Conventional versus protective lung ventilation strategy in laparscopic cholecystectomy surgery

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Abstract:

Background: Laparoscopic cholecystectomy is a commonly performed surgery that is associated with pneumoperitoneum‑induced respiratory compromise and altered pulmonary mechanics strategies have been investigated for use during laparoscopic cholecystectomy. The **Objectives:** to study the effects of low tidal volume with positive end-expiratory pressure (PEEP) on arterialblood gases of patients undergoing laparoscopic cholecystectomy.

Patients and Methods: This is a prospective study that included 60 adult patients undergoing elective laparoscopic cholecystectomywith BMI< 30at general surgery department in Qena university hospital "between October 2016to April 2018", the Sixty patients were assigned to two groups:group Athe tidal volume was 6 mL/kg, with PEEP of 5 cm of H2O(n = 30), group B received the tidal volume was 10 mL/kg, and the PEEP was set at 0 cm of H2O (n = 30). Patient hemodynamics, pulmonarymechanics, and arterial blood gases were measuredpre-operative,intraoperative and post-operative.

Results: All cases were completed successfully.Study showed significance between oxygenation in both groups. Post-operative oxygenation in protective ventilation (group A)Mean Post P aO_2 in group A was 91.1(± 5.1)mmHg, while in group B was 80.2(±4.2) mmHg, p value (0.001).

Conclusion: Study found that protective ventilation was superior to conventional ventilation as it was associated with better oxygenation in the post-operative in laparoscopic cholecystectomy

Keywords: Hypoxemia,Laparoscopy,Conventional, PEEP.

Introduction

A strategy of protective ventilation, consisting of low tidal volumes and plateau pressures and application of positive end expiratory pressure (PEEP) has gained widespread acceptance in intensive care units(**Ramachandranet al . , 2011).**It is associated with improved organ function, decreased level of inflammatory mediators, and a reduction in mortality. Consequent to the dramatic improvement in morbidity and mortality, use of low tidal volume ventilation strategy for shorter duration during intraoperative period in patients without ARDS has also been investigated(**Wolthuis et al.,2008**). In certain trials, it was associated with decreased inflammatory markers and improved lung functions(**Choi et al.,2006**).

Laparoscopic cholecystectomy is a commonly performed surgery that is associated with pneumoperitoneum‑induced respiratory compromise and altered pulmonary mechanics strategies have been investigated for use during laparoscopic cholecystectomy(**Valzena et al.,2010**).

Recently, the role of lung protective ventilatory strategy using low tidal volumes was evaluated in laparoscopic gynecologic as well as urologic surgeriesand showed improved gas exchange but no decrease in inflammatory markers(**Kokulu et al.,2015**). However, its use has not beenevaluated during laparoscopic cholecystectomy, where the patient positioning varies as compared to other investigated laparoscopic surgeries Against this background, we aimed to evaluate and compare the efficacy of intraoperative ventilatory strategy employing low tidal volume with one using higher tidal volume in patients scheduled for elective laparoscopic cholecystectomy.

Patients and methods:

This is a prospective study at general surgery department in Qena university hospital "between October 2016 to April 2018".

After approval of the local Ethics Committee and obtaining written informed consents, 60 adult patients undergoing elective laparscopic cholecystectomy surgerywith BMI<30 have been included..

All patients subjected to:

1.Complete clinical assessment including:Full history taking, Complete clinical examination.

2.Full investigations including: Complete blood count, Blood Sugar, Serum creatinine, Prothrombin time and concentration, Serum electrolytes level, Screening for HIV, HCV, and HBsAg, ECG.

Randomization:

Patients randomly classified into two groups by using a computer‑generated random number table each one included thirty patients, Patients were randomly allocated to receive ventilation :group Athe tidal volume was 6 mL/kg, with PEEP of 5 cm of H2O(n = 30), group B received the tidal volume was 10 mL/kg, and the PEEP was set at 0 cm of H2O (n = 30).

