POSITIVE END EXPIRATORY PRESSURE (PEEP);

COMPARISON DIFFERENT VALUES DURING ONE LUNG VENTILATION, FOR ITS EFFECTS ON BLOOD ARTERIAL OXYGENATION AND CARBON DIOXIDE LEVELS

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ABSTRACT... Introduction: Thoracic surgeries and aesthesia for lung resection has presented anaesthesiologists with certain unique physiological problems. These include placing (lateral decubitus position) in order to obtain optimal access for most operations on lungs, pleura, esophagus, and great vessels, opening the chest wall (open pneumothorax) and one lung ventilation anaesthesia. One lung ventilation anaesthesia and lateral decubitus position produces decrease in functional residual capacity and an obligatory right to left shunt that ranges from 15% to 40% leading to increase in ventilation perfusion (V/Q) mismatch thus causing hypoxia and or hypoxemia. An optimal level of positive end expiratory pressure of 5cmH_2O when added to dependent lung is known to improve arterial oxygenation and improve ventilator efficiency. **Objectives**: To compare different values of positive end expiratory pressure (PEEP) during one lung ventilation, for its effects on blood arterial oxygenation and carbon dioxide levels. **Study Design**: Randomized controlled trial (RCT). **Setting**: Conducted in surgical Unit-III and Department of anaesthesia and Intensive Care, Combined Military Hospital, Rawalpindi. **Duration of study with dates:** Ten months from 25-12-2008 to 01-10-2009, Additional quantum of Data was collected from 01-01-2011 to 25-01-2011. **Subjects and methods:** The patients were divided into two equal groups of 100 patients each, by random allocation of patients to either in-group A (subjected to zero PEEP) or group-B (subjected to PEEP 5cm of water). **Results:** At induction and start of two lung ventilation 14 (14.0%) of the patients from group-A and 16 (16.0%) from group-B had normal $PaCO_2$. At initiation of one lung ventilation 25 (25.0%) of the patients from group-A and 80 (80.0%) from group-B had normal PaO_2. At initiation of one lung ventilation 26 (26.0%) of the patients from group-A and 80 (80.0%) from group-B had normal $PaCO_2$ with $p < 0.001$. At end of procedure one lung ventilation 30 (30.0%) of the patients from group-A and 90 (90.0%) from group-B had normal PaO_2. At end of procedure one lung ventilation 32 (32.0%) of the patients from group-A and 91 (91.0%) from group-B had normal $PaCO_2$. **Conclusions:** The execution of one-lung ventilation still constitutes a challenge in clinical and surgical practice.

Key words: Positive end Expiratory Pressure, One Lung Ventilation, Arterial Blood Gases.

INTRODUCTION

Thoracic surgeries and aesthesia for lung resection has presented anaesthesiologists with certain unique physiological problems. These include placing (lateral decubitus position) in order to obtain optimal access for most operations on lungs, pleura, esophagus, and great vessels, opening the chest wall (open pneumothorax) and one lung ventilation anaesthesia.

One lung ventilation anaesthesia and lateral decubitus position produces decrease in functional residual capacity and an obligatory right to left shunt that ranges from 15% to 40% leading to increase in ventilation perfusion (V/Q) mismatch thus causing hypoxia and or hypoxemia. The mechanisms involved in V/Q mismatch are due to increase in physiological dead space and areas of hypoalveolar ventilation attributed to total collapse of non-dependant lung[1].

Ventilation perfusion (V/Q) mismatch represent the efficiency of gas exchange and ranges from zero (shunt) to infinity (alveolar dead space). Shunt correlates with blood oxygenation[2]. Thus, gas exchange can easily be measured by analysis of arterial blood gas tensions measuring PaO_2 and $PaCO_2$ values[3-5].

An optimal level of positive end expiratory pressure of 5cmH_2O when added to dependent lung is known to improve arterial oxygenation and improve ventilator efficiency[6]. Recent investigations in one lung ventilation

(OLV) anaesthesia has demonstrated the usefulness of lung recruitment strategy and adequate levels of positive end expiratory pressure improved ventilatory efficiency and gas exchange thus improving the overall outcome of patients postoperatively[7]. A similar observation in intensive care settings has shown that positive and expiratory pressure when applied adequately throughout the respiratory cycle improves oxygenation in patients with acute lung injury and acute respiratory distress syndrome[7].

