DOUBLE-LUMEN ENDOBRONCHIAL TUBE VERSUS SINGLE-LUMEN ENDOTRACHEAL TUBE USED IN MINIMALLY INVASIVE CARDIAC SURGERY

Asmaa I. Gad[1], Tarek El-said [2], Waleed A. Al-Taher [3], Amira A. Elnasr Awad [4]

Article History: Received: 25.08.2022 **Revised:** 05.10.2022 **Accepted:** 15.10.2022

Abstract

Background*:* Introduction of minimally invasive cardiac surgery (MICS) has been more commonly performed due to minimal bleeding, smaller incision and short hospital stay.

Aim of the work*:* Comparing the placement of a single-lumen endotracheal tube (SLT) vs a double-lumen endobronchial tube (DLT) during anesthetic management in (MICS) and determining the best technique for rapid lung deflation.

Methods: Prospective view of forty patients subjected to (MICS) procedure randomly allocated into two equal groups; Group D: use a (DLT) and Group S: use a (SLT). As regards of intra-operative ABG values, the length of mechanical ventilation, ICU stay, and hospital stay, we compare the two groups.

Results: The anesthetic induction time to skin incision time and the operation time in group D were significantly longer than those of group S with higher surgical satisfaction in group D.

Conclusion: Both SLT and DLT is considered an applicable safe method for lung deflation in MICS.

***Keywords*:** Minimally invasive cardiac surgery (MICS), single-lumen endotracheal tube (SLT), double-lumen endobronchial tube (DLT).

1 M.B.B.C.H. MSc, Faculty of Medicine for Girls in Cairo AL-Azhar University
2 Professor of Anesthesia, Intensive Care and pain Management, Faculty of Medicine for Girls in Cairo AL-Azhar University
3 Professor of Anesthesia, Intensive Care and pain Management, Faculty of Medicine Ain-Shams University
4 Assistant Professor of Anesthesia, Intensive Care and pain Management, Faculty of Medicine for Girls in Cairo AL-Azhar University

DOI: 10.48047/ecb/2022.11.11.57

INTRODUCTION

Minimally invasive cardiac surgery (MICS) is a technically difficult and suitable training that significantly lessens the invasiveness of ordinary surgical operations. While still achieving outstanding clinical results, minimal incisions result in lower wound infection rates, shorter hospital stays, improved postoperative recovery, and higher patient satisfaction. [1]

Cardiovascular surgery using a peripheral cardio-pulmonary bypass (CPB) with a minor thoracotomy (15 cm) is known as minimally invasive cardiac surgery (MICS). Since , minithoracotomy, which preserves the entire length of the sternum, has replaced parasternotomy or partial sternotomy as the method of choice for MICS. [2]

PATIENTS AND METHODS

Prospective randomized controlled clinical study included 40 patients were subjected to (MICS) in Heart Academy in Ain Shams University hospitals. The study was done after approval of Research ethics committee in Al-Azhar University and informed written consent from patients were obtained. Patients were randomly allocated by computer-generated sequence using sealed opaque envelopes into two equal groups. All patients with elective cardiac surgery between the age of 18 to 60 years, with classes II-III of American Society of Anesthesiologists (ASA) .

Patients were randomly assigned into two groups contains 20 subjects (group D) use DLT and (group S) use SLT . Patients with cardiac tumors, advanced liver disease, renal dialysis, urgent cardiac surgery, pregnant women and ASA physical status more than III were excluded from the study.

One day prior to surgery, patients underwent a history check, which included a cardio-respiratory status evaluation. Investigations included a comprehensive blood picture, coagulation profile including "prothrombin time, international normalising ratio (INR), and prothrombin concentration," , liver functions, kidney functions, serum electrolytes, ECG, chest X-ray and Echocardiography, as well as a thorough examination of the chest, heart, and abdomen.

On the operative room, the peripheral intravenous line was inserted and patients were given midazolam I.V (50-100µg/kg) as premedication .Full monitor using a five-lead ECG, pulse oximeter and noninvasive arterial blood pressure. Arterial cannula was obtained with the radial artery line under local anesthesia for invasive blood pressure monitoring. Also it helps us for good monitoring of arterial blood gases and sampling all over the surgery especially at room air, 15minutes after intubation and 15 minutes after weaning of CPB.

Anesthesia was induced using fentanyl (3-5µg/kg), thiopental (0.5-2 mg/kg) and pavlon (0.1mg/kg). During intubation we divide the patient into two groups: Group S: use a SLT and Group D: use a DLT and confirmed the location by using the fiber optic bronchoscope .

