Effect of Positive end expiratory pressure during one-lung ventilation on hemodynamics in thoracic surgeries in adult patients

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Abstract:
Background: One-lung ventilation (OLV) is a common practice during thoracic surgery involving pulmonary resection to facilitate surgical exposure. For long time, arterial hypoxemia during OLV was is the most important problem for the anesthesiologist. At present, there is increasing concern about the effects of ventilator settings on acute lung injury.
Objectives: The aim of this study is to compare the effect of different levels of Positive end expiratory pressure (PEEP) on hemodynamics in thoracic surgeries in adult patients.
Patients and Methods: This is a prospective study that included 60 adult patients undergoing elective thoracic procedures requiring one-lung ventilation through a posterio-lateral thoracotomy at cardio-thoracic surgery department in Qena university hospital "between October 2017 to April 2019", the Sixty patients were assigned to three groups: group I received no PEEP (n = 20),group II received a PEEP (5 cmH2O) (n = 20),and group III received a PEEP (10 cmH2O) (n = 20). Patient hemodynamics, pulmonary mechanics, and arterial blood gases were measured just after OLV(T1) and 20 (T2), 40 (T3), and 60 min(T4) after OLV.
Results: All cases were completed successfully. The heart rate and mean arterial blood pressure showed no significant changes between all groups.
Conclusion: During OLV, mechanical ventilation with PEEP 0, 5 or 10 cmH2O has no effect on hemodynamics in thoracic surgeries in adult patients.
Key words: Hypoxemia, One-lung ventilation, PEEP.

Introduction

One-lung ventilation (OLV), which is essential in thoracic surgery, induces ventilation/perfusion ratio (V/Q) mismatch by increasing intra-pulmonary shunts and dead space **(Karzai et al, 2009).**

Historically, large tidal volumes were appliedto prevent unfavorable intraoperative atelectasis and improve gas exchange during OLV(**Katz et al, 1982)**..

However, several studies have shown that lung injury after thoracic surgery is associated with OLV **(Ishikawa et al, 2011).**

Therefore, an optimal strategy for OLV is needed not only for maintaining adequate gas exchange, but also for protecting the lung.

Application of positive-end expiratory pressure (PEEP) is an important factor in optimal OLV strategy, and several studies have investigated the amounts of PEEP that are beneficial during OLV.

A recent study showed that an "individualized" PEEP level measuring around 10 cmH2O improved pulmonary oxygenation during OLV **(Ferrando et al, 2014).**

However, in two-lung ventilation (TLV), aggressive mechanical ventilation using high levels of PEEP exceeding 10 cmH2O can restrict venous return and elevate right ventricular (RV) afterload, leading to limited left ventricular (LV) diastolic filling and decreased cardiac output **(Huemer et al, 1994).**

A recent study demonstrated that applying 5 cmH2O of PEEP augmented oxygenation during OLV without altering biventricular function. However, increasing PEEP to 10 cmH2O decreased cardiac function, especially on RV function, without further enhancing pulmonary oxygenation**(Namo Kim et al, 2019).**

The primary purpose of this study was to compare the effect of different levels of PEEP on hemodynamics in patients undergoing thoracic surgery under OLV.

Patients and methods

The study was performed in Qenaunivesity Hospital – Cardiothoracic Unit between october 2017 and april 2019.

After approval of the local Ethics Committee and obtaining written informed consents, 60 adult patients undergoing elective thoracic procedures requiring one-lung ventilation through a posterolateral thoracotomy 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, Prothrombintime and concentration, Serum electrolytes level, Screening for HIV, HCV, and HBsAg, ECG.

3.pulmonary function tests.

Randomization:

Patients randomly classified into three groups by using a computer‑generated random number table each one included twenty patients, Patients were randomly allocated to receive ventilation during one-lung ventilation (OLV) either PEEP0,PEEP5 or PEEP10 cmH2O.

