Comparison of Single Lung Ventilation versus Two Lungs Ventilation in Video Assisted Thoracoscopic Lung Surgeries. Prospective Randomized Trial

Original Article

Salwa Omar El-Khattab Amin Mohamed, Omar Mohamed Taha Abdallah El-Safty, Mohamed Osman Awad Taeimah and Esraa Abd El-Latif Mohamed Shawky Abd El-Hameed Arafa

Department of Anesthesia, Intensive Care and Pain Management, Faculty of Medicine, Ain Shams University, Cairo, Egypt

ABSTRACT

Background: General anesthesia through double lumen endotracheal tube providing Single Lung Ventilation (SLV) is the standard technique used in Video Assisted Thoracoscopic surgeries (VATS) with the benefit of collapsing & isolating the operated lung so to protect the non-operated one against spread of infection & providing a good surgical exposure. This usually performed on expense of risks of side effects specially hypoxia in addition to other problems of cost & the needed training & experiences.

Many studies compared different strategies to overcome this conflict including the use of standard single lumen endotracheal intubation for providing Two Lung Ventilation (TLV) in VATS.

Objective: This study designed to compare TLV to standard SLV in VATS considering incidences of intra & post-operative hypoxia, surgeon's satisfaction & the recorded complications.

Patients and Methods: After getting ethical committee approval, patients were randomized to one of two groups (each of 30 patients). Group A: SLV using double lumen endotracheal tube. Group B: TLV using single lumen endotracheal tube. Intraoperative oxygen saturation, hypoxia, complications, mean surgical duration, surgeon's satisfaction & postoperative complications were recorded.

Results: The average arterial oxygen saturation was lower in SLV group during in the first 3 intra-operative hours. Six patients in SLV group developed hypoxia (SaO2<90%), Four of them were having resistant hypoxia not responding to usual lines of treatment. No patients in TLV group developed hypoxia.

Mean surgical duration was longer in TLV group with only 16.7% surgeon's satisfaction versus 100% satisfaction in SLV group. Intraoperative complications (apart from hypoxia) & post-operative ones were comparable in TLV versus SLV.

Conclusion: Both TLV & SLV can be used in VAT. Each strategy has several benefits & draw backs. The choice of one of them is based on several patient & procedural factors & should be managed through multidisciplinary discussion & understanding.

Key Words: Double-lumen tubes, intraoperative hypoxia, postoperative pulmonary complications, single lung ventilation, video-assisted thoracoscopy.

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Corresponding Author: Salwa Omar El-Khattab Amin Mohamed, MD, Department of Anesthesia, Intensive Care and Pain Management, Faculty of Medicine, Ain Shams University, **Tel.:** +2 012 2174 2262, **E-mail:** salwakhattab2011@hotmail.com

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INTRODUCTION

The traditional open thoracotomy has been replaced by video-assisted thoracoscopic surgeries due to its minimal invasiveness and associated low morbidity[1].

Adequate surgical exposure is a corner stone in thoracoscopic surgeries which can be achieved by single lung ventilation using double lumen tube & deflation of the operated lung.

The inability to completely deflate the nondependent lung during VATS leads to poor surgical exposure, which in turn can affect the success of the procedure, increasing the possibility of conversion to an open technique[2].

Hypoxemia is a risk associated with SLV. The intra-pulmonary shunt that created by SLV together with lateral decubitus position & intrathoracic pressure imbalance leads to state of ventilation-perfusion mismatch with the

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resultant hypoxemia[3]. Hypoxemia can complicate up to 10% of the thoracoscopic procedures under SLV[4,5]. Most of the cases of hypoxia corrected with application of PEEP to the ventilated lung & recruitment maneuver except those with severe obstructive lung disease. PEEP could be applied intermittently[6], Bronchoscopy-guided insufflation of oxygen into segments of the nondependent lung remote to the site of surgery2 or differential lung ventilation can be also used[7].

The use of high fraction of inspired oxygen can be also used but with risk of hyperoxia which could trigger an intense vasoconstriction response that might cause paradoxical reduction of oxygen delivery to vital organs[8] or accumulation of reactive oxygen species[9]. A beneficial effect of low concentration of reactive oxygen species have been reported[10].

Postoperative pulmonary complications are one of the most serious problems during perioperative period[11,12]. The incidence of postoperative pulmonary complications depends on patients' co-morbidity, surgical procedures and anesthetic factors[11,13]. Ventilator parameters are one of the most important risk factor[14] so, lung protective ventilation (low tidal volume, sufficient level of positive end-expiratory pressure, and limited airway pressure) can be used as a preventive measure for such complication[15,16].

