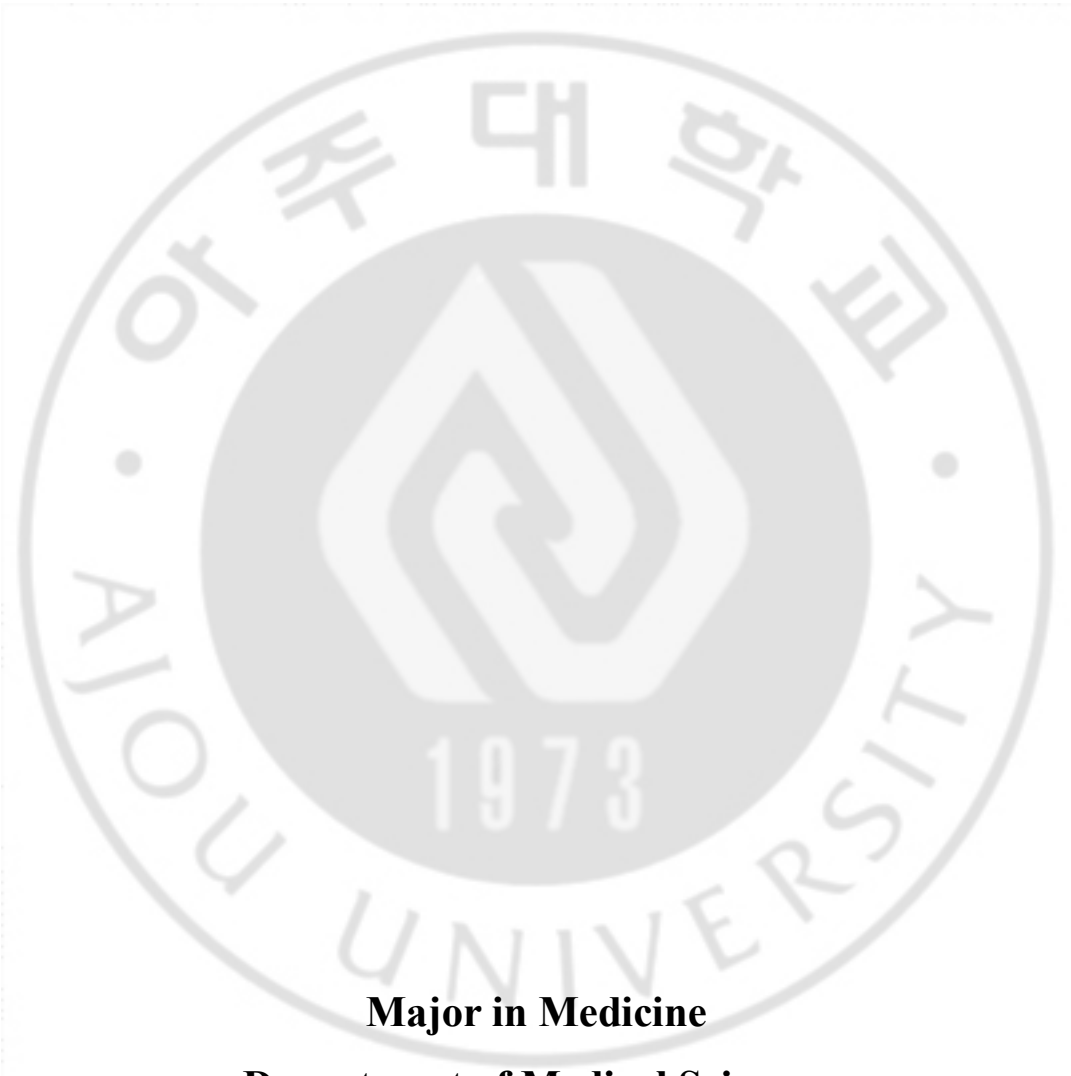
Disconnection Techniquewith a Bronchial Blockerfor Improving Lung Deflation

by

Ji Young Yoo



Major in Medicine

Department of Medical Sciences

The Graduate School, Ajou University

Disconnection Technique with a Bronchial Blocker for Improving Lung Deflation

: A Comparison with a Double-Lumen Tube and Bronchial Blocker Without Disconnection

by
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A Dissertation Submitted to The Graduate School of
Ajou University in Partial Fulfillment of the Requirements for the Degree of
Master of Medicine

