A randomized controlled trial to compare the outcome of high-flow oxygen versus conventional oxygen in extubated patients after lung resection

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Background

Pulmonary (lung) resection is used for the treatment of pulmonary malignancy, infection, and trauma. In addition, it can be used as a means to diagnose lung diseases. Lung resection procedures include wedge resection, metastasectomy, segmentectomy, lobectomy, and pneumonectomy. Lung resection can be done via either open techniques or video-assisted thoracoscopic surgery.

Objectives

To investigate whether high-flow nasal cannula oxygen therapy is superior to conventional oxygen therapy for reducing hypoxemia and postoperative pulmonary complications in extubated patients after lung resection.

Methods

This study is a randomized controlled trial comparing conventional oxygen to high-flow oxygen after lung resection at the Cardiothoracic Academy, Ain Shams University Hospitals. A total of 180 patients were extubated intraoperatively and transferred to ICU, where they received oxygen therapy to compare the outcomes between the two groups.

Results

Looking for postoperative hypoxemia and pulmonary complications after lung resection in conventional oxygen therapy group revealed the following: nine of 90 patients experienced postoperative hypoxemia, with a percentage of 10%; 13.3% of the patients after conventional oxygen therapy experienced atelectasis; four patients representing 4.4% had postoperative pneumonia; two of the 90 patients were diagnosed as having acute respiratory distress syndrome (ARDS); pulmonary edema was a complication seen in five patients in group 1; seven patients experienced prolonged air leak, representing 7.8%; two patients were in need for endotracheal reintubation in the ICU postoperative among this group of patients; three patients in the control group experienced POAF; and no postoperative mortalities were record among our control group. Regarding our study group, five of 90 patients, representing 5.6% of the patients among this group, experienced postoperative hypoxemia. Overall, 7.8% of the patients after high-flow nasal cannula oxygen experienced atelectasis. Only one patient experienced each of the following: pneumonia, ARDS, reintubation, and pulmonary edema. The patient who experienced ARDS needed to be put on extracorporeal membrane oxygenation (ECMO), where he stayed on it for 6 days till weaning, and then he was discharged safely. A total of six patients experienced prolonged air leak, representing 6.7%, and four of 90 patients in group 2 experienced postoperative atrial fibrillation (POAF). No postoperative mortalities were record among our study group.

Conclusion

When compared with conventional oxygen after lung resection, high-flow nasal oxygen did not reduce the incidence of postoperative hypoxemia nor improved other analyzed outcomes. Further adequately powered investigations in this setting are warranted to establish whether high-flow nasal oxygen may yield clinical benefit on extubated patients after lung resection.

Keywords:
conventional oxygen, high-flow oxygen, lung resection

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Introduction

Pulmonary (lung) resection is used for the treatment of pulmonary malignancy, infection, and trauma. In addition, it can be used as a means to diagnose lung diseases. Lung resection procedures include wedge resection, metastasectomy, segmentectomy, lobectomy, and pneumonectomy. Lung resection can be done either via open techniques or via video-assisted thoracoscopic surgery. In general, thoracoscopic/video-assisted and minimally invasive approaches are being considered a choice in most cases, given the advantages in terms of enhanced recovery, less complications, decreased length of stay, and particularly due to the possibility of sparing mechanical chest wall function when compared with thoracotomy procedures [1].

Regardless of the procedure, the goals for anesthetic and surgical management of patients for pulmonary resections are to achieve optimal pain control, minimal mechanical respiratory disturbance in an extubated patient, breathing spontaneously, coughing freely at the end of the procedure, and avoiding postoperative pulmonary complications [2].

After lung resection surgery, the risk of postoperative pulmonary complications remains significant, and the incidence has been reported to be as high as 50%. Clinically significant pulmonary complications include atelectasis, pneumonia, acute respiratory failure, tracheal reintubation, pulmonary edema, and prolonged air leak. As well as posing a significant morbidity and mortality risk, pulmonary complications may lead to prolonged hospital stay and increased health care costs [3].

