Original Article

Three-Port Two-Instrument Complete Thoracoscopic Lobectomy with Unique Retrieving Technique for Lung Cancer — Comparison Between Complete Thoracoscopic Lobectomy and Conventional Thoracoscopic Lobectomy

Yu-Jen Cheng

Objectives: For improving quality of patient care, complete thoracoscopic lobectomy was accomplished via three ports using two-instrument technique (TPTI). The resected specimen was removed without extending the port wounds (1.2 cm). We retrospectively compared the results of TPTI with those of conventional thoracoscopic lobectomy (CTL) in patients with lung cancer.

Methods: From January 2011 to October 2013, fifty lung cancer patients received lobectomy and complete mediastinal lymph node dissection using TPTI (group TPTI). The surgical outcomes were compared with those of 56 other patients who received CTL (group CTL). The first and the latest 10 cases in the TPTI group were also compared.

Results: There were no differences in age, sex, tumor size, location of the lobectomy, and mean post-operative drainage time between the TPTI and CTL groups (both $p > 0.05$). The mean blood loss and the mean hospitalization time were less in the TPTI group (both $p < 0.05$). The mean number of lymph nodes removed was less and the mean surgical time was longer in the TPTI group ($p < 0.05$). Compared to the first 10 cases in the TPTI group, the mean surgical time significantly decreased and the mean number of lymph nodes removed significantly increased in the latest 10 cases (both $p < 0.05$).

Conclusions: Compared with CTL that requires an accessory wound for manipulations, three-port complete thoracoscopic lobectomy with two-instrument technique is a less invasive strategy for lung cancer treatment with a short period of learning curve.

Key words: thoracoscopy, lung neoplasms, thoracic surgery, video-assisted, lymph node excision

From the Department of Surgery, E-Da Cancer Hospital, and Division of Thoracic Surgery, Department of Surgery, E-DA Hospital, and School of Medicine for International Student, College of Medicine, I-Shou University, Kaohsiung, Taiwan.

Received: April 11, 2015 Accepted: September 12, 2016

Address reprint request and correspondence to: Yu-Jen Cheng, Division of Thoracic Surgery, Department of Surgery, E-Da Hospital, No. 1, Yida Road, Jiaosu Village, Yanchao District, Kaohsiung City 82445, Taiwan.
Tel: +886-7-6151100, E-mail: yujen.cheng@msa.hinet.net

Introduction

Pulmonary lobectomy with lymph node resection is a standard treatment for lung cancer.[1,2] With advances in thoracoscopic technique, pulmonary lobectomy and lymph node resection via thoracoscopy has become an accepted procedure. Even for lung cancer treatment, this approach has been confirmed to comply with oncologic principles and produce surgical outcomes comparable to those of other conventional thoracotomy approaches.[3-5]

The conventional video-assisted thoracoscopic technique needs an accessory wound of 4 to 5 cm for manipulation. This accessory wound not only causes additional wound pain and impairs the quality of postoperative care, but it is also cosmetically undesirable. Three-port two-instrument thoracoscopic lobectomy (TPTI) is a thoracoscopic approach without accessory wound. In addition to the merits of minimal wound pain of the three-port technique, we proposed a distinct way to remove the resected specimen without extending any 1.2-cm port-wound.[6] Herein, we report our experience using this TPTI technique and retrospectively compare the results with those of the conventional video-assisted thoracoscopic technique with accessory wound (CTL).

Materials and Methods

From January 2011 to October 2013, 113 lung cancer patients were treated with thoracoscopic lobectomy (single lobe). Of the 113 patients, 7 receiving open-conversion were excluded. There were 50 patients treated successfully by TPTI without the need for an accessory wound (group TPTI). These patients were compared with 56 lung cancer patients, who received conventional video-assisted thoracoscopic lobectomy with an accessory wound (group CTL).

Three-port two-instrument lobectomy is defined as a lobectomy performed by a complete thoracoscopic procedure, with one instrument in each port (balloon-type port, Kii® Advanced Fixation Sleeve, Applied Medical, Rancho Santa Margarita, CA, USA) (Fig. 1). All three ports are 1.2 cm in size and only two operating instruments are allowed to manipulate the structures via the ports at the same time. The pulmonary vessels are individually manipulated and the lobar bronchus is always cut with an endo-stapler, green carriage. The CO_2 inflation is maintained at a pressure of 7-10 cmH_2O with the operation table tilted as needed. After being resected, the whole lobe is sliced into several strips using endo-staplers. The number and size of the lung strips depend on the location and size of the main tumor. The cutting margin should be at least 1 cm away from the tumor mass.[7] The lung strips are then put into a two-layered protection bag with one strip being moved at a time. The protection bag is pulled out through one of the port wounds without further wound extension as detailed in our previous publication.[6] The malignant tissue is the last one to be removed. Following removal of the specimen, complete mediastinal lymph node dissection is carried out as recommended in the European Society of Thoracic Surgeons (ESTS) guideline.[8,9] All the removed tissues were sent for detailed pathological examination. The conventional video-assisted thoracoscopic lobectomy (CTL) is done with three entering wounds. One of the wounds is an accessory wound created at the beginning of the operation and is usually

