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ORIGINAL ARTICLE

The uses of laryngeal mask airway ProSeal™ and endobronchial blocker for one lung anesthesia

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Abstract
Purpose The use of an endobronchial blocker in conjunction with a supraglottic device in elective thoracic cases has never been studied. The aim of this study was to report the success rate and time to placement of the endobronchial blocker in anaesthetized patients with a laryngeal mask airway (LMA)-ProSeal™ in place.
Methods This was a single-center, prospective, descriptive pilot study that enrolled 30 patients aged 18–75 years, with ASA I–III, who underwent elective thoracotomy or video-assisted thoracoscopy. We collected data on time to placement of the endobronchial blocker into the selected bronchus, time consumed for final blocker positioning and inflation, lung deflation score at chest opening, and postoperative airway complications.
Results One patient was excluded because of high peak airway pressure during LMA ventilation. The time required for blocker placement in the right main bronchus was shorter [mean 160 (78–480) s] compared with that for the left main bronchus [225 (117–420) s]. The blocker was successfully placed on the first attempt in 25 patients. Lung deflation score graded by the surgeon was 8/10 (median). Minor postoperative airway complications, such as sore throat (28.6 %) and hoarseness of voice (17.9 %), were reported.
Conclusions The use of LMA-ProSeal™ in conjunction with the COOPDECH Endobronchial Blocker Tube may be considered an alternative one-lung ventilation technique in selected cases. However, success rates and time required for placement of the blocker seem dependent on the operator's skill. Although postoperative sore throat and hoarseness of voice were reported, these improved in 24 h.

Keywords Laryngeal mask airway · ProSeal · Endobronchial blocker · One-lung ventilation

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Introduction

Anesthesia for thoracic surgery frequently employs one-lung ventilation (OLV) to facilitate surgical exposure. For many decades, double-lumen endobronchial tubes (DLTs) have been widely accepted as the gold standard for achieving OLV [1]. However, placement of a DLT is far more complicated than placement of a regular single-lumen tracheal tube owing to its larger outer diameter, unique shape, and relatively fixed curvatures. These characteristics may prevent its use in patients with difficult airway, distorted lower airway, or tracheostomy, as well as in pediatric patients [2–5].

A less frequently used technique consists of the insertion of an endobronchial blocker, such as an adapted Fogarty vascular catheter. However, it is preferable to use devices designed especially for this purpose, such as the Arndt wire-guided blocker, the Univent torque control blocker, the Cohen Flextip Plus endobronchial blocker, or the COOPDECH Endobronchial Blocker Tube. The conventional airway devices used in conjunction with these blockers are mainly single-lumen tracheal tubes, or occasionally, tracheostomy tubes.

The use of supraglottic airway devices for non-thoracic surgery has gained popularity [6–8]. The development of the laryngeal mask airway (LMA)-ProSeal™, in particular, allows a better oropharyngeal seal and provides access to both respiratory and gastrointestinal [9, 10] tracts [9, 10]. An increasing number of anesthesiologists comfortably substitute an endotracheal tube with an LMA-ProSeal™ with controlled positive pressure ventilation for routine general anesthesia in selected cases [8]. The use of an LMA-ProSeal™ bypasses the need for tracheal intubation and allows the conduction of surgery with ease in many patients [11–13].

The use of an endobronchial blocker in conjunction with a supraglottic device—that is, the LMA-ProSeal™—has been previously reported as a rescue technique in patients with difficult airway and other special circumstances [14–17]. The success rate of elective placement of an endobronchial blocker tube in patients with an LMA-ProSeal™ has not been studied yet. Therefore, we designed this pilot study to evaluate this possibility and also to measure other parameters, including time to placement, quality of lung collapse, incidence of dislodgement, and minor airway complications.

