Interactive CardioVascular and Thoracic Surgery 23 (2016) 196–201
doi:10.1093/icvts/ivw123 Advance Access publication 10 May 2016

ORIGINAL ARTICLE – THORACIC

Cite this article as: Guo Z, Yin W, Zhang X, Xu X, Liu H, Shao W *et al*. Primary spontaneous pneumothorax: simultaneous treatment by bilateral non-intubated videothoracoscopy. Interact CardioVasc Thorac Surg 2016;23:196–201.

Primary spontaneous pneumothorax: simultaneous treatment by bilateral non-intubated videothoracoscopy

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Received 12 November 2015; received in revised form 22 March 2016; accepted 9 April 2016

Abstract

OBJECTIVES: Through a retrospective study, we assessed the feasibility and safety of simultaneous bilateral thoracoscopic wedge resection of blebs or bullae for the treatment of primary spontaneous pneumothorax (PSP) under thoracic epidural anaesthesia with spontaneous ventilation.

METHODS: This retrospective analysis involved a cohort of 37 consecutive patients undergoing simultaneous bilateral thoracoscopic bullectomy under spontaneous ventilation thoracic epidural anaesthesia (n = 15) or intubated general anaesthesia (n = 22) between July 2011 and September 2015. The perioperative data, short-term outcomes and recurrence rates of the two groups were compared.

RESULTS: The two groups had comparable preoperative demographic profiles. There were no conversions to thoracotomy or intubated single-lung ventilation. The peak end-tidal carbon dioxide in the non-intubated group was significantly higher than that in the intubated group (mean: 48 vs 34 mmHg, P < 0.001). Both groups had comparable surgical duration, blood loss and lowest intraoperative pulse oxygen saturation level. Postoperatively, the two groups had comparable chest tube duration, volume of fluid administration, length of hospital stay and complication rates. No mortality occurred. The total anaesthesia cost in non-intubated group was significantly lower (mean: CNY 4584 vs 5649, P = 0.016). The mean follow-up was 23.6 ± 12.9 months in the non-intubated group and 21.1 ± 13.4 months in the intubated group. Two recurrent pneumothoraxes in 2 patients were observed after surgical procedures for PSP. One recurrence developed in the non-intubated group (7%) and one in the intubated group (5%).

CONCLUSIONS: Simultaneous bilateral non-intubated thoracoscopic bullectomy is not only well tolerated and technically feasible but also a safe alternative for selected patients with simultaneous bilateral PSP or with high risk of contralateral recurrence.

Keywords: Pneumothorax • Video-assisted thoracoscopic surgery • Bullectomy • Non-intubated • Spontaneous ventilation • Thoracic epidural anaesthesia

INTRODUCTION

Primary spontaneous pneumothorax (PSP) is a relatively common health problem. It typically occurs in thin, tall and young men [1]. In addition, PSP has a high possibility of recurrence with contralateral recurrence accounting for a large percentage. Specifically, computed tomography scans have shown more than 50% of patients with unilateral PSP to have blebs or bullae in the contralateral lung [2]. The primary goal of pneumothorax treatment is to prevent future recurrence. Conservative treatments were associated with an ipsilateral recurrence range of 16–52% and a contralateral recurrence rate of 5–15% [3, 4]. The incidence of contralateral recurrence after unilateral operation was significantly higher with a range of 18–50% [5–7].

Baronofsky *et al*. [8] first introduced the concept of simultaneous bilateral thoracotomy for SP because of an almost 100% occurrence of bilateral blebs in patients with unilateral SP. Chou *et al*. [9] reported that pre-emptive video-assisted thoracic surgery (VATS) for the contralateral blebs or bullae could exempt the subsequent hospitalization, anaesthesia and operation. Single-stage bilateral VATS bullectomy under intubated general anaesthesia has been proved to be safe and shown to be superior to conservative treatments and unilateral operation in terms of effectively preventing contralateral recurrence (recurrence rate ranged from 0 to 7%) [9, 10]. With the advantage of simultaneous bilateral VATS, it has

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become a valid alternative procedure for selected patients with PSP.