The inclusion criteria::ASA class I & II, Age between 18 and 65 year, BMI <30 kg/m2.

The exclusion criteria are:

- Patients with American Society of Anesthesia classification ASA III ASA IV .
- Uncompensated cardiac condition (New York Heart Association Class greater than II).
- Renal disease (preoperative serum creatinine level more than 1.4 mg/dl).
- BMI > 30kg/m2
- Evidence of preoperative pulmonary or systemic infection as evidenced byclinical examination, leukocytosis, or fever.
- Patient refusal

Comparison was done between the 2 groups intra operative for:

a. Primary (main):

Respiratory parameters:

PaO2.

PCO2.

Peak inspiratory pressure (Ppeak).

b. Secondary (subsidiary):

Hemodynamic parameters:

a.Mean arterial blood pressure.

b.Heart rate.

Preparation of patients:

Upon arrival to the operation theater patient identity was confirmed and all investigations reviewed.

On their arrival to the operating theatre, patients were premeditated with IV metoclopramide 10 mg, ranitidine 50mg and midazolam 0.1 mg/kg in the pre-anesthesia room.

Anesthesia:

After applying intraoperative monitors using 5 leads ECG, pulse oxymetry, capnography and non-invasive blood pressure, patients were pre-oxygenated with 100% O2 for 5 minutes and general anesthesia was induced with propofol 2 mg/kg, fentanyl 2µg/kg and succinylcholine 1.5 mg/kg. After oral endotracheal intubation with appropriate size cuffed endotracheal tube, anesthesia was maintained using 1-2 MAC Isoflurane over the period of the operation with fentanyl shots when needed. Neuromuscular blockade obtained by using Atracuriumbesaylate0.25 µg/kg as a bolus dose and 5 µg/kg/min as a maintenance dose.

All patients were mechanically ventilated with volume control mode (VCV) (Datex-Omeda Ventilator (S/5 Avance-Aisys)).

We divided the patients into two groups according to the ventilator settings In two groups(conventional and low tidal groups), inspiratory to expiratory time ratio was 1:2 and inspired oxygen fraction (FIO2) was 0.5 (balanced with air). In the conventional group, ventilatory settings included a rate of 12/minute, tidal volume; 10 mL/kg and a PEEP set at 0 cm H2O. In the low tidal group the ventilator settings were adjusted to a rate of 18/minute, tidal volume; 6 mL/kg and a PEEP of 5 cm H2O.

After induction of anesthesia and positioning of the patient, carbon dioxide was insufflated into the peritoneal cavity until the intra-abdominal pressure reached 10–15 mmHg, which was maintained throughout the procedure.

Patients were given 12-15 ml/kg of normal saline intravenously before the induction of anesthesia and were then maintained with 5 ml/kg/h of normal saline solution until the end of the surgery.

Intraoperative analgesia was achieved by perfalgan 15 mg/kg and nalbuphine 0.25 mg/kg once.

At the end of the surgery, Isoflurane was discontinued. The muscle relaxant was reversed by neostigmine 50 µg/kg and 0.015 mg/kg atropine sulfate. Tracheal extubation was performed after reaching satisfactory criteria for extubation. Patients were transferred to the recovery room (PACU) and duration of operation was recorded.

In the recovery room: Patients were put in semi-sitting position under basic monitoring and observed for 30 minutes for occurrence of any postoperative complications.

Participants in the study were allocated into two equal groups:

(1) Protective lung ventilation group (group A): Ventilation strategy consists of: Tidal volume (VT) 6 ml/kg, PEEP 5 cmH2O & recruitment maneuvers performed after induction of anesthesia, after pneumoperitoneum induction and before extubation. To conduct the alveolar recruitment maneuver we changed the ventilation settings from VCV into pressure control mode with driving pressure 15 cmH2O with PEEP 20 cmH2O, RR 10/min, I:E 1:1, FiO2 1.0 for 2 minutes then return to the previous parameters with close monitoring for the hemodynamics of the patient.

