Use of Imaging in Assessing Lung Carcinoma

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The evaluation of patients with lung cancer requires the imaging of various abnormalities. It is very likely that CT will continue to be used as the primary imaging modality for the evaluation of lung cancer patients. Although the routine use of MR is not recommended, MRI can be advantageous in certain situations.

Staging of Bronchogenic Carcinoma

In patients with lung cancer, the anatomic extent of the tumor is usually most important in determining what therapeutic approach will be chosen. Generally, tumors are considered to be unresectable if they are classified as T4, N3, or M1.[1] However, it is important to note that different surgeons can have different anatomic criteria for considering a tumor unresectable, and a careful and detailed discussion of the radiographic findings with the involved surgeon is necessary in individual cases.[2]

Invasive Primary Tumors

Assessment of the primary tumor extent is essential in planning treatment.[3,4] CT is most advantageous for assessing the primary tumor. Although MRI offers no significant advantage relative to CT in the diagnosis of T classification,[5-8] it can be valuable in specific situations.

A primary tumor is classified T4 if it 1) involves the trachea or carina, 2) invades the chest wall with involvement of great vessels, vertebral body, or brachial plexus, 3) invades the mediastinum with involvement of the heart, great vessels, trachea, esophagus, invades or 4) is associated with a malignant pleural effusion.[1] Tumors invading the chest wall, including the superior pulmonary sulcus, diaphragm, mediastinal pleural, pericardium, or proximal main bronchus are considered resectable by many surgeons, and are classified as T3.

Tracheal or Carinal Involvement

Although CT and MRI can be used to demonstrate tracheal involvement, bronchoscopy with biopsy is necessary in all cases. In patients with primary tracheal carcinoma, CT is important for demonstrating the extratracheal extent of disease. Central bronchial tumors are usually unresectable if the carina is involved.

Chest Wall Invasion

CT findings which have been considered to indicate chest wall invasion include the presence of obtuse angles at the point of contact between tumor and pleura, more than 3 cm of contact between tumor and the pleural surface, pleural thickening adjacent to the mass, and increased density of extrapleural fat, but these findings are not highly accurate.[9-10] In one study, CT criteria for diagnosing chest wall invasion were evaluated in a series of 112 patients who had surgery.[11] The findings assessed included (1) obliteration of the extrapleural fat plane, (2) the length of the tumor-pleura contact, (3) the ratio between the tumor-pleura contact and the tumor diameter, (4) the angle of the tumor with the pleura, (5) a mass involving the chest wall, and (6) rib destruction. Findings 1 (sensitivity 85%, specificity 87%) and 3 (sens. 83%, spec. 80%) were most accurate.[11]

The extent of chest wall invasion adjacent to a lung tumor may be better shown using MR than CT, because of the better contrast between tumor and chest wall fat and muscle.[6,12,13] Extrapleural fat may be better shown on MR, and may be effaced in the presence of early invasion The use of T1 weighted images or T1 weighted images with contrast enhancement are more accurate (sens. 90%; spec. 86%) than T2 weighted images.[14]

In patients with Pancoast tumors, vertebral body invasion or invasion of the mediastinum or great vessels above the lung apex prevent surgical resection.[1] MR images in the sagittal or coronal planes are advantageous in imaging apical tumors, and are more accurate than CT in diagnosing invastion,[13,15,16] and involvement of the subclavian artery or brachial plexus. The evaluation of Pancoast tumors is clearly an indication for MRI.

Recently, the use of artificial pneumothorax has been used in conjunction with CT for diagnosing chest wall invasion,[17,18] with a sensitivity of 100% and a specificity of 80%.

Sonography has also been investigated. Findings considered diagnostic of chest wall invasion were 1) disruption of the pleura, 2) extension through the chest wall, and 3) fixation of the tumor during breathing.[19] Sensitivity, specificity, and accuracy for sonography were 100%, 98%, and 98%. The use of dynamic CT obtained during respiration has, also been used to show whether a peripheral tumor moves relative to the chest wall or appears fixed. However, the accuracy of this technique is yet to be established, and appears to be of limited value in assessing apical lesions.