PATIENTS AND METHODS

This prospective, randomized controlled study was conducted to compare the use of Single Lung ventilation (SLV) versus Two Lung Ventilation (TLV) during Video Assisted Thoracoscopic (VAT) lung procedures as regard; incidence of intra & post-operative hypoxemia, surgeon's satisfaction about surgical field exposure & the incidence of post-operative complications.

Sample size calculation

Based on results of previous studies comparing two lung ventilation versus single lung ventilation (Kim *et al.*,2011)[17] & using PASS 11 program for sample size calculation setting power at 80% alpha error at 5%, a sample size of at least 60 patients (30/group) was used .

After getting approval of ethical committee (Faculty of Medicine, Ain Shams University Research Ethical Committee FM-ASU-REC) & consent from each patient to participate in the study, 60 adult patients who were scheduled for elective thoracoscopic procedures under general anesthesia in Thoracic Operating Theatre, Ain Shams University Hospitals over a period of 6 months (March to October 2022) were recruited in our study. Patients were included if they were 21 years old or more, ASA physical status II & III & scheduled for elective video thoracoscopic lung procedures under GA. Patients were excluded if they were on pre-operative oxygen therapy, having ischemic heart diseases, history of lung surgeries or having coexisted pathology in the non-operated side and patients for emergency procedures.

Patients were randomly assigned (through computer generated randomization) to one of two groups (30 each), (Group A: Single Lung Ventilation) receive their general anesthesia through double lumen endotracheal tube or (Group B: Two Lungs Ventilation) receive their general anesthesia through single lumen endotracheal tube.

Anesthesia was managed by the same anesthesia team & procedures were performed by the same surgeons for all patients.

Patients were excluded (after inclusion) if the procedure shifted to open thoracotomy or SLV shifted to TLV or the reverse for any reason.

Intra-operative management

Patients received the usual preoperative assessment including history, clinical examination, laboratory tests & radiological investigation & standard intra-operative monitoring (ECG, pulse oximetry, invasive blood pressure, end-tidal CO2 measurement, inhaled volatile agent concentration, and arterial blood gases measurement). Baseline parameters such (oxygen saturation, systolic, diastolic, and mean blood pressure & heart rate) were recorded.

General anesthesia was induced with intravenous midazolam 0.04mg/kg, fentanyl 1-2 µg/kg, propofol 1-2 mg/kg, atracurium 0.5 mg/kg followed by endotracheal intubation and mechanical ventilation followed:

Group A (the Single Lung Ventilation SLV): trachea was intubated with Left sided Double Lumen endotracheal Tube (DLT) (MALLINCKRODTTM endobronchial tube, COVIDIENTM). Single Lung Ventilation (SLV) was started with deflation of the lung on the operated side by clamping the tube connector to the operated lung at end expiration.

Group B (the two-lung ventilation): trachea was intubated using standard single lumen endotracheal tube. If lung inflation interfered with surgical procedure, a brief periods of intermittent lung deflation were used so to allow surgical access while avoiding hypoxia.

Ventilator was set on 8 ml/kg tidal volume (ideal body weight), peak inspiratory airway pressure limit 35 Cm H2O, PEEP pressure was set at 5Cm H_2O & respiratory rate was manipulated to keep end tidal CO2 at 35-45 mmHg. FiO2 was set at 1.0 initially at time of anesthesia induction & intubation then it was maintained at 0.5.

Anesthesia was maintained with isoflurane 1.5 % in oxygen and air (50:50) and atracurium 0.1mg/kg every 20 minutes. Arterial blood gases were sampled every hour & whenever there are any fluctuations in pulse oximetry readings & then every 10 minutes until stabilization of SaO2, end tidal CO2, vital data. Intraoperative complications mainly hypoxia, bleeding, and lung collapse were monitored.

If hypoxia (SaO_2<90%) developed, it was managed by increasing fraction of inspired O_2 up to 1.0, increasing PEEP up to 10 CmH_2O, or modulating I:E ratio until stabilization then resuming previous settings.

If these measures failed to correct hypoxia, this event was considered "resistant hypoxia" where more advanced management was tried as resuming two lung ventilations by removing the double lumen connector tube clamp in SLV, lung recruitment by hyperinflation of both lungs till regain normal bilateral lung inflation and improve oxygen saturation or trying single lung ventilation by double lumen tube in group B (TLV). If resumption of the original ventilation strategy was not possible because of hypoxia, the patient was excluded from the study. There were no patients excluded from the study because of persistent hypoxia

If lung inflation in TLV continued to interfere with surgery, lower tidal volume was tried for a while if not working, the single lumen tube was changed to double lumen tube & patient excluded from the study. No patient excluded because of problem of surgical field exposure

Surgeon's satisfaction was assessed after finishing the procedure by questioning surgeon directly if he/she was satisfied/comfortable about surgical field exposure. The expected answer was either yes or no.