Postoperative interventions effective in the reduction of pulmonary complications include good pain control, incentive spirometry, oxygen therapy, intermittent continuous positive airway pressure (CPAP), and early mobilization. Simple techniques such as incentive spirometry and patient positioning have proven to be ineffective in countering atelectasis, which can occur postoperatively in as many as 90% of patients. Noninvasive ventilatory support in the form of CPAP has been used as both a prophylactic and therapeutic intervention to improve ventilation in postoperative patients. Although CPAP may prevent pulmonary complications, it is uncomfortable for patients because it is applied by a tight-fitting mask, and patients may complain of difficulty with communication, eating and drinking, and mobilization, and consequently, compliance is often poor [3].

Conventional oxygen therapy via nasal prongs or a facemask can supplement oxygen administration, in some of the patients, especially those who have lobectomy; it is ineffective in compensating for loss in lung volume or in maintaining gas exchange. High-flow nasal cannula (HFNC) oxygen mainly delivers a flow-dependent positive airway pressure and improves oxygenation by increasing end-expiratory lung volume. It is considered to have a number of physiological advantages compared with other standard oxygen therapies, including the provision of positive end-expiratory pressure, constant fraction of inspired oxygen (FiO_2), and good humidification. More importantly, it can reduce the anatomical dead space [2].

HFNC can be widely employed for patients of all age groups in several types of respiratory failure from preterm infants to adults and is broadly used in ICU because of the ease of use, tolerability, and safety [2]. HFNC systems now are increasingly being used, as when compared with regular nasal cannula and facemask oxygen. HFNC appears to be linked to decreased level of respiratory complications and hypoxemia after lung resection [4].

Few studies were conducted comparing different modalities of oxygen therapy; however, the answer to this question is still controversial. Is HFNC should be used as an alternative to the conventional oxygen therapy for patients undergoing lung resection following extubation to reduce postoperative hypoxemia and pulmonary complications?

Aim of the work

The aim was to investigate whether HFNC therapy is superior to conventional oxygen therapy for reducing hypoxemia and postoperative pulmonary complications in extubated patients after lung resection.

Patients and methods

A simple multicentric randomized controlled trial was performed. The two groups were equally allocated on a 1:1 ratio into the control and treatment arms. There were two groups: those that received the conventional oxygen and those that received the high-flow oxygen therapy. Convenience sampling was used. All our participants who met all of the inclusion criteria and exclusion criteria were enrolled.

A total of 180 patients were recruited and divided evenly into two treatment groups. The study was conducted in the cardiothoracic surgery department, Ain Shams University Hospitals.

Inclusion criteria

Patients who underwent elective lung resection, including lobectomy, wedge resection, segmentectomy, metastasectomy; open thoracotomy, or video-assisted thoracoscopic surgery were included.

Exclusion criteria

The following were the exclusion criteria:

(1) Age younger than 10 years and older than 80 years.
(2) Immunocompromised patients.
(3) Pregnant females.
(4) Patients with history of obstructive sleep apnea.
(5) Tracheostomized patients.

Ethical considerations

Participants freely provided fully informed consent to participate. These informed consents in this prospective study were verbal consents. Participants' confidentiality and data security were guaranteed. Participants could withdraw their data from the research process at any time. Moreover, this study took the acceptance of the ethical committee in Faculty of Medicine, Ain Shams University.

Study procedures

This study was conducted on 180 patients who underwent lung resection (wedge resection, segmentectomy, metastasectomy, lobectomy, or pneumonectomy) surgery at the Cardiothoracic department, Ain Shams University Hospitals. Patients were extubated intraoperatively, and at the ICU, we compared HFNC with standard oxygen therapy. Postoperative pulmonary function expressed as ppoFEV1 (predicted postoperative forced expiratory volume in 1 s) was prognosticated preoperatively using spirometry. Oxygen therapy was delivered for at least 48 h, and if any patient needed more time on oxygen therapy, it was maintained, and patients were allowed to be transferred from the control group to study group if needed, but that did not happen.