It has recently been suggested that 3-D reconstruction of helical CT images can be valuable in diagnosing pleural invasion by lung cancer.

Mediastinal Invasion

Contiguous invasion of the mediastinum with involvement of the heart, great vessels, trachea, or esophagus precludes resection.[1] Invasion of the left pulmonary artery within 2 cm of its origin, or invasion of the main right pulmonary artery usually prevent resection. Invasion of the mediastinal pleura or pericardium does not prevent resection, although significant invasion of mediastinal fat usually does.

As seen on CT, contiguity of tumor mass with the mediastinal pleura or thickening of the mediastinal pleura does not indicate mediastinal extension or unresectability. However, a significant mediastinal mass contiguous with a lung tumor, which results in compression of mediastinal vessels or esophagus, or replacement of mediastinal fat by soft tissue density is strong evidence. Other findings which can indicate mediastinal invasion include 1) obliteration of the fat plane normally seen adjacent to mediastinal vessels, 2) tumor contacting more than 1/4 of the circumference of a vessel wall, or 3) tumor contacting more than 3 cm of the mediastinum [20]. In a recent study, the extent of contact between tumors and mediastinal structures was assessed using CT and compared to surgical results in patients with lung cancer.[21] In general, the more extensive the contact, the more likely invasion had occurred; when mass contacted more than half of the circumference of a mediastinal structure invasion was very likely. However, findings having a high positive predictive value were relatively insensitive.[21]

As with CT, MR is incapable of accurately demonstrating subtle mediastinal invasion. In one study,[7] accuracies of CT and MR measured 89% and 93% respectively. In the RDOG study[8] MR was found to be significantly more accurate than CT in diagnosing mediastinal invasion, but this result was based on a small number of patients who had invasion. MR is occasionally performed in this setting, particularly when vascular invasion is suspected. MR can be more accurate than CT in diagnosing mediastinal vascular invasion.[13,22] In some patients, obtaining both CT and MRI may be helpful in making this diagnosis.[23]

Malignant Pleural Effusion

Thoracentesis with cytologic examination is necessary for making this diagnosis. Pleural nodularity visible on CT suggests metastatic involvement of the pleura. Pleural thickening visible on CT indicates that the effusio'n is an exudate, although this finding does not necessarily indicate that cytology will be positive.[24] The absence of pleural thickening does not rule out a malignant effusion.

Lymph Node Metastases

Ipsilateral mediastinal or subcarinal node metastases are classified N2, and are considered potentially resectable; contralateral hilar or mediastinal node metastases are N3 and unresectable.[1] There is some consensus that in patients who have limited mediastinal node metastases, resection should be attempted. The presence of gross or bulky node metastases and node metastases which have invaded through the node capsule are associated with a poor survival after surgery and are generally not resected. Some also consider that the presence of mediastinal node metastases detected at mediastinoscopy contraindicate surgery.[25]

Mediastinal Nodes

The accuracy of CT in predicting the presence or absence of mediastinal node metastases is limited[3,26,27] In studies which use total nodal sampling as the gold standard, in which the mediastinum is carefully explored surgically with all nodes being submitted for histologic study, the measured sensitivity of CT is lower than in studies in which the mediastinum was evaluated only by mediastinoscopy or palpation at surgery.[28] In recent studies using nodal sampling,[5,8,26,28-30] the sensitivity (60%) and accuracy (67%) of CT in diagnosing mediastinal node metastases have been lower than the sensitivity and accuracy rates (78% and 87%) reported in earlier studies in which nodal sampling was not performed.[31-35] Although mediastinoscopy is more accurate than CT, some regions of the mediastinum are not usually accessible; CT is generally used to guide mediastinoscopy.

