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The use of ETView endotracheal tube for surveillance after tube positioning in patients undergoing lobectomy, randomized trial

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Abstract

The ETView tracheoscopic ventilation tube (TVT) is a tracheal tube (TT) incorporating a video camera and a light source in its tip. The view from the tip appears continuously on a portable monitor in the anesthesia area. We evaluated the effectiveness and usefulness of the single/double ETView TVT in monitoring the tracheal tube position during general anesthesia undergoing video-assisted thoracoscopic lobectomy.

Eighty-three patients with pulmonary bullae (American Society of Anesthesiologists (ASA) I-III) undergoing lobectomy, with general anaesthesia, were included. Patients were randomly assigned to 3 groups, based on the tube ETView double-lumen tube (VDT), ETView single-lumen tube (VST), or traditional double lumen tube (DT).

All 83 patients' intubations were successful to achieve 1-lung ventilation: 74 patients at the first attempt (22/26 in VDT, 26/28 in VST, 26/29 in DT group) and 9 patients at the second attempt. The time to achieve 1-lung ventilation with the VDT was 58.5 ± 21.5 (mean ± SD) seconds, the VST was 38.2 ± 10.1 (mean ± SD) seconds, and the DT group was 195.5 ± 40.3 (mean ± SD) seconds. During operations, the ETView tubes provided continuous airway visualization in all patients; a good view was obtained in 24/25 patients in VDT/VST, moderate in 4/12 patients in VDT/VST, and poor in 1/1 patients in VDT/VST. When the patient left the postanesthesia care unit, all had sore throat and 26/15/25 patients in VDT/VST/DT group had hoarseness. All had good outcomes of the surgical operations.

We found the ETView tube to be helpful in the endotracheal intubation and continuous surveillance of tube position in patients with video-assisted thoracoscopic lobectomy. The ETView single lumen endotracheal tube had fewer associated complications and is superior to the 2 double-lumen tubes.

Abbreviations: DLT = double-lumen tube, DT group = double lumen tube group, FOB = fibreoptic bronchoscope, SLT = single-lumen tube, TT = tracheal tube, TVT = tracheoscopic ventilation tube, VAS = visual analog scale, VATS = video-assisted thoracoscopic surgery, VDT = ETView double-lumen tube, VST = ETView single-lumen tube.

Keywords: ETView tube, pneumonectomy, video-assisted thoracoscopic lobectomy

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1. Introduction

Video-assisted thoracoscopic surgery (VATS) technique has been making great progress with the developments of the imaging system and skills of thoracic surgeon. All of the patients undergoing lobectomy had achieved with single hole thoracoscope which had only one 2 to 3-cm incision in anterior axillary line 4 or 5 intercostal space. So, we should provided good view of lung collapse.

Double-lumen endotracheal tubes are commonly used for this purpose; however, despite their widespread use, their positioning is still limited by the difficulty of insertion compared with a single-lumen tube (SLT) (related to the stiffness and the large diameter of the double-lumen tube [DLT]) and the need for a fibreoptic bronchoscopy to confirm the correct placement.

The use of a bronchial blocker passed through a single-lumen endotracheal tube is another way to separate lungs, but its use still requires a fibreoptic bronchoscope (FOB) to control its correct placement and achieve slower lung collapse, and it requires more frequent manipulation after initial placement.[1] Recently, a new tracheoscopic ventilation tube called the ETView (Welllead Medical Co., Ltd., Guangzhou, China) has been released.[2] This new device is equipped with a mini video camera embedded at the tip of the tube, allowing direct visualization of the tracheal mucosa, the carina, and the bronchi. The external structure and dimensions of the ETView single-lumen tube (VST) are similar to those of the conventional endotracheal tube, and the device is available in sizes 7.0, 7.5, and 8.0 mm. The external structure and dimensions of the ETView double-lumen tube (VDT) are identical to those of a conventional left-sided DLT, and the appliance is available in 4 sizes: 35, 37, 39, and 41 Fr. These 2 appliances have US Food and Drug Administration approval and Conformite Europeenne marking. The ETView SLT has been shown to be effective for emergency tracheal intubation. Truszewski et al[3] thought that the success rate for intubation of cadavers and the time to ventilation were improved with the ETView during continuous chest compressions. Gawlowski et al[4] compared the ETView single lumen and Macintosh laryngoscopes, and thought that the former performed better in a complex scenario of airway management of a trauma victim in need for cervical spine stabilization performed by novice caregivers and should be considered in this clinical setup. Much evidence has indicated that the ETView may be suitable for tracheal intubation in various settings where standard endotracheal tube cannot be performed.[5–7] By studying the technical features of its use, one can appreciate whether this novel device will add in the management of airway during operations of VATS. Thus, we decided to compare the time required for DLT tracheal intubation, the view of lung collapse, and postoperative comfort among the ETView SLT and the ETView DLT in patients with pulmonary bullae who were scheduled to undergo VATS.