HFNC oxygen therapy group (HFNCG) received a flow rate of 35–60 l/min and FiO_2 was titrated (from 45 to 100%) by the treating clinician to maintain a peripheral oxygen saturation (SpO_2) of 95% or more. The conventional oxygen therapy group (COG) received oxygen via either nasal prongs or facemask with oxygen flow titrated by the bedside clinician to maintain a SpO_2 of 92% or more. The end points of the study were to investigate whether HFNC therapy is superior to conventional oxygen therapy for reducing hypoxemia and postoperative pulmonary complications in extubated patients after lung resection.

Statistical analysis

The collected data were revised, coded, tabulated, and introduced to a PC using Statistical Package for the Social Sciences (IBM Corp., Released 2017. IBM SPSS Statistics for Windows, Version 25.0. IBM Corp., Armonk, New York, USA). Data were presented, and suitable analysis was done according to the type of data obtained for each parameter. Level of significance was set at *P* value <0.05.

Results

Analysis

This study was conducted on 180 patients who underwent lung resection (wedge resection, segmentectomy, lobectomy, or pneumonectomy) surgery between November 2019 and April 2022 at the Cardiothoracic department, Ain Shams University Hospitals. Patients were extubated intraoperatively, and in hospital, we compared HFNC with standard oxygen therapy. Patients were randomly allocated between the two groups in this study.

In this study, patients were randomized to receive high-flow oxygen therapy at 35–60 l/min (study group) or oxygen therapy through conventional facemask or nasal prongs (control group) in the first 48 h after pulmonary resection. In all patients, FiO_2 was set to maintain peripheral blood oxygen saturation at 92–98%. No patients needed to be transferred from the control group to the study group or vice versa.

Baseline New York Heart Association (NYHA) classification and baseline FEV1 were noted for all of the patients, ensuring that there is no significance in patients' allocation between the two groups. Postoperative pulmonary function expressed as ppoFEV1 (predicted postoperative forced expiratory volume in 1 s) was prognosticated preoperatively using spirometry, that is, simple calculation according to the number of the pulmonary segments to be removed. In all patients, the residual pulmonary function was predicted as follows: it is assumed that each segment of the lung, and there were 19 of them (upper right lobe – three, right middle lobe – two, right lower lobe – five; upper left lobe – three, lingula – two, and lower left lobe – four segments), in the healthy lung contributes equally to ventilation, that is, 1/19 (nineteenth part) or 5.26% of total lung ventilation (100%).

ppoFEVl in absolute values (l-L) is calculated as follows: ppoFEV1=preoperative FEVl×(19 segments–the number of segments to be removed)/19 or by the formula, ppoFEV1=preoperative FEV1×(l–(S×5.26)/100 (S=number of segments to be removed).

Looking for postoperative hypoxemia and pulmonary complications after lung resection in COG revealed the following. Nine of 90 patients experienced postoperative hypoxemia, with a percentage of 10%; 13.3% of the patients after conventional oxygen therapy experienced atelectasis; four patients representing 4.4% had postoperative pneumonia; two of the 90 patients were diagnosed as acute respiratory distress syndrome (ARDS); pulmonary edema was a complication seen in five patients in group 1; seven patients experienced prolonged air leak representing 7.8%; two patients were in need for endotracheal reintubation in the ICU postoperative among this group of patients; and three patients in the control group experienced POAF. No postoperative mortalities were record among our control group. Regarding our study group, five of 90 patients, representing 5.6% of the patients among this group, experienced postoperative hypoxemia. Overall, 7.8% of the patients after HFNC experienced atelectasis. Only one patient experienced each of the following: pneumonia, ARDS, reintubation and pulmonary edema. The patient who experienced ARDS needed to be put on ECMO, where he stayed on it for 6 days till weaning, and he was discharged safely. A total of six patients experienced prolonged air leak representing 6.7%, and four of 90 patients in group 2 experienced POAF. No postoperative mortalities were record among our study group (Tables 1–8).