When an SLT or DLT was confirmed to be in place, the tidal volume was adjusted to 4-6 mL/kg using the IBW, and the respiratory rate was adjusted to maintain an EtCO2 value between 35 and 40 mmHg. Peak inspiratory pressure and minute volume were also recorded.

To maintain the anesthesia, a mixture of oxygen and air (1: 1), isoflurane at 1-2% (MAC), fentanyl infusion at a dosage of 0.05 g/kg/min, and Pavlon (0.02 mg/kg) were given as needed .

- Under strict aseptic circumstances, a central venous catheter was inserted. The nasopharyngeal probe was also used to measure and keep track of the patient's core body temperature.

-Transeosphegeal Echocardiography was done for all patients to detect cardiac contractility, size of ASD, size mitral valve area, degree of regurg and stenosis. Also before CBP during femoral venous cannulation we used TEE to see guide wire in SVC and then used it 30 min after weaning of CPB to detect functioning of prothtic valve and closure patch in ASD.

In a 30 degree angle, the patients were then positioned on their left side. for mitral valve surgery and ASD, the right fourth intercostal space was incised, and the interval between anesthesia induction and skin incision was timed for each group. Heparinization with a first-bolus dose of 200-300 U/kg was given before cannulation planned to maintain (ACT) between 400-450 sec.

Right femoral artery and vein peripheral cannulation was carried out. After the cannula is advanced, the guide wire is advanced into the ascending aorta while transesophageal echocardiography is being performed. A single- or double-stage femoral venous cannula provides venous drainage. After that, the cannulation, cardiopulmonary by pass (CPB) will be initiated.

-Transthoracic aortic cross-clamping was induced followed by insertion of cardioplegia line for myocardial protection; the cardioplegia was administered in a short time to achieve the diastolic cardiac arrest by 20 mL/kg in the first dose followed by 10 mL/Kg administered every 25–30 min at a pressure of 250-300 mmHg. The solution was infused cold (4 - 8°C) and in antegrade manner through aortic root cannula which inserted in the ascending aorta proximal to the cross-clamp. Transthoracic aortic cross-clamping was induced, and then a cardioplegia line was inserted to protect the myocardium and at a low temperature (4–8°C).

-In Prior to CPB, the surgeon in group S requests intermittent lung deflation to allow exposure. In order to prevent fast desaturation after right thoracotomy, the patients were ventilated with 100% oxygen whenever the surgeon asked it. The anesthesiologists started ventilating the patients again when (O_2Sat. < 95%). The recruit manoeuvre was used in both groups to provide appropriate lung re-expansion prior to chest wall closure. When hematocrit levels were less than 22%, FFP and PRC transfusions were also given . When the patients were rewarmed to 35–37°C, weaning from CPB began. This was followed by the removal of the venous cannula and filtration. Protamine sulphate (1-1.5 mg/kg) was then administered to reverse the heparin effects and restore normal ACT prior to the removal of the cross-clamp.

After declamping we observed any arrhythmia or incidence of hypokalemia and acidosis and managed.

- Finally we asked surgeon about surgical satisfaction as regarded lung collapse and surgical exposure then patient transfer to intensive care unit intubated on mechanical ventilator and Postoperative Parameters were recorded: Duration of mechanically ventilation, ICU stay and hospital stay.

Sample size calculation

Before the research, a power calculation using the data acquired was used to establish the necessary number of patients in each group (Kim et al., 2016). In the study, the average length of time spent in I.C.U was 24.4613.82 for the DLT group and 27.8616.46 for the SLT group, with a large effect size of 0.50. Using G. Power 3.19.2 software, it was found that a sample size of 40 patients, with 20 patients in each group, would have 80% power for an independent samples T test at the level of 5% significance and a 95% confidence interval.

Statistical analysis:

The data was analyzed using the statistical programme for social sciences, SPSS Inc., version 20.0 (Chicago, Illinois, USA). To express quantitative data, the mean and standard deviation (SD) were utilised. To express qualitative data, frequency and percentage were utilised. The following experiments were run:The t-test for significance using independent samples was used to compare two means.Using the Chi-square (x2) test of significance, the proportions between qualitative measures were compared. The confidence interval

and the allowed margin of error were both set at 95%.

RESULTS:

In the current study forty patients were randomly split into two groups , group D and group S.