Though there is paucity of data regarding the use of positive end expiratory pressure during one lung ventilation in Pakistan surgical centers, however valuable western data may provide important clues regarding the application of above mentioned study to the local population[1].

The present study was planned to find the optimal level of positive end expiratory pressure during one lung ventilation in thoracotomy patients. Simply by applying optimal amount of positive end expiratory pressure will improve arterial oxygenation and ventilator efficiency without producing effects on hemodynamic variables thus improving the overall outcome of patients postoperatively.

OBJECTIVES

Objective of the study was:

To compare different values of positive end expiratory pressure (PEEP) during one lung ventilation for its effects on blood arterial oxygenation and carbon dioxide levels.

MATERIAL AND METHODS

Study Design

Randomized controlled trial (RCT)

Setting

Surgical Unit-III and Department of anaesthesia and Intensive Care, Combined Military Hospital, Rawalpindi.

Duration of Study

Study was carried out over a period of 10 months from 25-12-2008 to 01-10-2009, additional quantum of data was collected from 01-01-2011 to 25-01-2011.

Sample Size

Where level of significance=5%, power=80%, p1=0.01[6], p2=0.05[6] (from literature review), sample size (n) =200 patients (100 patients randomly allocated to either group–A or group-B).

SAMPLING TECHNIQUE

Purposive non-probability sampling

SAMPLE SELECTION

Inclusion Criteria

- Patients requiring one lung ventilation and direct arterial monitoring.
- Both gender with age >18 years
- ASA II or III
- Patients able to climb two to three flight of stairs without becoming too winded.

Exclusion Criteria

- Patients with ASA IV or greater
- Patients with arterial blood gas values $PaCO_2$ >45mmHg (on room air) PaO_2 < 50mmHg.
- Patients having FEV1 <2L and FEV1/FVC <50% of predicted.

DATA COLLECTION PROCEDURE

Permission from hospital ethical committee was sought. After obtaining detailed informed consent and informing the benefits and risks involved in the study on a structured consent proforma attached as per Annex. Patients were recruited for study on the basis of already explained criteria. Name, Age, Gender, and short clinical findings were endorsed on the research proforma attached as Annex'B''.

The patients were divided into two equal groups of 100 patients each by random allocation of patients to either in group-A or group-B by random numbers table method. It was single blind study. Datex Ohmeda S/5 advance with electronic flow control and measurement anaesthesia machine was used in all groups of patients, after passing appropriately sized double lumen tracheal tube. Pressure regulated volume controlled ventilation with preset inspiratory pressure to achieve a tidal volume of 7-

9 ml/kg, inspiratory expiratory ratio 1:2, whilst on two lung ventilation and similarly on one lung ventilation was acquired. Group-A was subjected to zero PEEP (ZEEP) and group-B was subjected to 5cmH_2O PEEP respectively. Arterial blood gas sampling was done at induction of anaesthesia, on initiating one lung ventilation anaesthesia and at the end of the procedure. The results of ABG analysis i.e PaO_2 and $PaCO_2$ were recorded for each group on proforma 'B'. PaO_2 values of >60 mmHg were taken as normal and PaO_2 <60 mmHg was considered as abnormal. Similarly $PaCO_2$ of 40±10 mmHg was taken as normal and $PaCO_2$ of >50 mmHg was considered abnormal.

DATA ANALYSIS

The data recorded on attached proforma were entered in a computer programme SPSS version 13.0. Descriptive statistics i.e. mean and SD was calculated for age and values of PaO_2 and $PaCO_2$. Frequency and percentages were presented for sex, PaO_2 (normal abnormal) and $PaCO_2$ (normal, abnormal). Chi-square test was used to compare PaO_2 and $PaCO_2$ (normal, abnormal).In group-A subjected to zero PEEP and group-B subjected to 5cmH_2O PEEP. P value less than or equal to 0.05 was taken as significant.

RESULTS

Our study included a sample size of 200 patients of various age groups. Both the genders were included in this study. They were divided into two groups group A and group B. Group A patients were subjected to zero positive end expiratory pressure, while group B patients were subjected to 5cmH_2O of positive end expiratory pressure.

