

Preoperative Detection of Pleural Adhesions Using Ultrasonography for Ipsilateral Secondary Thoracic Surgery Patients

MOTOAKI YASUKAWA¹, RYOSUKE TAJI², NAGAAKI MARUGAMI²,
TAKESHI KAWAGUCHI¹, NORIYOSHI SAWABATA¹, TAKASHI TOJO³,
JUNKO TAKAHAMA², NAOKI HAMAZAKI⁴, TOSHIKO HIRAI⁵ and SHIGEKI TANIGUCHI¹

¹Department of Thoracic and Cardiovascular Surgery, Nara Medical University School of Medicine, Nara, Japan;

²Department of Radiology, Nara Medical University School of Medicine, Nara, Japan;

³Department of Thoracic Surgery, Saiseikai Chuwa Hospital, Nara, Japan;

⁴Shioya Clinic of Internal Medicine, Nara, Japan;

⁵Department of Endoscopy and Ultrasound, Nara Medical University School of Medicine, Nara, Japan

Abstract. *Background/Aim:* Video-assisted thoracic surgery (VATS) for ipsilateral reoperations is challenging because of the potential for pleural adhesions. Insertion of the initial port can lead to lung injury because of the blinded intrathoracic area. We assessed the usefulness of ultrasonography before VATS to reduce the incidence of lung injury at the time of the initial port insertion during secondary ipsilateral VATS. *Patients and Methods:* Thirty-three patients who underwent repeat VATS for ipsilateral pulmonary lesions were included. All patients underwent preoperative ultrasonography to assess the possible presence of pleural adhesions using the lung sliding sign. *Results:* Seven adhesions were found at the VATS ports. Two of these adhesions were not evaluated as pleural adhesions using ultrasonography; however, they were loose. All initial ports were inserted without lung injury. There were no major complications. *Conclusion:* Preoperative detection of pleural adhesions using ultrasonography can determine the best initial port for secondary ipsilateral VATS.

The incidence of secondary thoracic surgery has increased as a result of longer survival times after resection of primary cancers and the widespread use of early detection tools such as computed tomography (1). Furthermore, repeated

pulmonary metastasectomy offers a chance for long-term survival to patients with prolonged disease-free intervals after initial pulmonary metastasectomy (2). During the last several decades, video-assisted thoracic surgery (VATS) has been validated as the favored technique for almost all thoracic surgical interventions (3, 4). However, the use of VATS for ipsilateral reoperations might be challenging because of the potential for pleural adhesions (5, 6). Because of secondary intrathoracic changes after the first surgical intervention, pleural adhesions occur frequently in the thoracic cavity and/or chest wall. Several authors (5, 7) have reported that almost 80% of ipsilateral reoperation patients had severe intrathoracic adhesions. The initial insertion port can lead to lung injury because of the blinded intrathoracic area during VATS. However, preoperative transthoracic ultrasonography is useful for detecting pleural adhesions in patients scheduled to undergo thoracotomy (8-11). Therefore, we presumed that preoperative evaluations of pleural adhesions are beneficial before surgical intervention.

This study assessed the usefulness of preoperative ultrasonography to reduce the incidence of lung injury during the initial port insertion during VATS.

Patients and Methods

Among 547 patients who underwent thoracic surgery at Nara Medical University Hospital from January 2017 to May 2019, 33 who underwent consecutive VATS for reoperations for ipsilateral pulmonary lesions were enrolled. All 33 patients underwent preoperative ultrasonography to assess the possible presence of pleural adhesions.

We used three-port VATS to resect the lung tumors. Placement of the initial port was usually performed in the seventh or eighth intercostal space along the anterior or mid-axillary line.

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Correspondence to: Motoaki Yasukawa, Department of Thoracic and Cardiovascular Surgery, Nara Medical University School of Medicine, Kashihara, Nara 634-8522, Japan. Tel: +81 744223051, Fax: +81 744248040, e-mail: myasukawa@naramed-u.ac.jp

Key Words: Pleural adhesion, ultrasonography, secondary thoracotomy.