Materials and methods

Patient selection

The study protocol was approved by the institutional ethics committee and posted on ClinicalTrials.gov under the identifier NCT02106273. Written informed consent was obtained from all patients or their legal surrogates. We enrolled 30 patients aged between 18 and 75 years, with ASA class I to III, who underwent elective thoracic surgery and required OLV between June 1, 2011 and May 30, 2012. The exclusion criteria were as follows: patients with known restrictive lung disease, oropharyngeal mass or hematoma, pregnancy, gastroesophageal reflux disease, active respiratory infection, active hemoptysis, and large lung mass (>20 cm) or lung lesion involving main stem bronchus, as well as patients with anticipated airway reconstruction (e.g., bronchial sleeve lobectomy or pneumonectomy). All patients were visited preoperatively and advised to have epidural catheter placement or a single dose of paravertebral block for postoperative pain control. They were also instructed to use the verbal numeric scale, graded from 0 to 3, for assessment of the severity of postoperative sore throat, dysphagia, and hoarseness of voice (see Online Resource 1).

Induction and LMA-ProSeal™ insertion

We placed an epidural catheter prior to induction in patients who provided consent and were scheduled for open thoracotomy. For patients undergoing video-assisted thoracoscopy, we administered a single dose of 0.3 % bupivacaine 25–30 ml by paravertebral block. Following the placement of non-invasive monitoring devices (blood pressure, electrocardiogram, and pulse oximeter), general anesthesia was induced with propofol 1–2 mg/kg, fentanyl 1–2 mcg/kg, atracurium 0.6 mg/kg, or cis-atracurium 0.2 mg/kg. We ventilated all patients with 100 % oxygen while awaiting disappearance of the train-of-four twitch response. When patients became completely paralyzed, the appropriate tidal volume (VT 10 ml/kg of ideal body weight) was delivered via face mask, and peak inspiratory pressure (PIP) was recorded. We excluded patients from the study if PIP exceeded 30 cmH_2O. If the PIP with a VT of 10 ml/kg was below 30 cmH_2O, we placed the LMA-ProSeal™ (LMA North America, Inc. San Diego, CA, USA) using the Salem-Sump guided insertion technique (modified from the bougie-guided insertion technique) [18]. We assessed proper LMA placement clinically; optimal oropharyngeal seal and oropharyngeal leak pressure (OLP) were recorded by the manometric stability test [19]. We inflated the LMA cuff to obtain an OLP of 20–30 cmH_2O and limited the cuff pressure to less than 60 mmHg. If this could not be achieved, we attempted adjustment of the LMA with an up–down movement [20], reinsertion, or changing to an LMA of a different size. If this remained unsuccessful after three attempts, the patient was excluded from the study, and a tracheal tube (with blocker) or DLT, was used. We set the ventilator (Datex-Ohmeda Aestiva anesthesia machine, Madison, WI) to deliver 10 ml/kg VT via LMA-ProSeal™ and ensure that the PIP was below OLP.

Endobronchial blocker insertion and management

Following proper LMA placement, we placed the COOPDECH Endobronchial Blocker Tube (Daiken Medical Company, Osaka, Japan) (Fig. 1) with fiberoptic bronchoscopy guidance into the trachea and subsequently into the selected main bronchus. Patients received 100 % oxygen ventilation during endobronchial blocker placement. If the blocker needed to be removed during placement (for tip readjustment, hypoxemia, hypercarbia, suctioning, or readjustment of the LMA), the procedure was counted as one attempt. If three attempts were made or the total time exceeded 15 min, the COOPDECH Endobronchial Blocker Tube would be substituted with the Arndt™ wire-guided endobronchial blocker (Cook Critical Care, Inc., Bloomington, IN, USA). Once the blocker was placed in the selected bronchus, it was secured to the LMA connector with the corresponding adapter while the LMA was secured with adhesive tape.

