Localization of Pulmonary Nodules Before Thoracoscopic Surgery: Value of Percutaneous Staining with Methylene Blue

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OBJECTIVE. Video-assisted thoracic surgery (VATS) is a new procedure that makes it possible to see the intrathoracic organs and to resect pulmonary nodules without thoracotomy. Preoperative localization of small nodules that may not be visible or palpable during VATS is desirable. Percutaneous placement of spring hookwires is widely used to localize pulmonary nodules before VATS; infrequently, the adjacent lung parenchyma is also stained with methylene blue. The purpose of this study was to evaluate the effectiveness of methylene blue staining of pulmonary nodules without placement of a hookwire.

SUBJECTS AND METHODS. Fifteen pulmonary nodules in 15 patients were localized preoperatively under CT guidance by using techniques identical to those for CT-guided fine-needle aspiration of pulmonary nodules. Approximately 0.3 ml of methylene blue dye was injected into the nodule with a 22-gauge Chiba needle to stain the nodule, the needle pathway, and the visceral pleura. In two patients, a hookwire also was placed. All patients had solitary nodules in which transbronchial or transthoracic biopsy had been unsuccessful. The mean nodule diameter was 16 mm (range, 8–33 mm), and the mean distance to the nearest pleural surface was 10 mm (range, 0–21 mm). The localization procedure required a mean of 32 min (range, 18–47 min).

RESULTS. All 15 nodules were stained successfully either in the center or within the margins; the two hookwires were found to be displaced. In three cases, pulmonary hemorrhage occurred as a complication of the percutaneous staining procedure: in one case, subsequent conversion to thoracotomy was necessary owing to pulmonary hemorrhage and additional pleural bleeding during VATS, which resulted from puncture with a trocar directly into the pleural adhesions. Anticipated complications, such as pneumothorax, occurred in five patients; one patient had pleuritic pain, but none required treatment. In one patient, conversion to thoracotomy was done so that an adenocarcinoma could be treated by means of a lobectomy. In two others, thoracotomy was done because of problems with technical devices.

CONCLUSION. Percutaneous staining of pulmonary nodules is an accurate technique for localizing nodules before VATS. The procedure is easily and safely performed, and it obviates wire-related complications, such as severe pleuritic pain.

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Recent developments in endoscopic video capability and corresponding instrumentation have expanded the role of thoracoscopy to include several procedures that previously could be performed only by open thoracotomy, including the resection of peripheral pulmonary nodules [1]. With endoscopic stapling devices, most peripheral pulmonary nodules can be removed by video-assisted thoracic surgery (VATS). During thoracoscopy, pneumothorax or lung collapse can occur, making the relationship of the target nodule to the anatomic landmarks seem distorted. If the nodule is less than 1 cm in diameter or is not pleura based or immediately subpleural, preoperative localization is beneficial [1].

For preoperative localization of impalpable breast masses, spring hookwires are frequently placed under mammographic guidance. Hookwires have also been used to localize other impalpable lesions [2]. Other types of hookwires are percutaneously placed under CT guidance to localize pulmonary nodules and to guide thoracoscopic resection [3–5]. Methylene blue is infrequently injected to mark the adjacent lung parenchyma if the hookwire becomes dislodged during VATS. We describe the use of staining with sterile methylene blue to localize pulmonary nodules in 15 patients. Staining is as efficient and as accurate for preoperative localization of pulmonary nodules as is placement of hookwires, and it is less costly.

Subjects and Methods

Between March 1992 and November 1993, 31 patients underwent videothoracoscopy for a pulmonary nodule detected on chest radiographs and confirmed by CT. In 15 of these patients with solitary pulmonary nodules, preoperative localization was required when the lesion was unlikely to be visualized or palpated at thoracoscopy. The patients included six women and nine men, 26–78 years old (mean age, 60 years). All patients had had nondiagnostic transbronchial biopsies, two had also had nondiagnostic percutaneous transthoracic needle biopsy. One woman had a history of renal cell carcinoma, another one had brain histiocytoma, one man had rectal carcinoma, and one man had a cervical lymph node metastasis of a squamous cell carcinoma of unknown origin.

