CT Staging of Lung Cancer*: The Role of Artificial Pneumothorax

Jin Seong Lee, M.D., Jung-Gi Im, M.D., Man Chung Han, M.D.

Department of Radiology, Seoul National University College of Medicine

To determine the role of artificially induced pneumothorax in the evaluation of the chest wall and mediastinal invasion in patients with peripheral bronchogenic carcinoma, CT scans of 22 patients obtained after induced pneumothorax were evaluated. All patients had peripheral lung mass abutting the pleura on a routine CT scan. Room air of 200 - 400ml was introduced through intrathoraciac negative pressure initially, followed by pressure injection through the 18 gauge long bevelled needle under fluoroscopic con-
The region of the mass abutting the pleura was positioned at the top for easy separation by interposed air during CT scanning. Eleven of the 22 tumors were separated from the parietal pleura by artificial pneumothorax, and 11 were not. Eight of the 11 cases whose masses were separated from the pleura underwent surgery. In all eight cases, the parietal pleura did not show any evidence of cancer infiltration on both gross and microscopic examinations. Four of the 11 cases whose masses were not separated underwent surgery. Surgico-pathological examination revealed mediastinal invasion in two, and chest wall invasion in one. The remaining one patient had only fibrous adhesion on histopathologic examination.

Overall accuracy of CT scan with artificial pneumothorax was 93% (14/15). Conclusively, CT with artificial pneumothorax added more information than conventional CT in the evaluation of the chest wall or mediastinal invasion by lung cancer without notable risk.

Surgical removal currently is known to be the treatment of choice in the non-small cell bronchogenic carcinoma, if it is resectable. In peripherally located tumors, preoperative identification of mediastinal or chest wall involvement could offer more accurate treatment planning and thus could decrease the morbidity associated with thoracotomy (1). A variety of radiological procedures has been used to detect the chest wall or mediastinal involvement by bronchogenic carcinoma. Although conventional CT is useful in assessing direct mediastinal tumor extension or chest wall invasion of primary bronchogenic carcinoma, recent reports have shown CT to be unreliable (2-6). CT with artificial pneumothorax might have several potential advantages over the conventional CT, and permit more accurate staging of peripherally located bronchogenic carcinoma.

We undertook this study to determine the role of CT with artificial pneumothorax in preoperative evaluation of the chest wall and mediastinal invasion in patients with bronchogenic carcinoma.

Methods

From August 1987 to October 1989, 22 patients with peripheral non-small cell carcinoma abutting costal or mediastinal pleura, were studied by using artificially induced pneumothorax and CT. Twenty were men and two were women. Ages ranged from 40 to 82 years with a mean of 59. Twenty-one cases were squamous cell carcinoma and the remaining case was giant cell carcinoma. Pathological diagnosis were made either by transthoracic needle aspiration biopsy or transbronchial lung biopsy.

Artificial pneumothorax was made just after the procedure of fluoroscopy guided transthoracic needle aspiration biopsy in 17 patients. In five patients the procedure was done separately. An 18 gauge needle tip with long bevel was placed to the point where it traverses the pleura. Optimal placement of the needle tip was assessed by measured distance from skin to the pleura on CT scan, and resistance on needle passing by fibrous layer of intercostal muscle fascia, endothoracic fascia and pleura itself. Advance of the needle was stopped where it begins to show pendulous movement on respiration and pulsatile movement. After confirming that the needle tip is not within pulmonary vessel by suction, the needle was open to room air allowing influx of the air into pleural space through intrathoracic negative pressure. Pneumothorax was identified through suction of air and disappearance of respiratory and pulsatile motion. Additional 200 - 400 ml of room air was introduced by using syringe. Optimal gas amount was assessed by fluoroscopy. The region of the mass abutting parietal pleura was located at the uppermost position for easy separation by interposed air during CT scanning. Then, contiguous 10mm thick scan were obtained at the level of the mass on a CT/T 9800 scanner (General Electric Medical Systems, Milwaukee) without contrast enhancement. After CT scan, the introduced air was aspirated from pleural space under fluoroscope.

We observed whether the lung mass was separated from the parietal pleura by introduced air or not on CT. The parietal pleura was assumed to be intact in cases of separation, and to be infiltrated by cancer tissue in cases of adhesion.

Results

Eleven of 22 tumors were separated from the
parietal pleura by artificial pneumothorax, and 11 cases were not.

Eight of 11 cases that showed separation under-

**Fig 1.** Lung cancer abutting lateral chest wall but without invasion. (a) Conventional CT scan shows the lung mass in left upper lobe abutting lateral chest wall without visible fat plane between the mass and chest wall. (b) Axial proton density weighted MR image (1933/30 msec) shows tumor mass and localized pleural thickening (arrows) adjacent to the mass indicating high probability of pleural invasion. (c) CT scan with artificial pneumothorax shows separation of the lung mass (arrows) from the chest wall. At surgery, the parietal pleura was found to be intact. Because metastatic lymph nodes were found at aortocopulmonary window and the cancer cell infiltrated into the left hilum through the bronchovascular bundle, the lung mass was not resectable.

