Management of intraoperative bleeding during thoracoscopic pulmonary resection in Japan

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Abstract: In thoracoscopic surgery, to ensure the safety of the operation and minimize the rate of conversion to thoracotomy, it is important to emphasize appropriate troubleshooting, particularly for intraoperative bleeding, because inappropriate management of significant bleeding can lead to catastrophic and life-threatening consequences. A few studies have focused on surgical techniques for managing massive intraoperative bleeding during thoracoscopic surgery in Japan. Based on the results of these studies, we created a modified treatment algorithm for the management of significant intraoperative bleeding. In this paper, we introduce the concepts of “attachment of a thrombostatic sealant” and “compression of the injury site using the adjacent lung” to our algorithm as useful methods to achieve hemostasis during thoracoscopic surgery, and provide further details of these techniques in accompanying videos.

Keywords: Intraoperative bleeding; thoracoscopy; pulmonary resection

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Introduction

Total thoracoscopic pulmonary resection is used worldwide, partly because of the good results that have been reported in recent years. Many authors have reported that the thoracoscopic approach is less invasive and provides greater benefits, such as more rapid postoperative recovery and shorter hospitalization, than thoracotomy approach although a prospective randomized trial to compare open thoracotomy and thoracoscopic lobectomy has yet to be conducted (1,2). In addition, the prognosis of patients who undergo surgery via the thoracoscopic approach may not be inferior to that of patients who undergo thoracotomy for early-stage lung cancer. This would make the thoracoscopy the preferred approach for early-stage lung cancer (2).

In thoracoscopic surgery, to ensure the safety of the operation and minimize the rate of conversion to thoracotomy, it is important to emphasize appropriate troubleshooting, particularly for intraoperative bleeding, because inappropriate management of significant bleeding can lead to catastrophic and life-threatening consequences. In addition, the management of vascular injury is considered to be much more complex during thoracoscopic surgery than during thoracotomy. This may be due to the difficulty achieving a vascular clamp as well as in the subsequent suturing of the injured site in intrathoracic vessels using a monitor during the thoracoscopic approach. Therefore, a simpler technique may be needed to achieve appropriate hemostasis in the thoracoscopic approach.

Various reports have described the management of intraoperative bleeding during thoracoscopic pulmonary resection. However, the strategy for hemostasis has differed among studies because the thoracoscopic approach is not a uniform procedure; thus, port positions, number of ports, length of incision, use/no use of an access port, and visualization of the surgical field either directly or via a monitor have varied (3-5). This has made it difficult to standardize the troubleshooting of issues such as intraoperative bleeding during thoracoscopic surgery.

Only a few studies have focused on the surgical
techniques used to manage massive intraoperative bleeding during thoracoscopic surgery, while many have described perioperative results, complications, and prognoses (6-13). To the best of our knowledge, only three studies reported in the English language have focused on troubleshooting for intraoperative bleeding during thoracoscopic surgery in Japan (11-13).

In this study, we reviewed the surgical techniques used to achieve hemostasis during thoracoscopic surgery and investigated the appropriate management of intraoperative bleeding.

**How to manage intraoperative bleeding during thoracoscopic surgery**

In our thoracoscopic surgery, a monitor was placed above the head of the patients and all procedures were carried out through the thoracoscopic vision. We used 5- or 10-mm flexible-type thoracoscope. The operating surgeon stood ventral to the patient, while the assistant surgeon in a dorsal position. The access incision (initially 3 cm in length) was in the 4th intercostal space on the anterior axillary line. While a port for a thoracoscope was placed in the 6th intercostal space on the posterior axillary line, two additional ports were placed in the 6th intercostal space on the anterior axillary line and inferior angle of scapula. These three ports except for the thoracoscopic port were covered with a size XXS wound retractor (Alexis Wound Retractor, Applied Medical, Rancho Santa Margarita, CA, USA). Large vessels and bronchi were usually divided by an endostapler. Hemostasis of small-caliber vessels was performed by ligation or using an electrocoagulator or a combination of both. On completion of the pulmonary resection, the specimen was placed into an endovascular bag and retrieved through the access port. If necessary, the incision was enlarged, depending on the specimen size. A rib-spreader was never used at any point during the operation. Among patients with primary lung cancer, systemic lymphadenectomy was performed for those who underwent lobectomy, and sampling of hilar lymph nodes was performed for those who underwent segmentectomy. No lymphadenectomy was performed for patients with metastatic lung cancer or benign disease. Finally, a drainage tube was placed in the thorax through the 6th intercostal port on the anterior axillary line.