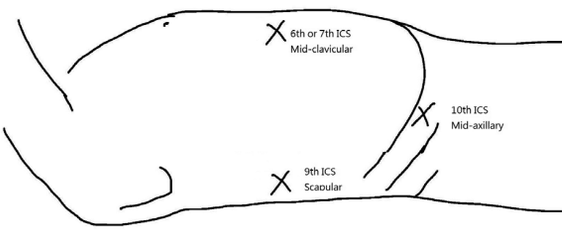

Fig. 1 This figure shows the position of the port-wound in the right chest. All the three ports are located in the lower chest for upward manipulation of the instruments and the thoracoscopy.

4-5 cm in size. The operation is conducted under visual monitoring and conventional instruments can be used. The resected lobe is put into a single-layered protection bag and removed through the accessory wound. Complete mediastinal lymph node dissection is done as described above.

All the patients were required to complete a satisfaction questionnaire consisting of 5 categories (i.e., cost, wellness sensation, hospitalization duration, wound cosmetic sensation and wound pain) in 5 grades (excellent = 5, good = 4, fair = 3, poor = 2, and bad = 1). These questionnaires were collected after discharges by an independent person who did not take part in the operative procedures.

We compared the first 10 cases (group F) with the last 10 cases (group L) in the TPTI group for learning curve investigation. The first 10 operations were performed in the period between Jun 2012 and October 2012, while the last 10 operations were performed in the period between July 2013 and October 2013.

Quantitative data are presented as mean ± SD. Two-sided Student's t-test was used to determine the significance of difference between the two groups. Pearson Chi-Square test was used for comparison of categorical data between the two groups. $p < 0.05$ is considered statistically significant.

Results

Among the 113 patients, conversion to open thoracotomy occurred in four and three patients for whom thoracoscopic lobectomies with TPTI and CTL were initially proposed, respectively, such a respective conversion rate of 7.4% (4/54) and 5.1% (5/59).

In the 50 patients of TPTI group, there were 28 females and 22 males with mean age of 61.5 ± 10.3 years (Table 1). The postoperative stages (pStages) were stage Ia in 21 patients, stage Ib in 14 patients, stage IIa in 5 patients, stage IIb in 2 patients, stage IIIa in 7 patients, and stage IV in 1 patient. The mean tumor size was 2.8 ± 1.1 cm. There were 11 right upper lobectomies (RUL), 6 right middle lobectomies (RML), 11 right lower lobectomies (RLL), 14 left upper lobectomies (LUL), and 8 left lower lobectomies (LLL). The mean number of lymph nodes removed was 25.6 ± 11.5. The mean surgical time was 313.0 ± 86.0 min, and the mean blood loss was 131.6 ± 140.5 mL. The mean duration of chest tube placement was 6.4 ± 3.5 days, and the mean length of hospital stay was 10.1 ± 4.1 days. There were no major complications. Minor complications consisted of prolonged air leak of more than 7 days in two patients, cerebral vascular accident in one patient, and pulmonary thrombosis on the operated side in an 80-year-old patient. All patients fully recovered after conservative treatment. In comparison, in the 56 patients of CTL group, there were 21 females and 35 males with mean age of 62.3 ± 12.1 years. The pStages were stage Ia in 23 patients, stage Ib in 9 patients, stage IIa in 6 patient, stage IIIa in 14 patient, and stage IV in 4 patients. The mean tumor size was 3.4 ± 3.2 cm. There were 20 RUL, 4 RML, 6 RLL, 18 LUL, and 8 LLL. The mean number of lymph nodes removed was 32.9 ± 15.8. The mean surgical time was 256.5 ± 73.1 min, and the mean blood loss was 208.0 ± 203.3 mL. The mean duration of chest tube placement was 7.0 ± 3.8 days, and the mean length of hospital say was 12.0 ± 5.0 days. There were no major complications. Minor complications consisted of wound infection in one patient, re-operation for bronchial stump bleeding in one patient, multiple admissions due to chest wound pain in one patient, post-operative pleural empyema in one patient, and prolonged air leakage for more than 7 days in three patients.

