Acta Med. Nagasaki 48 : 143−147

Chest Wall Invasion by Peripheral Lung Cancer: Preoperative Assessment with Respiratory Dynamic MRI

Kazuto ASHIZAWA[1], Masashi MURAOKA[2], Hideyuki HAYASHI[1], Tetuji YAMAGUCHI[1], Aya FUKUSHIMA[1], Naohiro MATSUYAMA[1], Hajime ABIRU[1], Shinji AKAMINE[2], Tsutomu TAGAWA[2], Tadayuki OKA[2], Takeshi NAGAYASU[2], Kuniko ABE[3], Tomayoshi HAYASHI[3], Kuniaki HAYASHI[1]

1) Division of Radiological Science, Department of Radiology and Radiation Biology, Nagasaki University Graduate School of Biomedical Sciences
2) Division of Surgical Oncology, Department of Translational Medical Sciences, Nagasaki University Graduate School of Biomedical Sciences
3) Department of Pathology, Nagasaki University Hospital

Purpose: The purpose of our study was to evaluate the usefulness of dynamic cine MRI during respiration in the assessment of chest wall invasion by lung cancer.

Materials and Methods: We prospectively performed respiratory dynamic MRI in 34 patients with peripheral lung cancer, in whom the presence of chest wall invasion was indeterminate on CT. Sequential images were obtained during respiration by using fast spoiled GRASS (SPGR) sequence, and were analyzed in cine mode display.

Results: In all 23 patients with free movement of the tumor along the chest wall on respiratory dynamic cine MRI, no chest wall invasion was found at surgery (negative predictive value 100%). In eleven patients with fixation of the tumor to the chest wall, invasion was confirmed pathologically in five patients, while benign fibrous adhesion was found in six.

Conclusion: Although it has some limitations, dynamic cine MRI during respiration is useful in evaluating chest wall invasion in patients with lung cancer, particularly when CT findings are indeterminate.

ACTA MEDICA NAGASAKIENSIA 48 : 143−147, 2003

Key Words: *lung cancer, chest wall invasion, MRI, respiratory dynamic study*

Introduction

Chest wall invasion by lung cancer is one of the indications for extended surgery. Although these patients can achieve long-term survival when complete resection is performed, the operative risk for mortality is still substantial[1-4]. Therefore, preoperative evaluation of chest wall invasion is important in planning the treatment and assessing the prognosis of the patient with lung cancer.

Conventional CT[5-7] and MRI[7-10] have been used to evaluate chest wall invasion by lung cancer. Several CT features have been proposed and evaluated as diagnostic criteria for invasion. However, distinction between tumoral contiguity with the pleural surface and actual tumor invasion is frequently difficult. Previous reports showed low accuracy of CT[5-7, 11-13] and MRI[7-10] based on static images.

Recently, Sakai et al.[14] reported a new MR technique with dynamic imaging during respiration and showed 100% high sensitivity and 100% negative predictive value (NPV). In this study, we prospectively evaluated the usefulness of this technique in the diagnosis of chest wall invasion, focusing on difficult cases in which tumor invasion was indeterminate on CT.

Materials and Methods

Between 1997 and February 2001, 48 consecutive patients with peripheral lung cancer that abutted the chest wall on CT images were prospectively studied with respiratory dynamic MRI after routine chest MRI. 14 patients were excluded from this study. 10 of these patients did not undergo surgery due to lymphnode or distant matastasis or high age, and 2 patients had evidence of rib destruction or a chest wall mass on CT images. In the remaining 2 patients, chest wall invasion was not suspected based on previously reported diagnostic criteria of CT features[5,6]. Therefore 34 patients in whom the presence of chest wall invasion was indeterminate on CT images were included in this study. One or more CT features of

Address Correspondence: Kazuto Ashizawa, M.D.
Division of Radiological Science, Department of Radiology and Radiation Biology, Nagasaki University Graduate School of Biomedical Sciences, 1-7-1 Sakamoto, Nagasaki 852-8501, Japan
TEL: +81-95-849-7355, FAX: +81-95-849-7357
E-mail: ashi@net.nagasaki-u.ac.jp

chest wall invasion (obtuse angle of the mass to the pleural surface, more than 3 cm contact with the pleural surface, visible pleural thickening associated with the mass, and obliteration of the extrapleural fat plane) were present in all patients[5,6]. These patients were 32 men and two women, ranged in age from 45-81 years (average, 66 years). Tumors included 16 squamous cell carcinomas, 10 adenocarcinomas, 4 large cell carcinomas, 3 adenosquamous cell carcinomas and 1 mucoepidermoid carcinoma. The presence or absence of chest wall invasion was confirmed surgically and/or pathologically in all of the patients.