At conclusion of surgery, inhalational anesthetic was switched off, muscle relaxant was reversed, tube connector clamp was removed & two lung ventilation was resumed in case of SLV both lungs were manually inflated, patient was extubated in supine position & transferred to post surgery ICU.

Post operatively, patients were transferred to surgical ICU for the next 24 post-operative hours for continuous monitoring of vital data & pulse oximetry oxygen saturation, six hourly blood gases evaluation, monitoring for chest drains every 8 hours, adequate pain relief, chest physiotherapy, inhaler therapy, and fluid balance. Chest X ray upon arrival to ICU & 24 hour later to diagnose thoracic duct injury, lung consolidation & collapse………...etc.

Data recorded: demographic data (age, sex, ASA physical status), type & duration of surgical procedures, intraoperative arterial oxygen saturation, events of resistant hypoxia, surgeon's satisfaction (same surgeons performed all the procedures), post-operative arterial oxygen saturation, hypoxia & other possible complications (bleeding, lung collapse/ atelectasis, slipped chest tubes, pneumothorax …. etc.) postoperative data were recorded over the next 24 hrs.

Quantitative data were expressed as mean and standard deviation and qualitative data as number and percentage. Comparison between the two groups was made by using the Chi-square test, independent t-test, or Mann–Whitney U-test according to the distribution of data. A *p-value* less than 0.05 was considered statistically significant.

Study outcomes

The primary outcome of this study was the incidence of intra-operative hypoxic events. Secondary outcomes were complications (intra & postoperative) & level of surgeons' satisfaction (as measured by direct yes/ no question)

- Hypoxia events (intra & post-operative)
- Surgeons' satisfaction (as measured by direct yes/ no question)

Secondary outcomes

- Intra/post-operative complications.

RESULTS

A total of sixty patients were recruited. No patients were excluded from the study after inclusion because of any reason.

Demographic data (age, sex, weight, ASA physical status) were comparable in the two groups (Table1).

Duration of surgery and anesthesia was longer in TLV group (2.93 hrs.) compared to SLV group (2.47 hrs.). Regarding the type of surgery, higher number of patients received TLV underwent lung biopsy (19 versus 7) & those underwent bullectomy were more in SLV (6 in TLV versus 1 in TLV group (Table 2). These differences in type of surgeries conducted might exert a notable impact on study outcomes.

Intra-operative arterial oxygen saturation was statistically higher in TLV group during the first 3 intra-operative hours (with no clinical significance) & no difference between the two groups was present in the 4th one (Tables 3, 4, Figure 1).

Four out of thirty patients in SLV group developed intra-operative resistant hypoxia compared to non in TLV group. (Table 5, Figure 2)

Surgeons were satisfied (answered yes when questioned "did you feel satisfied/comfort about surgical field exposure?) in all procedures done with SLV compared to only 5 (16.7%) in TLV (Table 5, Figure 3).

As regard post-operative follow up, it was found that over all post-operative arterial oxygen saturation was significantly higher in TLV group during first 12 post-operative hours & comparable in both groups during the second 12 post-operative hours (Table 6, Figure 4).

The recorded total intra-operative complications were higher in SLV group (9 versus 2 in TLV group) most of them were hypoxia (6 events in SLV versus zero in TLV). Other complications (bleeding & thoracic duct injuries) were comparable between the two groups. (Table 7)

During post-operative period, the recorded post-operative complications (lower lung collapse, bleeding, slipped chest tubes & pneumothorax) were comparable in both groups. (Table 7)

Table (1) shows that no statistically significant difference was found between the two groups as regard mean age, sex and ASA status.

Table (2) shows that a statistically significant difference was found between the two groups as regards the type of surgery, lung biopsy surgeries were found to be more in TLV group (19 versus 7) while lung bullectomy were found to be more in SLV (6 versus 1). A significant difference was found between the groups as regard mean duration of surgery being longer in two lung ventilations (2.93 hrs.) compared to single lung ventilation (2.47 hrs.)

Table (3) shows that intra-operative arterial oxygen saturation was higher in Two Lungs Ventilation group compared to Single Lung Ventilation group at 1st, 2nd & 3rd hours intraoperatively & no significant difference was found at the 4th hour.

