Mediastinoscopic Ultrasonography

Martin Hürtgen, MD, Michael Wolf, MD, and Biruta Witte, MD

Objectives: Pretherapeutic T4 staging of centrally located lung cancer is crucial for the treatment strategy, but non-invasive imaging techniques are of low accuracy. We have developed the new imaging technique of intraoperative mediastinoscopic ultrasound (MUS) to predict technical resectability in tumors staged cT4 based on computed tomographic scanning.

Methods: Intraoperatively, a sterilizable fingertip ultrasound probe is introduced and guided through the video mediastinoscope with a modified grasper during staging mediastinoscopy. The position of the probe in front of the tracheobronchial tree and in direct contact with the vena cava and pulmonary artery reduces air interference.

We reviewed the results for 24 patients with tumors staged cT4 between July 2002 and January 2006. For 18, the prediction of MUS concerning resectability could be compared with intraoperative findings at the time of thoracotomy.

Results: MUS visualizes all central vessels and their relation to the tumor with high accuracy. The pulmonary artery and pulmonary veins are displayed not only in their central parts but also in their interlobar branches.

Of the 24 patients, 18 proceeded to thoracotomy after conclusive MUS and had tumors proved to be technically resectable in accordance with prediction by MUS. Comparison of cT (computed tomographic scan), cT (MUS) and pT revealed that T stages defined by MUS accurately predict pathologic T stages.

Conclusion: MUS allows investigators to assess infiltration of the great vessels and the mediastinum, especially in right-sided tumors. MUS will supplement endoscopic ultrasound-guided fine needle aspiration for the right upper mediastinum in staging of centrally located tumors.

Key words: Staging, Lung cancer, Intraoperative ultrasound, Mediastinoscopy.

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Exploratory thoracotomy for technical or oncological unresectability of a tumor should be avoided. Induction therapy is preferred for patients with N2 disease or with T4 tumors. Combining PET, systematic video-assisted mediastinoscopic lymphadenectomy, and endoscopic ultrasound-guided fine needle aspiration (transesophageal: EUS, transbronchial: EBUS) positive mediastinal lymph nodes can be detected with specificity and sensitivity of nearly 100%.

However, there is still no imaging method to allow verification of T4 stage of central tumors. Computed tomography (CT) and magnetic resonance imaging (MRI) do not offer a satisfying level of sensitivity and specificity for staging of potential T4 lesions, both having a tendency for overstaging.

Overstaging may exclude patients with operable tumors from curative surgical resection, whereas other patients undergo unnecessary induction treatment. Further, without precise pretreatment staging, the rate of down-staging reported in neo-adjuvant therapy studies remains questionable. EUS is helpful in detecting tumor infiltration of the lower mediastinum and heart. However, it is impossible to see infiltration of vena cava, vena azygos, aortic arch, and important sections of the pulmonary artery because of air in the tracheobronchial tree (Figure 1).

We developed intraoperative mediastinoscopic ultrasonography (MUS) to avoid this air interference. (Figure 2).
MUS may be performed before or after the nodal dissection but is usually the last operative step, although there may be some artifacts from air bubbles and fatty detritus in the mediastinum. With all the nodes resected and the anatomical landmarks identified and exposed, it is easier to control the position of the ultrasound probe. In bulky disease, it may be advantageous to begin the operation with MUS. Ultrasound information about the diameter of the diseased nodes and their relation to the vessels reduces the risk of major bleeding when taking the biopsy.

RESULTS

From July 2002 to December 2005, we identified 24 patients presenting with centrally located pulmonary carcinoma staged cT4 based on a CT scan. The CT interpretation was adopted from the contributing radiologists according to the medical records. We examined 18 men and 6 women with an average age of 63 years (range, 48–79 years). Histological types of the tumors comprised 22 non-small cell lung cancer and 2 small cell lung cancer. There were 18 tumors on the right side and 6 on the left side.

No complications occurred during the examinations. MUS and the corresponding documentation of the findings prolonged the operation time by approximately 10 minutes.

Of the 24 patients, 3 had N2- or N3-positive lymph nodes. These patients proceeded to chemotherapy or chemoradiation even though their tumors were judged to be resectable based on the MUS results.

We did not proceed to thoracotomy in the one patient for whom MUS examination confirmed obvious irresectable T4 stage in accordance with a CT scan. Ultrasound examination showed infiltration of the pulmonary artery adjacent to the pulmonary trunk in accordance with a CT scan for Patient 7. Therefore, this patient was excluded from surgery and received chemoradiation therapy. Consequently, we cannot comment on the positive predictive value of MUS for pT4.

For Patients 6 and 24, with left-sided central tumors, infiltration of central vessels and mediastinum could not be judged conclusively by MUS because of artifacts resulting from the air-filled left main bronchus. By the time of thoracotomy, their tumors proved resectable.

Conclusive assessment of central infiltration on the basis of MUS could be correlated with intraoperative findings for the remaining 18 patients. For four of these patients (Patients 9, 12, 14, and 17), unexpected intraoperative functional or oncological inoperability precluded resection, but exploration of the central structures confirmed technical resectability as predicted by MUS. The remaining 14 patients proceeded to R0 resection. For these 14 patients, full data records are available, and T stage after CT scans, MUS evaluation, and pathological examination were compared (Figure 3). One patient whose tumor was predicted cT2 by MUS had to have the tumor staged pT3 for endobronchial tumor extension; thus, the tumor was formally understaged by MUS but was nonetheless correctly judged resectable.

Discussion

Although the distinction of tissue borders by CT requires a considerable difference in x-ray absorption and a
certain thickness of the tissue layers, the resolution offered by ultrasound is based on its ability to detect tissue borders through different sound conduction, quasi-independent of the thickness of the tissue layers. Mediastinal pleura and pericardium may help to rule out tumor invasion using ultrasound, although they are too thin to be detected by CT (Figure 4). Preserved pulsating movements of the vessels and respiratory movements of the lung, visible in the real-time mode of ultrasound imaging, may help to rule out tumor invasion while disturbing CT imaging.

However, ultrasound examination of the mediastinum is limited by the interferences caused by the air-filled structures (tracheobronchial tree and lung). With MUS, those structures of the upper mediastinum that are not accessible to EUS can be inspected. Further MUS identifies tumor infiltration of more peripheral parts of the upper pulmonary vein or artery as far as the interlobar branches.

Until now, we have had no experience with MUS for restaging after induction treatment what may be another valuable application for MUS. In pre-therapeutic staging, MUS was highly accurate in prediction of pT stage with a 100% negative predictive value for pT4. MUS is a valuable supplement to EUS for exclusion or verification of cT4 stage.

REFERENCES


FIGURE 4. Suspected infiltration of right brachiocephalic vein in computed tomographic scan. Mediastinoscopic ultrasound shows preserved reflection line between tumor (TU) and brachiocephalic vein (V) that ruled out infiltration and confirmed pT2. A, Brachiocephalic artery.