The inclusion criteria:adult patients undergoing elective thoracic procedures requiring one-lung ventilation through a posterolateral thoracotomy have been included between 18-60 years old.

The exclusion criteria are:

- Patients with American Society of Anathesia 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).
- Clinically relevant obstructive or restrictive lung diseases [vital capacity (VC) or forced expiratory volume in 1 s (FEV1) <50% of the predicted values].
- Evidence of preoperative pulmonary or systemic infection as evidenced byclinical examination, leukocytosis, or fever.
- Patient refusal

Comparison was done between the 3 groups intra operative for:

a. **Primary (main):**

Hemodynamic parameters:

a.Mean arterial blood pressure.

b.Heart rate

b. Secondary (subsidiary):

Respiratory parameters:

a-Peak inspiratory pressure (Ppeak)..

Preparation of patients:

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

Prior to the induction of anesthesia or preoperative sedation, all patients had a central venous and arterial lines inserted with local anesthetic and an arterial blood gas analysis was performed for baseline values.

Monitors included 5-lead electrocardiogram,non- invasive blood pressure, central venous pressure, and pulse oximetry.

Anesthesia:

Patients were pre-medicated with intravenous midazolam 1- 2 mg, and monitors were applied.

Patients were medicated by analgesia either with intravenous analgesics like morphine with combination of nonsteroids anti inflammatory drugs,or A thoracic epidural catheter was inserted at T4-5 to T7-8 interspace for intra- and post-operative analgesia management

After pre-oxygenation, anesthesia was induced with propofol 1-2 mg/kg, fentanyl 2 μg/kg, and atracurium 0.5mg/kg. Anesthesia was maintained with isoflurane, adjusted to an expired concentration of 1-1.5%.

Supplemental atracurium and fentanyl was administered as needed.

The trachea was intubated with a double lumen tube (Mallinckrodt-BroncoCath, Tyco Healthcare, Pleasanton, CA) size 39 for male and 37 for female patients. A left double-lumen tubes was chosen unless otherwise indicated.

The position of the tube was confirmed by auscultation and fiberoptic bronchoscopy in the supine position and after turning the patient to the lateral decubitus position.

All patients were ventilated with a Datex-Omeda Ventilator (S/5 Avance-Aisys). Initially, two lung ventillation (TLV) with VCV was performed in all patients using an FiO_2 of 0.5, a VT of 7-9 mL/kg, I:E ratio of 1:2, and a ventilator rate of 16/min, which was readjusted to maintain an end-tidal carbon dioxide tension ($ETCO_2$) of 30 to 35 mmHg.

During OLV patients received either PEEP0 ,PEEP5 or PEEP10 cm H_2O according to the study group:

Group A: PEEP of 0 cm H_2O

Group B: PEEP of 5 cm H_2O

Group C: PEEP of 10 cm H_2O

In all groups, the ventilator rate was adjusted to maintain $ETCO_2$ of 30 - 35 mmHg, and FiO_2 was increased up to 1.0 to maintain SpO_2 at or above 92%. I:E ratio remained at 1:2.

Fluids and blood transfusions were given as required to maintain central venous pressure (CVP) between 3 - 7 mmHg, urine output ≥ 1 ml /kg/hr, and hemaotocrite of ≥ 24% .

After completion of surgical resection, both lungs were suctioned and re-inflated.

A recruitment maneuver using an airway pressure of 30 cmH_2O for 30 seconds was performed, and ventilation was resumed using pre OLV values. At the end of the procedure patients were carefully suctioned, and reversal of muscle paralysis was achieved using neostigmine 0.08 mg/kg and atropine 0.02 mg/kg. Several manual inflations were performed before extubation. All patients were transferred to the postoperative ICU.

Hemodynamic parameters, blood gases, and respiratory measurements were performed after OLV and every 20 minutes for 4 times.

