

# Late Onset Postoperative Pulmonary Fistula Following a Pulmonary Segmentectomy Using Electrocautery or a Harmonic Scalpel

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**Purpose:** The purpose of this study is to retrospectively examine the postoperative pulmonary fistula as a complication after the use of either electrocautery or a harmonic scalpel without stapling devices.

**Patients and Methods:** The subjects of this study consisted of 28 patients who received a segmentectomy for a pulmonary malignant tumor, 25 cases of lung cancer and 3 of metastatic lung tumor. The electrocautery was used in 17 patients (EC group) and the harmonic scalpel in 11 (HS group). The levels of postoperative air leakage and postoperative complications were examined among the two groups retrospectively. The histological findings of the cut surface of the segmentectomy by electrocautery and harmonic scalpel were also examined.

**Results:** Hemostasis and air leakage both were well controlled during the operation, and the postoperative drainage period was short. No major postoperative complications occurred, and all patients began walking in the early postoperative days. However, 1 to 3 postoperative months after discharge, 8 patients showed late onset of a pulmonary fistula, 3 of the 17 (18%) in the EC group and 5 of the 11 (45%) in the HS group. The histological findings of the cut surface of the segmentectomy showed that most of the layer of coagulation necrosis by the harmonic scalpel measured 2 mm thick, and it was denser than that cut from electrocautery. The lumen of the bronchus markedly decreased in size, but it remained, as it also did under the effects of electrocautery.

**Conclusions:** In the months following the operation, the incidence of the late onset of a pulmonary fistula was higher when the harmonic scalpel was used. It was believed that the small bronchial stump could not tolerate the airway pressure because the thick coagulation necrosis delayed healing of the postoperative wound. It was necessary to ligate the stump of a small bronchus, even though the stump had been temporally closed by coagulation necrosis with the electrocautery or harmonic scalpel during the operation. (*Ann Thorac Cardiovasc Surg* 2010; 16: 21–25)

**Key words:** pulmonary segmentectomy, electrocautery, harmonic scalpel, complication, pulmonary fistula

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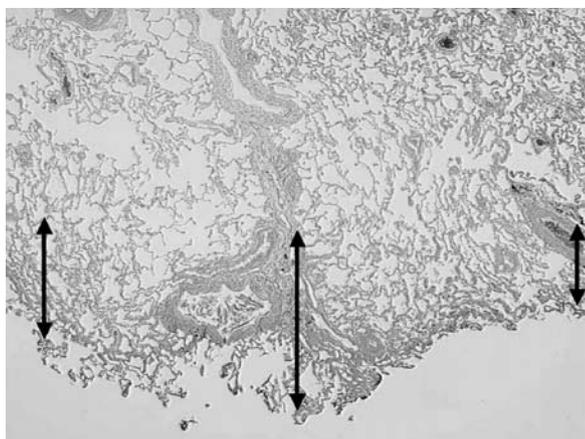
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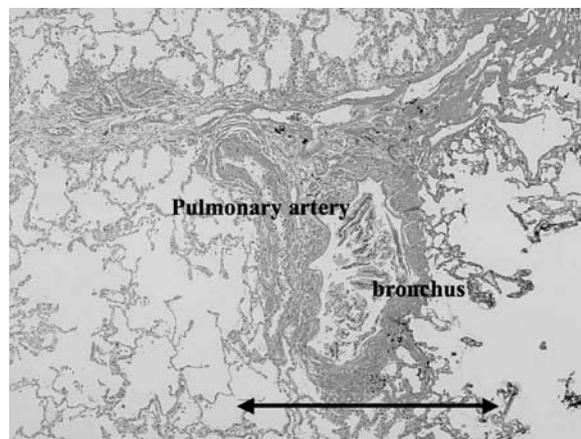
## Introduction

Currently, small nodules are easily found by a chest CT scan, thus resulting in an increasing frequency of lung segmentectomy for such lesions.

Stapling devices, which allow simple and safe procedures and less air leakage, have been used for the dissection of the intersegmental parenchyma, but the expansion of the



**Fig. 1.** Histological findings of the cut surface of a segmentectomy by electrocautery. The layer of coagulation necrosis (arrows) was 1 mm to 2 mm thick (electric power 40 watts) resulting from the mode of cutting and coagulation. (HE:  $\times 20$ )



**Fig. 2.** Histological findings of the cut surface of the lung by electrocautery. The range of coagulation necrosis is shown by the arrow. (HE:  $\times 40$ )

remnant lung is restricted by the stapling lines, which are folded on the edge of the lung parenchyma. The cutting plain of the segmentectomy should be free from tight adaptations by staplers to preserve the local lung function, though the problem of air leakage from the lung parenchyma remains. The purpose of this study is to demonstrate the utility of electrocautery or the harmonic scalpel in lung segmentectomy without the use of stapling devices, and to examine the complications associated with postoperative pulmonary fistula.