Traditionally, VATS is performed under general anaesthesia, using double-lumen endotracheal intubation. However, some potential disadvantages of this procedure can be avoided using a non-intubated anaesthetic method [11–13]. Non-intubated anaesthesia is reported to limit the adverse effects of intubated general anaesthesia and single-lung ventilation. It avoids the use of muscle relaxants, and has been used for the management of numerous thoracic diseases [11–15]. However, the non-intubated anaesthetic technique that combines thoracic epidural anaesthesia (TEA) with sedation for simultaneous bilateral non-intubated thoracoscopic wedge resection of blebs or bullae has yet to be reported. We performed a retrospective analysis to describe our simultaneous bilateral non-intubated VATS bullectomy experience, and to determine whether this procedure could achieve similar outcomes compared with simultaneous bilateral VATS bullectomy under intubated general anaesthesia in patients with simultaneous bilateral PSP or with high risk of contralateral recurrence.

MATERIALS AND METHODS

This study was reviewed and approved by the First Affiliated Hospital of Guangzhou Medical University Research Ethics Committee. All patients signed the 'Consent to Epidural Anesthesia with Nontracheal Intubation' or 'Consent to General Anesthesia with Tracheal Intubation' prior to anaesthesia.

Patients

Between July 2011 and September 2015, 37 consecutive patients undergoing simultaneous bilateral thoracoscopic wedge resection of blebs or bullae for the treatment of PSP by the same anaesthetist team and group of thoracic surgeons were included. The generally accepted indications for operative intervention in PSP are as follows: (i) ipsilateral recurrence + contralateral blebs or bullae; (ii) first occurrence + contralateral blebs or bullae; (iii) unilateral PSP with previous contralateral occurrence; (iv) bilateral simultaneous PSP; and (v) professions at risk, e.g. pilots and divers. The indications in this retrospective series are reported in Table 1. Patients considered appropriate for non-intubated anaesthesia include those with American Society of Anaesthesiologist's class (ASA) I–II, body mass index (BMI) <25, Mallampati grade I–II, little airway secretion and absence of epidural puncture contraindications. Prior to operation, eligible patients made their decision after the pros and cons of both non-intubated and intubated general anaesthesia were explained by surgeons and anaesthetists. If patients did not meet the criteria or patients and their families could not make the decision after our detailed explanation, they would receive intubated general anaesthesia.

Table 1: Operative indications

Indication	Non-intubated (*n* = 15)	Intubated (*n* = 22)
Ipsilateral recurrence + contralateral blebs or bullae	1	4
First occurrence + contralateral blebs or bullae	5	9
Unilateral PSP that had contralateral attacks before	7	3
Bilateral simultaneous PSP	1	3
Professions at risk (e.g. pilot and divers)	1	3

PSP: primary spontaneous pneumothorax.

Surgical technique

Anaesthesia in non-intubated patients. Patients received intramuscular midazolam 0.06 mg/kg and atropine 0.01 mg/kg 30 min before anaesthesia. Electrocardiogram, heart rate, blood pressure, pulse oxygen saturation (SpO_2), end-tidal carbon dioxide ($EtCO_2$), respiratory rate, bispectral index and urine volume were continuously monitored for patients after entering the operating room. After establishing intravenous rehydration, an epidural catheter was inserted in the thoracic T7–8 or T8–9 space. In the supine position, 2 ml of 2% lidocaine was injected through the epidural catheter. If signs of spinal anaesthesia were not present in 5 min, fractionated injection of 12 ml 0.375% ropivacaine was administered. Before surgery, the anaesthesia level should reach between T2 and T10.

Anaesthesia was induced with the target-controlled infusion of propofol (target plasma concentration of 2–3 μg/ml) and sufentanil 0.1–0.2 μg/kg. A laryngeal mask was positioned after induction and no muscle relaxants were used throughout the procedure. During the operation, all patients were provided supplementary oxygen (2–3 l/min) via laryngeal mask and the respiration rate was 12–20/min. Anaesthesia was maintained with target-controlled infusion of propofol (target plasma concentration of 1–2 μg/ml), dexmedetomidine (target plasma concentration of 0.5–1 μg/kg/h). Bispectral index monitoring was maintained at 40–60 during the operation.