Respiratory dynamic MRI was performed with 1.5-T MR system (Signa Horizon, GE Medical Systems, Milwaukee, WI, USA). Fast spoiled GRASS (SPGR) sequence was obtained at TR 8.9ms, TE 4.2ms and FA 30 deg. Field of view of 30cm, matrix of 256 x 128, and slice thickness of 7mm were used. Thirty sequential images during deep respiration were obtained in the coronal or sagittal planes, according to the locations of tumors.

Two radiologists analyzed the dynamic relationship between the tumor and the chest wall in the cine-loop mode on a CRT monitor. When the tumor moved freely along the parietal pleura, it was judged as negative for chest wall invasion. When the tumor was fixed to the chest wall structures, it was judged as positive for invasion. Respiratory dynamic MRI findings were then compared with the surgical and pathological findings. We evaluated chest wall invasion by the tumor that was located in the apical portion separately, because the movement of the lung along the chest wall is small even in normal individual.

Results

The dynamic MRI findings and the pathological findings are compared in Table 1. Twenty-three of the 34 patients were judged as negative for invasion because of free movement of the tumor on respiratory dynamic MRI. None of them had evidence of chest wall invasion at surgery (Fig 1). The other 11 patients demonstrated fixation of the tumor to the chest wall, and were judged as positive for tumor invasion. Pathological examination revealed that 5 of the 11 patients had chest wall invasion (Fig 2), but 6 patients had benign fibrous adhesions (Fig 3). The sensitivity, specificity, accuracy and NPV were 100%, 79%, 82% and 100%, respectively. Three patients with the tumor

Table 1. Comparison of respiratory dynamic MRI and pathological findings

	Pathological finding	
Respiratory dynamic MRI finding	Invasion	No invasion
Fixation	5	6
Free movement	0	23

Sensitivity 100%, Specificity 79%, Accuracy 82%, PPV 45%, NPV 100%

Figure 1. 57-year-old man with squamous cell carcinoma.
A: CT scan shows a cavitary mass as having a broad contact with the pleural surface, obtuse angle and partial obliteration of the extrapleural fat plane.
B: Respiratory dynamic MR images show free movement of the tumor along the chest wall, indicating no tumor invasion into the chest wall.