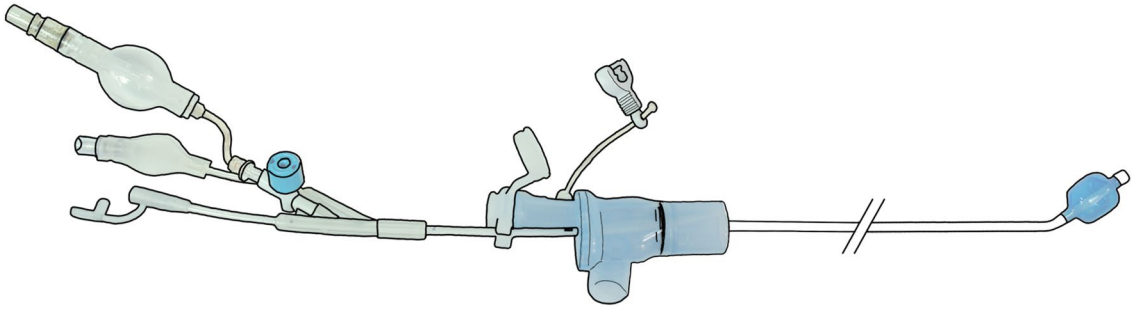

Fig. 1 A diagram of the type B COOPDECH Endobronchial Blocker Tube used mainly in this study. The balloon is a 40° preform flexion tip, which can be manipulated by torque motion into the desired bronchus. The adapter part is equipped with a bronchoscopy port, pilot balloon, and auto-inflating device

We re-checked the blocker again once the patient was positioned in lateral decubitus. During this final blocker positioning, we temporarily withheld the ventilation and suctioned air/oxygen out of the selected lung distal to the blocker tip with the fiberscope. We then inflated the bronchial blocker balloon with 5–7 ml of air to achieve adequate bronchial sealing and visualization with the fiberscope. The OLV was then commenced, and residual air was further suctioned out via the blocker. When the skin incision was made and the pleural cavity was entered, the surgeon (unaware of the airway technique) was asked to assess the lung deflation score using a grading scale of 0–10 (ranging from no lung collapse to complete lung collapse) [21].

Management during one-lung ventilation

Depth of anesthesia was maintained by isoflurane or sevoflurane at 0.5–2 MAC. We attempted to maintain oxygen saturation (SpO_2) ≥95 %. If mild hypoxemia (SpO_2 90–95 %) occurred during OLV, proper position of the endobronchial blocker was reassessed by fiberscope, and tracheal suctioning was performed to clear secretions as needed. Continuous positive airway pressure (CPAP) was applied to the non-ventilating lung and/or positive end expiratory pressure (PEEP) at 5 cmH_2O to the ventilated lung. We resumed two-lung ventilation when severe hypoxemia (SpO_2 <90 %) or persistent hypoxemia was observed.

During surgery, if lung inflation was required, the blocker's balloon was deflated, and positive pressure ventilation was delivered. We re-verified proper balloon position and seal quality with the fiberscope in the following three situations: (1) the surgeon asked to resume OLV once the lung was re-inflated, (2) dislodgement of the endobronchial blocker was suspected, or (3) if the operated lung still ventilated and the blocker's balloon was inflated. When OLV was no longer required, the endobronchial blocker was removed, while the LMA remained in place.

Assessment of postoperative airway complications

When the surgery was completed, we administered 25 mcg/kg of atropine and 50 mcg/kg of neostigmine for reversal of neuromuscular blockade. When patients met the standard criteria for extubation, we removed the LMA and transferred them to the post-anesthesia care unit (PACU). We assessed sore throat, dysphagia, and hoarseness of voice at 60 min in the PACU and at postoperative day 1.

Data recorded and definitions

We recorded the following: (1) demographic data; (2) duration of anesthesia; (3) operative data, including type of surgery, side of operation, and duration of surgery; (4) time required to place endobronchial blocker into the main bronchus (T_1), beginning with the insertion of the fiberscope and endobronchial blocker through the LMA until the blocker's balloon entered the selected main bronchus; (5) time required to place the blocker's balloon into the proper position after the patient was positioned in lateral decubitus (T_2); (6) time from initiation of OLV to entering the pleural cavity (T_3); (7) lung deflation score at chest opening; and (8) severity score of postoperative sore throat, dysphagia, and hoarseness of voice.

