Clinical outcomes of short hook wire and suture marking system in thoracoscopic resection for pulmonary nodules

Kentaroh Miyoshi, Shinichi Toyooka, Hideo Gobara, Takahiro Oto, Hidefumi Mimura, Yoshifumi Sano, Susumu Kanazawa, Hiroshi Date

Abstract

Objective: The short hook wire and suture marking system is a device for localization of small pulmonary nodules in thoracoscopic resection. We and other authors have shown the feasibility of the marking procedure. In this study, we reviewed our recent experience to examine the problems for resecting procedure using the device and determine if the system negatively impacts the survival rates for lung cancers.

Methods: Between November 1996 and March 2007, a total of 125 pulmonary nodular lesions in 108 patients were intended for thoracoscopic resection after localization with computed tomography-guided short hook wire and suture placement. We reviewed the major problems during surgery among all cases and prognosis in 64 patients with primary lung cancer.

Results: One hundred and seventeen lesions (93.6%) were successfully resected by initial resection with no major complication. However, we experienced missing events, the major problem during surgery, which was defined as temporarily missing lesions or hook wires. Eight missing events (6.4%) consisting of five unresected lesions and three remaining hook wires occurred after initial wedge resection. All the missing lesions and one remaining hook wire were recovered by additional resection. No specific factors of lesions, including location, diameter, distance from the pleural surface, and opacification were related to incidence of the 'missing event'. Five-year survival of patients with stage IA lung cancer was 90.0% with no local recurrence.

Conclusions: Our localization method assured a consistent quality of resection regardless of the lesion characteristics and a reasonable prognosis for patients with primary lung cancer. The short hook wire and suture system provides acceptable utility in thoracoscopic surgery.

1. Introduction

Thoracoscopic surgical techniques provide a minimally invasive approach for diagnostic or therapeutic excision of small pulmonary lesions [1,2]. With the development of diagnostic technology including high-resolution computed tomography (CT), an increasing number of small peripheral lung nodules have recently been detected [3]. These facts suggest expanding opportunities of thoracoscopic surgery for those lesions.

Preoperative localization of the targeted lesion is applied when the lesion seems to be undetectable by thoracoscopy [4]. Several approaches for tumor localization have been reported. We have used a short hook wire and suture system since we developed it in 1993. The hook wire is 10-mm long, and firmly attaches to a 30-cm long 5-0 monofilament nylon suture [5,6]. Preoperative injection is performed around the targeted lesion under CT guidance. The short hook wire and suture system is commercially available in Japan (Guiding-Marker System; Hakko, Tokyo, Japan) and is currently a popular device for localization. We previously reported a high success rate of the preoperative marking procedure with fine feasibility [7]. As one of the weak points of this device, we described dislodgement of the hook wire observed by thoracoscopy before lung resection. As other problems of this device, especially in surgery, we sometimes experience missing lesions or hook wires temporarily during resection procedure that we defined as a 'missing event'. Although this issue is an important problem for thoracic surgeons, no systematic analyses have been reported.

In this study, we focus on the incidence of missing events in relation to lesion characteristics. We also evaluate long-term outcomes of primary lung cancer patients who underwent the short hook wire and suture placement followed by thoracoscopic resection to investigate the usefulness of this localization strategy.
2. Patients and methods

2.1. Patient characteristics

From November 1996 to March 2007, CT-guided short hook wire and suture placement was performed on 125 pulmonary nodular lesions in 108 patients at Okayama University Hospital. Patients in this study comprised 44 males and 64 females, with a mean age of 59.1 years (range, 15—86 years). Written informed consent was obtained from all patients after explaining the necessity and risk for the procedure. All lesions were detected under CT, then, thoracoscopic surgery was considered for the purpose of diagnosis and/or treatment in each case. All lesions were located within the outer third of the lung parenchyma, which we considered to be applicable for wedge resection. Selection for preoperative localization was based on at least one of the following CT findings: lesion diameter ≤10 mm; distance from pleural surface >5 mm; or a lesion mostly comprising ground-glass opacity (GGO). Lesion characteristics are shown on Table 1. The diameter of the lesions was 3—35 mm (mean, 9.1 mm). Ninety-three lesions (74%) were ≤10 mm in diameter, and 87 lesions (70%) were located at >5 mm from the pleural surface. While 74 lesions (59%) showed GGO, 51 (41%) displayed solid opacity.