There were no differences between the TPTI and CTL groups with respect to sex ($p = 0.057$), age ($p = 0.704$), tumor size ($p = 0.220$), duration of chest tube placement ($p = 0.388$),

Table 1(A). Comparisons of demographic and clinical information between the TPTI and CTL groups.

	Group	Mean	Standard deviation	*p*-value*
Age (year)	TPTI	61.5	10.3	
	CTL	62.3	12.1	0.704
Tumor Size (cm)	TPTI	2.8	1.1	0.220
	CTL	3.4	3.2	
LN (number)	TPTI	25.6	11.5	
	CTL	32.9	15.8	0.010
Op time (min)	TPTI	313.0	86.0	
	CTL	256.5	73.1	0.000
Blood (ml)	TPTI	131.6	140.5	
	CTL	208.0	203.3	0.025
Hospital stay (day)	TPTI	10.1	4.1	
	CTL	12.0	5.0	0.032
Drainage (day)	TPTI	6.4	3.5	
	CTL	7.0	3.8	0.388

TPTI: A complete thoracoscopic lobectomy via three ports with two-instrument technique.; CTL: A conventional thoracoscopic lobectomy with an accessory wound for manipulations. * Significance of difference determined by Student's t-test

Table 1(B). Comparison of gender and pathologic information between TPTI and CTL groups.

	Group						*p*-value*
Sex		Male	Female				
	TPTI	22	28				
	CTL	35	21				0.057
Stage		Ia	Ib	IIa	IIb	IIIa	IV	
	TPTI	21	14	5	2	7	1	
	CTL	23	9	6	0	14	4	0.214
Lobe		RUL	RML	RLL	LUL	LLL		
	TPTI	11	6	11	14	8		
	CTL	20	4	6	18	8		0.324
Type		Ade	SqCC	SCC	Ad-Sq	Large		
	TPTI	42	5	1	1	1		
	CTL	44	11	1	0	0		0.411

TPTI: Complete thoracoscopic lobectomy via three ports with two-instrument technique.; CTL: Conventional thoracoscopic lobectomy with an accessory wound for manipulations.; LN: Total number of the resected lymph nodes reported by the pathology; Op time: Duration of operation; Blood: Intraoperative blood loss; Drainage: The duration of the drainage tube placement; Stage: Post-operative pathologic stage; Lobe: The resected lobe; Type: Tumor type (ade: adenocarcinoma; SqCC: squamous cell carcinoma; SCC: small cell carcinoma; Ad-Sq: adeno-squamous cell carcinoma; Large: large cell carcinoma) * Significance of difference determined by Pearson Chi-Square test

pStages (p = 0.214), location of the lobectomy (p = 0.324) and tumor type (p = 0.411). The number of lymph node removed, blood loss and length of hospital stay were less in group TITP (p = 0.010, 0.025 and 0.032, respectively), whereas the operation time was longer in the TITP group (p = 0.000). The statistic data are listed in Table 1.

Table 2. Results of the questionnaire obtained from the discharged patients.

Category	Group	Mean	Standard deviation	*p*-value
Cost	TPTI	4.2	0.7	
	CTL	3.6	0.6	0.006
llness	TPTI	4.4	0.6	
	CTL	3.6	0.6	0.001
Time	TPTI	4.4	0.5	
	CTL	4.1	0.6	0.054
Wound	TPTI	4.5	0.5	
	CTL	3.8	0.8	0.001
Pain	TPTI	4.5	0.6	
	CTL	3.4	0.7	0.000
Mean score	TPTI	4.4	0.2	
	CTL	3.7	0.3	0.000

The questionnaire contained 5 categories: Cost: the money spent during hospitalization; Wellness: the subjective wellness sensation after operation; Time: satisfaction with the length of the hospital stay; Wound: the cosmetic condition of the surgical wounds was evaluated; Pain: satisfaction with wound pain control. Each category in 5 grades (excellent = 5, good = 4, fair = 3, poor = 2, bad=1). TPTI: Complete thoracoscopic lobectomy via three ports with two-instrument technique.; CTL: Conventional thoracoscopic lobectomy with an accessory wound for manipulations.

The results of the satisfaction questionnaire showed significant advantages of TPTI over CTL in 4 of the 5 categories: the cost, wellness sensation, wound cosmetic satisfaction and wound pain (p = 0.006, 0.001, 0.001 and 0.000, respectively) (Table 2). However, the satisfaction with the length of hospitalization had no significant difference between the two groups (p = 0.054). The mean satisfaction score was 4.4 ± 0.1 in TPTI group and 3.7 ± 0.3 in CTL group (p < 0.001), showing significantly higher degree of satisfaction of the TPTI group compared to that of the CTL group.