Subsequently, bilateral sequential thoracoscopic surgery was performed with the patient in the lateral decubitus position. After performing the incisions, the ipsilateral lung was gradually collapsed to obtain maximal visualization of the lungs under iatrogenic pneumothorax. To reduce cough reflex induced by thoracoscopic manipulation, and to ensure a steady surgical environment, 6 ml of 2% lidocaine was sprayed on the surface of the lung under thoracoscopic guidance in the chest cavity. After the unilateral operation, the patient was turned to the other side to perform the contralateral surgery, and the resection procedure was repeated. When the pleural cavity was closed and the wound was sutured, administration of intravenous drugs was suspended.

After removal of the epidural catheter and laryngeal mask, patients were sent to the recovery room and returned to the ward after full anaesthetic recovery. The patient was allowed to walk immediately postoperatively and resume oral intake 4 h later.

Anaesthesia in intubated patients. Patient monitoring in this group is the same as that of the non-intubated group (described above). Anaesthesia was induced with target-controlled infusion of propofol (target plasma concentration of 2–3 μg/ml) and sufentanil 0.4–0.6 μg/kg. As soon as the patients lost consciousness, endotracheal intubation was facilitated with cisatracurium 0.2–0.3 mg/kg. When single-lung ventilation was started, the operative lung was deflated by clamping and disconnecting the ipsilateral tube of the double-lumen endotracheal tube. The dependent lung was ventilated with a tidal volume of 8–10 ml/kg at a respiratory rate of 15 breath/min. An inhalation-to-exhalation expiration ratio of 1:2 was maintained to keep the $EtCO_2$ between 28 and 35 mmHg. Anaesthesia was maintained with target-controlled infusion of propofol (target plasma concentration of

ORIGINAL ARTICLE

1–2 µg/ml), remifentunil (target plasma concentration of 4–6 ng/ml) and sevoflurane 1–2% during operation, and intermittent IV boluses of cisatracurium 0.1–0.2 mg/kg. It is important to use a fibreoptic bronchoscope to examine the correct location of double-lumen tubes when patient positioning is adjusted for the contralateral procedure.

After the operation, patients were extubated in the operating theatre and sent to the recovery room. The patient would return to the ward when he (she) was fully awake and could resume oral intake 6 h after extubation.

Surgical management

All video-assisted thoracic operations were performed using a Stryker 1288 HD 3-Chip Camera System. The patient was placed in the lateral position with the upper arm extended and fixed on the hand support. Unilateral surgery was performed first. For this part of the procedure, two ports were made. A 1-cm skin incision was created in the seventh intercostal space at the anterior axillary line after which a soft incision protector (Lap Protector; Hakko Co., Ltd, Chikuma-Shi, O-aza Isobe, Japan) was placed. A 10-mm 30° video thoracoscope was then inserted into the thoracic cavity, and the entire thoracic cavity was fully explored. On the basis of the preliminary exploration results, the second 1.5-cm incision was made in the fourth or fifth intercostal space at the linea pre-axillaris. Another soft incision protector was used. The operative procedure began with the introduction of grasping forceps through the operating incisions to help determine the exact locations of the pulmonary blebs or bullae. The lung was inspected to detect blebs/bullae and air leaks, moving from the apex to the base. Pleural adhesions were completely freed using electrocautery or endoscopic harmonic scalpel (Ethicon Endo Surgery, Inc., Johnson & Johnson Medical Spa, Somerville, NJ, USA) under video vision. Lung blebs or bullae were resected using an endostapler (Echelon 45 Endopath stapler; Ethicon Endosurgery Corp., Cincinnati, OH, USA). When no blebs or bullae were visible, we routinely resected a small portion of the apex of the lung. At the end of the procedure, sterile warm physiological saline was instilled and the operated lung was manually expanded via temporary positive-pressure ventilation to check for air leaks, afterwards an 18 Fr chest tube was introduced through the camera port incision guided to the apex under direct camera visualization. After the pleural cavity was closed and the wound was sutured, the collapsed lung was re-expanded with mild negative-pressure suction through the chest tube. After a short period of double-lung spontaneous ventilation, the patient was flipped over to the opposite side to perform the contralateral surgery. This procedure was identical to the first with the exception of the port locations (the second set of incisions were located parallel to the first set).