2. Methods

After approval from the Institutional Review Board of the First Affiliated Hospital of Guangzhou University of Chinese Medicine (Guangzhou, China), written informed consent was obtained from each patient during the year 2014 to 2017. The study was also registered as a clinical trial (http://www.clinicaltrials.gov, identifier: ChiCTR-IPR-14005246).

Eighty-three adult patients who underwent elective VATS for lung lobectomy in our hospital were enrolled from July, 2014 to September, 2017. Patients with the following types of conditions were excluded: American Society of Anesthesiologists class 4 or higher, age less than 18 years, risk of gastric aspiration, abnormalities of the upper airway, polyps requiring rapid sequence induction, known tracheal pathology, and anticipated difficult intubation.[8] The protocol for this trial and supporting Consolidated Standards of Reporting Trials checklist are available as supporting information.

Patients were randomly divided into 3 groups by a computer-generated randomization schedule. The 3 groups were the VDT group, in which intubations were performed by an ETView DLT; the DT group, in which intubations were performed by a conventional DLT; and the VST group, in which intubations were performed by an ETView SLT in conjunction with a bronchial blocker.

An experienced consultant anesthetist, who was certified in advanced airway life support, performed the airway management for all the study subjects, while 1 resident performed intubation. Anesthetic data and postoperative follow-ups were documented by a study nurse. Intubation conditions were graded by the consultant anesthetist who performed the intubation. The intubating anesthetist, patients, and the study nurse who recorded the details of the procedures were all blinded to the study.

In the operating room, the patients were monitored with noninvasive blood pressure monitoring, electrocardiogram, and pulse oximeter. Each patient was given 5 minutes of preoxygenation before anesthesia induction. General anesthesia was induced with a propofol target control infusion (4 μg/mL) and fentanyl 3 to 4 μg/kg followed by vecuronium 0.1 mg/kg. After anesthesia induction, direct laryngoscopy was performed with a Macintosh size 3 blade, and the trachea was intubated by 1 of 4 anesthesiologists who had more than 2 years of experience with DLT use. Before the study, each participating anesthetist was trained on a mannequin to use the ETView DLT and ETView SLT by an instructor from the device's manufacturer, and then by using the device in at least 5 patients, who were not included in the study.

In the VDT group, tracheal intubation was performed using the ETView DLT. The tube was advanced into position until a clear picture of the patient's carina was seen on the monitor, and the bronchial cuff's edge to the left of the main carina was visualized. When the monitor image was not clear, repeated flushes of the camera port with 2 mL saline 0.9% followed by 20 mL air, as recommended by the manufacturer, were attempted. If these maneuvers were ineffective, FOB was performed to verify the tube's position.

In the DT group, tracheal intubation was performed with a conventional DLT. The cuffs of the tube were tested for leaks before intubation and were lubricated with paraffin oil. The tube was inserted under direct laryngoscopy, and was fixed in position using FOB. The DLT was advanced into position until a clear picture of the patient's carina was seen through the FOB, and the bronchial cuff's edge to the left of the main carina was visualized.

In the VST group, tracheal intubation was performed by ETView SLT in conjunction with a bronchial blocker. The cuffs of the tube and bronchial blocker were tested for leaks before intubation and were lubricated with paraffin oil. The tube was inserted under direct laryngoscopy, and was advanced until a clear picture of the patient's carina was seen on the monitor. The bronchial blocker was advanced until its cuff's edge was to the left of the main bronchial.

The purpose of this study was to demonstrate that by using the ETView system, correct positioning of the DLT and the endobronchial blocker could be achieved without a FOB in patients undergoing left lung surgery.