(2) Conventional ventilation group (group B): Ventilation strategy consists of: Tidal volume (VT) 10 ml/kg, PEEP 0 cmH2O (ZEEP) & No recruitment maneuvers.

Measurements

1. After anesthesia induction in supine position (T1).
2. After CO2 pneumoperitoneum (T1).
3. After positioning of patient by 30 min (T3).
4. At the end of surgery, after abdominal deflation in supine position (T4).

-Arterial blood gas sample preoperative on room air.

Arterial blood gas sample postoperative on room air.

Statistical Analysis

All patients had been analyzed using Statistical package for Social Sciences (SPSS).

Results:

This is a prospective study that included 60 adult patients undergoing elective laparoscopic cholecystectomywith BMI< 30at general surgery department in Qena university hospital “between October 2016to April 2018”, the Sixty patients were assigned to twogroups:groupAthe tidal volume was 6 mL/kg, with PEEP of 5 cm of H2O(n = 30), group B received the tidal volume was 10 mL/kg, and the PEEP was set at 0 cm of H2O (n = 30).

Patient hemodynamics, pulmonarymechanics, and arterial blood gases were measured pre-operative, intraoperative and post-operative.

Table (1): Patient characteristics of the two groups and time of operation.

		A	B	P. Value
		Mean ± SD	Mean ± SD	
Sex	Male	17(56.7%)	13(43.3)	.302
	Female	13(43.3)	17(56.7%)	
Age		39.7±9.7	39.9±8.7	.911
BMI		25.1±2.2	25.1±2.3	.829
Smoker	Yes	2(6.7%)	4(13.3%)	.389
	No	28(93.3%)	26(86.7%)	
Time of operation (min)		54.9±11.2	53.1±10.2	.527
Postoperative hospital stay		1.32± .5	1.20± .4	.759

Data presented in (mean± SD) using ANOVA test for comparison.There was no significant difference inpatient characteristics and time of operationof the two groups .

Table (2):Intraoperative MAP during the surgery time.

	A	B	P.value
	Mean ± SD	Mean ± SD	
T1	93.1±10.6	93.6±11.2	0.56
T2	80.3± 9.3	88.2± 7.8	0.03*
T3	79.9± 9.1	89.1± 7.9	0.00*
T4	86.7± 4.9	87.6± 5.5	0.51

Data presented in (mean± SD) using ANOVA test for comparison.

There was significant difference in the mean arterial blood pressure between two groups in T2 and T3.

Table (3): Preoperative and postoperative partial pressure of arterial oxygen PaO_2 on room air:-

	A	B	P.value
	Mean ± SD	Mean ± SD	
Preoperative pao2	93.5± 5.5	94.6± 4.2	.393
Postoperative pao2	91.1± 5.1	80.2±4.2	.000*

Data presented in (mean± SD) using t- test for comparison.

*statistically significant difference (p<.05)

There was significant difference inpostoperativepartial pressure of arterial oxygen PaO2 on room air .

Table (4):Intraoperative PaO_2 during the surgery time

	A	B	P.value
	Mean ± SD	Mean ± SD	
T1	225.4± 27.3	224.9± 24.6	.941
T2	205.8± 20.3	195.6± 17.6	.042*
T3	203.3± 17.7	186.3±21.7	.001*
T4	214.5± 22.1	197.7± 12.2	.001*

Data presented in (mean± SD) using t- test for comparison ,*statistically significant difference ($p<.05$).

There was significant difference in intraoperative partial pressure of arterial oxygen PaO_2 in T2, T3 and T4.

Discussion:

This study compared a lung-protective mechanical ventilation strategy combining the use of lower tidal volume (TV), PEEP of 5 cm of H_2O, and intraoperative RMs, with a conventional standard mechanical ventilation (10 mL/kg tidal volume, ZEEP without intraoperative RMs) during abdominal laparoscopic cholecystectomy surgery.

