Original Article

Single-port thoracoscopic wedge resection using the Endo GIA Radial Reload: outcome of 15 cases

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Background: We previously described the technique for single-port thoracoscopic lung wedge resection using the Endo GIA™ Radial Reload surgical stapler. The GIA Radial Reload has a curved cut line that is perpendicular to the direction of instrument insertion, facilitating the approach to the lung tissue behind the lesion. Herein, we report the outcomes of 15 cases using this procedure.

Methods: Between August 2016 and February 2018, 15 patients underwent single-port thoracoscopic wedge resection using the Endo GIA Radial Reload. Single-port thoracoscopic surgery was performed through 3–5-cm incisions. For the first stapler, we used a GIA Radial Reload cartridge. For the second and subsequent staplers, we used the GIA Radial Reload cartridge or a straight cartridge based on the direction of the cut.

Results: In one patient, we extended the incision up to 7 cm and performed video-assisted thoracotomy because the lesion was too small to find. In the other 14 patients, the procedure was completed through a 3–5-cm port. In one patient, we added a suture for air leakage detected intraoperatively. Postoperative air leakage occurred in two patients. These three patients had emphysema based on computed tomography. In the remaining 12 patients, no air leakage was found and the chest tube was removed on postoperative day 1.

Conclusions: This procedure is suitable for resecting small nodules, because palpation with two fingers is easy. The GIA Radial Reload cartridge may not be a good choice for emphysematous lung, because air leakage sometimes occurs.

Keywords: Device; thoracoscopy; operative procedure

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Introduction

Single-port thoracoscopic surgery has recently emerged as an approach for procedures such as lobectomy, wedge resection, pneumothorax surgery, and other thoracic surgeries (1-3). Although lung wedge resection is a relatively simple procedure, some specific techniques are necessary when using an endostapler because it is difficult to approach the lung tissue behind the lesion with an articulating endostapler during single-port thoracoscopic surgery (4).

We have previously described the procedure for single-port thoracoscopic wedge resection using the Endo GIA™ Radial Reload device (Medtronic, Minneapolis, MN, USA) (5). The GIA Radial Reload has a curved cut line that is perpendicular to the direction of instrument insertion, which facilitates the approach to the lung tissue behind the lesion. Herein, we report the outcomes from 15 cases using this procedure.

Methods

This research study was approved by the institutional review board (No. 2013-3). We included patients who underwent wedge resection for peripheral lesions with a diameter of 20 mm or less for this procedure. Between August 2016 and February 2018, 15 patients underwent single-port thoracoscopic wedge resection with the Endo GIA Radial Reload device. Of the 15 patients, 9 (60%)

Table 1 Background characteristics of the study patients (n=15)

Patient	Age (years)	Sex	Smoking history (pack-years)	Diagnosis	Tumor diameter (mm)	Distance from surface (mm)
1	46	F	0	Pulmonary metastasis from uterine leiomyosarcoma	6	10
2	74	F	0	Pulmonary arteriovenous fistula	11	0
3	49	F	0	Pulmonary metastasis from uterine leiomyosarcoma	4	4
4	52	M	0	Pulmonary metastasis from rectal cancer	12	0
5	62	M	42	Undiagnosed pulmonary nodule	12	14
6	68	F	0	Primary lung cancer	18	3
7	67	M	100	Pulmonary hamartoma	16	0
8	73	M	30	Pulmonary metastasis from esophageal cancer	6	0
9	74	F	0	Pulmonary arteriovenous fistula	16	0
10	50	M	10	Undiagnosed pulmonary nodule	13	0
11	71	F	0	Primary lung cancer	7	6
12	59	M	24	Pulmonary metastasis from rectal cancer	11	11
13	75	M	13	Primary lung cancer	12*	12
14	73	M	32	Pulmonary metastasis from renal cancer	3	2
15	45	M	0	Pulmonary metastasis from rectal cancer	5	4

*, the diameter includes the area of the ground-glass opacity. F, female; M, male.

Table 2 Details about the cases of primary lung cancer (n=3)

Patient	Stage	Surgery	Lymphadenectomy	Resection margin (mm)
6	TisN0M0	Radical resection	None	20
11	Recurrence (intrapulmonary metastasis)	Biopsy for EGFR T790M	None	10
13	T1bN0M0	Radical resection (passive limited resection)	None	20

were male and 6 (40%) were female. Age ranged from 45 to 75 years, with a mean age of 62.5 years. Seven patients had a history of smoking. Three patients underwent lung resection for primary lung cancer, seven patients for pulmonary metastasis from tumors in another organ, two patients for pulmonary arteriovenous fistula, two patients for undiagnosed pulmonary nodule, and one patient for pulmonary hamartoma. Lesion diameter ranged from 3 to 18 mm. The distance from the surface of the lung to the lesion ranged from 0 to 14 mm. Background characteristics of the study patients are shown in *Tables 1* and *2*.