Preoperative investigation.

Regarding CBC, there was no statistically difference between the both groups. (WbCs, Hb, Hct, Plt) ,Chemistry (Urea, Createnine., Billirubin, AST, ALT) and coagulation profile (INR,PT,PC).

Intraoperative Parameters

1--Intraoperative ABG:

PH level

The intra-operative PH in ABG recorded at 15 min intervals after intubation shows a statistically significant increase in group S incomparison to group D but at room air and at 15 min after weaning there was no significant between both groups.

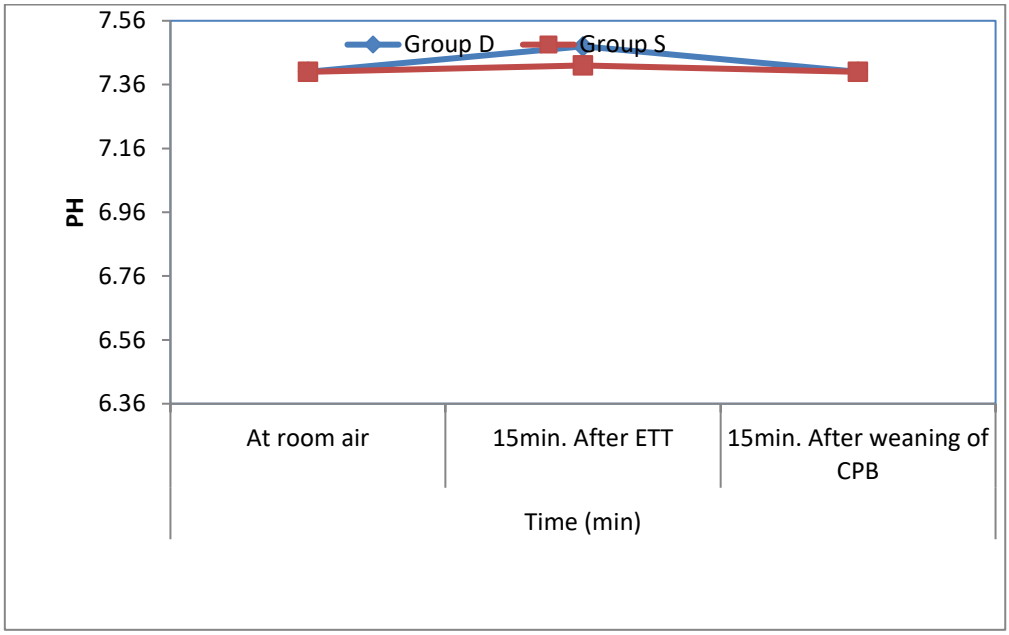

Fig. (1): Comparison between both groups according to intraoperative assessment ABG: PH level.

PCO_2 level

The intra-operative PCO_2 level in ABG recorded at 15 min after intubation shows a statistically significant increase in group D incomparison to group S While at room air and at 15 min after weaning there was no significant between both groups.