The mean age of study group 1 cases was 48.03 ± 14.7 years, ranging between 10 and 69 years. More than half (68.9%) of cases were males.

The mean age of study group 2 cases was 45.4 ± 15.5 years, ranging between 10 and 75 years. More than half (61.1%) of cases were males.

There was no significant difference between group 1 and 2 cases regarding age and sex.

From these results, our study showed that there is no clinical significance between conventional oxygen therapy and high-flow oxygen therapy regarding postoperative hypoxemia and pulmonary complications, as well as POAF and mortality after lung resection in extubated patients.

Discussion

Postoperative pulmonary complications are prevalent following major thoracic surgery with a risk up to 25% following lung resection [5]. Risk factors in this patient population include severe baseline pulmonary disease, smoking, lung collapse during surgery, resection of viable lung, and poor pain control after a thoracotomy incision. Development of postoperative respiratory failure following major surgery is associated with a mortality of up to 27%, compared with 1% in patients without respiratory failure [6]. Atelectasis formation is a key factor for the development of such postoperative pulmonary complications. Unfortunately, the occurrence of atelectasis is extremely common postoperatively, with an incidence of up to 85% [7], and it significantly increases the risk for pneumonia and acute hypoxic respiratory failure [8].

High-flow oxygen therapy is an alternative to standard oxygen therapy and noninvasive ventilation (NIV). This therapy involves high flows of oxygen (up to 60+ l/min) delivered through a modified nasal cannula. This treatment may provide many of the same respiratory advantages of NIV, without the significant drawbacks including patient discomfort, cost, and medical expertise [9]. Indeed, HFNC has been used successfully to reduce rates of reintubation in a low-risk mixed medical/surgical ICU population [10]. Similarly, it has been shown that HFNC appears to be noninferior to NIV in preventing reintubation in high-risk ICU patients [10].

A few studies comparing HFNC and conventional oxygen therapy in extubated patients after lung resection have been published in the last 5 years. Here, we sought to test the hypothesis that the use of high-flow O_2 in patients admitted to the ICU after lung resection would have shown lower rate of postoperative hypoxemia and fewer postoperative pulmonary

Table 1 Surgical interventions done for 180 patients

Operation	Group 1 cases	Group 2 cases	Total	*P* value
Wedge resection	21	19	40	0.719
Open	3	4	7	0.074
VATS	18	15	33	
Open segmentectomy	1	4	5	0.174
Right lobectomy	29	27	56	0.747
Open	24	23	47	0.805
VATS	5	4	9	
Left Lobectomy	18	24	42	0.290
Open	14	19	33	0.913
VATS	4	5	9	
Open right pneumonectomy	9	9	18	1.000
Open left pneumonectomy	12	7	19	0.225
Total	90	90	180	1.000

VATS, video-assisted thoracoscopic surgery.

Table 2 Description of personal data among group 1 cases (conventional oxygen)

	Mean±SD	Minimum	Maximum
Age	48.03 ± 14.74	10.00	69.00
Sex [*n* (%)]			
Male	62 ± 68.9		
Female	28 ± 31.1		

Table 3 Description of personal data among group 2 cases (high-flow oxygen)

	Mean±SD	Minimum	Maximum
Age (years)	45.41 ± 15.51	10.00	75.00
Sex [*n* (%)]			
Male	55 ± 61.1		
Female	35 ± 38.9		

Table 4 Comparison between group 1 and 2 cases regarding personal data

	Group		*P* value
	Conventional oxygen	High-flow oxygen	
	Mean±SD	Mean±SD	
Age, years	48.03 ± 14.74	45.41 ± 15.51	0.247*
Sex [*n* (%)]			
Male	62 ± 68.9	55 ± 61.1	0.274**
Female	28 ± 31.1	35 ± 38.9	

*Student's *t* test. **χ^2 tests.