Pulmonary nodules selected for preoperative localization were in the left lower lobe ($n = 6$), in the lingula ($n = 1$), in the left upper lobe ($n = 2$), in the right lower lobe ($n = 2$), in the right middle lobe ($n = 2$), and in the right upper lobe ($n = 2$).

The diameters of the targeted nodules ranged from 8 to 33 mm (mean, 16 mm). The depth of the lesion with respect to the nearest pleural surface ranged from 0 to 21 mm (average, 10 mm). In measuring the minimal distance of the lesions from the nearest pleural surface, we included the interlobar fissure and the mediastinal parts of the visceral pleura. In seven patients, the nodules were within 10 mm of the visceral pleura. In two patients, the distance from the nodule to the chest wall was greater than the distance to the interlobar fissure; in one patient, the distance to the chest wall was 42 mm vs 0 mm to the interlobar fissure; in the other patient, 21 vs 16 mm; in the latter patient, a transfissural approach was used successfully for the staining and the VATS procedure.

Only CT was used to guide all localizations, because of its superior discrimination of small nodules with respect to the pleural surfaces, the interlobar fissures, and the chest wall and mediastinal structures. The first five localizations were performed with a Siemens Somatom DR H unit or a Siemens AR T unit; the following 10 with a Siemens Somatom Plus S unit. The patients were placed on the CT table in a position (supine, prone, lateral decubitus) that allowed the shortest access to the targeted nodule without traversing interlobar fissures. In one patient, a transfissural approach was planned by the surgeon; therefore, the staining was also done by traversing the interlobar fissure. The targeted nodule was located with several preliminary scans of contiguous 4- or 5-mm sections in full inspiration. With the alignment lights of the CT gantry and a metallic mark, an appropriate skin location for needle placement was selected. For local anesthesia, a 1% procaine solution was used. As we do most of our lung biopsies with Chiba needles, this standard type of thin-walled aspiration needle [6] was also chosen for the staining procedure. A 9- or 15-cm 22-gauge Chiba needle (Sterylab s.p.a., Milan, Italy) was used for nodule localization and was placed into the nodule or as near as possible to the nodule (Fig. 1A). We made a great effort to place the needle optimally. The final needle position was confirmed by scanning several contiguous sections. Collimation of 3–5 mm was chosen, depending on the diameter of the nodule, to confirm the location of the needle tip [7]. Approximately 0.3 ml of sterile methylene blue dye was injected into the nodule and again during needle removal to stain the needle pathway (Fig. 1B) and the visceral pleura. In two patients, a hookwire also was placed. At the time of the localization, no attempts were made to aspirate material for diagnostic purposes.The CT localization procedure took 18–47 min (average, 32 min). The patients were then transported immediately to the operating room, where illustrative CT scans were provided for the surgeon. The mean delay between the CT-guided intervention and the beginning of the operation was 2 hr. In the operating room, the patient was intubated with a double-lumen endotracheal tube after institution of general anesthesia and was placed in a lateral decubitus position. At VATS, the nodules were visualized, then the wedge resection was performed, and the specimens obtained were sent for immediate pathologic examination.

Results

By means of this technique, preoperative localization of nodules was successful in all 15 patients. Staining with sterile methylene blue dye, either in the nodule or close to the nodule selected for VATS, was achieved in all patients. The hookwire placed in two patients was found to be displaced.