2.2. CT-guided marker placement and thoracoscopic surgery

The CT-guided short hook wire and suture placements were performed on the day of surgery. All procedures were performed under local anesthesia by experienced radiologists. Distance between the hook wire and lesions was <20 mm in all cases (Fig. 1). Multiple marker placements were simultaneously performed in 15 patients with 2 targeted lesions (12 patients with unilateral multiple lesions and 3 with bilateral lesions) and 1 patient with 3 lesions (1 lesion in the right lung and 2 lesions in the left). Suture outside the skin surface was loosely coiled and covered with sterile gauze. Following the procedure, patients waited for 1—8 h (median, 1 h) before undergoing surgery. Thoracoscopic surgery was then performed under one-lung ventilation general anesthesia. We attempted to extirpate targeted lesions through three access ports using wedge resection with endostaplers. The flexible suture was smoothly pulled in the pleural cavity without dislodging the hook wire when the lung collapsed. Of 125 lesions, 16 lesions (12.8%) were accompanied by subtle pleural changes such as indentation or discoloration, while others had no pleural change. We used the injected short hook wire and suture system not as a handle for traction during surgery but only as a visible marker. We took out a resected specimen from pleural cavity after putting it into a surgical bag.

2.3. Surgical strategy based on pathological findings

Specimens were inspected immediately after resection and identified lesions were histologically diagnosed by frozen-section examination during surgery when lesions had not been diagnosed preoperatively. Surgical margins were also histologically examined at surgeons’ discretion based on macroscopic status of specimens. If lesions were diagnosed as bronchioalveolar carcinoma (BAC) <20 mm in size without an invasive component, metastatic tumor or benign lesion, no additional resection was performed. If diagnosis was BAC with an invasive component or primary lung cancer other than BAC, lobectomy or segmentectomy with additional minithoracotomy was performed following initial resection during the same anesthetic because the prognosis of this population is considered to be poorer than that of pure BAC population [8]. When histological findings of frozen-section were not definitive regarding invasiveness of tumors, the surgical procedure was determined based on the radiologic findings. Segmentectomy or lobectomy was added for radiologically solid lesions and was not for lesions showing up as pure ground-glass opacity. Clinicopathological staging was determined according to the International Union against Cancer’s tumor-node-metastasis classification of malignant tumors [9]. Histological subtypes of lung cancer were determined according to WHO classification and Noguchi’s criteria [8,10]. Sixty-four patients with primary lung cancer were followed-up at our outpatient clinic for 1—109 months (median, 51 months).

Table 1

<table>
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<th>Characteristics of lesions.</th>
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<td><strong>Location</strong></td>
<td><strong>Upper or middle lobe</strong></td>
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<td></td>
<td><strong>Lower lobe</strong></td>
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<td><strong>Diameter</strong></td>
<td><strong>0 ≤ 10 mm</strong></td>
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<td></td>
<td><strong>&gt;10 mm</strong></td>
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<td><strong>Distance from pleural surface</strong></td>
<td><strong>0 ≤ 5 mm</strong></td>
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<tr>
<td></td>
<td><strong>&gt;5 mm</strong></td>
</tr>
<tr>
<td><strong>Opacification characteristics</strong></td>
<td><strong>Ground-glass opacity</strong></td>
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<td></td>
<td><strong>Solid</strong></td>
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2.4. Evaluation of the clinical outcomes

To evaluate the clinical outcomes of the short hook wire and suture system, we examined the incidence of surgery-related problems, local control capability for primary lung cancer lesions and long-term survival for patients with primary lung cancer. All the lesions were retrospectively stratified based on the mentioned characteristics shown in Table 1 to examine the relation between lesion characteristics and quality of thoracoscopic resection after the marking procedure. The reason why we chose 10 mm for lesion diameter and 5 mm for distance from pleural surface as a threshold of stratification is that lesion characteristics such as ≤10 mm in size and location at >5 mm from pleural surface were considered as significant risk factors for a failure to detect lesions by thoracoscopy alone [4].