An ultrasound study using the LOGIQ E9TM (GE Healthcare, Chicago, IL, USA) ultrasound system was performed within 2 weeks before the scheduled surgery. All patients were examined in the lateral position with the seventh or eighth intercostal space of the mid-axillary line undergoing respiration. We evaluated the lung sliding sign, which is the movement of visceral pleural sliding with breathing and is a hallmark of the absence of pleural adhesions. The VATS technique used for reoperation did not differ considerably from that used for routine lung cancer cases, except in the evaluation of adhesions using preoperative ultrasonography. If adhesions were expected on preoperative ultrasonography, the initial port was placed at a location where ultrasonography showed no adhesions.

We checked for adhesions and determined their locations during VATS. Loose adhesions and dense adhesions were considered blunt ablations that either could or could not be removed easily. Prolonged air leakage was defined as an air leak lasting more than 5 days postoperatively. The chest tube duration was measured in days.

The Ethics Review Board of our institute approved the study protocol (No. 1749) and waived the requirement to obtain written informed consent from patients because individual patients were not identified in this retrospective study.

All data were expressed as the mean±standard deviation (SD). All statistical analyses were conducted using EZR on R commander version 1.33 (Saitama, Japan) (12).

Results

Table I shows the clinical characteristics of all patients. Seven adhesions were present at the initial port during VATS. Two adhesions were not detected with preoperative ultrasonography, and the other five adhesions were found using preoperative ultrasonography that was performed for all patients. Among these five cases, we were able to place the initial port while avoiding the adhesions during VATS. Additionally, the two undetected adhesions were removed easily, without lung injury or massive bleeding, because they were loose and could be removed bluntly. Fortunately, there was no conversion from VATS to open thoracotomy. Visceral slide sonography detected the following adhesions: five true-positive adhesions; two false-negative adhesions; zero false-positive adhesions; and 26 true-negative adhesions (sensitivity, 71.4% [5/7]; specificity, 100.0% [26/26]; accuracy, 93.9% [31/33]) (Table II).

Table I shows the outcomes of surgical intervention. The following surgical procedures were performed: pneumonectomy (for one), lobectomy (for four), and wedge (for 28). The mean operative time was 86 minutes (SD, ±56 minutes). The mean intraoperative bleeding volume was 72.4 g (SD, ±325.1g; median, 5 g). One patient who underwent complete pneumonectomy required blood transfusion intraoperatively. The mean chest tube duration was 1.7 days (SD, ±1.7 days; median, 1 day). Fortunately, there were no complications, such as postoperative bleeding, myocardial infarction, cerebral infarction, arrhythmia, bronchial fistula, or pneumonia for any patients. One patient had prolonged (defined as more than 5 days) air leakage for 10 days.

Discussion

In this study, evidence is presented that preoperative detection of pleural adhesions using transthoracic ultrasonography could provide safe thoracoscopic access without lung injury and facilitate VATS among ipsilateral secondary thoracic surgery patients, by enabling the placement of the initial port.

Pleural adhesions occur frequently in pulmonary vessels and bronchial and pulmonary surgical stumps in the thoracic cavity and/or chest wall because of secondary intrathoracic changes after the first surgical intervention. Chen *et al.* (5) have reported that almost 78% of ipsilateral reoperation patients had severe intrathoracic adhesions. Several authors have reported that surgeons failed to perform complete VATS; there was a 6.5-23% rate of conversion from complete VATS to open surgery (13-15). Approximately 24% of conversions were related to intense adhesions and massive intraoperative bleeding (13-15). Therefore, VATS has been rarely used for reoperations for ipsilateral pulmonary lesions.

Several reports of patients who required reoperations for ipsilateral pulmonary lesions have demonstrated that patients in the VATS group had shorter hospital stay and fewer complications than patients in the open thoracotomy. VATS is feasible and safe for selected patients (5, 16, 17). However, the use of VATS for ipsilateral reoperations might be challenging because of the potential for pleural adhesions. For experienced surgeons, VATS in the presence of dense pleural adhesions might be controversial. Furthermore, for inexperienced surgeons, VATS in the presence of dense pleural adhesions could lead to unexpected massive bleeding and/or lung injury. Specifically, insertion of the initial port can lead to lung injury because of the blinded intrathoracic area during VATS. Preoperative transthoracic ultrasonography is useful for detecting pleural adhesions in patients scheduled to undergo thoracotomy (8-11). We presumed that preoperative evaluations of pleural adhesions are beneficial before surgical interventions.

