Semi-quantitatively Assessed Non-contrast-enhanced MRI for Lung Cancer Screening: Detectability and Initial Outcome in 161 cases

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Introduction: Lung cancer is the leading cause of cancer-related death in both men and women. For improvement of survival in lung cancer patients, some investigators have suggested low-dose CT lung cancer screening is useful for detection of lung cancer in earlier stage [1, 2]. However, high false-positive rate is one of the major limitations of CT lung cancer screening [1]. Therefore, some investigators have been trying the improvement of false-positive rate by using non-contrast-enhanced and contrast-enhanced pulmonary MR imaging [3, 4]. In addition, recent advancement of MR technique and system may be useful as whole-body screening tool in oncology [5, 6]. However, no direct comparison between non-contrast-enhanced (non-CE) MR imaging and CT has been reported. We hypothesized that non-contrast-enhanced MR imaging has potential for improvement of false-positive rate without significant decrease of sensitivity and survival, when compared with CT. The purpose of our study was to demonstrate the utility of semi-quantitatively assessed non-CE MR imaging for lung cancer screening.

Materials and Methods: One hundred sixty-one consecutive patients (110 male patients, 51 female patients; mean age, 66.5 years; age range 29 – 84 years) with 200 pulmonary nodules (PNs) equal to or less than 30 mm in diameter were enrolled in this study. All patients prospectively underwent non-CE MR imaging, bronchoalveolar lavage, microbiologic examination, and pathological examination of specimens, which were obtained by transbronchial or percutaneous biopsy, resection at thoracotomy or video-assisted thoracic surgery, and/or follow-up CT. Nodule diameter was defined as the largest diameter on CT scans obtained with a lung window setting or respected specimens. The standard reference was defined as consensus of two chest board radiologists and a board pulmonary pathologist based on the results of initial and more than 2-year follow-up CT, microbacterial and/ or pathological examinations. All PNs were classified into two groups: malignant PNs (n=103) and benign PNs (n=97). As non-CE MR imaging, axial ECG-gated T1WI (TR 1 <R-R> ms/ TE 15 ms/ 2NEX), axial ECG- and respiratory-gated T2WI (TR 2-3 <R-R> ms/ TEeff 90 ms/ ETL 8/ 4 NEX) and short inversion time inversion-recovery (STIR) turbo spin-echo (TSE) imaging (TR 3600-5000ms/ TEeff 15 ms/ TI 150 ms/ ETL 5) were performed by using 1.5-T superconducting magnet (Intera T-15, Philips Medical Systems, Best, The Netherlands) and a body coil. Other parameters were as follow; FOV 350-400mm, 205-256×256 matrix, 410-512×512 reconstruction matrix, 5-8 mm contiguous section thickness. Signal intensity of each PN was measured and semi-quantitatively assessed as contrast-ratio between PN and the right rhomboid muscle in the same slice of the nodule (CR) by measurement of regions of interest (ROI).

To determine the capability of non-CE MR imaging as screening tool for lung cancer, detectability of each sequence as initial screening was compared with that of CT by using McNemar's test. In detected nodule by each sequence, receiver operating characteristic (ROC)-based positive test was performed to evaluate the usefulness of CR as markers for distinguishing from malignant PNs from benign PNs at same time. Then, sensitivities, specificities and accuracies of three sequences were compared each other by using Mcnemar's test. Finally, average survival time of the patients assessed as true positive PNs on the best protocol, which had best non-CE MR imaging and with malignant PNs were estimated by using the Kaplan-Meier method and log-rank tests were used to compare the survival distributions. A P value of less than 0.05 was considered to indicate a statistically significant difference.

Results: Detectabilities of CT and non-CE MRI are show in Table 1. Although overall detectablity of each sequence was significantly lower than that of CT ($p<0.05$) and sensitivities of non-CE MRI and CT had no significant differences, false-positive rate of each sequence was significantly improved as compared with CT ($p<0.05$). Feasible threshold value, sensitivity, specificity and accuracy of each sequence are shown in Table 2. When feasible threshold value of CR on STIR was adapted as 0.5, sensitivity, specificity and accuracy were 93.2 (96/103) %, 50.5 (49/97) % and 74.0 (145/200) %, respectively. Specificity of STIR was significantly higher than that of T1WI and T2WI ($p<0.05$), and accuracy of STIR was significantly higher than that of T2WI ($p<0.05$). Survival curves of lung cancer cases detected by CT and STIR are shown in Figure1. On comparison of survival periods between CT and STIR, there was no significant difference between them ($p=0.89$).

Conclusion: Semi-quantitatively assessed non-contrast-enhanced MR imaging has potential as screening tool for lung cancer. In addition, STIR TSE imaging is the best sequence for semi-quantitatively differentiate malignant pulmonary nodules from benign pulmonary nodules.

Table 1. Overall detectabiities, true-positive rate and false-positive rate of CT and non-CE MRI.

	Overall detectability (%)	True-positive rate (%)	False-positive rate (%)
CT	97.0 (194/200)	100 (103/103)	93.8 (91/97)
T1WI	82.5* (165/200)	96.1 (99/103)	68.1* (66/97)
T2WI	82.5* (165/200)	96.1 (99/103)	68.1* (66/97)
STIR	82.5* (165/200)	96.1 (99/103)	68.1* (66/97)

*: Significant difference with CT ($p<0.05$)

Table 2. Feasible threshold value, sensitivity, specificity and accuracy of each sequence

	Feasible Threshold Value	Sensitivity (%)	Specificity (%)	Accuracy (%)
T1WI	0.5	96.1 (99/103)	44.3* (43/97)	71.0 (142/200)
T2WI	1.2	91.3 (94/103)	41.2* (40/97)	67.0* (134/200)
STIR	0.8	93.2 (96/103)	50.5 (49/97)	74.0 (145/200)

*: Significant difference with STIR ($p<0.05$)

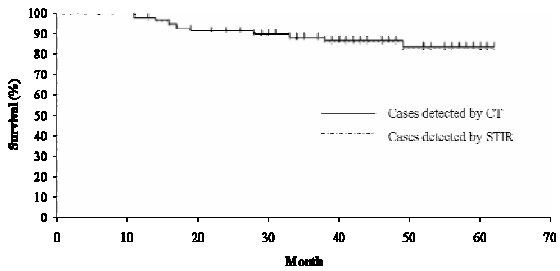

Figure 1. Survival curves of true-positive cases on CT and STIR as non-CE MR imaging.

There were no significant difference of survival periods between CT and non-CE MR imaging ($p<0.05$).

References:

1. Swensen SJ, et.al. Radiology. 2005 Apr;235(1):259-65.
2. Kaneko M, et.al. Radiology. 1996 Dec;201(3):798-802.
3. Ohno Y, et al. Radiology. 2002 Aug;224(2):503-11.
4. Both M, et al. Eur J Radiol. 2005 Mar;53(3):478-88.
5. Johnston C, et al. Eur J Surg Oncol. 2006 Apr;32(3):239-46.
6. Charles-Edwards EM, et al. Cancer Imaging. 2006 Sep 13;6:135-43..