2.5. Statistical analyses

The Kaplan—Meier method was applied to estimate overall survival, starting from the date of the surgery. Calculations and statistical tests were performed using SPSS statistical software (SPSS 11.0J, Chicago, IL, USA).

3. Results

3.1. Perioperative outcomes

Of the 125 lesions, 117 lesions (93.6%) with injected hook wires were resected without any complications. However, five lesions (4.0%) were not successfully resected (only hook wires were recovered) by initial wedge resection. In addition, three hook wires (2.4%) were not recovered but only tumors was resected. Consequently, we had eight missing events in our series. The incidence of the missing events in each stratified group was following: 4.2% of lesions in upper or middle lobe versus 9.3% of lesions in lower lobe, 7.5% of lesions ≤10 mm in size versus 3.1% of lesions >10 mm in size, 5.3% of lesions at ≤5 mm from the pleural surface versus 6.9% lesions at >5 mm from the pleural surface, and 4.1% of GGO lesions versus 9.8% of solid lesions (Table 2). Additional partial resection of the lung around the stapled margin was performed to excise these missing lesions or hook wires in those cases. Four lesions and one hook wire were successfully resected by additional resection by three port thoracoscopic approach. One lesion required minithoracotomy with an 8 cm skin incision to search for the lesion digitally. All targeted lesions including those cases were ultimately extirpated, but two hook wires remained in the lung. The patients with a remaining hook wire have been followed on CT after surgery and no harmful effects have been observed.

Other than missing the mass or hook wires, the only clinically significant complication was pneumothorax between procedure and surgery. A pleural drainage tube was placed in four patients (one patient had two targeted lesions and three had single lesions) for complications of pneumothorax between localizing procedure and surgery. Neither air embolism nor other serious complications such as massive hemorrhage were experienced. The hook wire was dislodged at thoracoscopy in one lesion (0.8%). However, slight hemorrhage on the visceral pleura visually guided successful wedge resection in that case.

3.2. Disease outcomes of patients with primary lung cancer

Histological diagnosis of the lesions is shown on Table 3. One hundred and twenty-five lesions consisted of 68 primary non-small cell lung cancers, 25 metastatic lung cancers, and 32 benign lesions (inflammatory nodules). There were 64 patients with primary lung cancer including 4 patients with simultaneous 2 lung cancer lesions. In cases of primary lung cancer, no local recurrence has been observed during follow-up. Twenty-nine lesions of BAC ≤20 mm in size without invasive component did not undergo additional resection. Other 39 lesions with primary lung cancer underwent additional resection consisting of 30 lobectomies and 9 segmentectomies. A Kaplan–Meier survival curve for primary lung cancer patients is shown in Fig. 2A. Five-year survival rate of 64 patients with primary lung cancer was 86.3%. Of 64 patients, 59 were diagnosed as stage IA lung cancer. Survival curve for patients with stage IA lung cancer is also shown in Fig. 2B. Five-year survival rate of this population was 90.0%. There was neither local recurrence nor tumor-related death in the 25 BAC patients who underwent only wedge resection during the follow-up (median, 68 months). Seven patients (6.5%) have died during follow-up period and three of seven deaths were not cancer-related.