In each patient, the primary endpoints were recorded during the preoperative examination, including the various parameters of airway assessment, the extent of mouth opening, the state of the patient's dentition, the thyromental distance, temporomandibular joint movement, neck condition, and the Mallampati score.[9]

The following intraoperative variables were recorded by the attending anesthesiologist: the duration of intubation (from introducing the laryngoscope into the month until detecting positive end-tidal pressure of carbon dioxide [$P_{ET}CO_2$]) and direct laryngoscopic view according to the Cormack–Lehane classification.[10,11]

Further, we recorded the number of intubation attempts until successful intubation was accomplished, and the number of times that the laryngoscope blade needed replacing, the intubation time, the quality of view via tube camera, and the versions lost during surgery.

The following postoperative occurrences were recorded by a postanesthesia care unit nurse, who was blinded to the study group; laryngospasm, sore throat, hoarseness, tooth damage, soft-tissue injury, operation time, amount of bleeding, postoperative pain VAS score, and duration of hospital admission.

2.1. Statistical analysis

The sample size was calculated based on a pilot study of 30 patients. We calculated that the rate of accurate positioning of the

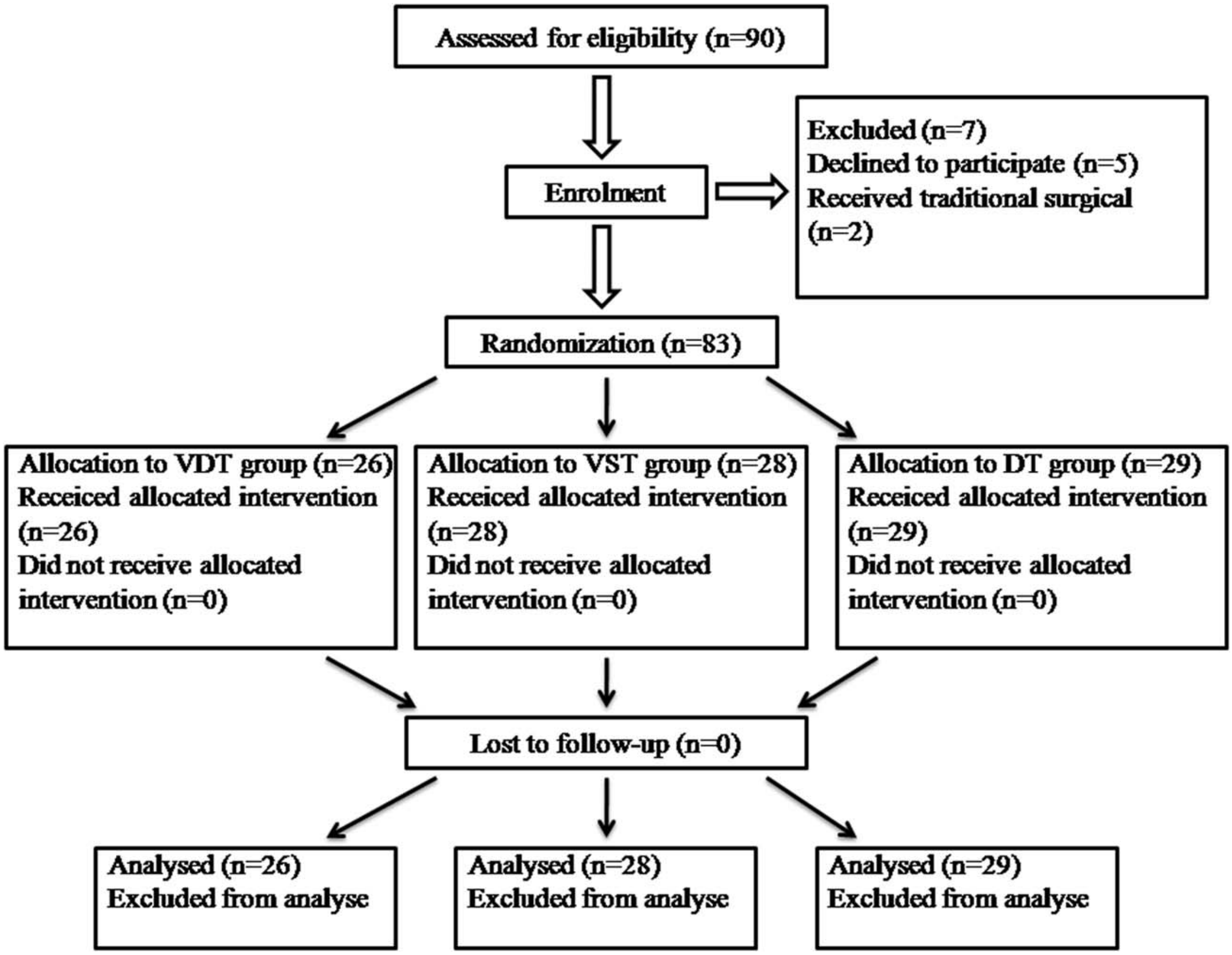

Figure 1. Randomization flow chart.