In general, MR is quite similar to CT in its ability to detect and define mediastinal lymph nodes. In studies which have compared the accuracy of CT and MR in this regard, they have been shown to be quite similar.[5-8,36-40]

The sensitivity of CT or MRI in diagnosing mediastinal node metastases on a patient-bypatient basis is higher than its sensitivity in detecting metastases in a specific node or node group. In a study of 143 patients,[26] the sensitivity of CT for detecting mediastinal lymph node metastases was 64%, with a specificity of 62%; in this study, the sensitivity of CT for detecting metastasis to individual node stations was only 44%. The MRI characteristics of mediastinal nodes are not helpful in distinguishing benign and malignant nodes; involved and uninvolved nodes cannot be accurately distinguished on the basis of T1 and T2 values.[41,42] The use of Gadolinium-DTPA for imaging mediastinal nodes and masses is not of great value in the differentiation of benign and malignant nodes or masses;[13] however, recently it has been suggested that the enhancement patterns of mediastinal nodes may be of some value.

Recently the use of positron emission tomography (PET) has been evaluated for the diagnosis of mediastinal lymph node metastases from lung cancer .[43] In this study, the 11 C-methionine uptake of mediastinal lymph nodes was expressed using the distribution absorption ratio (DAR). The average DAR in metastatic lymph nodes was 3.89 while that of non-metastatic nodes was 2.38 (p 0.001). A threshold for detection of metastasis of 3.3 had a sensitivity of 100%, specificity of 87.3%, and an overall accuracy of 89.7%. In a recent study by Wahl, FDG PET had a sensitivity of 82% and a specificity of 81% in detecting and localizing mediastinal metastases; CT in the same study had a sensitivity of 64% and a specificity of 44%.

Hilar Masses

Although the presence of extent of a hilar mass does not always affect resectability, assessment of the hila is important in preoperative evaluation. Contrast-enhanced CT and MRI are both quite accurate in detecting hilar mass [36,44]. However, in some patients with poor vascular opacification at CT, MRI allows a more confident diagnosis that the hilum is normal or abnormal. Also, in an occasional case, MRI can demonstrate node enlargement invisible at CT.[36] MRI is advantageous in patients who are unable to tolerate contrast. On the other hand, CT is much more accurate than CT in assessing hilar bronchi and their relationship to masses.

Because of its value in delineating hilar vessels, MRI may be helpful in determining which patients will require a pneumonectomy; invasion or involvement of the central pulmonary arteries or veins usually necessitates pneumonectomy.

Hilar mass and distal lung consolidation resulting from bronchial obstruction can often be distinguished on MR images. Bronchogenic carcinoma and distal collapse are most easily distinguished with T2 weighting;[22,36,45,46] on T2-weighted images, the lung consolidation appears more intense than the hilar mass. Gd-DTPA enhanced MRI allowed the differentiation of tumor and distal obstructive pneumonia or atelectasis in 85% of patients with hilar iung cancer .[47]

References

1. Friedman PJ. Lung cancer: update on staging classifications. *AJR* 1988; 150:261-264.

2. Epstein DM, Stephenson LW, Gefter WB, van der Voorde F, Aronchik JM, Miller WT. Value of CT in the preoperative assessment of lung cancer: a survey of thoracic surgeons. *Radiology* 1986; 161:423-427.

3. Webb WR, Golden JA. Imaging strategies in the staging of lung cancer. *Clin Chest Med* 1991; 12:133-150.

4. Klein JS, WeW WR. The radiologic staging of lung cancer. *J Thorac Imag* 1991; 7: 1:29-47.

5. Grenier P, Dubray B, Carette MF, Frija G, Musset D, Chastang C. Preoperative thoracic staging of lung cancer: CT and MR evaluation. *Diagn Inter Radiol* 1989; 1:23-28.

6. Musset D, Grenier P, Carette MF, et al. Primary lung cancer staging: prospective comparative study of MR imaging with CT. *Radiology* 1986; 160:607-611.

7. Laurent F, Drouillard J, Dorcier F, et al. Bronchogenic carcinoma staging: CT vs MR imaging. assessment with surgery. *Eur J Cardio-thorac Surg* 1988; 2:31-36.

8. Webb WR, Gatsonis C, Zerhouni EA, et al. CT and MR imaging in staging non-small cell bronchogenic carcinoma: report of the Radiologic Diagnostic Oncology Group. *Radiology* 1991; 178:705-713.

9. Pennes DR, Glazer GM, Wimbish KJ, Gross BH, Long RW, Orringer MB. Chest wall invasion by lung cancer: limitations of CT evaluation. *AJR* 1985; 144:507-511.