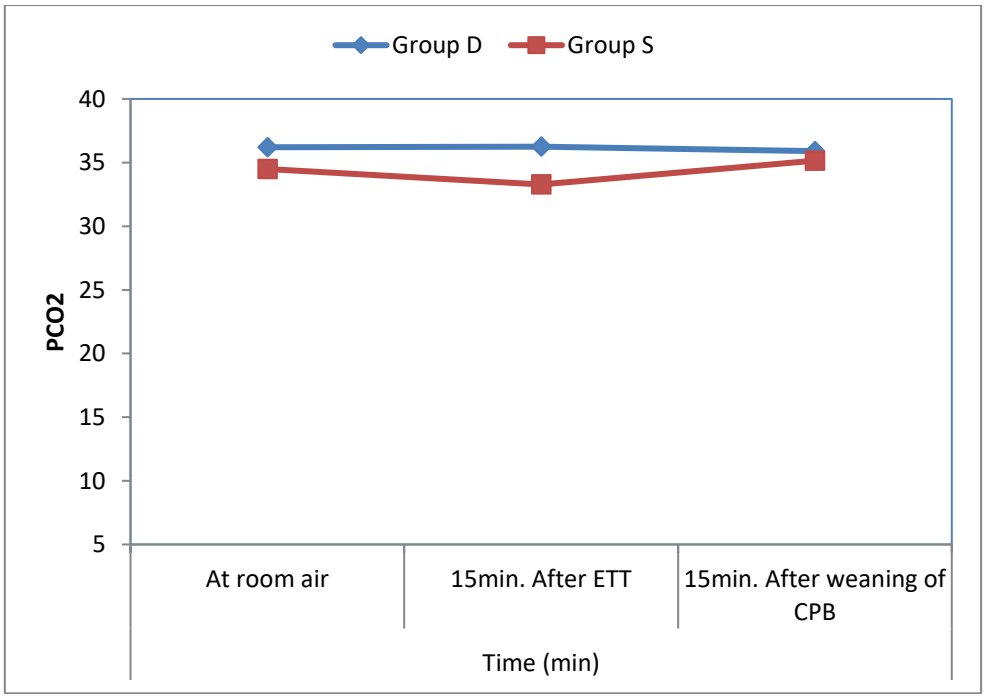

Fig. (2): Comparison between both groups according to intraoperative assessment ABG: PCO_2 level.

HCO_3level

The intra-operative HCO_3 level in ABG recorded at 15 min after intubation shows a statistically significant increase in group D in comparison to group S but at room air and at 15 min after weaning there was no significant between both groups.

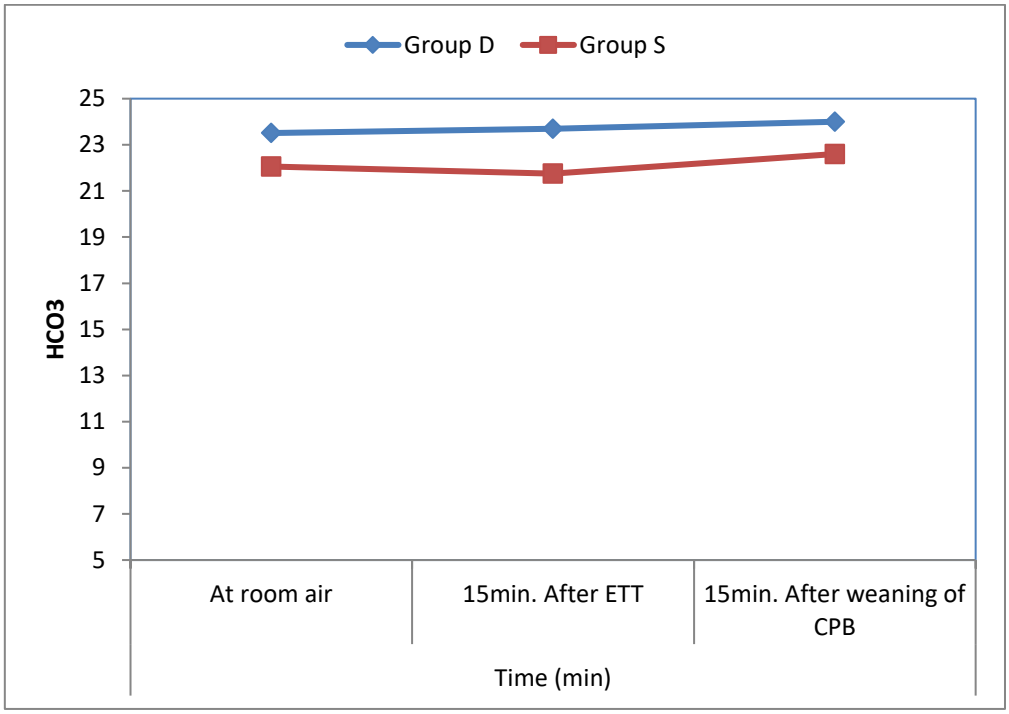

Fig. (3): Comparison between both groups according to intraoperative assessment ABG: HCO3 level

Spo_2 level

The intra-operative O_2 sat level in ABG recorded at 15 min after intubation shows a statistically significant decrease in group D incomparison to group S but at 15 min after weaning there was no significant between both groups.