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June, 2014

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Abstract

Background

One lung ventilation (OLV) is accomplished with a double lumen tube (DLT) or a bronchial blocker (BB). In this study, we compared the effectiveness of lung collapse using DLT, BB with spontaneous collapse, and BB with disconnection technique.

Methods

Fifty-two patients undergoing elective pneumothorax surgery were included in this study. The patients were randomly assigned to one of three groups: DLT with spontaneous collapse group (Group 1), BB with spontaneous collapse group (Group 2), and BB with disconnection technique group (Group 3). In Group 3, we modified disconnection technique; 1) turned-off the ventilator and opened the adjustable pressure limiting valve allowing both lungs to collapse, 2) after loss of CO_2 trace in the capnograph, 3) inflated blocker cuff and turned-on the ventilator allowing only dependent-lung reventilation. Five and ten min after OLV, lung collapse degree was

assessed by the surgeon, who was blinded to the isolation technique.

Results

The overall degrees of lung collapse were different among groups ($p = 0.001$ at 5 min, $p = 0.002$ at 10 min). In the paired intergroup comparisons, the qualities of lung collapse degree at 5 min and 10 min were better in the Group 1 and in the Group 3 than in the Group 2 significantly. There were no differences between Group 1 and Group 3 in lung collapse degrees at any time points. In Group 3, the average time for loss of CO_2 trace in the capnograph was 32.3 ± 7.0 sec.

Conclusions

BB with spontaneous collapse takes longer to deflate and do not provide equivalent surgical exposure to DLT. To accelerate the collapse of the lung in BB, disconnection technique could be helpful and the disconnection time required is about 30 sec.

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Abbreviations

OLV: one lung ventilation

DLT: double-lumen tube

BB: bronchial blocker

FEV1: forced expiratory volume in 1 second

COPD: chronic obstructive pulmonary disease

TLV: two lung ventilation

SLT: single-lumen tube

FOB: fiberoptic bronchoscopy

I. Introduction

The one-lung ventilation (OLV) technique is used to facilitate surgical exposure in intrathoracic surgical procedures. A double-lumen tube (DLT) or a bronchial blocker (BB) currently is used in clinical practice. DLT is used in most cases and is considered the method of choice. An alternative to the DLT is the BB, in which an inflated balloon obstructs the main stem bronchus, allowing the operative lung to becollapsed. (Campos, 2002)

Lung collapse is a major concern when selecting this OLV, because it permits adequate surgical exposure. Although overall clinical performance appears to be similar for both OLV methods, (Narayanaswamy et al., 2009; Ender et al., 2002; Campos, 2007)BB takes longerto deflate the operative lung, (Campos, 2003; Zhong et al. 2009) and there are some conflicting reports as to whether BB provides a similar degree of lung deflations(Narayanaswamy et al., 2009; Bauer et al., 2001; Dumans-Nizard et al., 2009) compared with that of DLT. Surgeons occasionally are reluctant to use a BB under the perception that lung deflation will be time-consuming.(Cohen, 2008)

Dumans-Nizard et al. used the disconnection technique to accelerate the collapse of the lung after the BB is positioned by disconnecting the endotracheal tube from the ventilator and allowing both lungs to collapse.(Dumans-Nizard et al., 2009)However, the effectiveness of this technique in elective thoracic cases has not been tested systematically in a prospective controlled study, and proper time for disconnection and

the monitoring technique were not provided.

