Fluoroscopy-Assisted Thoracoscopic Surgery After Computed Tomography-Guided Bronchoscopic Barium Marking

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**Background.** Small lesions of the peripheral lung have been detected more frequently with the recent prevalence of computed tomography (CT). Identification of these lesions is indispensable for wedge resection performed by video-assisted thoracic surgery. Previous reports of marking techniques showed some failure and complications. We have developed a new marking technique and herein describe the efficacy of this technique: fluoroscopy-assisted thoracoscopic surgery after computed tomography-guided bronchoscopic barium marking.

**Methods.** Twenty patients underwent this procedure for 21 small peripheral pulmonary lesions approximately 10 mm in size.

**Results.** All the lesions were successfully marked and identified during fluoroscopy-assisted thoracotomy. They were resected with sufficient margins. There were no complications related to this procedure. The pathologic examination of these 21 lesions revealed primary lung cancer in 14, atypical adenomatous hyperplasia in four, a metastatic tumor in one, and a benign tumor in two.

**Conclusions.** This procedure is both a reliable and minimally invasive technique in thoracoscopic wedge resection for small peripheral pulmonary lesions.


With the recent progress and prevalence of computed tomography (CT) examination, small pulmonary lesions that cannot be seen in a chest radiograph have been increasingly detected [1]. Among small lesions less than 10 cm in size, a considerable number of malignancies were reported [2]. The diagnosis of these lesions by percutaneous or transbronchial biopsy is difficult because the lesion is too small to perform these modalities [3]. Therefore, surgical resection is needed for the purpose of a definitive diagnosis, and thoracoscopic wedge resection may be an appropriate procedure because it is less invasive than a conventional thoracotomy [4]. However, it is difficult to detect small lesions without any changes on the visceral pleura during the thoracoscopic operation. Therefore, marking of the lesion is necessary to perform an accurate thoracoscopic resection. While several types of marking techniques have been reported [5–8], there have been some complications and identification failure.

We have already reported a new preoperative marking technique using barium sulfate injected through bronchoscopy under CT guidance followed by fluoroscopy-assisted thoracoscopic wedge resection [9]. With a review of the cases applied, we herein describe the safety and the reliability of this procedure: fluoroscopy-assisted thoracoscopic surgery after CT-guided bronchoscopic barium marking (FATS-BM).

**Patients and Methods**

The indications of FATS-BM are as follows: 1) peripheral pulmonary lesions approximately 10 mm in size that will undergo thoracoscopic wedge resection; 2) lesions suspected to be difficult to identify by thoracoscopic examination; 3) cases with informed consent. Twenty patients (19 solitary, 1 bilateral) underwent FATS-BM for 21 lesions from November 1996 to July 1999. There were 11 males and 9 females. The average age was 59 years (range 30 to 74 years). Four lesions were detected by CT for further examination of a fictitious lesion detected by the chest radiograph, nine by CT screening for follow-up of other diseases, six by CT screening for a health survey, and two by a chest radiograph for a health survey. Fifteen lesions could not be detected on chest radiograph even by a retrospective reexamination. The average distance from the outer margin of the lesion to the nearest pleural surface was 6.5 mm (range 0 to 18 mm).

**Technique of Localization**

An endoscopist performed the preoperative localization in a room equipped with CT (X vision; Toshiba Corporation, Tokyo, Japan). The procedure was basically the...
same as previously reported [9]. 1) The anatomical location of the target lesion was examined by thin-section CT (2-mm collimation). 2) Thin videobronchoscopes (EB-1530T2 and EB-1530T; Asahi Optical Co, Ltd, Tokyo, Japan) with a 5.3-mm distal rigid portion diameter were mainly used in addition to the FUR-9P ultra-thin fiberscope in one case. The bronchoscopes were inserted orally under local anesthesia and the tracheobronchial lumen was examined. 3) A transbronchial aspiration cytology (TBAC) needle (Olympus Optical Co, Ltd, Tokyo, Japan) was inserted into the target bronchus and was guided to the possible lesion site fluoroscopically, which was assessed by high-resolution CT before the procedure. The TBAC needle was prepared by inserting the inner catheter into the outer catheter after removing the needle tip of the inner catheter. In one case, only the inner catheter with its needle tip removed was used coupled with the ultra-thin fiberscope. 4) The patient was transferred into the CT scanner and the three-dimensional relation of the lesion and the tip of the TBAC needle was assessed by high-resolution CT with a 2-mm collimation. 5) When the tip of the TBAC needle was considered to have reached a target area such as that in the proximity of the lesion, 0.1 to 1.0 mL of 50 to 150 w/v% of barium sulfate suspension (Fushimi Pharmaceutical Co, Ltd, Kagawa Japan) was instilled into the bronchus under CT fluoroscopy guidance [9]. 6) Subsequently, the three-dimensional relation of the barium marker and the lesion was ascertained by high-resolution CT. The procedure was completed after fluoroscopically confirming the clarity of the barium marker (Fig 1).

**Technique of Thoracoscopic Resection**

The interval between marking and surgery depended on the operative schedule regardless of that of marking because intrabronchial barium marking remains almost permanently. The patient was given general anesthesia with a double-lumen tube and put in a lateral position. After initiating single-lung ventilation, a thoracoscope was inserted through a trocar in the seventh intercostal space in the midaxillary line. An additional trocar insertion or minithoracotomy less than 5 cm in length was done at appropriate sites after equipping a C-arm-shaped portable fluoroscopic unit. The nodule with barium marking was grasped in the forceps and resected by endostaplers under both fluoroscopic and thoracoscopic guidance (Fig 2). The specimen was immediately examined for ascertainment of the completeness of the resection and sent to a pathologist.