Table 3

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<th>Histological diagnosis of lesions.</th>
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<td>Lung cancer</td>
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<td>BAC without invasive component</td>
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<tr>
<td>Others</td>
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<tr>
<td>Stage</td>
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<td>IA</td>
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<td>Metastasis</td>
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<td>Benign</td>
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BAC, bronchioalveolar carcinoma.
4. Discussion

Localizing procedures for thoracoscopic resection of pulmonary lesions in the literature can be divided into following two types: (1) intraoperative localization using imaging modalities [11,12] and (2) preoperative localization procedure followed by thoracoscopic detection. Latter procedures were further classified into two subtypes based on materials for marking thoracoscopically directly visible procedure involving lung puncture. However, taking care to minimize the time of hook wire insertion and avoid

surgery, showing 2.4% in early experience [7] and 0.8% (one case) in the current study. Our system has overcome the problems that have been identified for the conventional rigid hook wire [5,7].

In the current study, we extensively examined the intraoperative and long-term clinical outcomes of the localization strategy with short hook wire and suture system in thoracoscopic surgery. First, we evaluated incidence of missing events (the only surgery-related problem) in each stratified lesion characteristic group to find out factors related to the quality of resection. No significant risk factor related to incidence of missing event was identified. One of the reasons for these failures may be displacement of hook wire in lung parenchyma. While further improvement of this device or procedure may be necessary to prevent the missing event in surgery, the short hook wire and suture system provides a consistent quality of resection regardless of these lesion characteristics. Second, we assessed the prognosis of primary lung cancer patients who underwent short hook wire and suture placement followed by thoracoscopic surgery. As possible adverse effects of our marking system for prognosis, we are concerned that if the hook wire may happen to hit or go through a tumor, it could prompt metastasis or dissemination. Thus we examined the long-term outcome for lung cancer patients who received this procedure. In this series, no local recurrence of primary lung cancer was seen and 5-year overall survival rate of stage IA primary lung cancer patients was 90.0%. We previously reported that 5-year overall survival of non-small cell lung cancer with stage I (<20 mm) was 91.4% [22]. While the study cohort was not the same, a long-term outcome of thoracoscopic surgery under localization with our device could be considered as reasonable.

Some limitations to short hook wire and suture placement have been suggested. First, anchoring power may be insufficient for traction in surgery. While the rigid and long hook wire acts as a handle on which the surgeon can exert traction, [19] our system may provide less anchoring power for traction on lung tissue [23]. Whereas traction with marking device may facilitate resection particularly for deep-seated lesions within the lung, we used the injected markers not as a handle for traction but only as a visible marker during surgery. Although some temporary missing events were experienced, we could extirpate all the targeted lesions with non-traction technique and verify reasonable prognosis of patients with primary lung cancer. We consider that the quality of resection is largely unaffected by non-traction technique.

Another limitation of the short hook wire and suture system may be a possible complication of massive air embolism. This serious complication could be caused by temporary penetration between the bronchiol and adjacent pulmonary vein [24,25]. We consider that needle insertion and hook wire placement should be performed as quickly as possible to prevent a lung injury. Thus, we have used simultaneous dynamic CT (CT fluoroscopy) during needle insertion to minimize the time required to place the hook wire in the lung, and have encountered no cases of air embolism. Massive air embolism is clearly a possible complication of hook wire placement, as with every procedure involving lung embolism. Massive air embolism is clearly a possible complication of hook wire placement, as with every procedure involving lung embolism. Massive air embolism is clearly a possible complication of hook wire placement, as with every procedure involving lung embolism.
puncture of large bronchioles or vasculature can reduce the incidence.

In our cases, 16 lesions (12.8%) might be recognized during thoracoscopic surgery without marking. By contrast, during the same study period, we performed thoracoscopic surgery for 167 lung tumors without marking because we were not satisfied with our selection criteria for marking these tumors. Of these 167 lesions, 8 lesions (4.8%) finally needed thoracotomy to identify tumors. Those cases indicated the importance of careful preoperative evaluation for indication of marking, encouraging us to improve selection criteria for preoperative marking.

In conclusion, our study indicated that thoracoscopic surgery under localization with the short hook wire and suture system provides simple techniques and acceptable utility in thoracoscopic surgery.

References