The primary aim of this study, therefore, was to compare the efficacy of BB and DLT for achieving lung collapse and to evaluate the efficacy of the disconnection technique, withmonitoring of the CO_2 trace on a capnograph in BB. The authorsfurther evaluated the disconnection time, which is the time to loss of the CO_2 trace on the capnograph needed to facilitate lung collapse.

II. Methods

The study was conducted after ethics committee approval, and participants provided written informed consent. Patients diagnosed at this institution's pneumothorax center with pneumothorax and whowere undergoing video-assisted thoracoscopic wedge resection requiring OLV, were randomized via a random-number generator for intubation into 1 of 3 groups: left-sided DLT (Mallinckrodt Medical, Athlone, Ireland) with spontaneous collapse (group 1), BB (Fuji Systems Corp, Tokyo, Japan) with spontaneous collapse (group 2), and BB with the disconnection technique (group 3). Patients with a history of thoracic surgery, abnormal expiratory recoil (FEV1 <80% of predicted value, chronic obstructive pulmonary disease [COPD] or asthma), or an ipsilateral collapsed lung estimated by Collins' method(Collins et al., 1995) (remaining pneumothorax size in an erect posterior-anterior chest x- ray >20%) were excluded.

Standard monitoring was applied after the patients arrived in the operating room. After anesthesia was induced with 2 to 3 mg/kg of propofol, 2μg/kg of fentanyl, and 0.6 mg/kg of rocuronium, the patients were intubated by experienced thoracic anesthesiologists involved in the study. During the initial two-lung ventilation (TLV) period, anesthesia was maintained with sevoflurane in oxygen and air (50% oxygen). In all groups, OLV was initiated and maintained with100% oxygen, and tidal volume and respiratory rate were adjusted within predefined ranges to maintain peak airway pressure ≤40 cmH2O and normocarbia.

In group 1, DLT size was determined by patient height and sex as follows: Women <1.6 m (5 ft 3 in), 35F; women >1.6m,37F; men ≤1.7 m (5ft7 in), 39F; and men >1.7 m, 41F.(Dumans-Nizard et al., 2009)In groups 2 and3, BBs were inserted through a 7- or 8-mm-sized inner diameter single-lumen tube (SLT) for women and men, respectively, while the patients were supine. The BB was introduced through the SLT to the desired bronchus. Correct placement of the DLT or BB was assessed using pediatric fiberoptic bronchoscopy (FOB).

OLV was initiated after turning the patient to a lateral decubitusposition. In group 1, the connector on the nondependent operative side was clamped and disconnected from the patient to spontaneously collapse the operative lung. In group 2, operative lung collapse was achieved by BB balloon inflation with at least 5 mL of air, and the amount of air was titrated to create a seal under direct visualization of FOB.

In group 3, the disconnection technique was modified as follows:(Dumans-Nizard et al., 2009)(1) before OLV initiation, the ventilator was turned off and an adjustable pressure-limiting valvewas fullyopenedallowing both lungs to collapse and (2) after loss of the CO_2 trace on the capnograph (Figure 1), the BB cuff was inflated with air, and (3) the ventilator was turned on allowing only dependent-lung reventilation.

Figure 1.Capnograph showing loss of the CO_2 trace during the disconnection in group3. The time between A and B was considered the disconnection time required for both lungs to collapse before initiating one-lung ventilation.

The main variables recorded in this study were the degree of lung collapse 5 and 10 minutes after OLV initiation and, in group 3, time to CO_2 trace loss on capnograph (i.e., time to collapse both lungs before initiating OLV). The degree of lung collapse was assessed using a verbal analog scale as a lung collapse score (0 = no collapse to 10 = complete collapse) by one thoracic surgeon, who was absent from the operating room during DLT or BB placement and was blinded to airway device used. During the procedure, the time for initial placement (i.e., between insertion of the laryngoscope and confirmation by FOB), additional intraoperative repositioning of devices (defined as besides the first examination performed to initially place the device in the correct position), development of hypoxemia (SpO2 <95%), or any other complications were recorded.