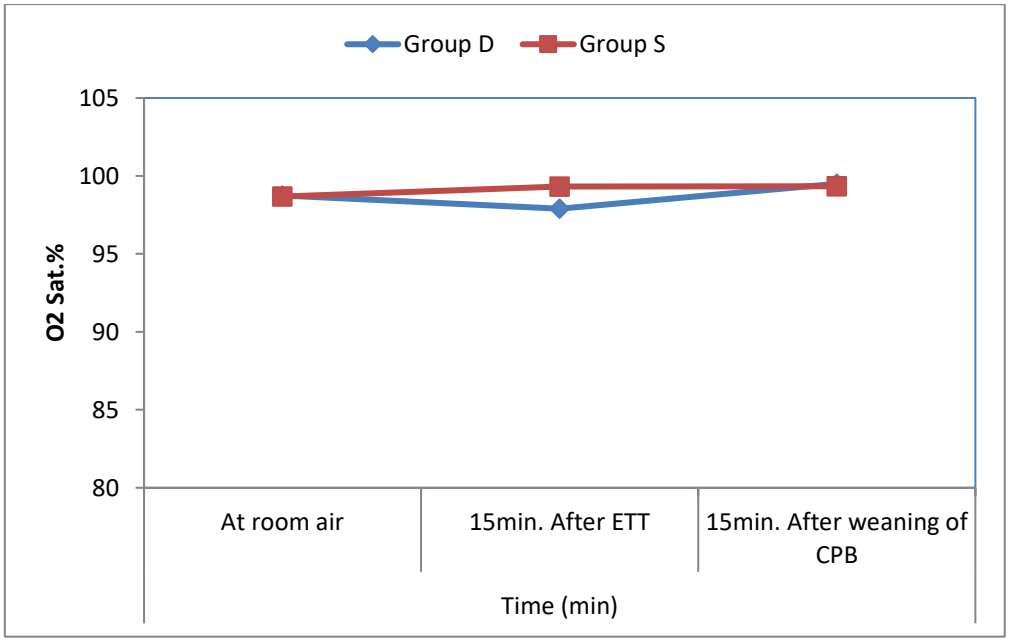

Fig. (4): Comparison between both groups according to intraoperative assessment ABG: O2 Sat% level.

PO_2 level

There was a statistically significant decrease in PO_2 level in ABG recorded at 15 min after intubation in group D in comparison to group S but at room air and at 15 min after weaning there was no significant between both groups.

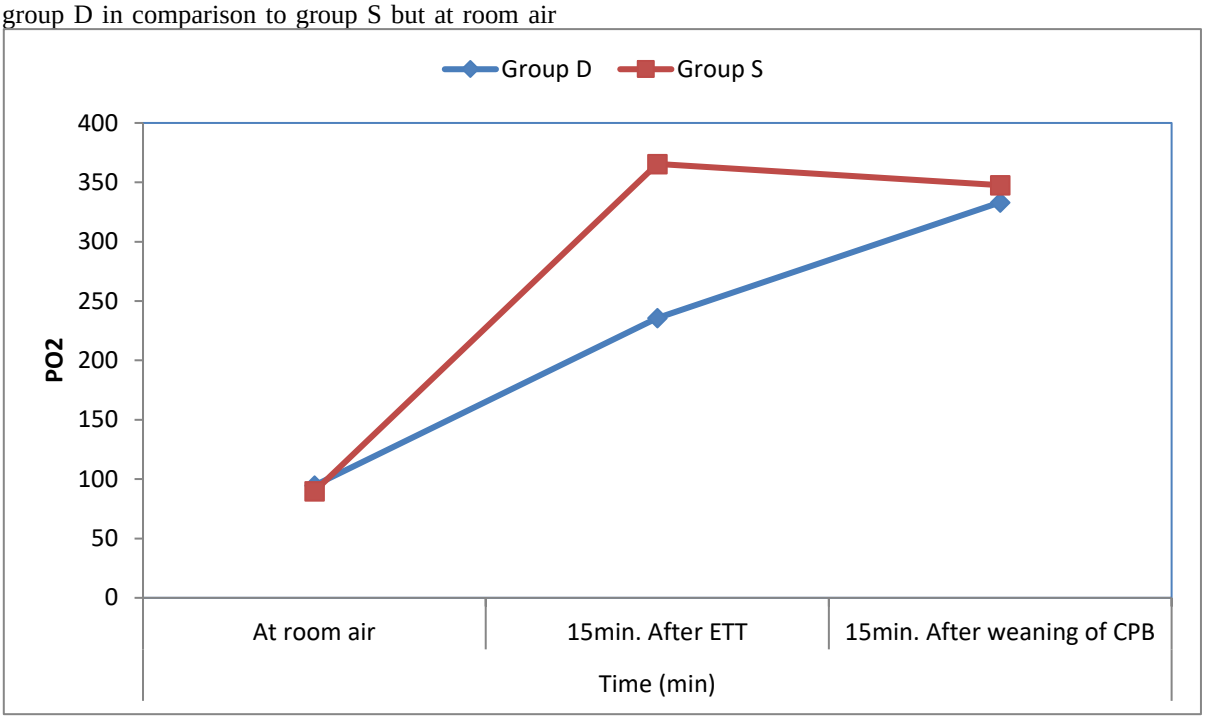

Fig. (5): Comparison between both groups according to intraoperative assessment ABG: PO2 level.