first intubation was 80% for the conventional SLT in conjunction with the bronchial blocker, 90% for ETView DLT, and 100% for the ETView SLT in conjunction with a bronchial blocker. Based on these figures, accepting a 2-tailed α error of 5% and β error of 20%, we calculated that 27 patients would be required for each group. Assuming the potential for patients to drop out of the study, the total sample size was increased to 83 patients.

All data were reported as mean ± standard deviation (SD), absolute number (n), or percentages. Statistical analyses were performed with the Statistical Package for Social Sciences Software (SPSS18.0 for windows; SPSS Inc., Chicago, IL). The intubation time, visual analog scale (VAS) score, and number of intubation attempts were analysed using analysis of variance (ANOVA) for 3-group comparisons. The Bonferroni correction was performed for between-group comparisons, as appropriate. The Kruskal-Wallis test was used to analyze Cormack–Lehane (C/L) grade. Fisher exact test was used to analyze the rate of successful intubation. A P value $<.05$ was considered to be statistically significant.

3. Results

All study patients in the 3 groups were successfully intubated. No patient was excluded from the study because of difficult intubation or for any other reason (Fig. 1).

No statistically significant differences were detected among the three groups with respect to demographic characteristics and C/L grade (Table 1).

All 83 patients' intubations were successful to achieve 1-lung ventilation: 74 patients at the first attempt (22/26 in VDT, 26/28 in VST, 26/29 in DT group) and 9 patients at the second attempt (Table 2). The time to achieve 1-lung ventilation with the VDT was 58.5 ± 21.5 (mean ± SD) seconds, the VST was 38.2 ± 10.1 (mean ± SD) seconds, and the DT group was 195.5 ± 40.3 (mean ± SD) seconds (Table 2). During operations, the ETView tubes provided continuous airway visualization in all patients: a good view was obtained in 24/25 patients in VDT/VST, moderate in 4/12 patients in VDT/VST, and poor in 1/1 patients in VDT/VST (Table 2). When the patients left the postanesthesia care unit, all had sore throat. The VDT group had more soft-tissue injury ($P = .018$) and hoarseness ($P = .00$) (Table 2). Two and 4 patients in the VDT and VST groups, respectively, required FOB, because the secretions made the camera view indistinct. All had good outcomes of the surgical operations (Table 3).

4. Discussion

Adverse respiratory events during general anesthesia are a major cause of morbidity and mortality. Tinker et al[12] suggested that most negative outcomes were considered to be preventable with

Table 1

The patients' preoperative characteristics and airway assessment.

Characteristic	VDT group (n=26)	VST group (n=28)	DT group (n=29)	P
Age (y)	39.5±13.5	38.9±13.4	40.0±13.3	.953
Male/female	16/10	16/11	18/10	.887
Weight (kg)	64.7±11.2	64.1±11.5	65.6±11.1	.879
Height; (cm)	167.5±6.8	166.4±5.9	166.5±5.3	.781
BMI (kg/m^2)	22.9±3.1	23.0±3.5	23.6±3.6	.739
Airway assessment				
MO (normal/limited)	26/0	28/0	29/0	1.000
Neck (normal/short)	22/4	25/3	28/1	.303
Thyromental distance (normal/short)	23/3	25/3	22/6	.539
Dentition state (denture/own teeth)	1/25	0/28	2/27	.831
TMJ movement (normal/limited)	26/0	28/0	29/0	1.000
Mallampati score (1/2/3/4)	10/14/2/0	12/14/2/0	11/17/1/0	.990

BMI=body mass index, MO=mouth opening, TMJ=temporomandibular joint.

Table 2

Data regarding endotracheal intubation and postoperative outcome.

