

Low-cost biportal endoscopic surgery for primary spontaneous pneumothorax

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Background: Like many other countries, including the United States, China faces the problem of rising health care costs, which have become a heavy burden on the state and individuals. Endoscopic surgery offers many benefits. However, the need for more expensive endoscopic consumables brings further high medical costs. Therefore, the development of video-assisted thoracic surgery with no disposable consumables will help to control medical cost escalation.

Methods: Between October 2011 and September 2014, a series of 66 patients with primary spontaneous pneumothorax underwent hand ligation of blebs under biportal video-assisted thoracoscopic surgery or bullectomy with stapler during triportal video-assisted thoracoscopic surgery. After treatment of blebs, pleural abrasion was performed with an electrocautery cleaning pad.

Results: Compared with the group treated by bullectomy with stapler, we found a significant reduction in postoperative costs in the group with bleb ligation. There was no difference in operating time, chest tube drainage, and postoperative stay between the two groups. The follow-up period varied from 1 to 35 months and six cases of recurrence were noted.

Conclusions: The technique that we described appears to offer better economic results than bullectomy with a stapler under three-port video-assisted thoracoscopic surgery for treating primary spontaneous. The clinical outcomes are similar.

Keywords: Biportal video-assisted thoracic surgery; primary spontaneous pneumothorax; ligation; medical costs

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Introduction

Like many other countries, including the United States, China faces the problem of rising health care costs (1-8), which have become a heavy burden on the state and individuals. To cope with the problem, many cost-control strategies have been tried, without success. Technological innovation in health care is an important driver of cost growth. Endoscopic surgery, as an innovating technology, provides excellent results for the treatment of a wide range of chest diseases including primary spontaneous pneumothorax. Although endoscopic surgery offers many benefits, the need for more expensive endoscopic consumables is often associated with high costs. Therefore,

avoiding the use of disposable consumables in video-assisted thoracic surgery will be help to control the escalation of costs. In this article, we describe low-cost, biportal video-assisted thoracic surgery for treatment of primary spontaneous pneumothorax.

Patients and methods

Patients

Between October 2011 and September 2014, we operated on a series of 66 consecutive patients with primary spontaneous pneumothorax using techniques of hand ligation of blebs under biportal video-assisted

Table 1 Patient characteristics

Characteristic	Bleb ligation	Bullectomy with stapler	P value
October 2011-June 2012 (Consecutive patients)	0	9	
July 2012-March 2014 (A randomised controlled trial)	29	21	
April 2014-September 2014 (Consecutive patients)	7	0	
Age (years)	26.14±7.55	26.27±7.43	0.899
Gender (male:female)	28:8	24:6	0.826
Operation			
Right lung/left lung/bilateral lung	20/13/3	19/14/3	0.969
Site of lesion			
The apex*/Not the apex	33 (84.62%)/6	31 (93.94%)/2	0.210
Operative time (min)	80.86±28.28	79.31±30.27	0.831
Chest tube drainage (mL)	290.47±160.50	323.11±333.55	0.703
Postoperative drainage duration (day)	1.67±1.12	2.27±2.08	0.141
Postoperative stay (day)	4.69±1.49	5.10±2.63	0.434
Surgical material costs			
CNY	5,673.36±2,206.95	8,630.49±3,742.23	0.001
USD	916.25±356.42	1,393.82±604.37	
Hospital cost			
CNY*	16,785.48±2,643.08	21,088.54±6,005.68	0.001
USD	2,710.86 ±426.86	3,405.80±969.92	
Prolonged air-leak (>5 days)	0	3	0.89
Recurrence*	3	3	0.91

*, there were three patients who underwent operation on both lungs in each group. The recurrence was analyzed using Kaplan-Meier curves and log rank tests (df =1, P=0.913). CNY 1= USD 0.1608. CNY (Chinese Yuan).

thoracoscopic surgery or bullectomy with staplers under triportal video-assisted thoracoscopic surgery. Preoperative computed tomography for complete localization of the blebs was performed. Indications for thoracoscopic surgery and resection of primary spontaneous pneumothorax were as follows: (I) recurrent ipsilateral pneumothorax; (II) prolonged air leak over 4 days in the first episode of pneumothorax; (III) visible large bullae >10 mm in diameter on chest computed tomography; (IV) bilateral pneumothorax in the first episode; (V) occurrence of contralateral pneumothorax. The patients' characteristics and surgical procedures are summarized in *Table 1*. All the procedures were carried out with the legal consent of the individual patient and with the approval of the Ethics Committee.