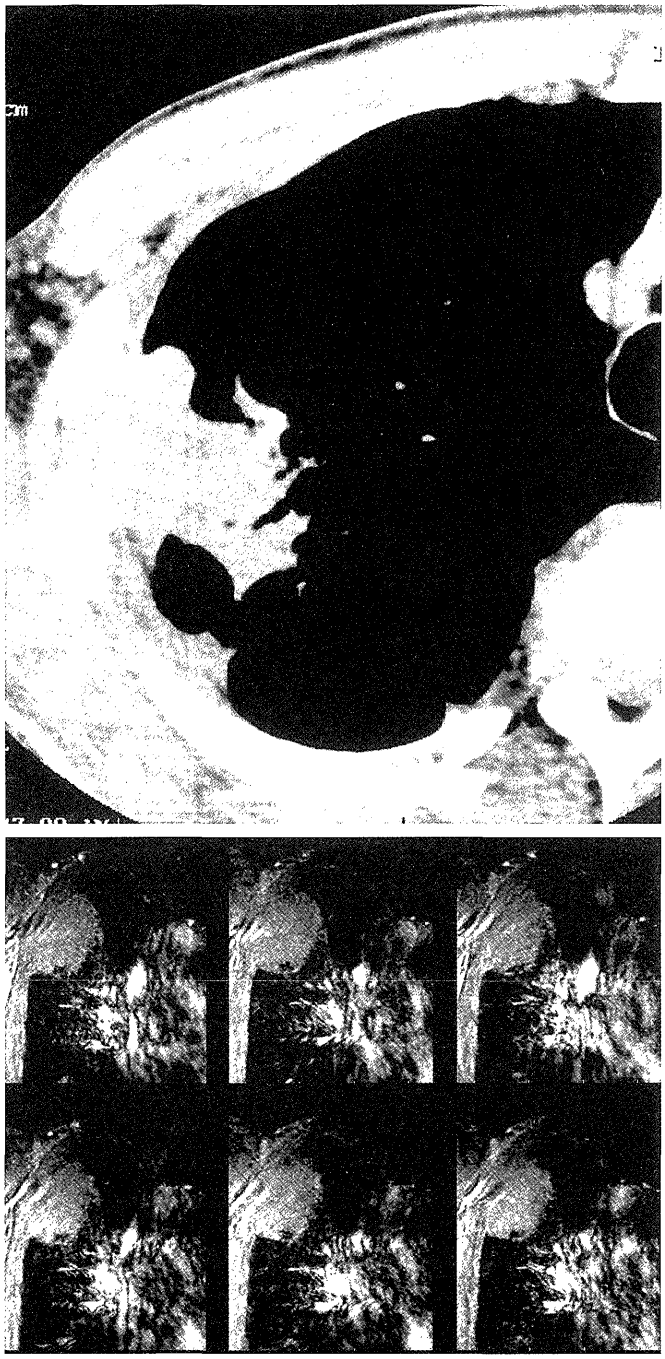

Figure 2. 64-year-old man with adenocarcinoma.
A: CT scan shows a mass as having a broad contact with the pleural surface, associated pleural thickening and obliteration of the extrapleural fat plane.
B: Respiratory dynamic MR images show that the relationship between the tumor and the chest wall is fixed. The tumor invasion into the chest wall was confirmed pathologically.