In a previous study that evaluated the degree of lung collapse, the number of patients per group required to detect global differences among the 3 groups was 16.(Dumans-Nizard et al., 2009) Because of the potential risk of failure to intubate or lung adhesions, the authors, decided to enroll a minimum of18 patients per group into the trial.

Continuous variable data were subjected to an analysis of variance with Tukey's test for 3 group's comparisons and a t-test for the two group's comparisons. Categorical variable data were subjected to Fisher's exact test. Statistical significance was defined as $p < 0.05$. The data analysis was performed using SPSS version 20.0 (SPSS Inc, Chicago, IL) and R version 2.14.1 (R Foundation for Statistical Computing, Vienna, Austria).

III. Results

Fifty-four patients, 18 patients in each group, were recruited forthe study. Tracheal intubation was successful in all patients in each group. Two patients in group 2 were excluded because of lung adhesions. Accordingly, 52 patients were enrolled in this study.

The demographic data were comparable among the 3 groups (Table 1). Lung collapse scores are shown in Table 2. A significant difference in the global comparison of lung collapse scores was observed among the 3 groups at 5 minutes ($p < 0.001$) and10minutes ($p = 0.003$) from the start of OLV. In the paired comparisons, the lung collapse scores at 5 minutes and 10 minutes were higher in groups 1 and 3 than in group 2 ($p = 0.001$ for group 1 vs. 2, $p = 0.003$ for group 3 vs. 2at 5 minutes, and $p = 0.006$ for group 1 vs. 2, $p = 0.011$ forgroup 3 vs. 2 at 10 minutes). However, no significant differences were observed between groups 1 and 3 for the lung collapse scores at any time points ($p = 0.875$ at 5 minutes, $p = 0.981$ at10 minutes).

Table 1.Patients' Demographic Data

Characteristics	Group 1 (n = 18)	Group 2 (n = 16)	Group 3 (n =18)
Age (year)	20.8 ± 7.0	18.1± 2.4	17.7± 2.3
Weight (kg)	60.3± 5.0	57.9± 5.0	58.7± 7.9
Height (cm)	176.3± 4.5	177.8± 3.1	174.9± 7.9
Sex (male/female)	17/1	16/0	17/1
Surgical side (Right/Left)	6/12	6/10	6/12
Operation time (min)	44.3± 19.0	44.6± 13.2	39.0± 8.4
Anesthesia time (min)	82.1± 20.5	85.4± 22.5	76.5± 15.6

Values are expressed as mean ± standard deviation or numbers. Group 1, double-lumen tube with spontaneous collapse; Group 2, bronchial blocker with spontaneous collapse; Group 3, bronchial blocker with disconnection technique.

Table 2. Lung Collapse Scores among the Three Groups at 5 and 10 minutes from the start of one-lung ventilation

Lung Collapse Score (0 = no collapse to 10 = complete collapse)			
	Group 1	Group 1	Group 1
5 minutes	6.6 ± 1.6	4.5 ± 1.3*†	6.3 ± 1.6
10 minutes	7.9 ± 1.5	6.4 ± 1.4*†	7.8 ± 1.1

Values are expressed as mean ± standard deviation.Group1, double-lumen tube with spontaneous collapse; group 2, bronchial blocker with spontaneouscollapse; group 3, bronchial blocker with disconnection technique.

*p< 0.05 compared with group 1 at 5 and 10 minutes.

†p< 0.05 compared with group 3 at 5 and 10 minutes.

The average time for loss of the CO_2 trace on the capnograph before initiation of OLV in group 3, was 32.3 ± 7.0 seconds.

The time for initial placement and the number of patients who required at least one additional repositioning of a device were not different between the DLT (group 1) and combined BBs (groups 2 and 3) (p = 0.191 and p = 0.333, respectively; Table 3). No complications were noted, such as hypoxemia (SpO2 <95%), as a result of tube placement or OLV.