Postoperative analgaesia consisted of non-steroidal anti-inflammatory drugs and/or opioids. Criteria for chest tube removal and discharge were standardized as thoracic fluid volume less than 200 ml for 24 h, complete lung re-expansion demonstrated on chest radiography, and no air leak. All patients were discharged the day after removal of the chest tube.

Statistical analyses

Statistical analysis was performed using SPSS 19.0 software (SPSS, Inc., Chicago, IL, USA). Continuous variables such as age and body weight were expressed as means ± standard deviations. Owing to the small cohort, the two-sample *t*-test was used for the statistical analysis. Categorical variables such as sex and smoking status were presented as frequencies (%), and Fisher's exact test was used for the analysis. Statistical significance was accepted as a *P*-value of less than 0.05 throughout the study.

RESULTS

Baseline characteristics

Patient characteristics are summarized in Table 2. Between July 2011 and September 2015, 37 patients underwent simultaneous bilateral thoracoscopic wedge resection of blebs or bullae for the treatment of primary spontaneous pneumothorax. Among them, 15 patients were treated without endotracheal intubation using TEA and sedation (non-intubated group). The other 22 patients were treated conventionally under general anaesthesia with a double-lumen endotracheal tube (intubated group). There was no significant difference in baseline characteristics between the two groups, including age, gender, height, weight, BMI and smoking status.

Surgical and anaesthetic results

The surgical and anaesthetic results are given in Table 3. In the non-intubated patients, the inhibition of cough reflex was effective after spraying 2% lidocaine on the surface of the lung. The mean surgical duration of the two groups was comparable. During the operation, the peak $EtCO_2$ measured during single-lung ventilation in the non-intubated group was significantly higher than that measured in the intubated group (48 ± 6 vs 34 ± 5 mmHg, $P < 0.001$). The lowest intraoperative SpO_2 level was 98 ± 2% in the non-intubated patients, which was not significantly different from that of the intubated patients (99 ± 2%) ($P = 0.16$).

The total anaesthesia cost (including analgaesic drugs cost and disposable materials cost) in the non-intubated group was CNY 4584 ± 1069, which was significantly lower than CNY 5649 ± 1381 in the intubated group ($P = 0.016$). In addition, blood loss, volume

Table 2: Demographic and clinical patient characteristics

Variable[a]	Non-intubated (*n* = 15)	Intubated (*n* = 22)	*P*-value
Age (years)	21.9 ± 5.2	26.2 ± 11.4	0.23
Weight (kg)	55.8 ± 10.6	56.1 ± 7.1	0.40
Height (cm)	172.8 ± 3.36	172.3 ± 4.2	0.52
BMI	18.6 ± 2.7	18.9 ± 2.3	0.42
Gender			>0.99
Male	14 (93%)	21 (95%)	
Female	1 (7%)	1 (5%)	
Smoking status			>0.99
Smoking	2 (13%)	2 (9%)	
No smoking	13 (87%)	20 (91%)	

BMI: body mass index.
[a]Continuous data are shown as mean ± standard deviation and categorical variables as number (%).

Table 3: Surgical and anaesthetic results

Variable[a]	Non-intubated (n = 15)	Intubated (n = 22)	P-value
Surgical duration (min)	121 ± 35	103 ± 37	0.15
Peak $EtCO_2$ during operation (mmHg)	48 ± 6	34 ± 5	<0.001
Lowest SpO_2 during operation (%)	98 ± 2	99 ± 2	0.16
Conversion to intubation (%)	0 (0%)	0 (0%)	
Conversion to thoracotomy (%)	0 (0%)	0 (0%)	
Total blood loss (ml)	12 ± 11	16 ± 14	0.28
Bilateral chest drainage (days)	2.4 ± 1.2	3.1 ± 2.8	0.54
Postoperative hospital stay (days)	4.5 ± 1.3	5.2 ± 2.1	0.28
Bilateral fluid administration (ml)	179 ± 133	224 ± 367	0.71
Total anaesthesia cost, CNY	4584 ± 1069	5649 ± 1381	0.016
Analgaesic drug cost, CNY	1444 ± 501	1937 ± 686	0.023
Disposable materials cost, CNY	3140 ± 720	3712 ± 863	0.042
Complication			
Air leak > 5 days	0 (0%)	2 (9%)	0.51
Perioperative death	0 (0%)	0 (0%)	
Follow-up period (months)	23.6 ± 12.9	21.1 ± 13.4	0.57
Recurrence	1 (7%)	1 (5%)	>0.99