Table 5 Baseline characteristics of 180 patients randomly allocated to conventional oxygen therapy or high-flow nasal oxygen

Conventional oxygen group	Mean±SD	Minimum	Maximum
Baseline PaO_2	83.29 ± 10.73	54.00	105.00
Baseline SpO_2	96.34 ± 2.85	88.00	100.00
Preoperative NYHA classification			
NYHA I (%)	42 ± 46.7		
NYHA II (%)	34 ± 37.8		
NYHA III (%)	14 ± 15.6		
Baseline FEV1 (l/min)	3.46 ± 0.036	3.23	4.06
ppoFEV1 (l/min)	3.29 ± 0.034	3.17	3.89
High-flow oxygen group	Mean±± SD	Minimum	Maximum
Baseline PaO_2	80.83 ± 13.01	56.00	113.00
Baseline SpO_2	97.38 ± 2.42	88.00	100.00
Preoperative NYHA classification			
NYHA I (%)	40 ± 44.4		
NYHA II (%)	37 ± 41.1		
NYHA III (%)	13 ± 14.4		
Baseline FEV1 (l/min)	3.49 ± 0.029	3.20	4.1
ppoFEV1 (l/min)	3.41 ± 0.029	3.11	3.88

complications compared with patients treated with conventional O_2 therapy.

Outcomes

Primary study outcome was the occurrence of the composite hypoxemia. Secondary outcomes included ICU length of stay, hospital length of stay, and postoperative pulmonary complications. Hypoxemia and postoperative pulmonary complications rarely occurred in both the conventional and the high-flow oxygen groups included in this randomized controlled trial. There were neither statistically significant differences for the primary outcome of hypoxemia nor the secondary outcomes of postoperative pulmonary complications in patients treated with high-flow oxygen therapy versus conventional oxygen therapy.

Hypoxemia

Pulmonary resection is frequently followed by a decrease in arterial oxygen that persists for many days postoperatively. This impaired gas exchange is called postoperative hypoxemia and adversely affects perioperative outcomes [11].

Postoperative hypoxemia is often attributed to general anesthesia, which temporarily decreases functional residual volume by reducing the muscle tone of the chest wall, impairs bronchomotor and vascular tone due to reflex effects of tracheal intubation, limits immune function, and depresses secretion mobilization [12]. In patients with underlying lung diseases, these impairments result in intrapulmonary shunting or reduction of ventilation/perfusion ratio by closure of small airways. Therefore, postoperative hypoxemia can result predominantly from atelectasis in the dependent part of the lung [11].

Postoperative hypoxemia also derives from the surgical procedure [13]. Three surgical factors are known to cause postoperative hypoxemia: abnormal gas exchange induced by excessive pulmonary resection, reduced chest wall compliance induced by wide thoracotomy, and reduced diffusing capacity induced by lung edema resulting from surgical stress [11].

The study of Yu *et al.* [4] showed that the occurrence rate of hypoxemia in COG was twice more than that in HFNCG (29.62 vs. 12.51%, $P<0.05$), and PaO_2, PaO_2/FiO_2, and SaO_2/FiO_2 were significantly improved in HFNCG ($P<0.05$) in the first 72 h following extubation.

Our study results showed no significant difference between control group and study group in terms of post lung resection hypoxemia. In group 1, nine of 90 patients experienced postoperative hypoxemia, with a percentage of 10%, compared with 5.6% of the patients in group 2, with *P* value equal to 0.266.

Alongside our study, the study by Nachira *et al.* [14] showed that HFNC does not seem to reduce postoperative hypoxemia after pulmonary lobectomy compared with conventional oxygen therapy. However, we observed that HFNC is an easy to use and well-tolerated device, even in the surgical ward.

