Imaging of Bronchial Carcinoma

Stefan O. Schoenberg, Christian Fink and Bastian Fischer

CONTENTS

42.1 Epidemiology 471
42.2 Radiological Staging 471
42.2.1 T Stage 471
42.2.2 N Stage 472
42.2.3 M Stage 473
42.3 Role of Parallel-Imaging Techniques 474
42.3.1 Increase of Temporal and Spatial Resolution 474
42.3.2 Reduction of Signal Decay and Blurring in Single-Shot Acquisitions 476
42.3.3 Reduction of Acquisition Time 476
42.3.4 Increase of Anatomic Coverage 479
42.4 Conclusion 479
References 479

42.1
Epidemiology

Non-small-cell lung cancer (NSCLC) is still the leading cause of death from a malignancy in men, with a rising incidence in women. In the past decade, the therapeutic options for advanced stages of NSCLC have been substantially improved, including new chemotherapeutic and anti-angiogenic agents for first- and second-line medical treatment, new protocols for neo-adjuvant and adjuvant chemotherapy as well as improved techniques for surgical resection of centrally growing tumors. These developments require improved non-invasive imaging modalities for staging of resectability and operability in order to select the adequate treatment options for the individual patient.

42.2
Radiological Staging

The staging of non-small-cell lung cancer has to be performed in an interdisciplinary approach considering all clinical, radiological, nuclear-medicine, and histological results. The radiological staging is done according to the TNM classification with T describing the extent of the primary tumor, N the presence and location of metastatic lymph nodes and M the presence or absence of distant metastases. It is important to remember that the individual stages of the TNM classification have undergone numerous revisions and thus need to be considered in their most recent version (Mountain 1997; Mountain and Dresler 1997). For the radiologist, it is also important to know which therapy the patient is possibly undergoing in order to optimize the imaging strategy. Spiral CT is currently viewed as the backbone of radiological staging. With the new 16- to 64-channel generation of multi-slice CT systems, the entire thorax can be scanned in less than 10 s with 1-mm slice thickness.

42.2.1
T Stage

For the assessment of the tumor extension, special attention has to be drawn to the assessment of chest-wall and mediastinal invasion, since these findings directly affect the tumor stage. The only reliable CT sign is a mass in the chest wall or the presence of rib destruction (Libshitz 1990; Pearlberg 1987). However, these signs have a poor sensitivity of only...
20% with moderate specificity. The accuracy can be moderately increased if other findings such as an obtuse angle with the thoracic wall, thickening of the underlying pleura, and presence of chest pain are also considered (Scott et al. 1998). Highest accuracies are found in dynamic expiratory scans that demonstrate a decreased or absent mobility of the ingrown tumor (Murata et al. 1994); however, this technique has not gained wide-spread use in the clinical routine. Due to the oblique course of the left and right main stem bronchus, delineation of an infiltration of the carina is difficult to assess on standard spiral CT with 5-mm-thick slices. Multi-slice CT has advantages compared to standard spiral CT since the course of the entire bronchial tree can be delineated on three-dimensional reconstructions of thin-slice images (Grandy 2001). Multiplanar reconstructions also reduce errors from partial volume effects, particularly in the apex of the lung where the convex surface of the lungs might erroneously cause an impression of superior sulcus infiltration.

Accuracy for the assessment of mediastinal invasion by CT, however, is limited. Definite proof of tracheal invasion is only present in the case of intraluminal or circumferential tumor growth, while the sole contact between the tumor and the trachea does not suffice to make the diagnosis of tracheal invasion. In these cases, mediastinoscopy or endotracheal sonography is necessary to make the diagnosis (Hert and Becker 2000). While tumors with partial encasement can usually be considered resectable, the assessment of the mediastinal fat planes as a criterion for operability is less reliable (Herman et al. 1994) with both false-positive and false-negative findings.

Due to the superior tissue contrast of magnetic resonance imaging, vessels can be delineated from surrounding mediastinal structures without any contrast agents as a result of the black-blood effect. In case of slow flow, however, inflowing blood might still contribute to the signal within the plane, giving the false impression of a thrombosed vessel or solid structure such as a lymph node. With the introduction of fast time-resolved three-dimensional contrast-enhanced MR angiography (3D-CE-MRA), these limitations can be overcome. Several studies have demonstrated the superiority of MRI for delineation of the extrapleural fat plane and detection of tumorous chest wall invasion, particularly on coronal scans (Manfredi et al. 1996). Sensitivity and specificity reach 90% (Padovani et al. 1993). MR imaging should be always performed for tumors with superior sulcus invasion. Invasion of pulmonary arteries and veins is well visualized on the individual 3D-CE-MRA scans (Schoenberg et al. 1998). Sometimes, atelectasis can be differentiated from the primary tumor by the different signal intensity on MR images (Kauczor and Kreitner 1999). These advantages are of importance since nowadays tumors with limited invasion of the pericardium, the mediastinal pleura and fat as well as infiltration of the vagal and phrenic nerve routinely undergo resection. Even advanced tumors with limited invasion of the left atrium or even the carina can be resected in selective cases (Mitchell et al. 1999; Shirakusa et al. 1998). However, the so-called desmoplastic reaction caused by tumor-induced proliferation of benign connective tissue adjacent to the tumor can result in an overestimation of the stage of the tumor (Webb et al. 1991). MR is advantageous for the delineation of the desmoplastic reaction due to the larger differences in signal intensity between the tumor and adjacent connective tissue. On the other hand, MR is inferior to CT for the assessment of endo-bronchial tumor growth due to the poorer spatial resolution and the signal loss in air-containing structures.

In conclusion, the sole use of CT alone is not sufficient for the accurate staging of borderline findings such as tracheal or mediastinal infiltration. In any case, multi-slice CT should be used to reformat the data set in multiple planes for the most accurate determination of the single longest tumor diameter according to the RECIST criteria. Compared to CT, MRI has various advantages for assessment of the T stage. Nevertheless, so far detection of mediastinal invasion has not proved to be superior compared to CT despite the better soft tissue contrast (Manfredi et al. 1996; Webb et al. 1985).

42.2.2 N Stage

Staging of lymph nodes still remains a major challenge to cross-sectional imaging since only 10% to 15% of all patients are found to be stage I, and thus do not reveal any metastatic lymph nodes. Complete resection of these nodes improves the prognosis of the patient (Keller et al. 2000). The key to the accurate staging and resection of lymph nodes is the correct localization of these nodes along anatomic structures (Mountain and Dresler 1997). Standardized lymph nodes maps should be used to correlate the location of an enlarged lymph node in CT, mediastinoscopy and bronchoscopy; however, not all