Operative techniques

The patients were placed in a lateral position with the

ipsilateral arm abducted. The procedures were performed under general anesthesia with double-lumen endotracheal intubation for single lung ventilation. After bleb ablation and pleural abrasion with an electrocautery cleaning pad (Shanghai Shangyi Kangge Medical Instruments, Shanghai, China), an 8.5 F drainage tube (Guangzhou Leadgem Medical Devices, Guangzhou, China) was inserted in thoracic cavity. When drainage was <100 mL/day in the postoperative period, the chest tube was removed. All the patients received routinely follow-up by telephone or cellphone and no patients were missed.

Hand ligation of blebs

One port of about 1 cm was placed in the seventh intercostal space on the middle axillary line and another of 2-3 cm in the fourth intercostal space on the anterior axillary line. After the lung on the operative side was deflated, a 30° thoracoscopy and endoscopic instruments were introduced into the thoracic cavity.

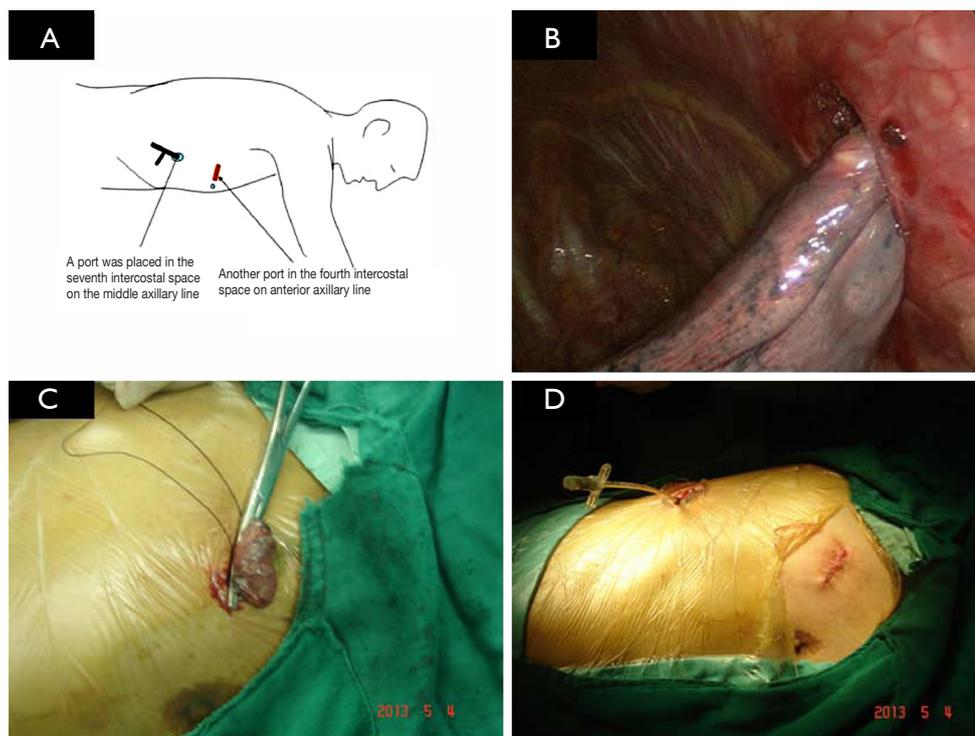


Figure 1 Extrapleural bleb ligation by hand. (A) Ports placed in the chest; (B) view of the lung apex withdrawn out of the utility incision from the pleural cavity; (C) the apex was suture-ligated under direct vision; (D) view of incisions and drainage tube.

Extrapleural bleb ligation

The procedures were done as in *Figure 1*. When blebs were found at the apex of the lung and patients had a thin chest wall, the apex and the blebs were grasped with a lung forceps and gently withdrawn through the utility incision. Extrapleural bleb ligation under direct vision and wedge resection were performed.