Mean age of the patients was 43.17±1.4 and 41.59±1.9 in group-A and B respectively (Table-I).

In group-A, 66 (66%) were males and 34 (34%) patient were females. Similarly in group-B, males were 68 (68%) while females were 32 (32%) (Table-II).

At induction and start of two lung ventilation 16 (16.0%) of the patients from group-A and 15 (15.0%) from group-B had normal PaO_2 (Table-III).

Table-I. Distribution of cases by age

Age	Group-A (Zero PEEP)		Group-B (5cmH_2O PEEP)	
	No.	%	No.	%
<20	06	06	04	04.0
21-30	11	11	15	15.0
31-40	21	21	27	27.0
41-50	28	28	22	22.0
51-60	19	19	12	12.0
>60	15	15	20	20.0
Total	100	100	100	100
Mean±SD	43.17±1.4		41.59±1.9	

Table-II. Distribution of cases by sex

Sex	Group-A (Zero PEEP)		Group-B (5cmH_2O PEEP)	
	No.	%	No.	%
Male	66	66.0	68	68.0
Female	34	34.0	32	32.0
Total	100	100.0	100	100.0

Table-III. Comparison of PaO_2 at induction (Two lung ventilation)

Sex	Group-A (Zero PEEP)		Group-B (5cmH_2O PEEP)	
	No.	%	No.	%
Normal	16	16.0	15	15.0
Abnormal	84	84.0	85	85.0
Total	100	100.0	100	100.0
Chi-square = 0.04		*df = 1*		*P value = 0.845*

At induction and start of two lung ventilation 14 (14.0%) of the patients from group-A and 16 (16.0%) from group-B had normal $PaCO_2$ (Table-IV).

At initiation of one lung ventilation 25 (25.0%) of the

Table-IV. Comparison of PaO_2 at induction (Two lung ventilation)

Sex	Group-A (Zero PEEP)		Group-B ($5cmH_2O$ PEEP)	
	No.	%	No.	%
Normal	14	14.0	16	16.0
Abnormal	86	86.0	84	84.0
Total	100	100.0	100	100.0
Chi-square = 0.16		*df = 1*		*P value = 0.692*

Table-V. Comparison of PaO2 at initiation (One lung ventilation)

Sex	Group-A (Zero PEEP)		Group-B ($5cmH_2O$ PEEP)	
	No.	%	No.	%
Normal	25	25.0	80	80.0
Abnormal	75	75.0	20	20.0
Total	100	100.0	100	100.0
Chi-square = 60.65		*df = 1*		*P value = <0.001*

Table-VI. Comparison of PaO_2 at initiation (One lung ventilation)

Sex	Group-A (Zero PEEP)		Group-B ($5cmH_2O$ PEEP)	
	No.	%	No.	%
Normal	26	26.0	80	80.0
Abnormal	74	74.0	20	20.0
Total	100	100.0	100	100.0
Chi-square = 58.53		*df = 1*		*P value = <0.001*

patients from group-A and 80 (80.0%) from group-B had normal PaO_2 with p <0.001 (Table-V).

At initiation of one lung ventilation 26 (26.0%) of the patients from group-A and 80 (80.0%) from group-B had normal $PaCO_2$ with p <0.001 (Table-VI).

At end of procedure one lung ventilation 30 (30.0%) of

Table-VII. Comparison of PaO_2 at end of procedure (One lung ventilation)

Sex	Group-A (Zero PEEP)		Group-B ($5cmH_2O$ PEEP)	
	No.	%	No.	%
Normal	30	30.0	90	90.0
Abnormal	70	70.0	10	10.0
Total	100	100.0	100	100.0
Chi-square = 75.00		*df = 1*		*P value = <0.001*

Table-VIII. Comparison of PaO_2 at end of procedure (One lung ventilation)

Sex	Group-A (Zero PEEP)		Group-B ($5cmH_2O$ PEEP)	
	No.	%	No.	%
Normal	32	32.0	91	91.0
Abnormal	68	68.0	09	09.0
Total	100	100.0	100	100.0
Chi-square = 73.51		*df = 1*		*P value = <0.001*

the patients from group-A and 90 (90.0%) from group-B had normal PaO_2 with p <0.001 (Table-VII).