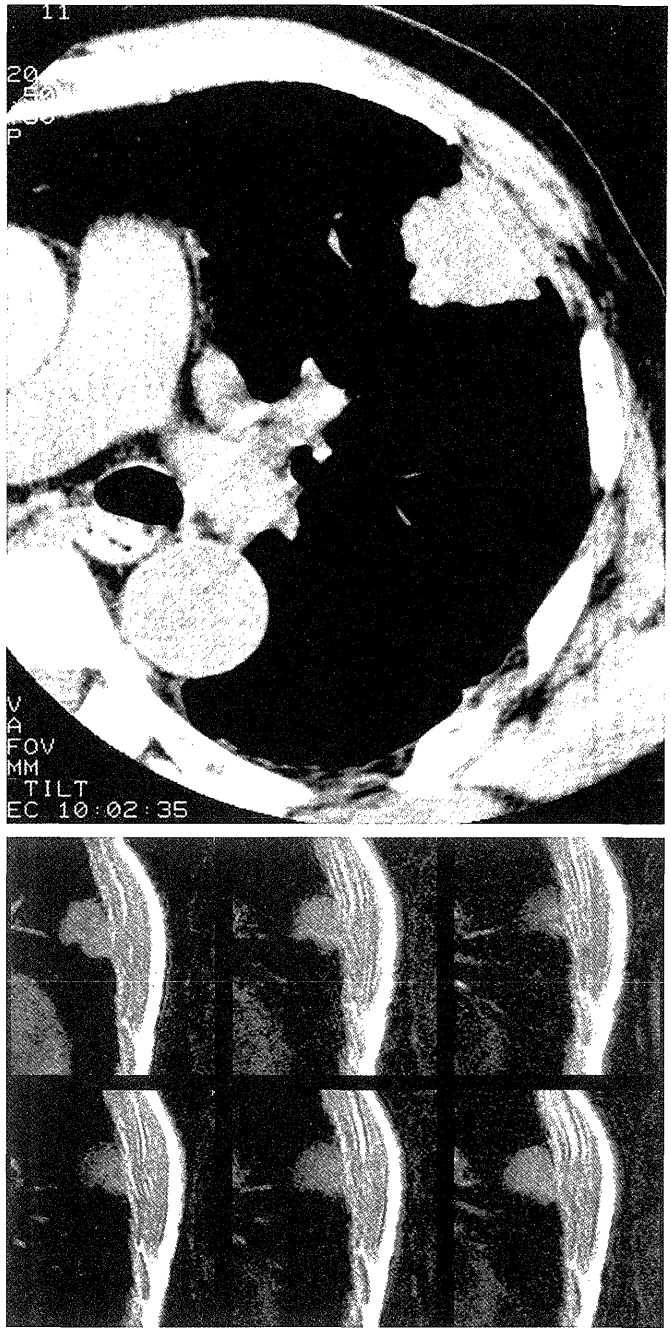

Figure 3. 80-year-old man with adenocarcinoma.
A: CT scan shows a mass as having a broad contact with the pleural surface, obtuse angle and associated pleural thickening.
B: Respiratory dynamic MR images show fixation of the tumor during respiration. Although tumor invasion into the chest wall was suspected preoperatively, benign fibrous adhesion was confirmed pathologically.

located in the apical portion were judged as positive for invasion. Two of these cases had chest wall invasion and the other one had benign fibrous adhesion pathologically.

Discussion

Conventional CT and MRI have widely been used to evaluate chest wall invasion by lung cancer

preoperatively[5-13]. When bone destruction or a chest wall mass is observed, the presence of chest wall invasion can be confidently diagnosed on CT. However several authors have reported low accuracy of CT and MRI in prediction of chest wall invasion[5-13]. CT features that have been proposed and evaluated as diagnostic criteria for invasion are as follows: obtuse angle of the mass to the pleural surface, more than 3 cm contact with the pleural surface, visible pleural thickening associated with the mass[5], obliteration of the extrapleural fat plane, or the ratio between the tumor-pleura contact and tumor diameter[6]. However, distinction between tumoral contiguity with the pleural surface and actual tumor invasion is frequently difficult with these criteria by static images.

In contrast to conventional static imaging, dynamic imaging during breathing can provide direct information about the presence or absence of attachment between the visceral and parietal pleura, and can improve diagnostic accuracy for chest wall invasion by lung cancer. Several authors have reported respiratory dynamic methods using ultrasonography[15], helical CT during deep inspiration and expiration[16], ultrafast CT with multisection expiratory dynamic scan[17] and respiratory dynamic MRI[14, 18]. All of these reports have shown high sensitivity (100%) and NPV (100%) of these methods for diagnosing chest wall invasion.

Artificial pneumothorax CT also enables a kind of dynamic assessment of chest wall invasion by lung cancer[19, 20]. Yokoi et al. reported that this method was 100% accurate in prediction of tumor invasion[19]. However, this technique is invasive and may result in symptomatic pneumothorax. In addition this technique may fail to produce artificial pneumothorax. In contrast, respiratory dynamic MRI is a quick, noninvasive examination, and can easily be performed after routine chest MRI.

We performed dynamic cine MRI in patients in whom the presence of chest wall invasion was indeterminate on static CT images, and sensitivity (100%) and NPV (100%) were comparable with the other respiratory dynamic methods in assessing tumor invasion. However, this method has some limitations in its diagnostic ability similar to the other reported dynamic methods. One limitation is the difficulty in distinction between actual tumor invasion and a benign fibrous adhesion[14]. In our study, 6 out of 11 patients with fixation of the tumor to the chest wall had benign fibrous adhesions. In 3 of the 6 patients, however, possibility of benign adhesions was considered because the tumor was not completely but partially fixed to the adjacent structures. Another limitation is that evaluation of the tumor invasion is difficult when the tumor is located in the apical portion, because of less relative movement of the lung during respiration[14, 21]. Although no patients with the tumor located in the apical portion were judged as negative in our study, this method may be superior to compared to other breathing dynamic methods because even a subtle movement of the lung could be observed in the cine mode display[14].

In conclusion, respiratory dynamic MRI is a quick, noninvasive examination, and our results indicate that this method is helpful in the evaluation of chest wall invasion by lung cancer, especially in patients in whom conventional CT findings of tumor invasion are indeterminate.

Acknowledgment

We thank Dr. Rashid Hashmi for his assistance in the preparation of this manuscript.