$EtCO_2$: end-tidal carbon dioxide; SpO_2: pulse oxygen saturation; CNY: China Yuan, which is unit of money in China.
[a]Continuous variables are presented as mean ± standard deviation and categorical variables as number (%).

of fluid administration and length of postoperative hospital stay were comparable between two groups.

Postoperative complication profiles

No patients required conversion from VATS to thoracotomy in either group. There were no conversions to intubated general anaesthesia in the non-intubated group. No mortality occurred in either group. Only one notable complication (air leaks > 5days) developed in 2 patients (9%) in the intubated group. There were no notable complications in the non-intubated group.

Follow-up

Patient follow-up was completed in 100% of patients through either a clinic visit or telephone interview. The mean follow-up was 23.6 ± 12.9 months in the non-intubated group and 21.1 ± 13.4 months in the intubated group. Two recurrent pneumothoraxes in 2 patients were observed after surgical procedures for PSP. The overall 2-year recurrence rate was 5%. One recurrence developed in the non-intubated group (7%) and the other in the intubated group (5%) (P > 0.99).

DISCUSSION

Our study analysed the postoperative outcomes of patients undergoing simultaneous bilateral non-intubated VATS for the treatment of PSP. This is the first report showing that simultaneous bilateral non-intubated VATS bullectomy is feasible and can be performed safely with satisfactory outcomes and a low rate of recurrence, similar to the results for bilateral VATS under general anaesthesia with single-lung ventilation.

The use of general anaesthesia with endotracheal intubation in thoracic surgery is common and has distinct advantages. However, it is still associated with several potential adverse effects, including trauma to teeth, peri-intubational hypoxia, airway injuries associated with the double-lumen endotracheal tube (sore throat, hoarseness and cough), unilateral ventilator-induced lung injury and neuromuscular problems [16].

In our opinion, general anaesthesia is more aggressive than non-intubated anaesthesia and excessive for simple procedures. Although there is much debate regarding the use of the non-intubated anaesthetic approach, recent publications have reported some advantages and are in favour of using this technique in suitable patients. The most attractive rationale of non-intubated anaesthesia is its avoidance of intubation-specific adverse effects. In addition, muscle relaxants are not used which lowers operative risk and expedites postoperative recovery [11, 17, 18].

The non-intubated anaesthetic technique has been advocated by some investigators for selected patients with unilateral SP [1, 12, 19]. In 1997, Nezu *et al.* [19] first reported satisfactory results with non-intubated VATS bullectomy for SP. In 2007, Pompeo *et al.* [1] reported VATS bullectomy under sole TEA results in shorter length of stay and better patient satisfaction through randomized 60 patients under either general anaesthesia or TEA. Consistent with our initial short-term outcomes, a principal finding was that using TEA in uniportal thoracoscopic wedge resection for PSP assured us that this approach was not only feasible but also as safe as general anaesthesia via intubation [12]. Considering the encouraging results of previous studies, it appeared worthwhile to propose simultaneous bilateral VATS bullectomy under non-intubated anaesthesia. We hypothesized that this technique may be a good alternative for selected patients with simultaneous bilateral PSP or with high risk of contralateral recurrence.

Bilateral VATS wedge resection under non-intubated anaesthesia was considered more challenging than that under intubated general anaesthesia. This is mainly attributed to the difficulties typically avoided with the use of muscle relaxants such as lung movement and the cough reflex. It is also attributed to the increased possibility of hypoxia and hypercapnia induced by sequential single-lung ventilation and significant mediastinal movement [18]. However, as our experience broadened, normal lung movements were no longer a problem in minor operations and techniques have been developed that assist in controlling these issues.

