The Validation of a No-Drain Policy After Thoracoscopic Major Lung Resection

Junichi Murakami, MD, PhD, Kazuhiro Ueda, MD, PhD, Toshiki Tanaka, MD, PhD, Taiga Kobayashi, MD, PhD, Yoshie Kunihiro, MD, PhD, and Kimikazu Hamano, MD, PhD

Department of Surgery and Clinical Science, Division of Chest Surgery, and Department of Radiopathology and Science, Division of Radiology, Yamaguchi University Graduate School of Medicine, Ube, Japan

Background. The omission of postoperative chest tube drainage may contribute to early recovery after thoracoscopic major lung resection; however, a validation study is necessary before the dissemination of a selective drain policy.

Methods. A total of 162 patients who underwent thoracoscopic anatomical lung resection for lung tumors were enrolled in this study. Alveolar air leaks were sealed with a combination of bioabsorbable mesh and fibrin glue. The chest tube was removed just after the removal of the tracheal tube in selected patients in whom complete pneumostasis was obtained.

Results. Alveolar air leaks were identified in 112 (69%) of the 162 patients in an intraoperative water-seal test performed just after anatomical lung resection. The chest tube could be removed in the operating room in 102 (63%) of the 162 patients. There were no cases of 30-day postoperative mortality or in-hospital death. None of the 102 patients who did not undergo postoperative chest tube placement required redrainage for a subsequent air leak or subcutaneous emphysema. The mean length of postoperative hospitalization was shorter in patients who had not undergone postoperative chest tube placement than in those who had. The omission of chest tube placement was associated with a reduction in the visual analog scale for pain from postoperative day 0 until postoperative day 3, in comparison with patients who underwent chest tube placement.

Conclusions. The outcome of our validation cohort revealed that a no-drain policy is safe in selected patients undergoing thoracoscopic major lung resection and that it may contribute to an early recovery.

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Chest tube placement after major lung resection has been shown to enhance postoperative pain [1–3], thereby leading to the deterioration of the pulmonary function [2] and exercise capacity [4]. In contrast, the early removal of a chest tube may contribute to a reduction in the length of stay, as well as health care costs [5, 6]. To promote fast-track rehabilitation, we attempted to omit postoperative chest tube placement in selected patients undergoing major lung resection. According to our initial experience, chest tube placement could be omitted in 29 (58%) of the 50 eligible patients without notable adverse events, such as chest tube reinsertion [7]. Nevertheless, thoracic surgeons routinely place chest tubes, probably because they are concerned about the recurrence of air leaks in patients who do not have air leaks immediately after the operation. Additional concern remains because the visual water leak test may not always be accurate, depending on the reexpansibility of the lung and the ability to submerge all possible sources of air leaks in saline. Thus, more experience will be needed to establish the validity of our original strategy for omitting chest tube drainage after major lung resection.

Patients and Methods

Patients

This study was approved by our institutional review board. We retrospectively reviewed our institution's prospective database of 228 patients who underwent pulmonary resection between June 2012 and December 2014. Patients who underwent open thoracotomy, bilobectomy, pneumonectomy, and wedge resection were excluded from the study (Fig 1). We routinely place chest tubes in patients undergoing wedge resection because of the risk of postoperative tearing or bursting of the staple line, particularly after wide-wedge resection. Patients with extensive intrathoracic adhesion, a history of induction therapy (chemotherapy or radiation), previous ipsilateral thoracic surgery, or a bleeding tendency were also excluded due to the considerable risk of postoperative air leak or bleeding. Finally, a total of 162 patients who underwent thoracoscopic anatomical lung resection for primary lung cancer (n = 143), metastatic lung tumors (n = 13), or benign tumors (n = 6) were enrolled in this study. We obtained

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Address correspondence to Dr Ueda, Department of Surgery and Clinical Science, Division of Chest Surgery, Yamaguchi University Graduate School of Medicine, 1-1-1 Minami-Kogushi, Ube, Yamaguchi 755-8505, Japan; email: kaueda@c-able.ne.jp.

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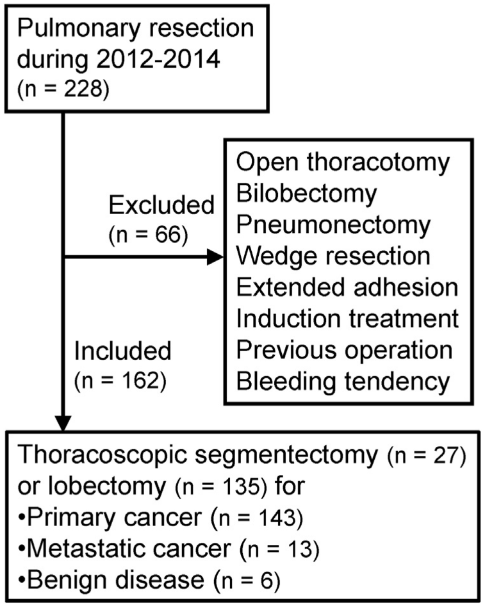