## Patients and Methods

The subjects enlisted in this study included 28 patients who had received segmentectomies for pulmonary malignant tumors from 1998 to 2006. A segmentectomy was performed with either electrocautery or a harmonic scalpel without the use of any stapling devices.

The subjects ranged in age from 27 to 83 years; 14 were male and 14 female; 25 were cases of lung cancer and 3 were pulmonary metastatic tumors; 17 patients underwent the electrocautery method (EC group); and 11 underwent the harmonic scalpel method (HS group). The scalpel used was a Harmonic Scalpel-II (Johnson & Johnson, K.K., Tokyo, Japan), and its blade was a curved shears type. The output level was controlled at 5 levels, i.e., level 5 (cut dominant) to level 1 (coagulation dominant). We selected level 3 to level 5, and the time duration was from 5 to 10 sec. The monopolar electrocautery unit was the ICC350 (ERBE Elektromedizin GmbH, Tuebingen, Germany), and the electrical power was 30–50 watts with

a blend mode for the functions of cutting and coagulation.

In all patients, we inspected for air leakage, using the water seal test (15 cmH<sub>2</sub>O at the closing of the chest), and applied fibrin glue (Volheal<sup>®</sup>) to the surface of the cut margin of the parenchyma. A chest drainage tube was set under the water-sealed system. The levels of postoperative air leakage and postoperative complications were examined among the two groups retrospectively.

The histological findings of the cut surface of the segmentectomy by electrocautery and harmonic scalpel were also examined. A written informed consent was obtained from each patient before the operation.

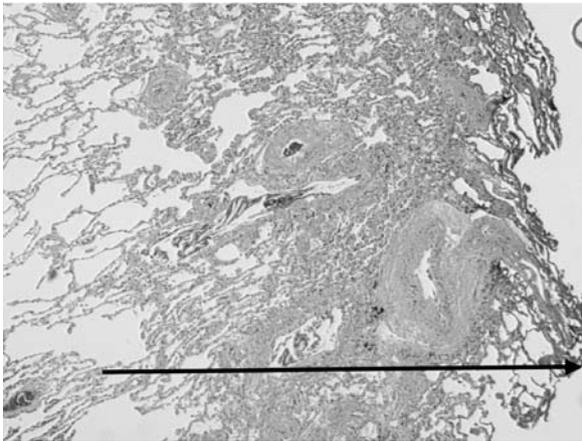
## Results

### 1. The histological findings of the cut surface of the segmentectomy by electrocautery (Figs. 1 and 2)

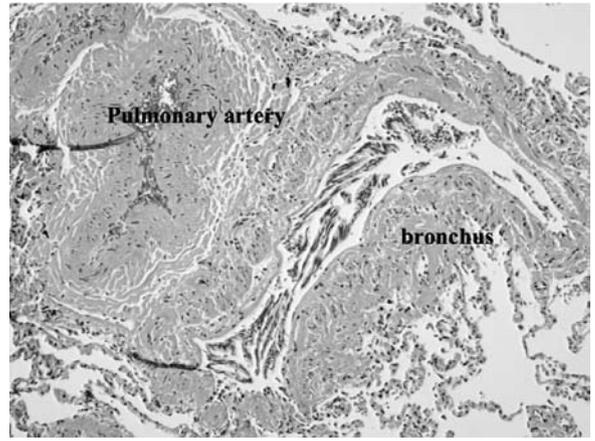
The cut surface of the segmentectomy was shielded by the coagulation necrosis 1 to 2 mm deep, and the lumen of the vessels were adequately constricted by the coagulation necrosis of the wall, though the bronchi demonstrated no such constriction.

### 2. The histological findings of the cut surface of the segmentectomy by harmonic scalpel (Figs. 3, 4, and 5)

Most of the layer of the coagulation necrosis by harmonic scalpel measured 2 mm in thick, and it was denser than that from the electrocautery. The lumen of the bronchus markedly decreased in size, but it remained, as it also did under the effects of electrocautery.