Cough reflex induced by stretching the hilum or compression of cartilaginous bronchi was troublesome and could interfere in the performance of non-intubated major pulmonary resection. Chen *et al.* reported that intrathoracic vagal block using 2 ml of 0.25% bupivacaine performed somewhere adjacent to the ipsilateral vagus nerve could effectively abolish this reflex, without affecting heart rate, breathing rate and blood pressure. However, it was not necessary for us to perform this procedure in wedge resection. Our experience has shown that using a spray of 2% lidocaine on the surface of the lung instead of vagal blockade, cough reflex is also effectively abolished [12, 13]. Vagal blockade might raise the risks of damage to adjacent vessels and its effects may last for more than 3 h [18]. Residual vagal blockade occasionally resulted in transient recurrent laryngeal nerve palsy after short operations. Nevertheless, vagal blockade may be useful in more complex procedures when the spray of lidocaine may be unable to control the cough reflex well.

The mandatory surgical requirement during non-intubated VATS is to prevent lung intrusion of the operative field and to achieve a good view of the thorax. In our non-intubated experience, a satisfactory view is achieved in all patients, unless there are diffuse pleural adhesions, due to the natural collapse of the operative lung that occurs as a result of iatrogenic pneumothorax. Theoretically, nearly complete ipsilateral lung collapse may receive both less ventilation and less perfusion in the lateral position that results in functional compromise under spontaneous ventilation. However, in our study, the SpO_2 and $EtCO_2$ levels measured during the operation were adequate in all cases. The non-intubated patients breathed oxygen through a laryngeal mask during the procedure to maintain a good oxygenation index. The lowest intraoperative SpO_2 level in these patients was above 90%, which was comparable with that of the intubated patients. The peak $EtCO_2$ was significantly higher in non-intubated patients than that in the intubated group, which was consistent with previous reports [18, 20]. A potential result of partial collapse of the operative lung and the rebreathing effect, hypercapnia was observed after epidural anaesthesia and target-controlled infusion analgaesia were administered. The respiratory rate grew compensatively and $EtCO_2$ increased continuously when iatrogenic pneumothorax occurred on the operative side, nevertheless, $EtCO_2$ levels rapidly returned to normal values after the operation. According to our experience, the hypercapnia that occurs in this procedure is well-tolerable and had little effect on the haemodynamics [20].

According to our experience and the published literature, the indications for conversion from non-intubated anaesthesia to intubated general anaesthesia include significant mediastinal or lung movement, persistent hypoxaemia, unstable haemodynamic status or uncontrolled bleeding [17]. No conversions occurred in this study; however, single-lumen endotracheal intubation is prepared as back-up in all non-intubated procedures. In the event that a conversion is required surgeons should place a chest tube to the apex through the camera port incision immediately and seal the wounds with transparent waterproof dressings. Simultaneously, anaesthetists should perform intubation using a single-lumen endotracheal tube under guidance of fibre bronchoscopy or visual laryngoscopy, followed by insertion of a bronchial blocker, without changing the lateral position of the patient. In our experience, an expert and skilled anaesthesiologist can perform the conversion safely and quickly. Surgeons should not hesitate to convert to intubated general anaesthesia.

Mechanical pleurodesis by pleural abrasion is one of the most widely used techniques for PSP as an adjunctive procedure to wedge resection of blebs or bullae. But there is little evidence that pleural abrasion actually reduced recurrence of PSP [21]. However, there exists a correlation between the extent of abrasion and development of complications. These complications include postoperative chest discomfort manifesting as dull chest pain, postoperative bleeding or haemothorax, Horner syndrome, impairment of pulmonary function and fibrothorax [21]. Pleural abrasion also increased intraoperative bleeding and postoperative pleural drainage, causing additional trauma to patients [22]. Multiple papers have reported encouraging results after wedge resection without pleural abrasion, which has been the standard method in our centre [23]. In 2014, Min *et al.* [24] described an experience similar to ours that wedge resection alone was sufficient to prevent recurrence, especially in patients with isolated or limited bullae.