Table (4) shows that there was statistically significant difference between the two groups as regards average intraoperative arterial oxygen saturation found higher in two lung ventilation (99.80 ± 0.18) compared to single lung ventilation (98.21± 2.12), *P- value* <0.01.

Table (5) shows that four patients in SLV group developed intra-operative resistant hypoxia events compared to no patients in TLV group, *P- value* = 0.038 (< 0.05).

Also, surgeons expressed their satisfaction /comfort regarding surgical field exposure in all cases in SLV group compared to five cases only in TLV group, *P-value* = 0.000 (<0.01).

Table (6) shows that there was a statistically significant difference between the groups regarding post-operative arterial oxygen saturation being higher in the two lung ventilation (TLV) group at 1st 6 hours (99.83 ± 0.20 Vs 98.63 ± 2.24) with *p-value* < 0.001, at 2nd 6 hours (99.78 ± 0.28 Vs 99.29 ± 1.23) with *p- value* < 0.001 while non-significant at 3rd 6 hours (99.75 ± 0.35 Vs 99.50 ± 1.05) with *p-value* < 0.227 (> 0.05) and non- significant at 4th 6 hours (99.79 ± 0.34 Vs 99.74 ± 0.50) with *p-value* = 0.651 (> 0.05).

Table (7) shows that there was no statistically significant difference between the two groups as regard intra-operative and post-operative complications except intra-operative hypoxia, which was higher in single lung ventilation (SLV) group, *p-value* = (0.010).

Table 1: Comparison between SLV and TLV among demographic data.

		Single lung Ventilation	Two lungs Ventilation	Test value	*P-value*	Sig.
		No. = 30	No. = 30			
Age (years)	Mean ± SD Range	41.03 ± 16.31 21 – 82	47.43 ± 14.46 25 – 69	-1.608•	0.113	NS
Sex	Female Male	8 (26.7%) 22 (73.3%)	15 (50.0%) 15 (50.0%)	3.455*	0.063	NS
ASA	II III	28(93.3%) 2 (6.7%)	24(80.0%) 6 (20.0%)	2.308*	0.129	NS

P-value > 0.05: Nonsignificant; *P-value* < 0.05: Significant; *P-value* < 0.01: Highly significant *: Chi-square test; •: Independent t-test

Table 2: Comparison between SLV and TLV among surgical data.

		Single lung ventilation	Two lungs ventilation	Test value	*P-value*	Sig.
		No. = 30	No. = 30			
Surgery	Biopsy	7 (23.3%)	19 (63.3%)			HS
	Decortication	10 (33.3%)	9 (30.0%)	9.774* 0.077*	0.002 0.781	NS
	Bullectomy	6 (20.0%)	1 (3.3%)	4.043* 1.964*	0.044 0.161	S
	Excision	4 (13.3%)	1 (3.3%)	2.069*	0.150	NS
	Pleural wash	0 (0.0%)	2 (6.7%)			NS
	Pneumonectomy	2 (6.7%)	0 (0.0%)	2.069*	0.150	NS
	Lower lobectomy	1 (3.3%)	0 (0.0%)	1.017*	0.313	NS
	Drainage	1 (3.3%)	0 (0.0%)	1.017*	0.313	NS
Duration of surgery (hrs.)	Mean ± SD Range	2.47 ± 0.68 2 – 4	2.93 ± 0.69 2 – 4	-2.633•	0.011	S

P-value > 0.05: Nonsignificant; *P-value* < 0.05: Significant; *P-value* < 0.01: Highly significant *: Chi-square test; •: Independent t-test

Table 3: Comparison between SLV and TLV regarding arterial O2 saturation, intraoperative follow-up.

Intra-operative arterial oxygen saturation		Single lung ventilation	Two lung ventilation	Test value	*P-value*	Sig.
		No. = 30	No. = 30			
1st hour	Mean ± SD Range	99.13 ± 0.81 97.3 – 100	99.87 ± 0.24 98.8 – 100	-4.864•	0.000	HS
2nd hour	Mean ± SD Range	98.02 ± 2.54 87.3 – 100	99.74 ± 0.36 98.7 – 100	-3.673•	0.001	HS
		No. = 11	No. = 22			
3rd hour	Mean ± SD Range	94.64 ± 5.49 87.9 – 100	99.83 ± 0.27 98.8 – 100	-4.500•	0.000	HS
		No. = 3	No. = 6			
4th hour	Mean ± SD Range	95.87 ± 4.10 91.8 – 100	99.37 ± 0.42 98.8 – 99.8	-2.230•	0.061	NS