2- Transophegeal Echocardiography (TEE)

There was no significant difference in the TEE data before and 30 minutes after the surgery between both groups.

Table (1): Comparison between both groups according to intraoperative transophegeal echocardiography data.

TEE	Group D	Group S	x^2	p-value
Before surgical procedure				
ASD	5 (25.0%)	4 (20.0%)		
MR	7 (35.0%)	6 (30.0%)	0.410	0.815
MS	8 (40.0%)	10 (50.0%)		
30 min After procedure				
Closure of ASD	5 (25.0%)	4 (20.0%)	0.143	0.705
Function Prostheses	15 (75.0%)	16 (80.0%)		

3-The interval between anesthetic induction to skin incision

Comparing group D to group S, there was a statistically significant lengthening of the interval between anesthesia induction and skin incision.

Table (2): Comparison between both groups according to intraoperative assessment anesthetic induction to skin incision time (min).

Anesthetic induction to skin incision time (min)	Group D	Group S	t-test	p-value
Mean±SD Range	27.75±6.78 20-40	15.90±3.54 10-23	6.929	<0.001**

4-Respiratory parameters:

When comparing peak inspiratory pressure, in group D to group S statistically increased , but minute volume there was no significant difference in both groups.

Table (3): Comparison between both groups according to intraoperative assessment respiratory parameters.

Respiratory parameters	Group D	Group S	t-test	p-value
Peak inspiratory pressure				
Mean±SD	34.20±2.69	23.90±2.53	12.476	<0.001**
Range	30-38	20-28		
Minute volume (liter)				
Mean±SD	5.34±1.42	5.67±1.50	1.259	0.130
Range	4.7-6	4.8-6.7		

5- Complication after declamping:

Between the each groups, there was no statistically difference in adverse effects following declamping.

Table (4): Comparison between both groups according to adverse effects

Adverse effects	Group D	Group S	x2	p-value
Arrhythmia	**8 (40%)**	**6 (30%)**		
Hypokalemia	**5(25%)**	**8(40%)**		
Acidosis	**7 (35%)**	**6 (30%)**	0.699	0.705

6-Duration of operation, Extubation in operating room and Surgical satisfaction.

There was statistically significant increase in group D according to time of operation and surgical satisfaction. There was no extubation in operating room as policy in Heart Academy in Ain Shams University hospital.

Table (5): Comparison between both groups according to intraoperative assessment time of operation (min), extubation in operating room and surgical satisfaction.

	Group D	Group S	Test	p-value
Time of operation (min)				
Mean±SD	287.43±13.73	276.00±15.37	t=2.48	0.018*
Range	240-330	240-340.2		
Surgical satisfaction				
Poor	2 (10.0%)	6 (30.0%)		
Moderate	5 (25.0%)	8 (40.0%)	x^2= 7.271	0.041*
Good	13 (65.0%)	6 (30.0%)		
Extubation in operating room	0 (0.0%)	0 (0.0%)	0.000	1.000

Postoperative Parameters

1-*Duration of mechanical ventilation after surgery&Length of stay in intensive care unit and hospital.*

There was no statistically significant difference between the two groups for the number of hours spent on mechanical ventilation, the number of hours spent in intensive care, or the number of days spent in the hospital.

Table (6): Comparison between both groups according to post-operative parameters .

	Group D	Group S	t-test	p-value
Duration of mechanical ventilation (hrs)				
Mean±SD	12.25±3.54	10.55±4.81	1.278	0.209
Range	10-15	8-14		
Length of intensive care (hrs)				
Mean±SD	30.10±6.94	32.70±7.80	-1.114	0.272
Range	23-48	27-55		
Hospital stay (days)				
Mean±SD	6.40±1.88	5.90±1.33	0.972	0.337
Range	4-11	4-8		

2-Postoperative complications:

in terms of complications , there is no significant difference between the each groups.

Table (7): Comparison between both groups according to complications.