We have established a novel algorithm for managing significant intraoperative bleeding (13). Significant bleeding was defined as the bleeding which required compression for longer than 30 seconds to get hemostasis. Using that algorithm, the bleeding site of an intrathoracic vessel is treated by compression with lung parenchyma or a cotton stick. In addition, thrombostatic sealants, TachoSil (CSL Behring, Japan), are usually attached to the bleeding site to avoid intraoperative or postoperative re-bleeding. The sealant is initially cut into a 7×7 mm square and then attached to the top of a cotton stick using medical jelly. Then it is introduced into the thorax via a port and applied to the bleeding site. A second or third piece of sealant is added if necessary. This technique is easier to perform than suturing the injured vessels. Therefore, it is suitable for achieving hemostasis during thoracoscopic surgery.

The wall of the pulmonary artery is thin and fragile compared to other intrathoracic vessels. Therefore, it is often injured, and can lead to catastrophic bleeding if not treated appropriately (6,7,11,13). In view of this, attachment of a thrombostatic sealant is a simple and suitable method for achieving homeostasis in thoracoscopic surgery. In our previous study, 44.4% of significant intraoperative bleeding during thoracoscopic surgery was caused by injury of pulmonary arterial branches, and most of them were treated by compression of the adjacent lung and/or attachment of thrombostatic sealant (13).

Following our algorithm, the bleeding site is usually compressed using the adjacent lung or a cotton stick to control bleeding prior to the attachment of the thrombostatic sealant (13). This compression technique is frequently utilized in Japan to temporally control bleeding (11,14). Moreover, Miyamoto *et al.* (14) recently reported the useful technique of “lung folding”. “Lung folding technique” is very similar to compression of the lung; however, there is a slight difference between the two techniques. Miyamoto *et al.* insisted that the adjacent lung should be folded. Doing so traps the bleeding site between the adjacent lung and the hilar structure, which can provide more stable compression than traditional compression of the lung alone. We have modified our algorithm to include this step (*Figure 1*).

Injury to other vessels such as the pulmonary vein, ayzygos vein, superior vena cava, subclavian artery or vein, and bronchial artery can also be catastrophic. While thrombostatic sealant is again mainly used to control bleeding from low-pressure vessels including the pulmonary vein, ayzygos vein or superior vena cava, high-pressure vessels such as systemic arteries may not be amenable to repair using sealant. Previously, Yamashita *et al.* (11) reported that application of a sealant to a subclavian arterial
injury resulted in a pseudoaneurysm. They recommended using thrombostatic sealants for low-pressure vessels only. Therefore, clipping or ligation might be a better way to achieve hemostasis when these high-pressure vessels were injured although we have experienced successful hemostasis of bleeding from bronchial arterial injury.

Along with this report, we include videos that illustrate both the attachment of a thrombostatic sealant and compression of the injury site by the adjacent lung to achieve hemostasis during thoracoscopic surgery (Figures 2, 3).

**Summary**

In Japan, attachment of a thrombostatic sealant and compression of an injury site using the adjacent lung to achieve hemostasis during thoracoscopic surgery are...
frequently utilized; these techniques are considered of great importance in reducing the conversion rate to thoracotomy. However, all of the studies that describe troubleshooting for intraoperative bleeding have suggested that surgeons should not hesitate to convert from thoracoscopic surgery to thoracotomy when difficulty arises in controlling intraoperative bleeding because such bleeding, particularly in the case of a pulmonary arterial injury, might be catastrophic. Therefore, surgeons should become skilled in the fast and smooth conversion to thoracotomy as well as in providing appropriate hemostasis in thoracoscopic surgery.

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**Footnote**

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