Table 6 Outcomes in patients randomly assigned to conventional oxygen group

	Mean±SD	Minimum	Maximum
ICU stay (days)	1.20 ± 0.90	1.00	8.00
Hospital stay (days)	6.38 ± 1.79	2.00	17.00
Patients required oxygen therapy after discontinuation (%)	6 ± 6.7		
Hypoxemia (%)	9 ± 10.0		
Atelectasis (%)	12 ± 13.3		
Pneumonia (%)	4 ± 4.4		
ARDS (%)	2 ± 2.2		
Pulmonary edema (%)	5 ± 5.6		
Pulmonary embolism (%)	0		
Prolonged air leak (%)	7 ± 7.8		
Reintubation (%)	2 ± 2.2		
POAF (%)	3 ± 3.33		
Death (%)	0		

ARDS, acute respiratory distress syndrome

Table 7 Outcomes in patients randomly assigned to high-flow oxygen therapy

	Mean±SD	Minimum	Maximum
ICU stay (days)	1.17 ± 0.69	1.00	6.00
Hospital stay (days)	6.01 ± 1.89	3.00	14.00
Patients required oxygen therapy after discontinuation (%)	5 ± 5.6		
Hypoxemia (%)	5 ± 5.6		
Atelectasis (%)	7 ± 7.8		
Pneumonia (%)	1 ± 1.1		
ARDS (%)	1 ± 1.1		
Pulmonary edema (%)	1 ± 1.1		
Pulmonary embolism (%)	0		
Prolonged air leak (%)	6 ± 6.7		
Reintubation (%)	1 ± 1.1		
POAF (%)	4 ± 4.44		
Death (%)	0		

Postoperative pulmonary complications

After lung resection surgery, the risk of postoperative pulmonary complications remains significant, and the incidence has been reported to be as high as 50% [15]. Clinically significant pulmonary complications include atelectasis, pneumonia, acute respiratory failure, tracheal reintubation, pulmonary edema, and prolonged air leak [16].

Postoperative pulmonary complications have a significant clinical and economic effect associated with increased observed number of deaths, morbidity, length of stay, and associated cost [17].

Patients undergoing lung resection are jeopardized by relevant postoperative morbidity and mortality [18]. Acute respiratory failure is the most common life-threatening complication after thoracic surgery. Supplemental oxygen is often needed to improve arterial oxygenation in the postoperative period: despite it is effective in treating most cases of hypoxemia, patients with low ventilation-perfusion ratio may be only partially responsive to an increase in oxygen concentration.

The use of nasal cannula to deliver high-flow rates of heated and humidified gas at a predetermined FiO_2 is an attractive alternative to conventional oxygen therapy and, possibly, to NIV [10]. The beneficial effects of HFNC include (a) delivery of high flows, that better match patients' peak inspiratory flow, finally enabling administration of set FiO_2; (b) provision of a small degree of positive pressure in the airways, that increases end-expiratory lung volume; (c) washout of nasopharyngeal dead space, which enhances carbon dioxide removal; and (e) good tolerance and comfort [19]. HFNC, as compared with low-flow oxygen, prevents respiratory failure after extubation in the ICU and is as effective as NIV after cardiothoracic surgery and in patients with difficult separation from mechanical ventilation [5].

Little clinical experience has been reported to date in the use of high-flow nasal oxygen (HFNO) in the cardiothoracic surgical patient population. Patients undergoing cardiothoracic surgery are at significant risk of postoperative pulmonary complications, and these complications may increase morbidity and mortality and lead to prolonged ICU and hospital length of stay. The

Table 8 Comparison between group 1 and 2 cases regarding baseline clinical characteristics as well as postoperative outcomes