P-value > 0.05: -Nonsignificant; *P-value* < 0.05: Significant; *P-value* < 0.01: Highly significant •: Independent t-test

Table 4: Average intraoperative oxygen saturation

Average intra-operative oxygen saturation	Single lung ventilation	Two lung ventilation	Test value	*P-value*	Sig.
	No. = 30	No. = 30			
Mean ± SD	98.21 ± 2.12	99.80 ± 0.18	-4.100•	0.000	HS
Range	92.2 – 99.9	99.3 – 100			

P-value > 0.05: Nonsignificant; *P-value* < 0.05: Significant; *P-value* < 0.01: Highly significant •: Independent t-test

Table 5: Comparison between SLV and TLV among events of resistant hypoxia and surgeon satisfaction.

		Single lung ventilation	Two lung ventilation	Test value	P-value	Sig.
		No. = 30	No. = 30			
Resistant hypoxia	No Yes	26 (86.7%) 4 (13.3%)	30 (100.0%) 0 (0.0%)	4.286*	0.038	S
Surgeon satisfaction	No Yes	0 (0.0%) 30 (100.0%)	25 (83.3%) 5 (16.7%)	42.857*	0.000	HS

P-value > 0.05: Nonsignificant; *P-value* < 0.05: Significant; *P-value*< 0.01: Highly significant *: Chi-square test

Table 6: Comparison between SLV and TLV regarding postoperative arterial O2 saturation.

post-operative arterial oxygen saturation No. = 30		Single lung ventilation	Two lung ventilation	Test value	*P-value*	Sig.
		No. = 30				
1st 6 hours	Mean ± SD Range	98.63 ± 2.24 92.4 – 100	99.83 ± 0.20 99.3 – 100	-2.930•	0.005	HS
2nd 6 hours	Mean ± SD Range	99.29 ± 1.23 96 – 100	99.78 ± 0.28 98.9 – 100	-2.151•	0.036	S
3rd 6 hours	Mean ± SD Range	99.50 ± 1.05 94.8 – 100	99.75 ± 0.35 98.2 – 100	-1.221•	0.227	NS
4th 6 hours	Mean ± SD Range	99.74 ± 0.50 98 – 100	99.79 ± 0.34 98.6 – 100	-0.454•	0.651	NS

P-value > 0.05: Nonsignificant; *P-value* < 0.05: Significant; *P-value* < 0.01: Highly significant

Table 7: Comparison between SLV and TLV regarding intra-operative and postoperative complications.

Complications	Single lung ventilation	Two lung ventilation	Test value	*P-value*	Sig.
	No. = 30	No. = 30			
Intra operative complications					
No	21 (70.0%)	28 (93.3%)	5.455*	0.020	S
Yes	9 (30.0%)	2 (6.7%)			
Hypoxia	6 (20.0%)	0 (0.0%)	6.667*	0.010	S
Bleeding	3 (10.0%)	2 (6.7%)	0.218*	0.640	NS
Thoracic duct injury	1 (3.3%)	0 (0.0%)	1.017*	0.313	NS
Post-operative					
No	23 (76.7%)	24 (80.0%)	0.098*	0.754	NS
Yes	7 (23.3%)	6 (20.0%)			
Lower lung collapse	5 (16.7%)	3 (10.0%)	0.577*	0.447	NS
Re-bleeding	2 (6.7%)	2 (6.7%)	0.000*	1.000	NS
Slipped chest tube and pneumothorax	0 (0.0%)	1 (3.3%)	1.017*	0.313	NS

P-value > 0.05: Nonsignificant; *P-value* < 0.05: Significant; *P-value* < 0.01: Highly significant *: Chi-square test

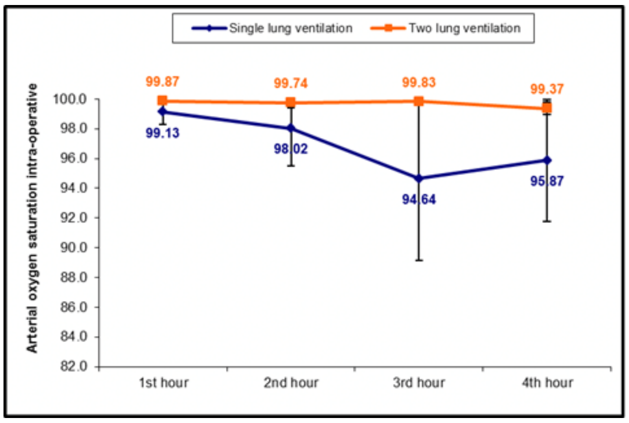

Fig. 1: Comparison between single and two lung ventilation regarding intra-operative arterial O2 saturation