Table 3.Time to initial placement and number of patients requiring additional repositioning of a device for DLT vs. Combined BB.

	DLT (n=18)	BB (n=34)	p
Surgical side (right/left)	6/12	12/22	1.000
Time to initial placement	190.8 ± 78.4	217.1 ± 61.4	0.191
Number of patients requiring additional repositions	3/18 (16.7%)	11/34(32.4%)	0.333

Values are expressed as mean ± standard deviation ornumbers.

IV. Discussion

The results of this study show that the BB withoutdisconnection technique requires a longer time to deflate the isolated lung compared with the DLT. The disconnection technique - collapsing both lungs before initiating OLV in the BB group - facilitated deflation of the operative lung without hypoxemia. In the BB with disconnection group, the quality of lung collapse was significantly better than that in the BB without disconnection group and equivalent to that in the DLT group. The average time required to disconnect was32.3 ± 7.0 seconds.

OLV is accomplished with either DLT or BB. DLT remains the method of choice to achieve OLV, and it is used in most clinical practices that require OLV. The largelumen of a DLT facilitates suctioning of blood or secretionsfrom the bronchi, and the switch from two-lung ventilation to OLV is easy and reliable.(Campos, 2003) However, DLT use might be associated with complications such as hoarseness, tracheo-bronchial rupture, traumatic laryngitis, or arytenoid dislocation,(Fitzmaurice and Brodsky, 1999; Gilbert et al., 1999; Knoll et al., 2006) and it might not be possible in difficult intubation situations.(Narayanaswamy et al., 2009; Campos, 2010) A possible alternative is the BB. A BB, placed through SLT, provides the benefits of less airway trauma and ease of procedure. DLT use requires switching to an SLT at the end of surgery, posing unnecessary added risk to the patient. Endotracheal tube exchange can be challenging because of an edematous airway and potentially can com- promise the

airway. Using an existing SLT also eliminates the need for postoperative tube exchange for patients who remain intubated.(Campos, 2003)

No consensus exists on whether a BB can be an initial option or alternative method to a DLT. The added time necessary for lung deflation might be a primary concern for some clinicians,(Cohen, 2008) although once lung deflation is achieved, the overall clinical performance appears to be similar.(Narayanaswamy et al., 2009; Ender et al., 2002; Campos, 2007) Campos and Kernsteine reported that the average time for optimal lung deflation is 17 minutes for the DLT and 19 to 26 minutes for the BB.(Camposand Kernsteine, 2003) There is some controversy as to whether a BB provides a similar degree of lung deflation(Bauer et al., 2001; Dumans-Nizard et al., 2009)compared with a DLT. The small diameter of a BB (2 mm) for venting the operative lung results in increased air flow resistance and explains the increased time for lung collapse with a BB compared with a DLT.(Campos, 2003)

To overcome the aforementioned problem and to accelerate the collapse of the operative lung, some clinicians disconnect the patient briefly from the ventilator.(Ender et al., 2002; Dumans-Nizard et al., 2009)However, the prospective comparative clinical performance of these techniques has not been studied. In addition, various disconnection times have been proposed (15 seconds to 1 minute),(Ender et al., 2002; Dumans-Nizard et al., 2009)and no study has clarified the disconnection time and why a particular time was selected. In the present study, the authors used a capnographic monitor to confirm collapse of the lungs before initiating LV. This method might be a reliable, easy, and inexpensive maneuver to check for lung collapse and could beapplied to variousclinical situations. In this study, assessing the disconnection timeusing the capnograph, about 30 seconds of disconnection time was appropriate to accelerate operative lung collapse. Additionally, there was no need for assisted suction to expedite the lung collapse. This disconnection technique could not be used for cases carrying a risk of blood or infected secretions contaminating the dependent lung.(Bauer et al., 2001) In these situations, DLT is the safe and effective choice to achieve operative lung

collapse.