To investigate the learning curve, we compared the first 10 cases (group F) with the latest 10 cases (group L) in the TPTI group (Table 3). There were no differences between F and L groups with respect to sex (p = 0.371), age (p = 0.240), tumor size (p = 0.391), blood loss (p = 0.158), length of hospital stay (p = 0.296), duration of chest tube placement (p = 0.790), pStages (p = 0.107), location of the lobectomy (p = 0.255) and the tumor type (p = 0.317). The number of lymph node removed was significant more in the L group (p = 0.022) and the operation time was significant less in

Table 3(A). Comparisons of demographic, operative, and postoperative data between the first 10 cases (group F) and the latest 10 cases (group L) in the TPTI group.

	Group	Mean	Standard deviation	*p*-value*
Age	F	65.0	9.5	
(year)	L	59.1	12.1	0.240
Size	F	2.65	1.1	
(cm)	L	2.23	1.0	0.391
LN	F	22.5	3.4	
(number)	L	31.2	10.4	0.022
Op time	F	365.0	80.0	
(min)	L	248.5	20.7	0.001
Blood	F	197.0	194.3	
(ml)	L	100.0	52.7	0.158
Hospital stay	F	9.1	2.4	
(day)	L	8.1	1.7	0.296
Drainage	F	6.1	3.0	
(day)	L	5.8	1.9	0.790

LN: The total number of the resected lymph nodes reported by the pathology; Op time: The operation time from skin to skin; Blood: The blood loss during the operation; Drainage: The duration of the drainage tube intubation; * Significance of difference determined by Student's t-test

Table 3(B). Comparisons of gender and pathologic date between the first 10 cases (group F) and the latest 10 cases (group L) in the TPTI group.

Group							*p*-value*
Sex		Male	Female				
	F	6	4				
	L	4	6				0.371
Stage		Ia	Ib	IIa	IIIa		
	F	5	3	2			
	L	6	1	0	3		0.107
Lobe		RUL	RML	RLL	LUL	LLL	
	F	1	2	1	4	2	
	L	5	0	1	2	2	0.255
Type		Ade	SqCC	SCC	Large		
	F	7	1	1	1		
	L	10	0	0	0		0.317

Stage: Post-operative pathologic stage; Lobe: The resected lobe; Type: Tumor type (ade: adenocarcinoma; SqCC: squamous cell carcinoma; SCC: small cell carcinoma; Ad-Sq: adeno-squamous cell carcinoma; Large: large cell carcinoma) * Significance of difference determined by Pearson Chi-Square test

the L group ($p = 0.001$) compared to that in the F group.

Discussion

It has been reported that the extent of the lymph node dissection through the thoracoscopic approach is not inferior to that of open thoracotomy.[10,11] In this study the mean number of lymph nodes removed was less in the TPTI group than that in the CTL group. Consistent with the finding of our previous study,[12] the present study showed that the number of resected lymph node increased with experience as reflected in the latest 10 cases of the TPTI group (L group).

Surgery alone is considered not enough for treating non-small cell lung cancer due to its high recurrence rate. The 5-year recurrence rate ranged from 25% (15% distant recurrence) in stage IA to 75% (60% distant recurrence) in stage IIIA. Post-operative adjuvant chemotherapy is recommended for prolonging survival time and decrease the incidence of recurrence.[13,14] The less invasive thoracoscopic operation has been reported to reduce the adverse influence of operation on immune response[15] and may facilitate the implementation of adjuvant therapy. Adjuvant therapy was given to both groups of patients in this study within 4 weeks after operation if indicated. No obvious differences were noted between these two groups regarding the incidence of chemotherapy-related side effects (data not shown).

One technical tip in complete thoracoscopic surgery without an accessory wound as in TPTI is the use of gravity to replace the 4th port to pull the lung aside through tilting the operating table. Using CO_2 inflation to increase the intra-thoracic pressure up to 7-10 cm H_2O can provide more space to manipulate the pulmonary structures. Successful one-lung ventilation with continuous endobronchial suction of the operative side during anesthesia is the prerequisite for successful three-port thoracoscopic lobectomy.

Surgical wound size matters to the patients.[16] Not only do the 1.2 cm small wounds in the three-port technique have a cosmetic merit, but they can also reduce wound pain and enable early discharge as supported by the results of questionnaires and the reduction of mean hospital stay by 2 days in the TPTI group.