Intrapleural bleb ligation

The procedures were done as in *Figures 2 and 3*. When the blebs were located outside the lung apex or the patient had a thick chest wall, a curved vascular clamp was placed beneath the bleb, which was pulled close to the utility incision and ligatured by hand. In the last ten patients, the technique of intrapleural bleb ligation by hand was used wherever the blebs were located.

Bullectomy with stapler

Bullectomy was performed by staplers [Reach Surgical (Beijing), Beijing, China] under triportal thoracoscopic surgery. A video thoracoscope was inserted through the trocar in the seventh intercostal space and other instruments through the two ports placed in the fourth intercostal space on the anterior axillary line and the eighth intercostal space

on the posterior axillary line. After bullectomy, pleural abrasion was performed and a drainage tube was inserted as described above.

Statistical analysis

Data are expressed as mean \pm SD. Groups were compared with a two-sided independent samples *t* test or two-independent samples tests or Kaplan-Meier curves and log rank tests. Using Statistical Package for the Social Sciences version 15 (SPSS Inc., Chicago, IL, USA). Significance was set at $P < 0.05$.

Results

Compared with the technique of bullectomy with stapler, we found a significant reduction in postoperative costs for hand ligation of blebs. There was no difference in operating time, chest tube drainage, postoperative stay, and recurrence between the two groups (*Table 1*). No conversion to open surgery was necessary and there were no complications in the two groups. The follow-up period varied from 27 to 1,060 days and six patients had recurrence.

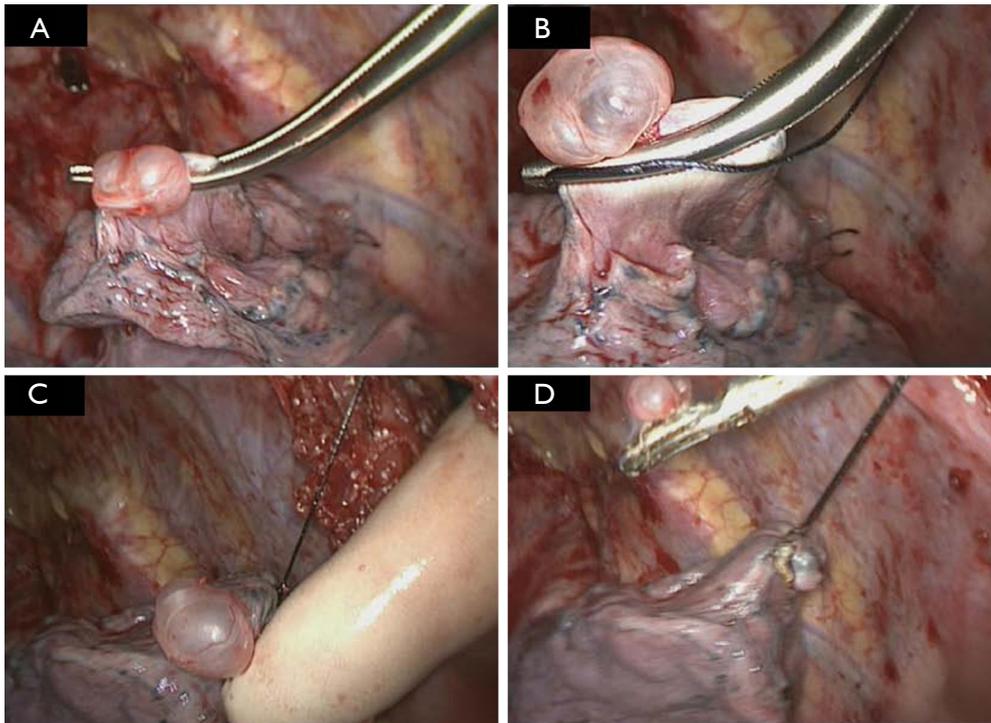


Figure 2 Intrapleural bleb ligation by hand. (A) A curved vascular clamp was placed beneath the bulla; (B) a 1/0 silk thread was placed beneath the curved vascular clamp and pulled the bleb close to the utility incision; (C) intrapleural hand ligation of the bleb; (D) resection of the bleb.