	VDT group (n=26)	VST group (n=28)	DT group (n=29)	P
Endotracheal intubation				
C/L grade 1/2/3/4	14/10/2/0	10/16/2/0	12/15/2/0	.504
Success at first attempt (n)	22	26	26	.627
Intubation time (s)	58.5±21.5	38.2±10.1	195.5±40.3	.000
lung collapse successful	26	28	29	1.000
Quality of view via tube camera (good/moderate/poor)	21/4/1	15/12/1	—	
Vision lost during surgery	0	0	—	
FOB needed after endobronchial intubation	2	4	29	.000
Postoperative				
Laryngospasm	0	0	0	1.000
Hoarseness	26	15	25	.000
Sore throat	26	28	29	1.000
Stridor	1	0	0	.328
Soft-tissue injury	13	4	9	.018
Tooth damage	0	0	0	1.000

C/L grade=Cormack–Lehane grade, FOB=fibreoptic bronchoscope.

better monitoring. Though, various clinical signs and technical aids are described to verify tracheal intubation,[13] but direct visualization of the tracheal rings and carina is the only foolproof method of confirming proper tube position. So, the use of the ETView tube verifies tube position indisputably (Fig. 2). Respiratory complications occur not only during intubation but also in place during anytime of operation. Tracheal tube displacement during general anesthesia can be the result of inadequate fixation or patient position change, such as during thoracoscopy or laparoscopy.[14] In our study, the view of the carina on the portable monitor enabled online continuous monitoring of the tube position. Then avoid the complications caused by the movement of the tracheal tube position during the operation, which made all outcomes of the surgical operations well (Table 3) and we provided good view of lung collapse continuous (Fig. 3). However, every patient in DLT group needed FOB after position changes (Table 2).

We have shown that endobronchial intubation and lung isolation using the ETView tube are fast and effective. Correct tube placement required only 60 seconds in most patients in the VDT group and 40 seconds in most patients in the VST group. Lung isolation was successful, but required 200 seconds in the DT group. The results were the same as those reported by Levy-Faber et al.[15] Koopman et al[16] also found that the ETView tube is fast and effective in lung isolation. Massot et al[17] believe that the DLT-ETView tube probably will be the third technique for performing lung isolation after the manufacturer has resolved its technical problems. Intubation with a DLT is more difficult than with a SLT,

Table 3

The patients' outcomes of the surgical operations.

operation	VDT group (n=26)	VST group (n=28)	DT group (n=29)	P
Operation time	31.7±5.0	33.3±4.9	31.9±6.1	.500
Amount of bleeding (mL)	22.7±3.4	24.5±5.0	23.9±4.7	.303
Postoperative pain VAS score	4.4±1.6	5.0±1.7	4.6±1.5	.378
Duration of hospital admission	5.6±0.6	5.3±0.7	5.3±0.6	.230

VAS=visual analog scale.

Figure 2. (A) The patient after endotracheal intubation with the ETView DLT. (B) The patient after endotracheal intubation with the ETView SLT.

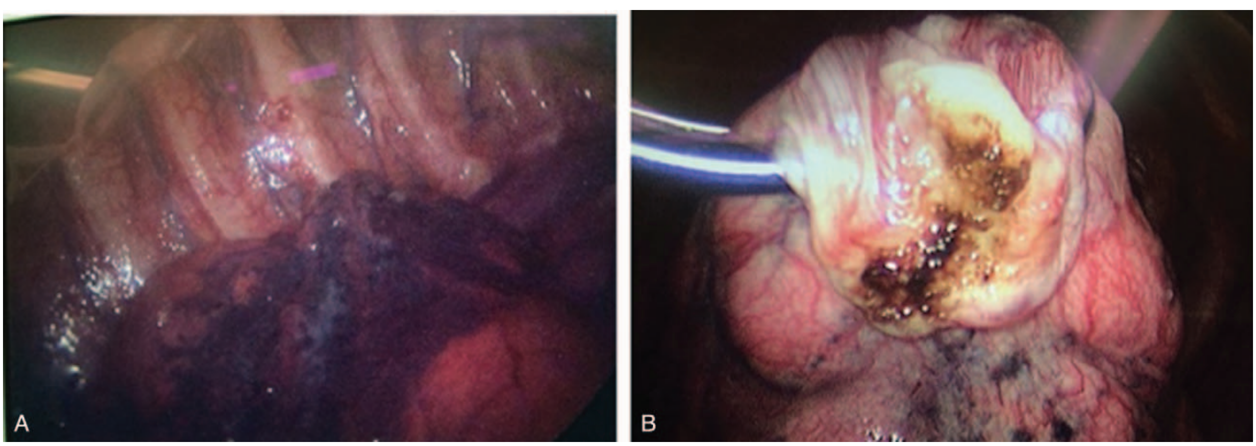

Figure 3. (A) The collapsed lung was the view which we used ETView tube to achieve 1-lung ventilation. (B) Collapsed lung bubble.