In one patient, a small to moderate pneumothorax developed during the procedure; however, appropriate needle placement was achieved when the needle was reinserted. This patient felt moderate pleuritic pain, but treatment was not necessary. Minimal localized pneumothoraces occurred in five (33%) of 15 patients; none required placement of a chest tube. Pneumothoraces were detected either on the CT scans obtained to confirm needle-tip localization or on the routine scans after the needle was removed. None of the patients had a chest wall hematoma. All patients tolerated the instillation of methylene blue dye well; no adverse reaction was attributed to the staining. In three patients, lung hemorrhages occurred during the staining procedure; in one of them, additional bleeding due to puncture with a trocar right into pleural adhesions made the surgical field difficult to inspect during VATS, and therefore conversion to open thoracotomy followed. Apart from this patient, conversion to open thoracotomy was necessary in two other patients because of problems with technical devices (i.e., dysfunction of light source, misfitting of different devices). Resected nodules included two metastases, one adenocarcinoma, two squamous cell carcinomas, three tuberculomas, three hamartomas, one silicofibrotic nodule, and three chronic pneumonic lesions. In one patient, lobectomy and hilar lymph node dissection was done via open thoracotomy immediately after examination of the resected nodule showed adenocarcinoma. In the patient with the metastasis to the cervical lymph nodes, the operation was ended after the immediate histologic examination revealed squamous cell carcinoma; lobec-

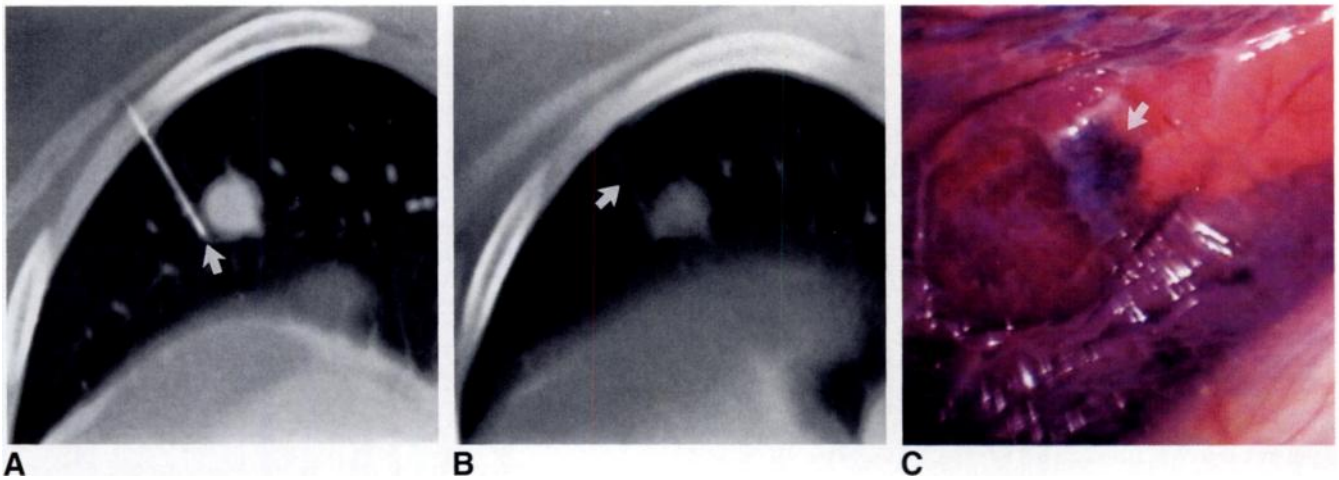

Fig. 1.—Final needle placement.
***A*, CT scan shows needle tip close to targeted nodule (*arrow*) in left lower lobe of lung.**
***B*, CT scan after staining and removal of needle shows pathway (*arrow*) extending to visceral pleura.**
***C*, Thoracoscopic view shows methylene blue stain on visceral pleura (*arrow*).**

tomy was not performed. In another patient with squamous cell carcinoma, impaired lung function prevented lobectomy.