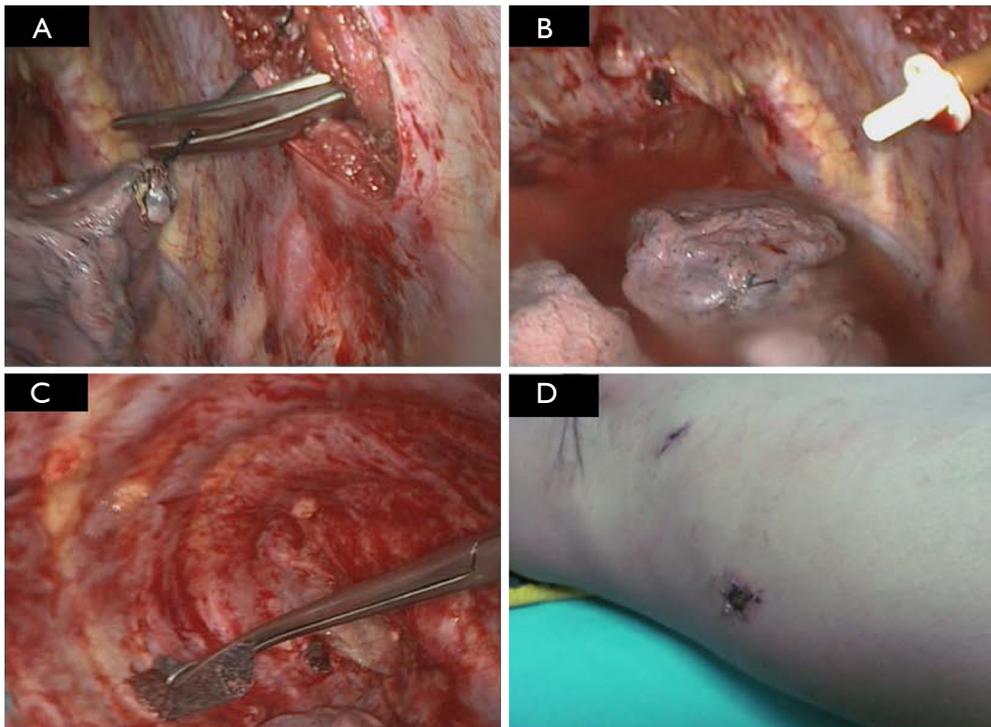


Figure 3 Making air leak tests and pleural abrasion with an electrocautery cleaning pad. (A) Cutting silk thread; (B) making air leak tests; (C) pleural abrasion with an electrocautery cleaning pad; (D) view of the final cosmetic postoperative result from the two-port thorascopic technique.

In the hand ligation group, extrapleural bleb ligation and wedge resection were performed in 16 patients (44.44%, 16/36), intrapleural bleb ligation in 19 (52.78%, 19/36), and the blebs were tied using an endo-push instrument in one (2.78%, 1/36).

Discussion

Health care costs have become a heavy burden on the state and individuals worldwide (1-8). Technological innovation in health care is an important driver of cost growth. So, the development of advanced and low-cost technology to stop cost growth is necessary. Primary spontaneous pneumothorax occurs frequently (9,10) and many treatment options exist. Video-assisted thoracoscopic surgery for primary spontaneous pneumothorax has become a popular procedure because it is less invasive than conventional thoracotomy (11-17). There are many options for this therapeutic approach, including three-port (11,12,14,17,18), double-port (19-22) and uniport (23-29) techniques. There are also various methods for the treatment of blebs, including endo-stapling/resection (11,17,18,20-22), ligation (11-13,15), electrocoagulation (30,31), or laser coagulation (31). Bullectomy with stapler combined with pleurodesis through three ports is the most commonly used procedure. Although endoscopic surgery offers many benefits, such as smaller incisions, less pain, less blood loss, less respiratory compromise, and shortened length of stay, the need for more expensive endoscopic consumables is often associated with high costs. It is estimated that the use, on average, of one staple cutter and two reloadable cartridges for each case of bullectomy, costs > USD 400 (32). [A staple cutter is about CNY (Chinese Yuan) 2,500 and a reloadable cartridge is CNY 1,848. So, the costing of consumables alone is USD 996.32 for each patient]. The high cost of the stapler deters many hospitals from adopting this approach. Here, we report a simple, quick and cost-effective biportal video-assisted thoracoscopic technique for treatment of primary spontaneous pneumothorax.