Statistical analysis

We performed statistical analysis using the Stata software (version 11.0, Stata Corporation, College Station, TX, USA). Categorical data are presented as frequency (percent). Continuous data are presented as mean ± SD or median (range).

Results

Thirty patients were initially enrolled in the study. We excluded one patient because of high peak airway pressure

during ventilation via the LMA. Demographic and operative data and duration of anesthesia are shown in Table 1. A COOPDECH Endobronchial Blocker Tube was successfully placed in 28 cases. There was only one case in which an Arndt™ wire-guide bronchial blocker was inserted as a rescue blocker.

The time required to place the blocker into the main bronchus (T_1) and time required for final blocker positioning and blocker balloon inflation (T_2) are shown in Table 2. Both T_1 and T_2 were significantly longer in patients with left-sided OLV. The median time from initiation of OLV to entering the pleural cavity (T_3) was 17.1 ± 10.0 (mean ± SD) minutes. The median lung deflation score rated by the surgeon was 8 (5–9), which generally provides adequate surgical exposure. The endobronchial blocker was successfully placed in the first attempt in 25 patients, second attempt in three patients, and third attempt in only one patient.

Dislodgement of the endobronchial blocker occurred intraoperatively in four cases (14 %), of the right main bronchial blocker in three cases (16 %), and of the left main bronchial blocker in only one case (10 %) (Table 3). Clinical manifestations of blocker dislodgement included sudden increase of airway pressure, decrease of VT, and absent or greatly diminished end tidal carbon dioxide. When blocker dislodgement was suspected, we promptly performed fiberoptic confirmation. Repositioning was completed with or without balloon deflation depending on the severity of the dislodgement and patient oxygen saturation. All four patients had their OLV re-established, and their hypoxemia did not worsen.

Displacement of the LMA during the procedure occurred in three cases (10 %). Two patients required LMA and blocker repositioning. One patient experienced loss of adequate oropharyngeal seal, and required tracheal tube placement. Despite all these reported issues, all patients maintained an oxygen saturation ≥95 % during OLV. Witnessed gastric content regurgitation or clinical signs and symptoms of pulmonary aspiration were not observed.

The assessment of postoperative minor airway complications in PACU revealed that eight patients (28 %) experienced sore throat and five patients (17 %) experienced hoarseness of voice with varying degrees of severity. No dysphagia was reported. Nearly all patients were fully recovered on the first postoperative day; only two patients (7 %) still reported mild hoarseness of voice (grade I).

Table 1 Demographic and operative data and duration of anesthesia

Characteristics	Results ($n = 30$)
Age (years)	51.2 ± 13.0
Gender	
Male:female	10 (33.3):20 (66.6)
Type of surgery	
Thoracotomy:VATS	20 (70.0):10 (30.0)
Side of operation	
Right:left	20* (70.0):10 (30.0)
Duration of anesthesia (min)	183.4 ± 62.4
Duration of surgery (min)	139.9 ± 59.8

Data in the table are presented as mean ± standard deviation and *n* (%)

* One patient planned for right thoracotomy was excluded later because of high peak airway pressure during laryngeal mask airway ventilation

Discussion

Our selection of supraglottic devices and endobronchial blockers was based on the results of an unpublished trial by the investigators using a manikin. We compared (1) LMA-ProSeal™, (2) LMA-Supreme, and (3) i-gel disposable airway combined with (1) Arndt endobronchial blocker or (2) COOPDECH Endobronchial Blocker Tube in a crossover fashion. This manikin study revealed that the LMA-Supreme combined with the COOPDECH Endobronchial Blocker Tube was associated with the highest failure rate, and the combination of i-gel with the Arndt blocker resulted in the highest success rate. However, the oropharyngeal sealing quality and the ability to adjust the seal with cuff inflation led us to choose the LMA-ProSeal™ over the i-gel disposable airway [22]. Despite the high success rate of the Arndt blocker in the preliminary manikin study, we chose the COOPDECH Endobronchial Blocker Tube because it is half the cost of the Arndt blocker, and its availability in our institution was greater. We used the Arndt blocker only as a rescue blocker.