References

1. Roviaro G, Varoli F, Grignani F, et al. Non-small cell lung cancer with chest wall invasion: evolution of surgical treatment and prognosis in the last 3 decades. *Chest* 123: 1341-1347, 2003
2. Akay H, Cangir AK, Kutlay H, Kavukcu S, Okten I, Yavuzer S. Surgical treatment of peripheral lung cancer adherent to the parietal pleura. *Eur J Cardiothorac Surg* 22: 615-620, 2002
3. Magdeleinat P, Alifano M, Benbrahem C, et al. Surgical treatment lung cancer invading the chest wall: results and prognostic factors. *Ann Thorac Surg* 71: 1094-1099, 2001
4. Downey RJ, Martini N, Rusch VW, Bains MS, Korst RJ, Ginsberg RJ. Extent of chest wall invasion and survival inpatients with lung cancer. *Ann Thorac Surg* 68: 188-193, 1999
5. Glazer HS, Duncan-Meyer J, Aronberg DJ, Moran JF, Levitt RG, Sagel SS. Pleural and chest wall invasion in bronchogenic carcinoma; CT evaluation. *Radiology* 157: 191-194, 1985
6. Ratto GB, Piacenza G, Frola C, et al. Chest wall involvement by lung cancer; computed tomographic detection and results of operation. *Ann Thorac Surg* 51: 182-188, 1991
7. Webb WR, Gastosins C, Zerhouni EA, et al. CT and MR imaging in staging non-small cell bronchogenic carcinoma; report of the Radiologic Diagnostic Oncology Group. *Radiology* 178: 705-713, 1991
8. Padovani B, Mouroux J, Seksik L, et al. Chest wall invasion by bronchogenic carcinoma; evaluation with MR imaging. *Radiology* 187: 33-38, 1993
9. Haggar AM, Pearlberg JL, Froelich JW, et al. Chest wall invasion by carcinoma of the lung: detection by MR imaging. *AJR* 148: 1075-1078. 1987
10. Musset D, Grenier P, Carette MF, et al. Primary lung cancer staging: prospective comparative study of MR imaging with CT. *Radiology* 160: 607-611, 1986
11. Scott IR, Muller NL, Miller RR, Evans KG, Nelems B. Resectable stage III lung cancer: CT, surgical and pathologic correlation. *Radiology* 166: 75-79, 1988
12. Shin MS, Anderson SD, Myers J, Ho KJ. Pitfalls in CT evaluation of chest wall invasion by lung cancer. *J Comput Assist Tomogr* 10: 136-138, 1986
13. Pennes DR, Glazer GM, Wimbish KJ, Gross BH, Long RW, Orringer MB. Chest wall invasion by lung cancer: limitations of CT evaluation. *AJR* 144: 507-511, 1985

14. Sakai S, Murayama S, Murakai J, Hashiguchi N, Masuda K. Bronchogenic carcinoma invasion of the chest wall; evaluation with dynamic cine MRI during breathing. *J Comput Assist Tomogr* 21: 595-600, 1997
15. Suzuki N, Saito T, Kitamura S. Tumor invasion of the chest wall in lung cancer; diagnosis with US. *Radiology* 187: 39-42, 1993
16. Shirakawa T, Fukuda K, Miyamoto Y, Tanabe H, Tada S. Parietal pleural invasion of lung masses; evaluation with CT performed during deep inspiration and expiration. *Radiology* 192: 809-811, 1994
17. Murata K, Takahashi M, Mori M, et al. Chest wall invasion and mediastinal invasion by lung cancer: evaluation with multisection expiratory dynamic CT. *Radiology* 191: 251-255, 1994
18. Shiotani S, Sugimura K, Sugihara M, et al. Diagnosis of chest wall invasion by lung cancer: useful criteria for exclusion of the possibility of chest wall invasion with MR imaging. *Radiat Med* 18: 283-290, 2000
19. Yokoi K, Mori K, Miyazawa N, Saito Y, Okuyama A, Sasagawa M. Tumor invasion of the chest wall and mediastinum in lung cancer; evaluation with pneumothorax CT. *Radiology* 181: 147-152, 1991
20. Watanabe A, Shimokata K, Saka H, Nomura F, Sakai S. Chest CT combined with artificial pneumothorax: value in determining origin and extent of tumor. *AJR* 156: 707-710, 1991
21. Koalli N, Erzen C, Yuksel M. Evaluation of parietal pleural invasion of lung cancers with breathhold inspiration and expiration MRI. *Clin Imaging* 23: 227-235, 1999