**Results**

The marking procedure took from 15 to 60 minutes for each case (mean procedure time, approximately 30 min) from the insertion to removal of the bronchoscope. No complications by the marking procedure and the barium marker itself were noted. All the barium markers were stable until the surgical approaches. The lesions were resected after 1 to 12 days after barium marking (mean interval, 6 days). Eleven resections were performed with three thoracoports, nine with two ports combined with a minithoracotomy, and one with a single port combined with a minithoracotomy. The minithoracotomy was only performed during the early stage of the experience. At
present, all resections are performed with three ports. There were 11 cases without any changes on the visceral pleura related to either the lesion or marking. Ten markers that were instilled immediately under the visceral pleura could be observed through the pleura thoracoscopically as whitish spots. All the lesions were identified as a barium nodule on fluoroscopic imaging and resected with sufficient margins. It took 78 minutes on average (range 30 to 125 minutes) from the incision to the removal of the specimen. The average intraoperative blood loss was 13 mL (range 5 to 50 mL). Thoracoscopic wedge resection was performed in all cases without any complications. Two cases of adenocarcinoma diagnosed by frozen section were converted to an open thoracotomy to perform a curative lobectomy.

The average lesion size was 10 mm (range 5 to 17 mm) in the greatest dimension. Pathological examinations revealed the 21 lesions to be primary adenocarcinoma in 14, atypical adenomatous hyperplasia in four, and pulmonary metastasis from esophageal cancer, hamartoma, and inflammation in one each. Margins of the specimens were negative in all cases. There was no difficulty in making a pathological diagnosis due to the affection of the barium injection. Of 14 cases with primary lung cancer, 10 cases revealed localized bronchioloalveolar carcinoma (BAC) without an invasive component by frozen section. On the basis of the excellent prognosis of this type of adenocarcinoma [10], we decided to follow up these patients instead of an additional completion lobectomy with consent, excluding 1 patient who underwent a lobectomy. The remaining 4 patients were diagnosed as localized BAC with an invasive component. In the 2 patients diagnosed by frozen section, 1 patient subsequently underwent a curative lobectomy and the other underwent no more resection because of the risk. Another 2 patients were diagnosed by permanent preparation, and we elected careful follow-up instead of reoperation for a curative lobectomy with consent.

The chest tube was removed on 1.5 postoperative days on average (range 1 to 4 days). There was no recurrence in all 14 patients with primary lung cancer on average follow-up of 616 days (range 53 to 1,073 days).

Comment

Thoracoscopic resection is an appropriate procedure for the diagnosis of indeterminate pulmonary nodules with regard to safety and accuracy [4]. However, the most common cause of conversion from thoracoscopic resection to open thoracotomy was the failure to identify the lesion [4]. Suzuki and associates reported that thoracoscopic identification was impossible in the case of 10-mm or less sized lesions located over 10 mm deep from the pleura [11]. In our series, the average size and depth of the lesions was 10 and 6.5 mm, respectively. We could not identify all lesions by thoracoscopic inspection alone because most of them were very small and radiographically faint, which meant they were not so solid even by palpation.

Several types of marking techniques for thoracoscopic resection of small pulmonary nodules were reported. We reviewed representative reports from the standpoint of failure of identification and complications. In the transthoracic hook-wire injection, wire dislodgement occurred in 4% to 20% of the cases and failure of intraoperative identification in 0% to 5% [5, 12–14]. In the localization by dye injection, failure of intraoperative identification occurred in 0% to 7% of the cases because of the diffusion of dye or severe anthracosis of the visceral pleura [6, 15]. Because these procedures were basically the percutaneous needling technique, pneumothorax was inevitable, which occurred in 4% to 50% of the cases. In addition, there are some latent possibilities of implantation along the needle tract [16] and fatal air embolization [17]. With regard to the pathological examination, an injected marker or secondary hematoma originating from these procedures may disturb the diagnosis of complicated cases. Although intraoperative ultrasonography is considered safe, it is difficult to detect small and radiographically faint lesions by this procedure. In patients with obstructive lung disease such as emphysema, completely deflating the lung would be difficult. In such cases, intraoperative ultrasonography may be limited [8].

We have developed a new marking technique using barium sulfate followed by thoracoscopic resection under fluoroscopic guidance. In addition, we have applied this procedure to 21 lesions of 20 patients with small periph-
eral pulmonary lesions and confirmed its safety and reliability. According to an animal experiment, barium sulfate showed low histologic damage [18]. Furthermore, it has a feature of long retention [19], which can avoid the loss of the lesion due to marker diffusion. In addition, the marking procedure does not need to coordinate with the operating room schedule. The practical application of barium sulfate as a substitute for dye, which is injected by the percutaneous needle procedure, has been reported [20]. In our procedure, barium sulfate was administered via the transbronchial route to avoid complications such as pneumothorax, secondary hematoma, and the intravascular injection of the substance originating in needling. Because pneumothorax will basically never occur, this procedure is applicable to the lesion located near the interlobar or mediastinal region and multiple or bilateral lesions. Because barium sulfate was located exactly central to the lesion under CT guidance, we could resect the lesion with a sufficient surgical margin. Furthermore, the damage of the specimen resulting from marking and/or resection is minimal. It is an important advantage compared with the needling procedure in diagnosing small and subtle lesions.

FATS-BM is a more reliable and less invasive technique than others previously reported. It is a useful method for not only diagnosis but also therapeutic wedge resection in selected early lung cancer.

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References