Another concern about the BB is the additional time required for initial positioning compared with DLT(Narayanaswamy et al., 2009; Campos, 2003) and dislodgement of this device needing more correction to place the proper positions with additional FOB examinations.(Narayanaswamy et al., 2009; Bauer et al., 2001) In this study, no significant differences were observed between the DLT (group 1) and BB combined groups (groups 2 and 3) for the time required to initially place the devices ($p = 0.191$) and for the number of patients requiring at least one additional intraoperative repositioning of a device ($p = 0.333$). However, statistical significance might not be reached for this comparison because the sample size was calculated to provide sufficient power for a comparison of lung collapse score. A study with a larger sample size would be needed to confirm this difference.

This study had some limitations. First, only patients with normal lung parenchyma and expiratory recoil were included. The authors thought that it was reasonable to first assess a new treatment or management modality in normal subjects and, if proven effective, to extend testingtoimpaired subjects.Althoughthe disconnection maneuver described here will significantly improve surgical exposure in patients with normal lung function, the speed of lung collapse depends on lung condition, particularlythe degreeof COPD. To generalize the results to all patients undergoing thoracic surgery, further study is needed, particularly in patients with COPD. Second, in group 2 (BB with spontaneous collapse), no strategies to accelerate lung collapse were used. It is known that a BB should be inflated after the lung has deflated, and in the BB with spontaneous collapse group, it could have been inflated during inspiration. Also, because denitrogenation of thelung would increase initial lung collapse rate,(Ko et al., 2009) use of 100%oxygen or N2O instead of air during the initial TLV period would have improved lung collapse. Although these strategies would have accelerated lung collapse in the BB with spontaneous collapse group, the authors thought that their use would generate potential bias in the study.

V . Conclusion

This prospective controlled study revealed that the initial quality of lung deflation with a BB without disconnecting was poorer than that of a DLT. To facilitate operative lung deflation, use of a disconnection technique, i.e., disconnecting the patient from the ventilator circuit before initiating OLV while monitoring the CO_2 trace on a capnograph, could be helpful.

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국문요약

서론

일측폐환기를 위해 사용되는 도구로는 이중내강튜브나 기관지차단기가 있다. 본 연구는이중내강튜브와 기관지차단기 그리고 분리기술을 적용한 기관지차단기법 간의 폐허탈을 유도하는데 있어서의 유용성에 대해 비교하였다.

연구방법

환자는 무작위적으로 1에서 3 그룹으로 나뉘어졌다. 그룹 1은 이중내강튜브 그룹으로, 그룹 2는 기관지차단기 그룹으로, 그룹 3은 분리기술을 적용한 기관지차단기 그룹으로 분류하였다. 저자는 그룹 3에서 적용한 분리기술에 대해선 다음과 같이 적용하였다: (1) 전신마취기를 정지하고 압력제한판막을 개방해 양측폐가 모두 허탈 되도록 한다. (2) 호기말 이산화탄소분압이 측정되지 않는 시점에서 기관지차단기를 팽창시키고 전신마취기를 작동시켜 의존폐만 환기되도록한다.

결과

일측폐환기를 시작한 뒤 5~10분뒤에 술기에 대해 모르는 수술의가 폐허탈의 정도를 평가하였다. 5~10분뒤의 폐허탈 정도는 그룹 1과 3에서 그룹 2보다 우수하였다. 그룹 1과 그룹 3 간의 폐허탈의 정도는 측정한 시점과 관계없이 두 군간에 큰 차이를 보이지 않았다. 그룹 3에서 호기말이산화탄소분압이 측정되지 않는데 걸린 시간은 평균 32.3 ± 7.0 초였다.

결론

기관지차단기 사용시 자발적 폐허탈이 일어나는데는 시간이 오래 걸리고 이중내강튜브만큼 수술에 용이한 폐허탈을 유도하기 힘들다. 따라서 기관지차단기를 사용시에는 분리기술 적용하는 것이 이중기관내강을 이용한 폐허탈과 비슷한 환경을 유도할 수 있겠다.