Preoperative transthoracic ultrasonography was useful for detecting pleural adhesions in patients who had undergone thoracic surgical intervention (8-10). When we could not detect adhesions in patients who did have them, the adhesions were not dense and could be removed easily without injuring the lung. Therefore, before pulmonary resection, preoperative ultrasonography was used to evaluate the feasibility of providing safe thoracoscopic access without lung injury and/or unexpected massive bleeding, thereby facilitating VATS (11). The lung sliding sign can discriminate between dense and non-dense adhesions. If there were dense adhesions, then the lung would not slide with breathing. If there were no adhesions or if there were loose adhesions, then the lung would slide with breathing. Regarding the safety of VATS, especially when adhesions are present, it is important to not discriminate between adhesions and no

Table I. *Clinical characteristics of all patients.*

	All patients (n=33)
Age (years)	67.1±13.8
Gender, n (%)	
Male	24 (72.7)
Female	9 (27.3)
Procedure, n (%)	
Pneumonectomy	1 (3.0)
Lobectomy	4 (12.1)
Wedge resection	28 (84.8)
Thoracic adhesions observed, n (%)	
Dense	2 (6.1)
Loose	5 (15.2)
None	26 (78.8)
Length of surgery (min)	86±56
Intraoperative bleeding (g)	72.5±325.1
Chest tube duration (days)	1.7±1.7
Postoperative complications, n (%)	1 (3.0)
	prolonged air leakage

adhesions; instead, one should distinguish between simple cases and difficult cases and between high potential and low potential for complications.

During this study, operative time, intraoperative bleeding, and chest tube duration were acceptable for patients who underwent ipsilateral secondary thoracotomy. Furthermore, there were no conversions from VATS to open thoracotomy. Therefore, using ultrasonography might be a helpful method of reducing complications during VATS for ipsilateral secondary lung resection patients. Moreover, use of preoperative ultrasonography could decrease factors of prolonged postoperative air leakage due to pleural adhesions.

Preoperative ultrasonography was used to determine the existence of adhesions in lung neoplasm patients undergoing reoperation. Unfortunately, excepted port site adhesions were not examined because it is difficult to detect adhesions near the apex area with ultrasonography. Especially for ipsilateral secondary VATS, insertion of the initial port can be the most crucial point of leading to lung injury because of the blinded intrathoracic area. If adhesions were visible, adhesions can be removed carefully during VATS, then pulmonary resection can be performed safely, without lung injury and massive bleeding.

In the near future, uniportal VATS will be more widespread than conventional multiport VATS (3, 4). Preoperative evaluation of port site and placing the port while avoiding the adhesions would be of significant importance in the uniportal VATS era. Ultrasonography might become a more important examination for clinicians. Ultrasonography is a simple non-invasive procedure that provides real-time and immediate results. Furthermore, ultrasonography offers other advantages; free from radiation hazards, portable, and relatively cost-effective (18). Because

Table II. *Results following lung slide sign identification using ultrasonography to detect pleural adhesions.*

Adhesions predicted	Adhesions observed	
	Yes	No
Yes	5	0
No	2	26

Adhesions were found at the initial port in all patients (n=33).

ultrasonography is easy to learn and use, portable, and accurate when examining the pleural space, it has allowed for safer pleural procedures, including that of VATS.

This study has certain limitations. First, it was a single-institute study with a small sample size. Therefore, it is necessary to perform additional investigations involving a large multi-institutional cohort to validate these findings. Second, as mentioned, the expected port site adhesions were not examined during this study because it is difficult to detect adhesions near the apex site with ultrasonography.

In conclusion, preoperative detection of pleural adhesions using transthoracic ultrasonography was useful for ipsilateral secondary pulmonary resection patients undergoing VATS. Using preoperative ultrasonography can improve the safety and feasibility of placing the initial port in VATS.

Conflicts of Interest

The Authors declare that they have no conflicts of interest in regard to this study.

Authors' Contributions

MY is the corresponding author and wrote the manuscript. RT, NM, and TH performed the ultrasonographic diagnosis. TK, NS, TT, and MY participated in the surgery and postoperative management. TT, JT, NH, and ST supervised the writing of the manuscript. All Authors read and approved the final manuscript.

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Received May 31, 2019

Revised June 24, 2019

Accepted June 25, 2019