Complications	Group D	Group S	x^2	p-value
lung atelectasis	**13 (65%)**	**12 (60%)**	0.699	0.705
Post-operative bleeding	**2 (10%)**	**3 (15%)**		
Anemia	**2 (10%)**	**3 (15%)**		
Hypokalemia& Acidosis	**3 (15%)**	**2 (20%)**		

DISCUSSION

In this study as regarding to difference between two groups according to intra-operative ABG parameters: (PH, PCO_2, HCO_3, O_2 Sat, PO_2 level) 15min after intubation. The parameters were higher in group S than group D as regard (PH, PO_2, O_2 Sat. level) While significant increase in group D regarding (PCO_2, HCO_3 level)

In agreement with our results, ***Ender et al., 2002***[3] who assess patients planned for elective minimally invasive direct coronary artery bypass (MIDCAB) surgery, support our findings. Patients were divided into two groups: group A received left-sided (DLT) treatment, whereas group B had bronchial blocker and SLT intubation. According to their findings, SLT decreased PaO2/FIO2 by 62 to 70% in MICS and caused statistically significant variations during OLV.

And the same authors on 2010 [4] were done another study and They discovered that at 5 and 15 minutes, the intraoperative PaO2 was considerably greater in the HFJV group compared to the DLT group. After 5 minutes, the PaCO2 was noticeably higher in the HFJV group, and this difference lasted for the full 60 minutes of ventilation.

In accordance with our results ***Zhang et al., 2019***[5] who underwent MICS was compared the use of DLT group with the use of SLT in combination with bronchial blocker in another group .After CPB, they discovered that SpO2 and PaO2 in SLT group were noticeably greater than in the DLT group.

In the present study, the peak inspiratory pressure showed a highly statistically difference between both groups, with the DLT group having a higher value and the SLT group having a normal value.

In line with our findings, ***Ender et al., 2002*** discovered that, whereas Pplat pressures during OLV did not change substantially between the DLT group and the SLT group when combined with bronchial blockers, the peak and mean inspiratory pressures during OLV were significantly greater in the DLT group.

Also, ***Ender et al., 2010*** revealed that the peak inspiratory pressure (PIP) was significantly lower during HFJV group in comparison DLT to group.

Supportive to our results, ***Zhang et al., 2019*** the mean airway pressure (P_{mean}) and (PIP) were significantly lower in subjects (use of SLT in combination with bronchial blocker) than in subjects (use of DLT) after OLV.

In the present research,we found that group D's surgical satisfaction was higher and that group D's anesthetic induction to skin incision time and surgical duration were both significantly longer than those present in the group S.

These findings are in line with ***Kim et al., 2016***[6] who conducted a retrospective evaluation of patient clinical data who underwent MICS using an SLT or DLT. The SLT group exhibited considerably less anesthetic time overall, surgical time, and anesthetic induction to skin incision time than the DLT group.

In line with our finding ***Sen et al.,2020*** [7] who evaluate patients underwent robotically-assisted atrial septal defect closure surgery with (DLT) compared with patients undergoing the same procedure with (SLT) .

They discovered that the SLT group's anesthesia time was much shorter. The patients in the SLT group had considerably greater first-pass intubation success rates.

According to ***Zhang et al., 2019*** research found , SLT with bronchial blocker required considerably longer intubation and tube localization times than DLT. Use of DLT is easier to put and is less likely to be positioned wrongly. Compared to a DLT, a single-lumen tube paired with BB needs more laryngoscopies and takes longer to replace.

Grocott et al., 2003[8] who examine patients intubation with either DLT or SLT with concurrent use of B B , in contrast to our findings. They observed that the intubation times were comparable among groups. Additionally, compared to the blocker group, the DLT required more tries during laryngoscopy.

Our finding showed no statistically difference between two groups according the postoperative complications (such as arrhythmia, hypokalemia and acidosis). We also couldn't find any significant differences regarding post-operative arterial blood gases analysis.

Also, ***Kim et al.,2016*** reported no difference in postoperative complications (such as arrhythmia, neurologic insult)and reoperation due to bleeding.

In agreement with our results, ***Zhao et al., 2017***[9] who evaluate mainstem approaches of establishing lung separation by either putting a bronchial blocker through an SLT or using a DLT and concluded that the DLT had higher complications.

In accordance with our results, ***Zhang et al., 2019*** who found that no short-term postoperative complications were observed in patients of (SLT with bronchial blocker) and patients using DLT during 3 month follow up.