**Fig. 3.** Histological findings of the cut surface of the segmentectomy by harmonic scalpel. The coagulation necrosis (arrow) was 2 mm thick with the power of level 1 (coagulation dominant). (HE:  $\times 40$ )



**Fig. 4.** High-powered view of the histological findings of the cut surface by harmonic scalpel. The lumen of bronchus and pulmonary artery was constricted because of the coagulation necrosis of its wall. (HE:  $\times 100$ )

### 3. The effects of hemostasis and the shielding effects of an air leakage during the operation

Intraoperative hemostasis was controlled well, and air leakage from the cut surface of the segmentectomy was revealed via a small bubble by the water-sealed test in all patients. It was shielded completely by the application of fibrin glue at the time of chest closure, and there was no difference between the two groups.

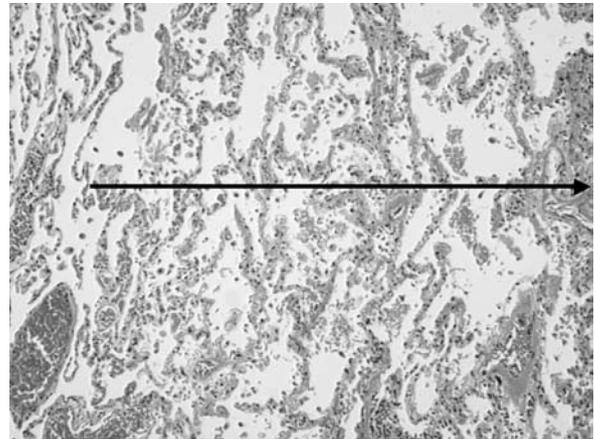
### 4. Postoperative course and complications (Table 1)

#### (1) Acute phase

Postoperative air leakage in the acute phase was not found in 24 out of 28 patients. The duration of the drainage period was no different between the two groups, i.e., from 1 to 13 days (mean  $\pm$  standard deviation [SD]: 3.3 days  $\pm$  2.8 days) in the EC group and from 2 to 17 days (mean  $\pm$  SD: 4.5 days  $\pm$  5.3 days) in the HS group. These modalities influenced withdrawal of the chest tube in the early postoperative days, and also permitted early ambulation.

#### (2) Chronic phase

Almost all of the patients recovered uneventfully, but there was a late onset air leakage, such as pneumothorax (Fig. 6) or parenchymal cavity formation, in some patients after 1 to 3 months postoperatively. These complications caused no symptoms; neither did they require any special treatment. Complications were seen in 45% (5/11) of patients in the HS group and in 18% (3/17) in the EC group. The parenchymal cavities were divided into two types, i.e., the early closure type, which closed within 6 months (Fig. 7) and the long-lasting type of more than



**Fig. 5.** Histological findings of the alveolar wall at the cut surface showed coagulation necrosis (arrow) by harmonic scalpel. (HE:  $\times 100$ )

6 months duration (Fig. 8). The former type was found in 2 patients of the EC group, and the latter was found in 2 patients of the HS group and in 1 of the EC group.

### Comment

Perel'man<sup>1)</sup> reported in 1983 that electrocautery was a good device for dissecting the lung parenchyma, and this technique has been used ever since. Recently, a harmonic scalpel has been developed for the resection of solid tissue, and it has been applied to the lung. Because small pulmonary nodules are found easily with the development of CT, a partial resection of the peripheral parenchyma or a segmentectomy has been frequently performed. When

**Table 1. Comparison of postoperative complications**

	Electrocautery group (n = 17)	Harmonic scalpel group (n = 11)
Air leakage in acute phase	2 (12%)	2 (18%)
Late onset pulmonary fistula	3 (18%)	5 (45%)

Postoperative complications of each group. Occurrence rates of late-onset pulmonary fistula in the HS group were higher than in the EC group, but there is no statistical difference ( $P = 0.12$ , by Fisher).



**Fig. 6.** Late onset pneumothorax (arrow) occurred in 3 patients in HS group.



**Fig. 7.** The early closure within 6 months of the late onset thin-wall cavity had occurred in 2 patients of the EC group.

A chest CT showed the process of the resected area, one month postoperatively (a), 3 months postoperatively (arrow: thin-wall cavity) (b), and 6 months postoperatively (c).