**Fig. 2.** Lung cancer abutting the aorta but without invasion. (a) CT scan shows a mass abutting the descending thoracic aorta. (b) CT scan obtained with the patient in left lateral decubitus position shows complete separation of the mass(arrows) from the descending aorta. (c) Photograph of the left lower lobectomy specimen shows tumor mass extending to the visceral pleura(arrows) but not penetrating the visceral pleura. Tumor was confined to the lung at histopathologic examination.
Four cases of 11 non-separated group had operation. In one case abutting to right anterior mediastinal pleura, the cancer tissue penetrated the parietal

study(Fig. 1, 2). In the remaining three cases curative resection was not done because of metastatic lesions at lymph nodes or other organs.

Fig. 3. Centrally located lung cancer encasing the left main pulmonary artery. (a) CT scan shows the mass abutting left main pulmonary artery and descending thoracic aorta. (b) Coronal MR image (660/30 msec) shows mediastinal invasion of the mass (arrowheads) encasing left main pulmonary artery (arrow). (c) CT scan with artificial pneumothorax shows the mass adherent to hilar area but separated from the posterior portion of descending thoracic aorta. At exploratory thoracotomy, the mass invaded into the main pulmonary artery and was not resectable.

Fig. 4. Lung cancer with invasion to lateral chest wall. (a) CT scan shows a lobulated mass in posterolateral portion of the right upper lobe abutting the chest wall on conventional CT scan. (b) CT scan obtained with prone position after the induction of pneumothorax shows the mass adherent to chest wall. (c) Gross photography of en block resection of the rib and right upper lobe shows the adhesion of the tumor to adjacent chest wall. Microscopically, the tumor invaded into the intercostal muscle (arrows).
pleura and invaded superior vena cava, which led to partial resection. In one case, main pulmonary artery invasion was identified at the exploratory open thoracotomy, and mass was not resectable (Fig. 3). In two cases, the masses were resected as en bloc resection of adjacent chest wall. One case had invasion into the intercostal muscle (Fig. 4), and the other case had only dense fibrous adhesion to chest wall without cancer infiltration on histopathologic examination (Fig. 5). In the remaining seven cases open thoracotomy was not performed because of assumed non-resectability from either CT result or mediastinoscopic biopsy of lymph nodes.

Thus, artificial pneumothorax showed tumor adhesion to the parietal pleura in all 3 cases that were confirmed to have cancer invasion (3/3, sensitivity 100%).

Discussion

Pulmonary neoplasms that locally invade intrathoracic structures such as the chest wall had formerly not been considered to be resectable (7). Recently, however, advances in operative technique and the perioperative management of patients undergoing pulmonary resection have expanded the thoracic surgeon's ability to successfully resect locally advanced pulmonary tumors (8,9). Invasion of the chest wall is not generally a contraindication to surgery in bronchogenic carcinoma; however, en bloc resection of the chest wall is associated with higher operative mortality and morbidity (1,10,11). Similarly, mediastinal invasion is not a contraindication to surgery if there is no invasion to the heart, great vessels, trachea, esophagus, or vertebral bodies (12,13). In Epstein's survey, contiguity of the cancer with the mediastinum or chest wall was considered a contraindication to surgery by 6% of responders, and CT contiguity or invasion of mediastinum or chest wall is considered useful in planning the surgical approach by 71% (14). The thoracic surgeons prefer to know if extension to either the chest wall or mediastinum is present so that the risks of additional surgery to encompass all of the disease can be factored into the assessment of the surgical risk. It is therefore desirable to determine preoperatively if chest wall invasion or mediastinal invasion is present.
since this information may be important in deciding which patients are operative candidates. Unfortunately, conventional CT has not been shown to be an effective way to evaluate either the chest wall or mediastinal invasion unless the involvement is definite. In previous articles concerning the role of CT, the findings suggesting chest wall or mediastinal invasion were the pleural thickening, increased density of extrapleural fat, apparent mass invading the chest wall, rib destruction and obtuse angle, 3cm contact with pleural surface. Using those criteria, the overall accuracy is reported as 39% - 69% (2-6.15).

Inflammatory pleural adhesion could result in false positive decision of chest wall or mediastinal invasion by cancer as in our case(Fig. 5). However, the presence of coincidental inflammatory adhesion confined to the tumor site would be rare. In cases of diffuse pleural adhesion in ipsilateral hemithorax, adhesion at the tumor site should not be regarded as invasion. In retrospective review of CT scan of false positive case, the interposed fat plane between the mass and chest wall was noted(Fig. 5). Normally, the layer of fatty connective tissue is located between the parietal pleura and endothoracic fascia (16). In patients with chronic pleural disease, some thickening of this fatty layer may occur (17,18). Thus, dense fibrosis due to chronic inflammatory pleural disease might be distinguished from the cancer infiltration.

Conclusively, CT with artificial pneumothorax added more information than conventional CT in the evaluation of the chest wall or mediastinal invasion by lung cancer without notable risk.

REFERENCES

7. Mountain CF, Carr DT, Anderson WAD. A system for the clinical staging of lung cancer. AJR 1974;120:130-138