The decision to set the cut-off at 8 mm was made based on the risk of malignancy [17]. The duration of surveillance is determined by the initial nodule size and the patient risk. The larger the diameter of the nodule, the greater the patient's risk and suggested shorter time interval for follow-up. The follow-up procedure for pulmonary nodules smaller than 8 mm will be determined by the patient's risk (high or low) and whether the size is below 6 mm or between 6 and 8 mm. The CT follow-up might last between 3 and 24 months, depending on the patient's risk.

According to a recent survey, radiologists tend to report every detected nodule and to routinely recommend follow-up CT examinations in oncologic patients [18]. In this situation, 75.84% of responders urge a short-term follow-up CT for any incidentally found nodule, with the size of the nodule being the most critical determinant in establishing follow-up intervals.12 Baseline nodules (prevalent) have a lower malignancy risk in oncologic patients than new or incident (not incidental) nodules, just as they do in nononcologic individuals [19]. In oncologic patients, prevalent nodules are common, and many of them are benign. In patients with colorectal cancer, the prevalence of indeterminate pulmonary nodules on staging chest CT ranged from 4 to 42%, with the majority (70%) having no clinical relevance [20]. Other than the size of the nodule, the number of nodules, contour irregularity, and the presence of pleural studding are the other radiological criteria that are used to raise the likelihood of malignancy in patients with cancer [21]. In a study by Munden *et al*, in oncologic patients, they found that 28% of small nodules detected at initial CT increased in size in the follow-up CT, suggesting metastasis [22].

MRI thorax sequences are susceptible to minimal motion artifacts and hence likely to result in reduced spatial resolu- tion when compared with the LDCT images, which could hinder the diagnostic ability of MRI; however, this was noted only in the case of nodules with size less than or equal to 4 mm in our study. In the evaluation of nodules more than 4 mm, MRI was

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noted to have a diagnostic ability at par with CT. To avoid missing a small metastasizing nodule, LDCT is the appropriate imaging modality for initial screening. The rest of the follow-up imaging can be performed with MRI at short intervals (2 months). This results in a decrease in radiation dose to the oncologic patients on regular follow-up.

Conclusion

Our study results indicate that lung MRI had a near-complete detection rate for nodules equal to or more than 5 mm in size, a reasonable detection rate for nodules between 4 and 5 mm, but a lesser detection rate for nodules less than 4 mm. Since the smallest nodule could have a clinical significance in oncology patients, baseline imaging in such patients should be preferably LDCT, and further follow-ups can be done with UTE lung MRI that can reduce the radiation dose to the oncology patients. Since the VDT of metastatic nodules is small, MRI at short intervals is suggested for detection of small new nodules that can upstage the disease.

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