In contrast to our findings, **Sen et al., 2020** noticed that no patients with SLT experienced this complication, but 21.7% of patients with DLT experienced unilateral re-expansion pulmonary edema.

In our results there was no extubation in operating room as policy in Heart Academy in Ain Shams University hospital.

In disagreement to our results ***Kim et al., 2016*** who recorded that there's incidence of extubation in operation room in both groups with no significant difference .

In current study the effect of DLT and SLT on the fast-tract successes was similar. As there was no significant difference between two groups according to duration of mechanical ventilation (hrs), Length of intensive care (hrs) and Hospital stay (days).

In similar with our results, ***Kim et al.,2016*** provided equivalent duration of ICU stay and mechanical ventilation after the MICS in both groups.

Also, ***Park et al.,2018*** [10] outcomes between the two groups with shorter mechanical ventilation times who examine patients intubation with either a left-sided DLT or SLT with concurrent use of a bronchial blocker, in contrast to our findings. They observed that the intubation times were comparable among groups. Additionally, compared to the blocker group, the DLT required more tries during laryngoscopy.

In contrast with our results, ***Sen et al.,2020*** discovered that , patients with SLT had considerably shorter mean ventilation duration ,I.C.U stay , and hospital stay were significantly decreased in patients with SLT

CONCLUSIONS:

A SLT could be used as an alternative approach to a DLT in MICS since it will help the fast track protocol's like DLT.

Conflicts of interest

No overlapping interests.

REFERENCES:

1-Ruel, M., Shariff, M. A., Lapierre, H., Goyal, N., Dennie, C., Sadel, S. M., et al., Results of the minimally invasive coronary artery bypass grafting angiographic patency study. The Journal of thoracic and cardiovascular surgery, (**2014)**147(1), 203-209.

2-Kiessling, A. H., Kisker, P., Miskovic, A., Papadopoulos, N., Zierer, A., & Moritz, A. Long-term follow-up of minimally invasive cardiac surgery using an endoaortic occlusion system. In The heart surgery forum. (2014). Vol. 17, (2), 93-7.

3-Ender, J., Bury, A. M., Raumanns, J., Schlünken, S., Kiefer, H., Bellinghausen, W., et al. The use of a bronchial blocker compared with a double-lumen tube for single-lung ventilation during minimally invasive direct coronary artery bypass surgery. Journal of cardiothoracic and vascular anesthesia, (2002). 16(4), 452-455.

4-Ender, J., Brodowsky, M., Falk, V., Baunsch, J., Koncar-Zeh, J., Kaisers, U. X., High-frequency jet ventilation as an alternative method compared to conventional one-lung ventilation using double-lumen tubes during minimally invasive coronary artery bypass graft surgery. Journal of cardiothoracic and vascular anesthesia, (2010). 24(4), 602-607.

5-Zhang, C., Yue, J., Li, M., Jiang, W., Pan, Y., Song, Z., & Pan, Z. Bronchial blocker versus double-lumen endobronchial tube in minimally invasive cardiac surgery. BMC pulmonary medicine, (2019). 19(1), 1-5.

6-Kim, H. Y., Baek, S. H., Kim, T. K., Kim, H. J., Ahn, J. H., & Park, S. J.et al Comparison of the single-lumen endotracheal tube and double-lumen endobronchial tube used in minimally invasive cardiac surgery for the fast track protocol. Journal of thoracic disease, (2016). 8(5), 778.

7- Sen, O., Onan, B., Aydin, U., Kadirogullari, E., Kahraman, Z., & Basgoze, S. Robotic-assisted cardiac surgery without lung isolation utilizing single-lumen endotracheal tube intubation. Journal of cardiac surgery, (2020). 35(6), 1267-1274.

8-Grocott, H. P., Darrow, T. R., Whiteheart, D. L., Glower, D. D., & Smith, M. S. Lung isolation during port-access cardiac surgery: double-lumen endotracheal tube versus single-lumen endotracheal tube with a bronchial blocker. Journal of cardiothoracic and vascular anesthesia, (2003). 17(6), 725-727.

9-Zhao, Z. R., Lau, R. W., & Ng, C. S. Anaesthesiology for uniportal VATS: double lumen, single lumen and tubeless. Journal of visualized surgery, (2017). 3:(3): 103

10- Park, J., Baek, S. H., & Je, H. G. Effective Use of Single-Lumen Endotracheal Tube with Intermittent Lung Deflation in Minimally Invasive Cardiac Surgery.(2018) 8(5): 778–783.