General anesthesia was induced and separate lung ventilation was established with a double-lumen endotracheal tube. The patient was placed in the recumbent position. We made the incision near the lesion so it can be palpated. Single-port thoracoscopic surgery was performed through a 3–5-cm incision. The incision was covered with an Alexis Wound Protector/Retractor™ X-small (Applied Medical, Rancho Santa Margarita, CA, USA) or small or extra small SurgiSleeve™ Wound Protector (Medtronic). We used a rigid scope of 5 mm in diameter with a 30° angle. We used finger palpation to find the lesion when it was not visible through the visceral pleura. When we could not find the lesion through the incision, we extended the incision to find the lesion through finger palpation. For the first stapler, we used a purple (medium) or black (large) GIA Radial Reload cartridge (*Figure 1*). For the second and subsequent staplers, we used the GIA Radial Reload cartridge or a straight

cartridge, depending on the direction of the cut. Intercostal block or epidural anesthesia was used for postoperative pain management. Oral non-steroidal anti-inflammatory drugs were administered starting on the next day of surgery.

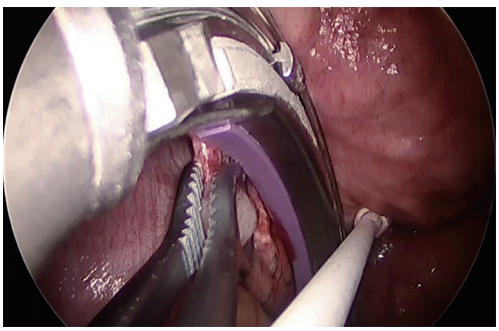

Figure 1 Intraoperative view in Patient 8. The pulmonary nodule was grasped with ring-shaped forceps. The nodule was resected with a purple GIA Radial Reload cartridge. The stapler, ring-shaped forceps, thoracoscope, and a straight instrument with cotton were inserted through the incision. With the GIA Radial Reload, we could easily approach the lung tissue behind the nodule.

Details of the procedure have been described previously (5).

Results

The details of each procedure are shown in *Table 3*. General anesthesia was used for all patients. Before wound closure, an intercostal block was routinely performed using ropivacaine hydrochloride hydrate. Since some patients complained of pain on the day of surgery, epidural anesthesia was used in three patients later in the series instead of an intercostal block. Continuous epidural infusion was performed for at least 1 day after surgery.

The duration of the procedure ranged from 24 to 55 minutes. The length of the skin incision ranged from 3 to 5 cm. In general, the length of skin incision was 3 cm for benign lesions and 4 cm for malignant lesions. We made longer incisions for malignant lesions in order to achieve sufficient surgical margins.

In Patient 14, we started the operation with a 5-cm skin incision. However, the lesion was too small to find (*Figure 2*). Therefore, we extended the incision to 7 cm and performed video-assisted thoracotomy. In all cases, 1 or 2 Radial Reload cartridges were used. The type of cartridge (black

Table 3 Details about the procedure

Patient	Lobe	Anesthesia type	Procedure duration (minutes)	Length of skin incision (cm)	Number and type of Radial Reload cartridges used	Number of straight cartridges used
1	RU	General	47	4.5	1 black	2
2	LL	General	24	3	1 purple	0
3	RU	General	43	4	2 black	0
4	LL	General	40	4	2 black	1
5	RU	General	44	4	2 purple	2
6	LU	General	43	4	1 purple and 1 black	0
7	RU	General	37	3	2 purple	0
8	LL	General	26	3	1 purple	0
9	RM	General	26	3	2 purple	0
10	RU	General	55	4	2 purple	0
11	RU	General	30	4	1 purple	1
12	RL	General and epidural	34	4	2 purple	1
13	LU	General	34	5	2 black	1
14	LU	General and epidural	41	5	1 purple	0
15	LL	General and epidural	35	4	2 purple	0

LU, left upper; LL, left lower; RU, right upper; RM, right middle; RL, right lower.

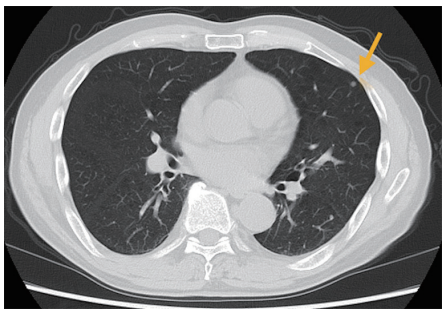

Figure 2 Computed tomography of the chest in Patient 14. A nodule of 3 mm in diameter was located in the left upper lobe, 2 mm away from the parietal pleura (yellow arrow). Since the lesion was too small to find, we extended the incision to 7 cm.