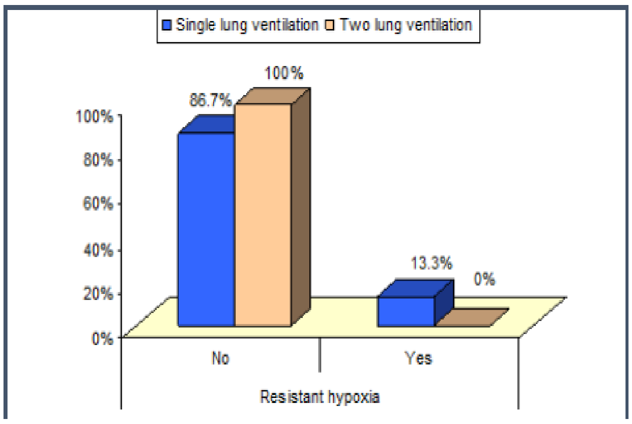

Fig. 2: Comparison between single and two lung ventilation regarding resistant hypoxia

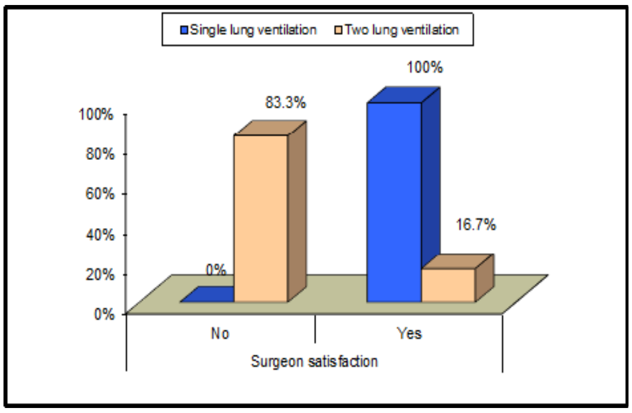

Fig. 3: Comparison between single and two lung ventilation regarding surgeon satisfaction

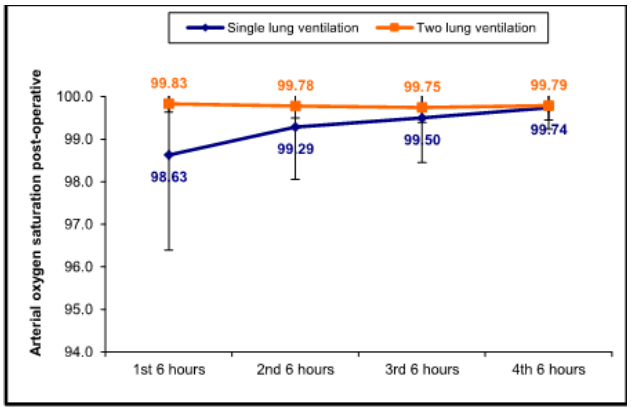

Fig. 4: Comparison between single and two lung ventilation regarding post-operative arterial O2 saturation

DISCUSSION

Video Assisted Thoracoscopy (VAT) is widely used for large number of diagnostic & therapeutic procedures involving lungs, pleura, thymus gland & others intrathoracic structures. General anesthesia with single lung ventilation using double lumen endotracheal intubation is the standard anesthesia technique for such procedures providing adequate surgical exposure by isolating & deflating the operated lung giving higher level of comfort & satisfaction of the working surgeon which provides a better chance to minimize surgical complications. Unfortunately, the use of a double lumen endotracheal tube has known disadvantages, including the need for experienced personnel, the use of bronchoscopy for proper positioning (especially with right-sided tubes), the time required for insertion and positioning, and the risks associated with single lung ventilation, particularly hypoxia. Alternatively, the standard single lumen endotracheal tube providing two lung ventilations has been tried in VATS procedures to overcome problems associated with double lumen endotracheal tube use specially hypoxia. Different ventilator strategies have been studied to provide the best surgical field exposure while maintain adequate arterial oxygen saturation[2].

This prospective randomized study compared the use of TLV to the standard SLV in VATS for lung procedures (pneumonectomy, lower lobectomy, bullectomy, lung biopsy, excision, decortication…etc.). Thirty patients were included for each anesthesia technique with the use of the same ventilator settings. Anesthesia induction & maintenance was performed by the same anesthesia team & VAT procedures were performed by the same senior surgical team.