Because of the significant increases in intra-abdominal pressure and intra- thoracic pressure as a result of insufflated CO_2, a steep Trendelenburg position, and lengthy procedures, general anesthesia is the method of the choice **(Malhotra et al.,2010).**

The main findings of this study were PaO_2 values measured postoperatively were significantly higher in Group A ($P = .001$). in patients in whom low tidal with PEEP ventilation was performed.

Laparoscopy procedures require pneumopretonium (PNP), and prolonged PNP in patients undergoing general anesthesia may cause a continuous decrease in arterial oxygenation due to compressive atelectasis, particularly in gravity-dependent regions of the lungs **(Duggan et al.,2005).** Also, there was clear evidence from animal and human data that mechanical ventilation can induce and exacerbate lung injury, and thus the current standard of care was the use of a lung-protective ventilation strategy in patients suffering from acute lung injury or adult respiratory distress syndrome **(Slutsky et al.,2001)**.Protective ventilation refers to the use of low tidal volume, often in the range of 4–8mL/kg of predicted bodyweight. Many investigators have conducted several large randomized trials that have shown the use of lower tidal volume is associated with improved outcomes and a reduction in the incidence of ventilatory-induced lung injury **(Eichacker et al., 2002)**. However, evidence also exists that mechanical ventilation can be injurious to the lung and organ systems in patients without acute lung injury or adult respiratory distress syndrome. Determann recently performed a randomized trial comparing the conventional rate of 10mL/kg with a rate of 6 mL/kg in 152 critically ill patients; they measured cytokine levels in broncho-alveolar lavage fluid and plasma and observed the development of acute lung injury/adult respiratory distress syndrome, duration of ventilation, and overall mortality. In their study more patients developed lung injury in the conventional group (13.5% versus 2.6%), and plasma interleukin-6 levels were more pronounced in the low tidal volume group(**Determann et al.,2010**).

A trial by Lee et al. in a surgical ICU randomized 103 patients to 12mL/ kg versus 6mL/kg; they documented a reduction in pulmonary infections, a trend toward a reduced ICU length of stay, and reduced duration of intubation in the group with lower tidal volume **(Lee et al.,2013).**

YukselEla, et al compared the conventional rate of 10 mL/kg with 6mL/kg in laparoscopic urologic patients and documented better oxygenation postoperatively. In addition to the reduction of tidal volume, increasing the level of PEEP was considered an integral part of protective ventilation **(Ela et al., 2014)**

Lower tidal volume might lead to atelectasis, especially if PEEP not used at all. Sufficient PEEP must be used to minimize atelectasis and to maintain oxygenation.

The use of high PEEP levels is potentially associated with an increase in mean airway pressure within the respiratory system, likely promoting higher incidence of hemodynamic complications and higher fluids' requirement. The current study tried to overcome the deleterious effects of PEEP, recruitment maneuvers and large tidal volumes in both groups by giving sufficient preoperative preload with crystalloid solution (12-15) ml/kg of normal saline intravenously before the induction of anesthesia and were then maintained with 5 ml/kg/h of normal saline solution until the end of the surgery). However, there was an affection of the hemodynamics in patients received protective ventilation and RMs.

This agreed with **(Grasso et al. ,2002)**who reported reduction in cardiac output and MAP after application of the RM in ARDS patients and **(Nielsen et al. ,2005)** who reported that RM lead to a significant reduction in cardiac output in critical care patients

This disagreed with **(Talab et al.,2009)** who stated that application of PEEP and VCM was not accompanied by a significant reduction in MAP, even after pneumoperitoneum and positioning, perhaps because they administrated more fluids to the patients before positioning (20 ml/kg/h) and also the vital capacity maneuver (VCM) was applied only once immediately after intubation and maintained for 7–8 s.

Conclusion:

In conclusion, the results of this study demonstrated that protective ventilation was superior to conventional ventilation as it was associated with better oxygenation in the post-operative in laparoscopic cholecystectomy.

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