	Group				Odds ratio (CI)‡‡	*P*
	Conventional oxygen		High-flow oxygen			
	Mean±SD	Odds ratio	Mean±SD	Odds ratio		
Baseline PaO_2	83.29±10.73		80.83±13.01		3.388 (1.353–8.481)	0.169‡
Baseline SpO_2	96.34±2.85		97.38±2.42		2.558 (1.336–4.897)	0.01‡
	Baseline NYHA classification					
NYHA I (%)	42±46.7		40±44.4		Reference	0.899
NYHA II (%)	34±37.8		37±41.1		1.143 (0.605–2.158)	
NYHA III (%)	14±15.6		13±14.4		0.975 (0.408–2.328)	
Baseline FEV1	3.46±0.036		3.49±0.029		1.014 (0.865–1.321)	0.192‡
ppoFEV1	3.29±0.034		3.41±0.029		1.125 (0.902–2.324)	0.186‡
ICU stay≤4	1.20±.90		1.17±0.69		2.023 (0.180–22.713)	0.781‡
Hospital stay≤5	6.38±1.79		6.01±1.89		2.269 (1.171–4.397)	0.184‡
Required oxygen therapy after discontinuation (%)	6±6.7	0.071	5±5.6	0.058	0.823 (0.2420 to 2.802)	0.755**
Hypoxemia (%)	9±10.0	0.111	5±5.6	0.058	1.4 (0.6–2.9)	0.266*
Atelectasis (%)	12±13.3	0.153	7±7.8	0.084	1.39 (0.76–2.5)	0.225*
Pneumonia (%)	4±4.4	0.046	1±1.1	0.011	2.54 (0.43–14.7)	0.368**
ARDS (%)	2±2.2	0.022	1±1.1	0.011	1.50 (0.3–7.5)	1.0**
Pulmonary edema (%)	5±5.6	0.058	1±1.1	0.011	3.06 (0.5–8.4)	0.211**
Pulmonary embolism (%)	0	NA	0	NA	NA	NA
Prolonged air leak (%)	7±7.8	0.084	6±6.7	0.071	1.09 (0.5–1.9)	0.773*
Reintubation (%)	2±2.2	0.022	1±1.1	0.011	1.5 (0.3–7.5)	1.0**
POAF (%)	3±3.33	0.034	4±4.45	0.046	1.42 (0.3–6.8)	0.232*
Death	0	NA	0	NA	NA	NA

Student's *t* test. ARDS, acute respiratory distress syndrome; CI confidence interval.
*χ^2 tests.
**Fisher exact test.
‡‡Confidence interval.

incidence of pulmonary complications ranges from 8 to 79% following cardiac surgery and has been reported to be as high as 50% after lung resection surgery. Postoperative pulmonary complications manifest early as arterial hypoxemia, during the later course as pneumonia, and in rare cases also as ARDS. The pathogenesis of postoperative pulmonary dysfunction is complex and seems to be mainly related to injurious invasive mechanical ventilation and stress of surgery and its associated factors that cause significant systemic inflammatory response leading to lung injury [20].

A few studies compared conventional oxygen therapy to high-flow oxygen after lung resection particularly, and no study ever compared HFNC and conventional oxygen after lung resection regarding postoperative pulmonary complications. We hereby reported the results of a randomized trial conducted to determine whether treatment with HFNC, as compared with conventional oxygen, is superior to reduce postoperative pulmonary complications.Our study results go beyond previous reports, showing that there was no significant difference between study group and control groups regarding all our secondary outcomes: postoperative pulmonary complications in the terms of atelectasis, pneumonia, pulmonary edema, pulmonary embolism, prolonged air leak, the need for tracheal reintubation, ARDS, POAF, and mortality.

The study by Yu *et al*. [4] stated that the incidence of reintubation and the need for noninvasive ventilation were decreased in HFNCG ($P<0.05$, compared with a P value of 1.000 in our study), whereas the incidence of pneumonia and atelectasis were similar ($P>0.05$ after thoracoscopic lobectomy, compared with $P=0.368$ and 0.225, respectively, in our results).

These results may reflect on the length of ICU stay and hospital stay, as experiencing any of these pulmonary complications postoperatively would have increased hospital stay.

Contrary to the findings of Villeneuve [21] whose study resulted in significantly reduced length of hospital stay from a mean of 4 days to 2.5 in the HFNO group, we did not find any significance between our two groups in terms of length of hospital stay.

One observational trial by Sztrymf *et al.* [22] demonstrated that HFNC was not associated with significant reductions in length of hospital stay. Our findings are consistent with this study.

Conclusion

When compared with conventional oxygen after lung resection, HFNO did not reduce the incidence of postoperative hypoxemia nor improved other analyzed outcomes. Further adequately powered investigations in this setting are warranted to establish whether HFNO may yield clinical benefit on extubated patients after lung resection.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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