Lung Cancer Assessment Using MR Imaging
An Update

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KEYWORDS

• Lung cancer • MR imaging • Nodules • Staging • Therapeutic effect

KEY POINTS

- Non–contrast enhanced (CE) MR imaging techniques can improve differentiation of malignant from benign nodules compared with routine clinical protocols.
- Dynamic MR imaging with three-dimensional GRE sequence and ultrashort TE has the potential to play a complementary role in the characterization of pulmonary nodules and as a viable alternative to dynamic CE CT, FDG-PET, and/or PET/CT.
- Because multidetector row CT is widely used clinically, potential use of MR imaging in T-factor assessment may be limited; when MR imaging is used in this setting, STIR turbo SE imaging and three-dimensional CE GRE sequence may be helpful.
- For N-factor assessment, STIR turbo SE imaging can improve diagnostic performance compared with DWI and FDG-PET and/or PET/CT, although DWI is considered at least as valuable as PET or PET/CT.
- For M-factor assessment, whole-body MR imaging with and without DWI is as effective as FDG-PET or PET/CT in routine clinical practice.

OUTLINE

Since the 1980s many physicists and radiologists have been trying to evaluate the efficacy of MR imaging for various lung diseases, and for mediastinal and pleural diseases. Until 2000, however, thoracic MR imaging had shown limited clinical relevance, and could not be substituted for computed tomography (CT) and other modalities. It was therefore generally used for select clinical indications. During the first decade of this century, numerous basic and clinical researchers in radiology reported technical advances in sequencing, scanners and coils, adoption of parallel imaging techniques, use of contrast media, and development of postprocessing tools. In addition, several promising new techniques, including short inversion time inversion recovery (STIR) turbo spin echo (SE) imaging, diffusion-weighted imaging (DWI), and pulmonary functional MR imaging,

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have been extensively researched and developed, leading to a re-examination of MR imaging as a new research and diagnostic tool for various pulmonary diseases, especially lung cancer. As a result, state-of-the-art thoracic MR imaging now has the potential to be used as a substitute for traditional imaging techniques and/or to play a complementary role in patient management.

This article focuses on these recent advances in MR imaging for lung cancer imaging, especially for pulmonary nodule assessment, lung cancer staging, prediction of postoperative lung function, prediction of therapeutic response, and recurrence. The potential and limitations for routine clinical application of these advances are also discussed and compared with those of other modalities, such as CT, PET, and PET/CT.

INTRODUCTION

Lung cancer is one of the most common cancers worldwide with the highest mortality for men and women,[1] and frequently manifests as a lung nodule or mass. Radiologically identified lung lesions that are less than 30 mm in diameter are known as pulmonary nodules, whereas those larger than 30 mm are called masses. Diagnosis and further characterization of pulmonary nodules is one of the most important areas of pulmonary medicine for appropriate management. Early diagnosis is important because non–small cell lung cancer (NSCLC), which currently accounts for 80% of all lung cancers, can be cured surgically if detected at an early stage.[2] However, most patients with NSCLC present late in the course of their illness, often at an inoperable, advanced stage.[3–5]

Apart from characterization, another potential application of MR imaging is tumor staging. NSCLC is usually staged with the tumor, lymph node, and metastasis (TNM) staging system, which has been recommended by the Union Internationale Contre le Cancer, the American Joint Committee on Cancer, and the International Association for the Study of Lung Cancer. However, small cell lung carcinoma, which constitutes approximately 13% to 20% of all lung cancers,[6] is staged with a two-stage system developed by the Veteran's Administration Lung Cancer study group. Irrespective of the type of staging system, radiologic examinations including CT, MR imaging, PET with 2-[fluorine-18] fluoro-2-deoxy-D-glucose (FDG-PET), and FDG-PET combined with CT (FDG-PET/CT) are important for pretherapeutic assessment in conjunction with pathologic information from transbronchial/CT-guided/mediastinoscopic biopsies.

Recent technical advances in MR systems, application of parallel imaging, introduction of new MR techniques, and use of contrast media have markedly improved the diagnostic accuracy of MR imaging in this setting. Also, FDG-PET combined or fused with MR imaging (FDG-PET/MR imaging) is now being evaluated in several studies as an emerging technique. This article focuses on these recent advances in MR imaging, and its potential clinical applications and limitations particularly in pulmonary nodule assessment and lung cancer staging.

PULMONARY NODULE AND MASS ASSESSMENT

Most solitary pulmonary nodules are incidental findings on chest radiographs obtained for unrelated diagnostic work-ups. In addition, a growing number are being detected on chest CTs as a direct result of increased use of CT examinations in routine clinical practice. Results of national lung cancer screening trials and previous CT-based lung cancer screening studies have led to a growing need for management of pulmonary nodules.[7] Although CT facilitates detection of an unsuspected lung cancer, the major drawback is exposure to ionizing radiation and a concomitant increase in the detection of benign and indeterminate nodules. This upsurge in the frequency of nodule detection is associated with an increase in the number of follow-up studies, further radiologic examinations, and/or of interventional procedures and associated costs. MR imaging is associated with no radiation, and is being evaluated as a possible alternative or complementary technique for management of such nodules in addition to traditionally used techniques.

Since the clinical application of MR imaging in the chest, SE or turbo SE sequences have aided in the detection of numerous pulmonary nodules including lung cancers, pulmonary metastases, and low-grade malignancies, such as carcinoids and lymphomas. Such lesions usually show low or intermediate signal intensity on T1-weighted imaging (T1WI) and slightly high intensity on T2-weighted imaging (T2WI). Previous reports[8–18] have suggested that T2WI and pre– and post–contrast-enhanced (CE) T1WI are useful for diagnosis of specific types of nodule or masses, such as bronchoceles, tuberculomas, mucin-containing tumors, hamartomas, and aspergillomas based on their specific MR findings, although significant overlap occurs between benign and malignant nodules or masses.

To overcome this limitation, STIR turbo SE imaging and DWI were introduced in 2008 as promising sequences for nodule assessment.[19,20] Koyama and colleagues[19] demonstrated that