Discussion

Thoracoscopy with a cystoscope was originally described by Hans Christian Jacobaeus in the early 1900s for the treatment of tuberculosis by pneumothorax. It was then in limited use until the 1970s [8]. In recent years, the development of endoscopic video systems and instrumentation has allowed a thoracoscopic therapeutic approach to procedures that had been reserved for thoracotomy. Without the improved thoracoscope with high-quality video optics, thoracoscopic peripheral lung resection, pleural biopsy, and other procedures would not be possible. Because of its reduced morbidity and mortality and the decreased duration of hospitalization, VATS is preferred to thoracotomy. VATS is used as a minimally invasive procedure either as a therapeutic means or when transbronchial or transthoracic needle aspiration biopsy has failed to yield a definite diagnosis of benign disease in an indeterminate pulmonary nodule. We therefore made no attempt at needle aspiration when a localization procedure for VATS was scheduled. Percutaneous localization of pulmonary nodules or small lesions, mainly using hookwires, has been described recently [3–5]. Occasionally, methylene blue staining has been added to allow visualization of nodules when the wire becomes displaced. Our results suggest that for preoperative localization of pulmonary nodules, the accuracy and efficacy of methylene blue staining are similar to those of hookwire placement [3–5].

As with diagnostic transthoracic needle biopsy, the shortest possible route can be selected if this route will also be chosen by the surgeon during VATS. Thus, the possibility must be considered that the surgeon may use a transfissural approach during VATS for deep lesions, and it is essential for the surgeon and the radiologist to discuss the desired route by which to approach the nodule.

In our study, methylene blue staining allowed quick identification of the area overlying the targeted nodule; in all cases the dye could be detected on the visceral pleural surface (Fig. 1C). The staining procedure alone provides no direct guide to the nodule, such as placing a hookwire would provide; however, after staining, all nodules can be palpated and grasped with a conventional forceps.

The surgeons found the stained tissue in the anticipated location in all cases (i.e., within the nodule or close to the margins) on the sectional plane of the resected nodule. The staining reassured the surgeons that they had resected the correct nodule. And the clearly detectable staining meant that the mean delay of 2 hr between the CT-guided intervention and the beginning of the operation is not too long, as the dye had not disappeared. The dislodgment of hookwires that we noted, and that has been reported in other series [3, 5], might have occurred while the patient was being transported or when the lung was collapsed on introduction of the pneumothorax for VATS.

Patients waiting for surgery are undoubtedly more comfortable without a percutaneously placed hookwire, and wire-related complications, such as severe pleuritic pain [3], are avoided. Only one of our patients had pleuritic pain after a small to moderate pneumothorax occurred during the localization procedure. The rate of pneumothoraces (33%) in our series is comparable with the rates seen in other larger series of CT-guided needle aspiration lung biopsies [9]. Insertion of a chest tube was not necessary in any case. Our 20% prevalence of lung hemorrhages compares with other series [3] in

which hookwires were placed. In one patient, this hemorrhage was the main reason that the surgical field was difficult to survey, and it necessitated a conversion to thoracotomy. An additionally placed hookwire probably would have enabled thoracoscopic resection of this nodule by tenting up the desired portion of the lung or by acting as a handle by which the nodule might have been retracted. On the other hand, no difficulty was attributed to the lung hemorrhages that occurred in the two other patients in whom VATS was easily performed.

One limitation of methylene blue staining as the sole procedure for preoperative localization of nodules might be in patients with extensive anthracotic pigmentation. In this condition, the dye can be difficult to see at VATS. In combination with a discrete hemorrhage on the visceral pleura, the targeted region should be detected. In our series, anthracotic pigmentation was seen in a few cases, but did not interfere with VATS.

In summary, methylene blue staining without use of a hookwire facilitates the thoracoscopic resection of indeterminate pulmonary nodules, in which standard techniques, such as transbronchial and transthoracic needle biopsy, are nondiagnostic. With the intraoperative guidance provided by this staining procedure, the effectiveness of VATS seems to be increased. Furthermore, wire-related complications, such as severe pleuritic pain, can be avoided, and without hookwire placement, the procedure is less costly.

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