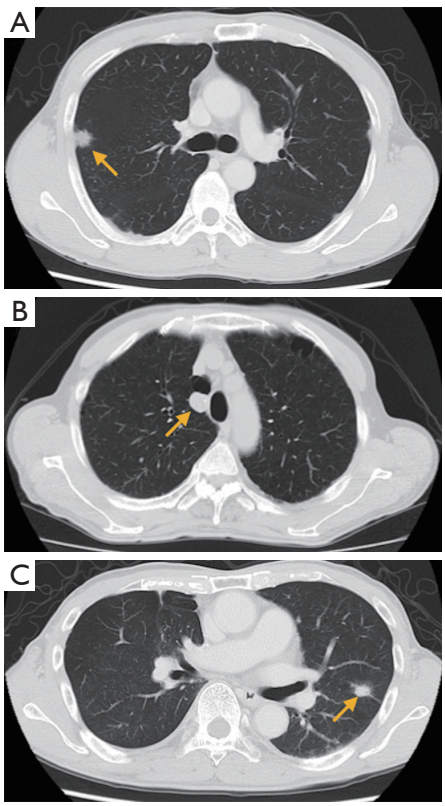

Figure 3 Computed tomography of the chest. (A) Patient 10 had an undiagnosed nodule in the right upper lobe (yellow arrow). Diffuse emphysematous changes were also found. (B) Patient 7 had a nodule diagnosed as pulmonary hamartoma in the right upper lobe adjacent to the trachea (yellow arrow). Emphysematous changes were also found in the right upper lobe. (C) Patient 13 had a solid nodule with a ground-glass opacity diagnosed as primary lung cancer in the left lower lobe (yellow arrow). Diffuse emphysematous changes were also found.

Table 4 Postoperative course

Patient	Duration of drainage (days)	Duration of postoperative hospital stay (days)	Postoperative complications
1	1	3	None
2	1	4	None
3	1	4	None
4	1	6	None
5	1	6	None
6	1	4	None
7	9	16	Prolonged air leakage, brain infarction
8	1	3	None
9	1	3	None
10	1	2	Wound infection
11	1	3	None
12	1	3	None
13	5	6	Prolonged air leakage
14	1	6	None
15	1	3	None

or purple) was selected based on the location and size of the lesion. In Patient 10, a stitch of suture and a polyglycolic acid sheet used as a covering were added to control air leakage identified after resection (*Figure 3A*).

The postoperative course is shown in *Table 4*. In 13 of 15 patients, the chest drain was removed on postoperative day 1. In our clinical pathway, the duration of postoperative hospital stay was set to 3 or 4 days. Three patients whose chest tubes were removed on postoperative day 1 stayed in the hospital for 6 days for the following reasons. One patient has diabetes mellitus and one patient has interstitial pneumonia. We observed these patients for longer than usual because of their comorbidities. The other patient stayed longer due to postoperative pain. In 2 patients (Patients 7 and 13), chest drainage lasted for 9 and 5 days, respectively, due to prolonged air leakage. Both patients had a history of smoking and had evidence of pulmonary emphysema on computed tomography (*Figure 3B,C*). In Patient 7, air leakage resolved without any additional procedures. In Patient 13, chemical pleurodesis and

coagulation factor XIII concentrate were needed to control air leakage. Brain infarction occurred after the resolution of air leakage during hospitalization. The duration of postoperative hospital stay ranged from 2 to 16 days, with a mean of 4.8 days. In one patient, wound infection occurred after discharge.

The duration of the postoperative follow-up ranged from 128 to 674 days. During this follow-up period, no local tumor recurrences were observed.

Discussion

We reported 15 cases of single-port thoracoscopic lung wedge resection, which included one case converted to thoracotomy. At first, we used general anesthesia with an intercostal block for this procedure, because single-port thoracoscopic surgery is less painful than multi-port thoracoscopic surgery, as previously reported (6). However, patients often complained of pain after the intercostal block wore off. Therefore, we switched to general and epidural anesthesia during the more recent cases. Although single-port thoracoscopic surgery is less painful, epidural anesthesia is still useful for pain management.

The minimum length of the skin incision was 3 cm. For the nodules adjacent to the pleura, a 3-cm incision is sufficient when it is not necessary to use palpation to locate the nodule. A longer incision is needed to find nodules distant from the pleura. One advantage of this procedure is that we can palpate the nodule with two fingers through the port, while only one finger is generally used in multi-port thoracoscopic surgery (7). In Patient 14, who had a 3-mm nodule that was 2 mm from the pleura, we could not find the lesion through a 5-cm port, so we extended the incision to find it. In such cases, it is easy to extend and widen the incision, which is another advantage of this procedure.

Air leakage occurred in three patients, including one intraoperative leak and two postoperative leaks. All three patients with air leakage were smokers and had evidence of emphysema on computed tomography. Although air leakage frequently occurs in patients with emphysema, the Radial Reload cartridge may not be a good choice for the resection of emphysematous lung. In patients with a history of heavy smoking or emphysema, we should consider using other staplers such as the Endo GIA™ Reinforced Reload (Medtronic).

In conclusion, this procedure is suitable for the resection of small nodules, because palpation with two fingers is easy. For pain management, general anesthesia combined with epidural anesthesia is recommended. Care must be taken in patients with emphysema; the GIA Radial Reload cartridge may not be a good choice for emphysematous lung.

Acknowledgements

None.

Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

Ethical Statement: This research study was approved by the institutional review board (No. 2013-3). Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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