Because lung collapse and re-expansion may require higher airway pressure, obtaining a good-quality airway seal is critical. We carefully designed the research protocol to exclude patients with restrictive lung diseases and high peak airway pressure that may be detected during face-mask ventilation or with LMA ventilation after anesthesia induction. Of the 30 enrolled patients, one was excluded because of high peak airway pressure during LMA ventilation.

Placement of the COOPDECH Endobronchial Blocker Tube via LMA-ProSeal™ requires skills for both bronchoscopy and torque technique blocker manipulation. Both procedures can be performed by one person, as we have tested in a manikin. However, in this study, we employed two anesthesiologists for blocker placement to achieve a faster process. From our study, the majority of patients (28/29 or 96.6 %) underwent successful placement of

Table 2 Time required to place endobronchial blocker

Time interval (s)	Side of operation	
	Right ($n = 19$)	Left ($n = 10$)
Time required to place endobronchial blocker into the main bronchus; T_1	83 (45–180)	167 (94–660)
Time required for final blocker positioning; T_2	160 (78–480)	225 (117–420)

Data in the table are medians (range)

Table 3 Dislodgement of endobronchial blocker during operation

Dislodgement of endobronchial blocker	Endobronchial blocker placement	
	Right main bronchus ($n = 19$)	Left main bronchus ($n = 10$)
Yes	3 (15.8)	1 (10)
No	16 (84.2)	9 (90)

Data presented in the table are *n* (%)

the COOPDECH Endobronchial Blocker Tube into the selected bronchus; only one patient (3.4 %) was switched over to the Arndt blocker.

The time required for blocker placement into the left main bronchus was twice as long as that of the right main bronchus (median time, 167 vs. 83 s). The time required for final blocker placement and balloon inflation was also longer for the left bronchus (median time, 225 vs. 160 s). Dislodgement occurred more often with the right-sided blocker, because the airway anatomy requires that the device be closer to the carina. The quality of lung collapse obtained was acceptable, and the intraoperative blocker management for lung collapse, lung inflation, and dislodgement of blocker were unremarkable. No major catastrophic events occurred—that is, severe hypoxemia or pulmonary aspirations. However, one patient, who underwent bilateral mini-thoracotomy, required the substitution of LMA for a tracheal tube after turning to the other side. We employed a special video laryngoscope (Pentax-AWS) to manage the airway and to proceed with tracheal tube and blocker [23]. However, this experience reminded us that repositioning of patients from one side to another increases the risk of losing the appropriate LMA sealing quality.

The incidence of sore throat (−28 %) and hoarseness of voice (−17 %) in this study were quite high. A possible explanation is that placement of both devices requires airway manipulations to a higher degree when compared with the use of LMA in non-thoracic surgeries. Direct placement of the COOPDECH Endobronchial Blocker Tube through the vocal cords and multiple passes of the fiberscope both for initial placement and subsequent adjustments throughout the surgery may have a greater impact than that of a single pass of the larger DLT.

Conclusions

The present study showed that the elective use of an LMA-ProSeal™ in conjunction with the COOPDECH Endobronchial Blocker Tube is highly feasible when careful selection criteria are applied. Special attention is required to properly place the LMA and obtain a good oropharyngeal seal. Vigilance for blocker and/or LMA dislodgement is also needed, especially for the right-sided blocker. Incidence of minor postoperative airway complications—that is, sore throat and hoarseness of voice—are higher than for LMA use in non-thoracic surgeries. Further comparative studies between this technique and conventional techniques are needed to confirm its safety.

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Conflict of interest None of the authors have conflicts of interest to declare.

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