After the initial operation, an auxiliary suction device was used to suction the 18 Fr chest tube and facilitated the re-expansion of lung tissues. The chest tube was then connected to a water-sealed drainage bottle while performing the other side. After the contralateral procedure and lung re-expansion, the second 18 Fr chest tube was connected to another water-sealed drainage bottle. We believe this procedure is more tolerable for patients and ensures full lung ventilation on at least one side. Both chest tubes were removed after X-ray ensured full lung re-expansion, no air leak and thoracic fluid volume was less than 200 ml for 24 h. We believe that removal of postoperative chest drainage as soon as possible is safe, and may assist in a faster and less painful recovery. Our experience was in agreement with Bjerregaard *et al.* [22]. Any residual pneumothorax or intrathoracic air leak could be easily managed by closed thoracic drainage.

One finding of note is that simultaneous bilateral non-intubated VATS wedge resection did not impair recognition of blebs or bullae. After the initial incision, the blebs or bullae remained inflated, while the lung gradually collapsed. This was conducive to recognition as the exact location of blebs or bullae could be easily confirmed on the lung surface. Therefore, the recurrence rate after bilateral VATS bullectomy was 7% in the non-intubated group and 5% in the intubated group. These results are consistent with previous reports of bilateral VATS bullectomy [9, 10].

TEA was mostly adopted in previously reported non-intubated VATS studies and the results achieved are promising [1, 11–13, 18, 20]. Even so, there are some potential disadvantages. First, this technique is both time-consuming and technically demanding. In addition, there are some potential adverse effects including epidural haematoma, spinal cord injury and phrenic nerve palsy. Other anaesthesia-related phenomena may also arise such as intraoperative hypotension and bradycardia. Though the adverse effects are rare, their life-altering negative impact must still be considered. Prompt management of these adverse effects can stall or diminish undesired sequelae. Other effective alternative measures such as thoracic paravertebral blockade, intercostal block or simple local anaesthetic injection should be considered for non-intubated VATS.

Furthermore, in our experience, laryngeal mask was not necessary for simple non-intubated operation. However, patient safety is always the priority. Although some studies have reported the successful use of a nasal cannula or facial mask in different type of non-intubated thoracic surgery, the use of non-intubated VATS especially in bilateral non-intubated VATS, may sometimes result in airway obstruction and respiratory depression. In our experience, securing the patients' airway using a laryngeal mask during the procedure allows us to provide deep sedation and improve patient comfort without compromising patient safety. It allows spontaneous ventilation with ventilator pressure and volume monitoring, therefore reducing the risk of bronchoaspiration. In our study, the laryngeal mask was used only for airway management and inhalation of oxygen. It provides assisted ventilation in case of significant hypoventilation or respiratory depression. The use of a laryngeal mask potentially combines the strengths of the non-invasive face mask and the invasive endotracheal tube. This technique was created to fill an important functional gap that exists between the standard methods of airway management and the novel non-intubated method.

Limitations

We acknowledge there are several limitations to this study. First, this is a retrospective single-institution study. The retrospective analysis result is influenced by various bias, which comes from the sources that could not be identified or controlled. Second, limited by the retrospective nature, we do not have sufficient data about both values of $EtCO_2$ and SpO_2 registered at the end of the first and the second procedure, respectively, so the extend of the second procedure affected the overall $EtCO_2$ and oxygenation in the non-intubated group is not included in this paper. Third, the small study population may affect the final results. A larger study population could potentially yield differences in analyses outcomes. A well-designed randomized clinical trial in large patient population with longer period of follow-up is warranted to confirm our findings.

CONCLUSIONS

In summary, this study suggests that simultaneous bilateral thoracoscopic wedge resection of blebs or bullae utilizing non-intubated anaesthesia is safe, feasible and well tolerated. We believe that this technique is a simple and valid alternative to conventional intubated general anaesthesia for the surgical management of selected patients with simultaneous bilateral PSP or with high risk of contralateral recurrence.

ACKNOWLEDGEMENTS

We thank Lindsey Hamblin for reviewing the manuscript.

Conflict of interest: none declared.

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