The average intra-arterial oxygen saturation was found to be lower in SLV group during the first three intra-operative hours. While significant variations exist in PaO2 and Sao2 levels between the two groups, it is imperative to underscore that these differences lack clinical relevance.

Yun *et al*, reported less oxygen saturation & higher fraction of inspired oxygen in SLV group at all points of time in VAT under SLV versus VAT under TLV[18]. Similarly, a higher fluctuation in oxygenation in SLV group compared with TLV in patients underwent VAT procedures for spontaneous pneumothorax as reported by Chang *et, al.*[19].

Apart from hypoxia, intraoperative complications were comparable in SLV & TLV groups. Six patients (20%) developed intraoperative hypoxia (SaO2<90%) in SLV group compared to no intra-operative hypoxia in TLV group. Out of these 6 patients, 4 cases (13.3%) were considered resistant cases as they were not corrected by the usual measures of increasing fraction of inspired oxygen & needed more advanced measures. This was the case in report of Toolabi et, al.[20].

However, as post-operative hypoxia was comparable between SLV & TLV in our study, so the effect of intraoperative hypoxia did not extend to postoperative period which might denote limited significance of these events. This could not be generally applied as inclusion in our study was limited to patient with adequate preoperative oxygenation status.

We used the same ventilator settings in both SLV and TLV (tidal volume of 6-8 ml/kg (ideal body weight), respiratory rate was set to maintain an end tidal CO2 between 30 and 35 mmHg, peak inspiratory pressure limit of 35 cm H_2O with constant PEEP of 5 Cm H_2O) while different ventilator strategies have been studied in thoracic surgeries aiming to achieve the best oxygenation with the least post-operative pulmonary sequalae.

Different values of several low tidal volumes were compared retrospectively in study of Blank et, al.[21] who concluded that, the best protection against lung injury was the combining low tidal volume with sufficient PEEP to prevent alveolar atelectasis without causing overdistension.

A systematic review of the use of driving pressure-oriented ventilator strategies with SLV in thoracic surgeries found to provide adequate oxygenation with few post-operative pulmonary complications[22].

Despite our findings that demonstrated poor surgeon's satisfaction about surgical field exposure in SLV (16.7%) compared to 100% satisfaction with SLV, the use of TLV was satisfactory by Kim et, al.[17] who conducted a prospective study on patients underwent needlescopic bleb resection for spontaneous pneumothorax either under two lung ventilation using low tidal volume (4ml/kg) or one lung ventilation using standard tidal volume (8ml/kg) & Toolabi et, al.[20] who compared two lung ventilation to single lung ventilation in mediastinal procedures of sympathectomy & thymectomy.This difference can be attributed to nature of the procedure done, how important the collapsing of the lung on the operative side was, the used tidal volume & airway pressures while using TLV in VAT.

We found longer mean surgical duration in VAT procedures with TLV (2.93 hrs.) compared to (2.47 hrs.) with SLV. The use of double lumen endotracheal tube & the implementation of TLV usually takes longer time[20,17]. So, the longer time for intubation in SLV group was balanced by longer time took for the surgery itself with the reported less comfort about surgical field exposure in this study.

A statistical analysis was observed between the two groups in our study concerning the types of surgeries conducted, a factor that may exert a notable impact on the study outcomes.

CONCLUSION

In conclusion, the use of TLV in VAT for lung procedures looks as an attractive choice providing better oxygenation, easy use & less complications but on the expense of surgical field exposure specially when this is crucial as while working on deeper structures. SLV is still a good option specially if used for patients with adequate preoperative oxygenation & other low risk patients where hypoxia events found to be of limited significance. The choice between them needs a comprehensive multidisciplinary evaluation, understanding & discussion of the patient's characters, comorbidities, functional status, surgical procedure's nature, extent, site of the lesion & other related factors. This multidisciplinary approach will help to formulate anesthesia & surgical plan which satisfy most of the needs & limit the possible negative sequalae.

This study was limited by its small sample size, a very conservative inclusion criteria which allow the inclusion of patients with adequate preoperative pulmonary functional status only, Also, the used ventilator settings were fixed. A larger randomized controlled trials comparing TLV to SLV in different ventilator settings, different surgical procedures, different operative positions……etc. are needed to find out the best technique in VATs.

CONFLICT OF INTERESTS

There are no conflicts of interest.