Bleb ligation was used in open surgery for treatment of primary spontaneous pneumothorax (33,34). Endo-ligation using an endo-push instrument is cumbersome and time consuming (16). Difficulty in tying knots resulted in the development of the endo-stapler, however, this is expensive. To avoid too rapid an increase in medical costs, bleb ligation under endoscopic surgery was used to treat small discrete blebs by Yim in 1995 (32). In addition, endo-loop ligation has been used in other cases because it is cost-effective,

convenient, ubiquitously available (13,15), and associated with a lower rate of recurrence than mechanical stapling for bullectomy (15). In 2007, Chang *et al.* (12) reported a technique of video-assisted extrathoracic bleb excision using a conventional stapler. Our technique is different from these others. Hand ligation of blebs was performed in 35 patients (97.22%, 35/36) and no dislodgment of the ligature was found. Compared with endo-loop ligation, bleb ligation by hand may be more convenient and safe. The incidence of primary spontaneous pneumothorax is 8 per 100,000 population per year (35); 40% of patients need surgical treatment (36) and USD 400 is saved per case (32); therefore, our technique could save \$17,920,000 annually in China alone (1,400,000,000 population).

Why can the blebs be ligated by hand? First, primary spontaneous pneumothorax is commonly observed in young, tall, thin individuals. A thin person always has a thin chest wall and compliance of the lung parenchyma is good in young adults. Second, the blebs are most often located in the apex of the lung (12,14) and lung surface. Finally, the longitudinal diameter of the lung is greater than its transverse diameter. All these reasons allow the blebs to be pulled out through or near the utility incision and ligated. Hand ligation of blebs can be performed by extrapleural or intrapleural ligation. Extrapleural ligation can be applied to blebs located at the apex of the lung and in patients with a thin chest wall. Intrapleural ligation can be applied in almost all circumstances. Our technique of hand ligation of blebs could be used in all patients, except those in whom the blebs are in oblique fissures of the right lung and near the hilum. Although most of the cases in our series had apical blebs, the utility of extrathoracic bleb excision would fall short in dealing with blebs outside the lung apex, or in patients with a thick chest wall. Under these circumstances, the blebs are pulled close to the utility incision and hand ligation is advised. The technique of intrapleural ligation could be applied when the blebs are located in the lung apex. The blebs were not removed in some of our cases because we thought that the preserved bleb tissues were of help in wound healing and prevented air leakage from the wound, which can shorten the duration of chest tube insertion (15).

Experimental and clinical experience with biportal endoscopic surgery has led to the conclusion that this method is effective and less traumatic than triportal endoscopic surgery. Bleb ligation, decompression, and excision are believed to be a simplified method for the surgical management of blebs. The combination of biportal

endoscopic surgery and bleb ligation is advocated as a method of choice in the surgical management of primary spontaneous pneumothorax. Our technique used no expensive endoscopic consumables and made only two incisions. Thus, the technique has the following potential advantages: (I) reducing hospital costs; (II) reducing postoperative pain and thereby speeding recovery (19,20); (III) providing better cosmetic results; (IV) hand ligation is a simple and reliable method of tying knots; (V) the method is easy to master; (VI) lower rate of recurrence (15); and (VII) bleb ligation may be quicker and more effective than wedge resection with a mechanical stapler. The technique that was used for biportal thoracoscopic surgery is more limited than the endoscopic stapling devices and the potential disadvantages of this technique are not known.

Conclusions

Funding: The technique we described appears to offer better economic results than the standard three-port video-assisted thoracoscopic surgery for treating primary spontaneous pneumothorax, and the clinical outcomes are similar. Nevertheless, our experience with this method is limited. It is important that further research confirms the benefits of this technique.

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