Fig 1. The diagram outlining the study population.

the following preoperative patient data: age, gender, height, smoking habit, spirometric variables, presence or absence of chronic obstructive pulmonary disease (COPD), COPD grade (mild: percent forced expiratory volume in 1 second [%FEV_1] $\geq$80%; moderate: %FEV_1 50% to 79%; severe: %FEV_1 <50%), surgical procedure, number of resected subsegments, resected site, and the occurrence of postoperative complications (Clavien-Dindo grade $\geq$2) [8, 9]. The smoking data included the pack-years smoked (smoking index: the average number of packages of cigarettes smoked per day multiplied by the number of years the individual smoked). There were 88 men and 74 women (mean age 70.2 $\pm$ 10.4 years). A total of 135 patients underwent lobectomy and 27 patients underwent segmentectomy (mean number of resected subsegments 7.9).

Pulmonary Function Tests

The patients' preoperative spirometric variables were obtained within 1 month before surgery. These included the forced vital capacity (FVC) and FEV_1. The % predicted FVC and % predicted FEV_1 are expressed as the percentage of the predicted value for age, gender, and height. COPD was defined by an FEV_1/FVC value of <70% [10]; the degree of COPD was categorized as mild (predicted FEV_1 $\geq$80%) versus moderate to severe (predicted FEV_1 <80%).

Computed Tomography Scanning and Image Interpretation

Helical computed tomography (CT) scans were obtained using 64-detector (Somatom Definition or Sensation 64; Siemens, Erlangen, Germany) row CT scanners. High-resolution CT images of the entire lungs were obtained with a 512 $\times$ 512 matrix at 120 to 130 kVp and 220 to 230 mA. Histogram analysis for the entire lung was made with a commercially available software (AZE, Virtual Place Raijin, Tokyo, Japan). The volume of the entire lung (–600 to –1,024 Hounsfield units) was defined as the total lung volume (TLV), and the volume of the emphysematous lung area (<–910 Hounsfield units) was defined as the low-attenuation area (LAA) [11]. Our previous study showed that the LAA/TLV is an accurate predictor for the length of postoperative chest tube drainage [12].

Operation

The operation was performed via 3 port sites (1 to 3 cm) without rib spreading. We used an endoscopic stapler (Ethicon, Cincinnati, OH; or Covidien, Minneapolis, MN) without reinforcement to divide the fused fissures as well as the pulmonary artery, vein, or bronchus. During anatomical segmentectomy, we used an electrocautery or an endoscopic stapler to dissect the intersegmental plane. We performed mediastinal lymph node dissection in patients with primary lung cancer in a lobe-dependent manner (upper mediastinal dissection for upper lobe disease, and lower mediastinal dissection for lower lobe disease).

Procedure for Pneumostasis

After anatomical lung resection, a water-seal test was performed with warm sterile saline under thoracoscopy after irrigation of the pleural space with 2 L of warm saline. During the water seal test, the air leak sites were localized carefully via a visual assessment. If air leaks from the alveolar fistula were detected, we used polyglycolic acid (PGA) mesh (Neoveil, Gunze, Osaka, Japan) and fibrin glue (Beriplast, CSL Behring, King of Prussia, PA) to achieve pneumostasis, as described previously [7, 13]. The fibrin glue used in this study was composed of solutions A and B. Solution A contained 80 mg/mL of human fibrinogen, 60 IU/mL of human plasma coagulation factor XIII, and 1,000 Kallikrein-Inhibitor-Einheit/mL bovine aprotinin. Solution B contained 300 IU/mL of human thrombin and 5.88 mg/mL of calcium chloride. Solution A was sprayed over the dissected lung parenchyma or the stapled line, and then it was rubbed on the surface so that the fibrinogens could effectively penetrate the lung parenchyma. Solution B was then sprayed over the surface to create primary sealing. A piece of PGA mesh, 2.5 cm $\times$ 2.5 cm in size, soaked in solution A, was placed over the primary sealing site, then adhesion was achieved by spraying solution B onto the mesh. Because most air leaks are found at the bare area, caused by dissection of the incomplete fissure or intersegmental plane, the bare area was completely covered with mesh. It took roughly 10 minutes to perform the previous pneumostasis procedures. The cost of the PGA mesh (10 cm $\times$ 5 cm) and fibrin glue are \$63 and \$296, respectively.

Confirmation of Pneumostasis

An original test was performed after the previously mentioned procedure to confirm pneumostasis, as described previously [7, 13]. Briefly, a 20F chest tube was inserted into the pleural cavity via 1 of the ports. The wounds were temporarily closed with adhesive film sheets to obtain an airtight condition. The chest tube was connected to a continuous suction device (MERA