To remove the whole resected lobe from

the 1.2 cm wound is a challenge. Cutting the resected lung tissue into several strips with endo-staplers allows the specimen to be easily removed through the port wound. Our results showed that tumors as large as 6.0 cm could be removed via the three-port thoracoscopic lobectomy approach. It is important that the cutting edge should have a safe margin of at least 1 cm from the tumor to avoid tumor seeding in the thoracic cavity.[7] In addition, removal of the specimen with a double-layer protection bag provides greater security against breakage. We always use a rubber glove in the inner layer which is covered outside by a commercial endobag®. Our study showed no bag breakage in the TITP group.

Our results demonstrated that the technique of three-port two-instrument thoracoscopic lobectomy without port wound extension is feasible and welcomed by the patients. Further follow-up is required for long-termed prognosis evaluation.

Conflict of interest statement

I am fully responsible for this manuscript. I have no conflicts of interest and have no financial disclosure.

Disclosure

The author reports no conflict of interest concerning the materials, methods, and findings in this study.

Professor Yu-Jen Cheng (1962 - 2016)

In loving memory of Professor Yu-Jen Cheng whose wholehearted devotion to improving the quality of care for surgical patients, to helping children with special needs and to medical education will long be remembered.

References

1. Ginsberg RJ,Rubinstein LV: Randomized trial of lobectomy versus limited resection for T1 N0 non-small cell lung cancer. Lung Cancer Study Group. Ann Thorac Surg 1995;60:615-22; discussion 622-3.
2. Whitson BA, Groth SS, Andrade RS, et al.: Survival after lobectomy versus segmentectomy for stage I non-small cell lung cancer: a population-based analysis. Ann Thorac Surg 2011;92:1943-50.
3. Murthy S: Video-assisted thoracoscopic surgery for the treatment of lung cancer. Cleve Clin J Med 2012;79 Electronic Suppl 1:eS23-5.
4. Tajiri M, Maehara T, Nakayama H, et al.: Decreased invasiveness via two methods of thoracoscopic lobectomy for lung cancer, compared with open thoracotomy. Respirology 2007;12:207-11.
5. Hanna WC, de Valence M, Atenafu EG, et al.: Is video-assisted lobectomy for non-small-cell lung cancer oncologically equivalent to open lobectomy? Eur J Cardiothorac Surg 2013;43: 1121-5.
6. Cheng Y-J: A Convenient Technique for Retrieving a Lung Lobe in Three-port Two-instrument Thoracoscopic Lobectomy in Lung Cancer. MITT KLOSTERNEUBURG 2015;65:166-175.
7. Higashiyama M, Kodama K, Takami K, et al.: Intraoperative lavage cytologic analysis of surgical margins as a predictor of local recurrence in pulmonary metastasectomy. Arch Surg 2002;137:469-74.
8. De Leyn P, Lardinois D, Van Schil P, et al.: European trends in preoperative and intraoperative nodal staging: ESTS guidelines. J Thorac Oncol 2007;2:357-61.
9. Lardinois D, De Leyn P, Van Schil P, et al.: ESTS guidelines for intraoperative lymph node staging in non-small cell lung cancer. Eur J Cardiothorac Surg 2006;30:787-92.
10. Watanabe A, Koyanagi T, Ohsawa H, et al.: Systematic node dissection by VATS is not inferior to that through an open thoracotomy: a comparative clinicopathologic retrospective study. Surgery 2005;138:510-7.
11. Watanabe A, Nakazawa J, Miyajima M, et al.: Thoracoscopic mediastinal lymph node dissection for lung cancer. Semin Thorac Cardiovasc Surg 2012;24:68-73.
12. Cheng YJ: The learning curve of the three-port two-instrument complete thoracoscopic lobectomy for lung cancer-A feasible technique worthy of popularization. Asian J Surg 2015;38:150-4.
13. Pisters KM,Le Chevalier T: Adjuvant chemotherapy in completely resected non-small-cell lung cancer. J Clin Oncol 2005;23:3270-8.
14. Alam N, Darling G, Evans WK, et al.: Adjuvant chemotherapy for completely resected non-small cell lung cancer: a systematic review. Crit Rev Oncol Hematol 2006;58:146-55.

15. Whitson BA, D'Cunha J, Andrade RS, et al.: Thoracoscopic versus thoracotomy approaches to lobectomy: differential impairment of cellular immunity. Ann Thorac Surg 2008;86:1735-44.

16. Chen P-R, Chen C-K, Lin Y-S, et al.: Single-incision thoracoscopic surgery for primary spontaneous pneumothorax. Journal of Cardiothoracic Surgery 2011;6:1-4.