10. Glazer HS, Duncan MJ, Aronberg DJ, Moran JF, Levitt RG, Sagel SS. Pleural and chest wall invasion in bronchogenic carcinoma: CT evaluation. *Radiology* 1985; 157:191-194.

11. Ratto GB, Piacenza G, Frola C, et al. Chest wall involvement by lung cancer: computed tomographic detection and results of operation. *Ann Thorac Surg* 1991; 51:182-188.

12. Haggar AM, Pearlberg JL, Froelich JW, et al. Chest-wall invasion by carcinoma of the lung: detection by MR imaging. *AJR* 1987; 148:1075-1078.

13. Kono M, Sako M, Adachi S, et al. [MR imaging in the assessment of lung cancer patients: primary lung cancer staging, evaluation of therapeutic effect and diagnosis of recurrent tumor]. *Nippon Acta Radiologica* 1989; 49:831-840.

14. Padovani B, Mouroux J, Seksik L, et al. Chest wall invasion by bronchogenic carcinoma: evaluation with MR imaging. *Radiology* 1993; 187:33-38.

15. Webb WR, Jensen BG, Gamsu G, Sollitto R, Moore EH. Coronal magnetic resonance imaging of the chest: normal and abnormal. *Radiology* 1984; 153:729-735.

16. Heelan RT, Demas BE, Caravelli JF, et al. Superior sulcus tumors: CT and MR imaging. *Radiology* 1989; 170:637-641.

17. 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* 1991; 181:147-152.

18. 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* 1991; 156: 707-710.

19. Suzuki N, Saitoh T, Kitamura S. Tumor invasion of the chest wall in lung cancer: diagnosis with US. Radiology 1993; 187:39-42.

20. Glazer HS, Kaiser LR, Anderson DJ, et al. Indeterminate mediastinal invasion in bronchogenic carcinoma: CT evaluation. *Radiology* 1989; 173:37-42.

21. Herman SJ, Winton TL, Weisbrod GL, Towers MJ, Mentzer SJ. Mediastinal invasion by bronchogenic carcinoma: CT signs. *Radiology* 1994; 190:841-846.

22. Kameda K, Adachi S, Kono M. Detection of T-factor in lung cancer using magnetic resonance imaging and computed tomography. *J Thorac Imaging* 1988; 3:2:73-80.

23. Adachi S, Kono M, Tanaka K, et al. [Diagnosis of invasion to thoracic aorta and superior vena cava in lung cancer. comparative studies on CT and MRI in resected or autopsied cases. *Japanese Journal of Clinical Radiology* 1990; 35:803-810.

24. Aquino SL, Webb WR, Gushiken BJ. Pleural exudates and transudates: diagnosis with contrast-enhanced CT. *Radiology* 1994; 192:803-808.

25. Pearson FG, DeLarue NC, Ilves R, et al. Significance of positive superior mediastinal nodes identified at mediastinoscopy in patients with resectable cancer of the lung. *J Thorac Cardiovasc Surg* 1982; 83: 1- 11.

26. McLoud TC, Bourgouin PM, Greenberg RW, et al. Bronchogenic carcinoma: analysis of staging in the mediastinum with CT by correlative lymph node mapping and sampling. *Radiology* 1992; 182:319-323.

27. Dales RE, Stark RM, Raman S. Computed tomography to stage lung cancer: approaching a controversy using meta-analysis. *Am Rev Respir Dis* 1990; 141: 1096-1101.

28. McKenna RJ, Libshitz HI,' Mountain CE, McMurtrey MJ. Roentgenographic evaluation of mediastinal nodes for preoperative assessment in lung cancer. *Chest* 1985; 88:206-210.

29. Staples CA, Muller NL, Miller RR, Evans KG, Nelems B. Mediastinal nodes in bronchogenic carcinoma: comparison between CT and mediastinoscopy. *Radiology* 1988; 167:367-372.

30. Mori K, Yokoi K, Saito Y, Tominaga K, Miyazawa N. Diagnosis of mediastinal lymph node metastases in lung cancer. *Jpn J Clin Oncol* 1992; 22:35-40.