as the relatively large size and special shape of the tube frequently obstruct the view of the glottis during direct laryngoscopy. Thus, to facilitate endobronchial intubation with a DLT, some authors advocate video-laryngoscopy or the use of a video stylet.[18,19]

In the majority of cases, the tube camera provided a good view of the airway, making the use of an additional FOB unnecessary, and also avoiding unintentional displacement of the VDT with hypoxaemia during 1-lung ventilation compared with a conventional DLT. Numerous reports mention tracheal lesions after DLT placement,[20,21] and predicting the optimal insertion depth of a DLT can also be challenging.[22] When placed too deep, a DLT can cause serious complications, including rupture of the main-stem bronchus.[23] On the contrary, when the bronchial tip is positioned too proximally, its cuff may block air from entering the right main-stem bronchus. Szarpak et al[24] believe that ETView DLT proved to be a promising device for DLT intubation, and it seems to offer advantages over the conventional DLT. With the ETView group, the entire process from the tube's entering the patient's mouth until reaching its final position with the bronchial tip in the left main bronchus can be viewed on the monitor. The disadvantage of the ETView camera compared with a FOB is that its position is set at the distal part of the tracheal lumen of the tube. Therefore, the camera cannot be used to inspect the main-stem bronchus if this is deemed necessary. In our study, we encountered this problem once when a mucus plug in a distal bronchus caused atelectasis. We could not see it using the ETView camera; thus, we needed FOB to assist us. Two and 4 patients in the VDT and VST groups, respectively, required FOB because the secretions made the camera view indistinct, and we could not clear it using inflating air and/or saline.

In this study, VST with smaller internal diameters (ie, 6.5, 7.0, and 7.5 mm) were used, thus causing less mucosal injury. It was possible to use small-diameter tubes because the placement of the blocker was made without using a bronchoscope. In the VDT and DLT groups, air was used to inflate the blocker cuff to seal the bronchus; therefore, we could not chose a smaller size in the study, and nearly all patients had sore throat that may have been caused by the camera at the tip, which gives the tube a larger internal diameter. The VST group had less hoarseness than the other groups, perhaps because of the small internal diameter, making intubation easy.

In the VDT/VST groups, the surgeon has a continuous view throughout the surgical produce, which also benefits the anesthesiologist. After endobronchial tube placement, most patients must be repositioned before surgery into the lateral decubitus position, which is associated with endobronchial tube movement. Klein et al[25] found that up to 35% of DLTs that were judged as being correctly placed after auscultation appeared malpositioned when re-examined using bronchoscopy, and Smith et al found the same thing in 48% of patients. Using the ETView tube, malpositioning could be corrected instantly in most cases without using a bronchoscope.[26] Barak et al found that the ETView tube facilitated surveillance of tube position by providing a clear high-quality view of the carina throughout percutaneous nephroscope lithoipsy (PCNL) with several changes of patient position.[27] Heir et al[28] believe that the real-time continuous visualization potentially affords an added measure of patient safety. In our study, In our study, the view was lost during surgery in one patient each in the VDT and VST groups due to secretions. Because it did not affect the surgeries, no further action was taken. Also, because the ETView camera and monitor have no alarm, their value relies entirely on the judgment of the anaesthetist who watches the monitor.[3]

5. Conclusions

In conclusion, lung isolation with ETView DLT and SLT is fast and effective. Endobronchial intubation success is high, and the entire process from the moment the tube enters the patient's mouth until the bronchial tip reaches the main-stem bronchus can be seen on a video screen. Therefore, the fibreoptic scope is unnecessary, which can save time and money. We also use the ETView tube for continuous direct vision of the carina in selected cases and procedures, improving patient safety and providing reassurance and confidence for the anaesthetist. However, ETView tubes positioning is still limited by several factors, such as the price. The tube is 1-use disposable, and cannot be reused. Also, because the anterior part of the tube is stiff, the patients nearly all had a sore throat postoperatively.

The main weakness of this study is the fact that the intubating anesthesiologist was not blinded to the device used.

Author contributions

Data curation: Jian-Qi Wei, Yan-Kui Huang.
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Investigation: Yong Wang.
Methodology: Jia-Yi Liu.
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Writing – review & editing: Tao Zhou, Wu-Hua Ma.

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