Statistical Analysis

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

Results

sixty adult patients undergoing elective thoracic procedures requiring one-lung ventilation through a posterior-lateral thoracotomy at cardio-thoracic surgery department in Qena university hospital “between October 2017 to April 2019”were included in our study.

Table 1. Comparison between groups as regard HR

	HR			P-value
Variable	group 1 (N =20)	group 2 (N =20)	group 3 (N =20)	
T1	79.3 ±5.904	76.45±5.735	77.25±5.63	.279
T2	78.2±5.278	76.65±5.95	77±5.439	.654
T3	78.45±5.549	76.3±5.75	77.15±5.537	.48
T4	78.15±5.412	76.4±5.61	76.9±5.49	.587

Data presented in (mean± SD) using ANOVA test for comparison.There was no significant difference in the heart ratebetween all groups

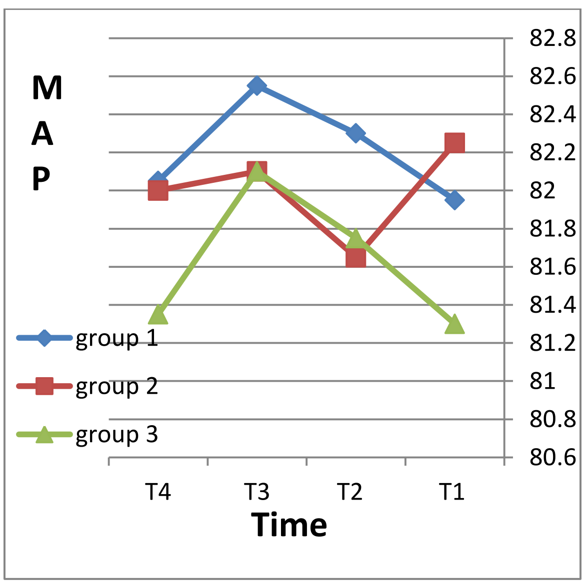

Figure1:Comparison between groups as regard MAP

There was no significant difference in the mean arterial blood pressure between all groups.

Discussion

The study evaluated the effects of different PEEP levels on hemodynamics.

General anesthesia with positive pressure ventilation impairs pulmonary gas exchange and respiratory mechanics, even in patients with healthy lungs **(Hedenstiernaet al, 2005**). Such effects result primarily from the development of atelectasis with subsequent shunting of pulmonary blood flow and impaired oxygenation **(Tokics et al, 1987**). During OLV, V/Q mismatch can be aggravated, due to the increase of intrapulmonary shunt. Application of positive-end expiratory pressure (PEEP) is an essential part of OLV strategy, since it can overcome V/Q ratio mismatch **(Valenza et al, 2004)** and increase pulmonary compliance **(Hoftman et al, 2011)**Injury to a patient's lungs can occur during OLV, and the risk for such complication can be reduced by applying low tidal volume with PEEP **(Yang et al, 2011**).

In the present study, **(Table 1)** hemodynamics presented by heart rate and mean arterial blood pressure showed no significant variation in application of different levels of peep in the all groups in agreement to**(Rauseo et al, 2018)** that confirm that a correct hemodynamic management during the OLA strategy, does allow a safe maneuver indeed, once the volumic status was optimized through the Stroke volume variation, the open lung approach did not affect hemodynamic.

in the other side positive-pressure ventilation increases lung volume only by increasing Paw, the degree to which both ITP (being esophageal, pleural or pericardial) and lung volume increase will be a function of airway resistance as well as lung and chest wall compliance. As proposed by **(Pinsky,1997**), all hemodynamic effects of positive-pressure ventilation and PEEP can simply be grouped into processes that, by changing lung volume and ITP, affect left ventricular preload, afterload and contractility.

Conclusion

In conclusion, the results of this study demonstrated that applying 0,5 or10 cmH2O of PEEP did not affect hemodynamics ,according to these findings, physicians can elevate till peep 10cmH2O during OLV for improving oxygenation purpose.

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