31. Baron RL, Levitt RG, Sagel SS, White MJ, Roper CL, Marbarger JP. Computed tomography in the preoperative evaluation of bronchogenic carcinoma. *Radiology* 1982; 145:727-732.

32. Daly BDT, Faling LJ, Pugatch RD, et al. Computed tomography: an effective technique for mediastinal staging in lung cancer. *J Thorac Cardiovasc Surg* 1984; 88:486-494.

33. Faling LJ, Pugatch RD, Jung-Legg Y, et al. Computed tomographic scanning of the mediastinum in the staging of bronchogenic carcinoma. *Am Rev Respir Dis* 1981; 124:690-695.

34. Khan A, Gersten KC, Garvey J, Kahn FA, Steinberg H. Oblique hilar tomography, computed tomography, and mediastinoscopy for prethoracotomy staging of bronchogenic carcinoma. *Radiology* 1985; 156:295-298.

35. Osborne DR, Korobkin M, Ravin CE, et al. Comparison of plain radiography, conventional tomography, and computed tomography in detecting intrathoracic lymph node metastases from lung carcinoma. *Radiology* 1982; 142: 157- 161.

36. Webb WR, Jensen BG, Sollitto R, et al. Bronchogenic carcinoma: staging with MR compared with staging with CT and surgery. *Radiology* 1985; 156: 117- 124.

37 Poon PY, Bronskill MJ, Henkelman RM, et al. Mediastinal lymph node metastases from bronchogenic carcinoma: detection with MR imaging and CT. *Radiology* 1987; 162:651-656.

38. Batra P, Brown K, Collins JD, Ovenfors CO, Steckel RJ. Evaluation of intrathoracic extent of lung cancer by plain chest radiography, computed tomography, and magnetic resonance imaging. *Am Rev Respir Dis* 1988; 137: 1456-1462.

39. Patterson GA, Ginsberg RJ, Poon PY, et al. A prospective evaluation of magnetic resonance imaging, computed tomography, and mediastinoscopy in the preoperative assessment of mediastinal node status in bronchogenic carcinoma. *J Thorac Cardiovasc Surg* 1987; 94:679684.

40. Dubray B, Grenier P, Carette MF, Frija G, Chastang C. [Mediastinal lumph node involvement in bronchogenic carcinoma. CT and MRI evaluation using ROC methodology]. *Rev Im Med* 1991; 3:249-256.

41. Glazer GM, Orringer MB, Chenevert TL, et al. Mediastinal lymph nodes: relaxation time/pathologic correlation and implications in staging of lung cancer with MR imaging. *Radiology* 1988; 168:429-431.

42. de Geer G, Webb WR, Sollitto R, Golden J. MR characteristics of benign lymph node enlargement in sarcoidosis and Castleman's disease. *Eur J Radiol* 1986; 6: 145- 148.

43. Miyazawa H, Arai T, Inagaki K, Morita T, Yano M, Hara T. [Detection of mediastinal lymph node metastasis from lung cancer with positron emission tomography (PET) using 1 [Cmethionine]. *Nippon Kyobu Geka Gakkai Zasshi* 1992; 40:2125-30.

44. Glazer GM, Gross BH, Aisen AM, Quint LE, Francis IR, Orringer MB. Imaging of the pulmonary hilum: a prospective comparative study in patients with lung cancer. *AJR* 1985; 145:245-248.

45. Tobler J, Leviu RG, Glazer HS, Moran J, Crouch E, Evans RG. Differentiation of proximal bronchogenic carcinoma from postobstructive lobar collapse by magnetic resonance imaging: comparison with computed tomography. *Invest Radiol* 1987; 22 : 538 – 543.

46. Bourgouin PM, McLoud TC, Fitzgibbon JF, et al. Differentiation of broncogenic carcinoma from postobstructive penumonitis by magnetic resonance imaging: histopathologic correlation. *J Thorac Imag* 1991; 6 : 22-27.

47. Kusumoto M. [Clinical studies for usefulness of Gd-DTPA enhanced MRI in lung cancer]. *Nippon Acta Radiologia* 1992; 52 : 358-371.