REFERENCES

1. Torresini G, Vaccarili M, Divisi D, *et al*. (2001): Is video-assisted thoracic surgery justified at first spontaneous pneumothorax? Eur J Cardiothorac Surg, 20: 42–5.
2. Cohen E. (2011) Anesthesia for Video-Assisted Thoracoscopic Surgery. Principles and Practice of Anesthesia for Thoracic Surgery.
3. Yoon S, Kim BR, Min SH, Lee J, Bahk JH, Seo JH. (2021) Repeated intermittent hypoxic stimuli to operative lung reduce hypoxemia during subsequent one- lung ventilation for thoracoscopic surgery: a randomized controlled trial. PLoS One. (2021) 16(4):e0249880.
4. Karzai W & Schwarzkopf K. (2009): Hypoxemia during one-lung ventilation: Prediction, prevention, and treatment, Anesthesiology, 110:1402-11.
5. Campos JH& Feider A. (2018): Hypoxia during one-lung ventilation-a review and update, J Cardiothorac Vasc Anesth, 32 (5): 2330–8.
6. Russell WJ. (2011): Hypoxemia during one-lung ventilation: looking the other way. Anesthesiology, 115 (2): 437, Author reply 9-41.
7. Kremer R, Aboud W, Haberfeld O, *et al*. (2019): Differential lung ventilation for increased oxygenation during one lung ventilation for video assisted lung surgery, J Cardiothorac Surg, 14 (1): 89.
8. Brugniaux JV, Coombs GB, Barak OF, *et al*. (2018): Highs and lows of hyperoxia: physiological, performance, and clinical aspects, Am J Physiol Regul Integr Comp Physiol, 315 (1): 1-27.
9. Roberts SM& Cios TJ. (2019): Con: Hyperoxia should not be used routinely in the management of cardiopulmonary bypass, J Cardiothorac Vasc Anesth, 33 (7): 2075–8.
10. Lavie L. (2015): Oxidative stress in obstructive sleep apnea and intermittent hypoxia–revisited–the bad ugly and good: implications to the heart and brain, SleepMed Rev, 20:27–45.
11. Smetana GW, Lawrence VA, Cornell JE. (2006): Preoperative pulmonary risk stratification for non-cardiothoracic surgery: systematic review for the American College of Physicians, Ann Intern Med, 144(8):581–95.
12. Canet J& Gallart L. (2013): Predicting postoperative pulmonary complications in the general population, Curr Opin Anaesthesiol, 26(2):107–15.
13. Canet J& Mazo V. (2010): Postoperative pulmonary complications, Minerva Anestesiol, 76(2):138–43.
14. Serpa Neto A, Cardoso SO, Manetta JA *et al*. (2012): Association between use of lung-protective ventilation with lower tidal volumes and clinical outcomes among patients without acute respiratory distress syndrome: a meta-analysis, JAMA, 308(16):1651–9.
15. Futier E, Constantin JM, Paugam-Burtz C *et al*. (2013): AIMPROVE study group, A trial of intraoperative low-tidal-volume ventilation in abdominal surgery, N Engl J Med, 369(5):428–37.
16. Severgnini P, Selmo G, Lanza C, *et al*. (2013): Protective mechanical ventilation during general anesthesia for open abdominal surgery improves postoperative pulmonary function, Anesthesiology, 118 (6): 1307–21.
17. Kim H, Kim HK, Kang DY, *et al*. (2011): A comparative study of two- versus one-lung ventilation for needlescopic bleb resection, European Respiratory Journal, 37: 1183-8.
18. Yun M., Kim G.H., Ko S.C., Han Y.J., and Kim W. (2022): Comparison of two-lung and one-lung ventilation in bilateral video-assisted thoracoscopic extended thymectomy in myasthenia gravis: a retrospective study. Anesth Pain Med; 17:199-205
19. Chang Y. J., ShinJ.W., Cho M. S., Cho D. G. (2023):Video-assisted thoracic surgery for spontaneous pneumothorax under two-lung ventilation and single-lumen endotracheal tube intubation. Journal of Thoracic Disease;15(7):3605-3611
20. Toolabi K, Aminian A, Javid M, *et al*. (2009): Minimal access mediastinal surgery: One or two lungs ventilation? Journal of Minimal Access Surgery, 5(4):103-7.

21. Blank RS, Colquhoun DA, Durieux ME, *et al*. (2016): Management of one-Lung Ventilation: impact of tidal volume on complications after thoracic surgery, Anesthesiology, 124(6):1286–95.

22. Xuan Li, Wenqiang Xue, Qinyu Zhang, Yuyang Zhu, Yu Fang & Jie Huang . (2022): Effect of Driving Pressure-Oriented Ventilation on Patients Undergoing One-Lung Ventilation During Thoracic Surgery: A Systematic Review and Meta-Analysis. Front. Surg. 9:914984.