a | b | c

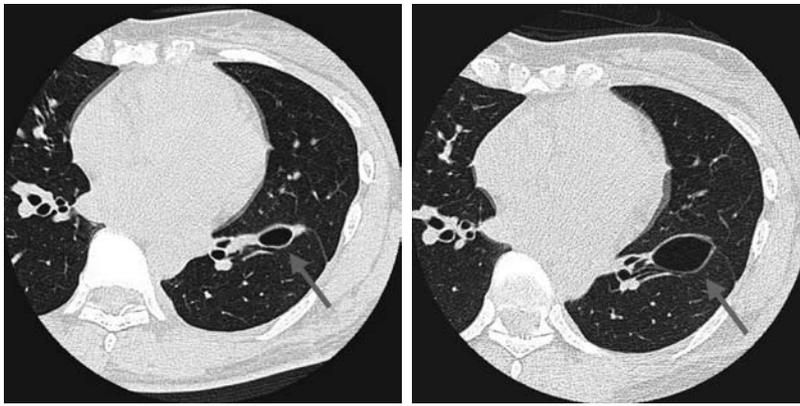
dissection of the lung is done close to the structure of the hilum, the formation of a postoperative pulmonary fistula should be considered. Stark et al.<sup>2)</sup> reported that a thin-walled cavity could be identified for months or even years after the resection of a lesion, and this cavity is the same as that described in this report.

The basic research and clinical reports on using the harmonic scalpel have been generated over the past 10 years. Suzuki et al.<sup>3)</sup> reported the effects of a prototypical harmonic scalpel on the lung in an experimental study, which showed less invasiveness than the electronic knife. The degree of lung destruction was light and shallow in depth, and the coagulation tissue was attached to the lung with a few contractions after 2 weeks. However, the curved shears type knife could not be adapted to the thick-cut margin of the lung parenchyma because of mechanical tearing caused by the grasping force after the cutting of the visceral pleura. Thus although hemostasis was possible, the air leakage could not be controlled by this method. The blade was subsequently improved, however, and the air leakage was controllable with adequate coagulation by holding the lung parenchyma. Molnar et al.<sup>4)</sup> reported the utility of the harmonic scalpel by an experi-

mental study of the survival of small animals for four weeks after resection of the lung parenchyma.

In clinical trials, Tanaka et al.<sup>5)</sup> reported on the usefulness of the harmonic scalpel in the lung resections of 56 patients, and it showed the same results on the postoperative drainage and hospitalization periods as the use of the autosuture instrument did. Although Molnar et al.<sup>6)</sup> also reported on the usefulness of the harmonic scalpel, the progress of the acute postoperative course, and the postoperative complications, they<sup>7)</sup> recommended careful use because complications combined with pulmonary fistulae occurred in 44% of the operated patients.

Regarding the comparative analysis of the histological findings of the harmonic scalpel and electrocautery, Cakan et al.<sup>8)</sup> reported that the tissue damage with coagulation necrosis was smaller in the harmonic scalpel than with the electrocautery in the experimental study of small animals, but we could find no clinical studies. We herein reported that coagulation necrosis showed a good effect on hemostasis and air leakage in the early postoperative period and that these phenomena were beneficial for the patients' early discharge from the hospital, but pulmonary fistulae occurred frequently in the chronic post-



**Fig. 8.** The long period (more than 6 months) of the late onset thin-wall cavity had occurred in 2 patients of the HS group and in 1 of the EC group. A chest CT showed the process of the thin-wall cavity (arrow) at 6 months postoperatively (a), and 12 months postoperatively (b).

operative stage. The layer of coagulation necrosis created by the harmonic scalpel with a curved shears type blade was thick, but the air leakage might come later from the dehiscence of this layer at the end of the shielded bronchus. On the other hand, the layer of coagulation necrosis created by the monopolar electrocautery was thinner and more easily broken than that created by the harmonic scalpel. As a result, the surgeon may elect to manually ligate the small bronchus around the point close to the pulmonary hilum, resulting in a lower incidence of pulmonary fistulae. Shields commented in a report by Cooper et al.<sup>9)</sup> that postoperative bleeding or pulmonary fistula would happen because of the dehiscence of the coagulation necrosis made by electrocautery, and that we should carefully observe patients in the postoperative course following a dissection of the lung parenchyma by means of a harmonic scalpel.

## Conclusion

The dissection of the lung parenchyma by either electrocautery or harmonic scalpel was useful for obtaining a shield effect of the cut surface during the operation and in the acute postoperative phase, and this effect was useful for the early ambulation of the patient. However, the late onset of pulmonary fistula after discharge occurred more frequently in the harmonic scalpel group than in the electrocautery group. Because of the thick coagulation necrosis (coagulum) generated by the harmonic scalpel, the postoperative wound healing was delayed, and it was thought that the small bronchial stump could therefore not tolerate the airway pressure. There was no problem in the dissection of peripheral lung parenchyma with either an electrocautery or harmonic scalpel. However, it seemed to be necessary to ligate the stump of the small

bronchus of the cut surface around the point close to pulmonary hilum, even if the stump was closed by coagulation necrosis with either an electrocautery or a harmonic scalpel.

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