At end of procedure one lung ventilation 32 (32.0%) of the patients from group-A and 91 (91.0%) from group-B had normal $PaCO_2$ with p <0.001 (Table-VIII).

DISCUSSION

One-lung ventilation (OLV) is essential in some surgical situations. The use of double- lumen tubes (DLTs) can achieve OLV more quickly and more easily than bronchial blockers. The management of a difficult airway is a challenge for anesthesiologists when, at the same time, OLV is needed for a surgical procedure[8].

Recent advances in thoracic surgical techniques have led to an increased use of one-lung ventilation techniques. One lung ventilation is performed by doubled lumen tubes, fogarty catheters, Univent tubes and bronchial blockers. In this paper our bronchial blocker experiences were presented in fifteen thoracic surgery patients. Bronchial blockers were placed in fifteen patients who needed one-lung ventilation during thoracic surgery between January-April in 2007. Type of the bronchial blockers were selected randomly and total eight Cohen and seven Arndt bronchial blocker were placed. Following endotracheal intubation some of the bronchial blockers were performed at supine and the others were in lateral position to patients. Fiberoptic investigation was performed in all of the patients following lateral position. Bronchial blocker was placed in fifteen patients. In one patient who had congenital tracheal bronchus, one lung ventilation could not be achieved by bronchial blocker. Following lateral positioning bronchial blocker of two patients were malpositioned and they were repositioned. Successful one lung ventilation was performed by both bronchial blocker type. While the patient's airway position, postoperative period and type of the surgery have been considered, bronchial blockers may be an alternative airway device for one-lung ventilation[9].

When switching from two-lung to one-lung ventilation (OLV), shunt fraction increases, oxygenation is impaired, and hypoxemia may occur. Hypoxemia during OLV may be predicted from measurements of lung function, distribution of perfusion between the lungs, whether the right or the left lung is ventilated, and whether the operation will be performed in the supine or in the lateral decubitus position. Hypoxemia during OLV may be prevented by applying a ventilation strategy that avoids alveolar collapse while minimally impairing perfusion of the dependent lung. Choice of anesthesia does not influence oxygenation during clinical OLV. Hypoxemia during OLV may be treated symptomatically by increasing inspired fraction of oxygen, by ventilating, or by using continuous positive airway pressure in the nonventilated lung. Hypoxemia during OLV may be treated causally by correcting the position of the double-lumen tube, clearing the main bronchi of the ventilated lung from secretions, and improving the ventilation strategy[10].

Hypoxemia is a complication that affects from 9% to 27% of patients undergoing one- lung ventilation and is influenced by several factors. Initially, soon after the beginning of one-lung ventilation, the blood flowing in the nonventilated lung becomes deoxygenated. This is because of reduced surface area available for gas exchange and consequently decreases PaO_2[11].

Patient positioning during thoracic surgery is another significant factor affecting oxygenation. Studies show that oxygenation is more satisfactory when the patient is placed in the lateral decubitus, rather than the dorsal decubitus, position. Watanabe et al. demonstrated that alveolar oxygen tension decreases more rapidly in the dorsal decubitus position than in the lateral decubitus position, thereby leading to more accentuated hypoxemia[12]. Therefore, the lateral decubitus position is used in most studies aiming to minimize the effects of patient position on arterial oxygenation[12].

When one-lung ventilation is instituted, the dependent lung is ventilated and the nondependent lung is not. As a result, the nondependent lung will be in total collapse, thereby presenting significant reduction in the surface area available for gas exchange, in addition to loss of normal autonomic respiratory regulation. Subsequently, a transpulmonary shunt is created in the nondependent lung and, even in the presence of similar FiO_2 and comparable metabolic and hemodynamic conditions, arterial oxygen tension (PaO_2) is lower than in traditional mechanical ventilation. Hypoxemia is a complication that affects from 9% to 27% of patients undergoing one-lung ventilation and is influenced by several factors. Initially, soon after the beginning of one-lung ventilation, the blood flow in the non-ventilated lung becomes deoxygenated. This reduces the surface area available for gas exchange and consequently decreases PaO_2[12].

Our study included a sample size of 200 patients of various age groups. Both the genders were included in this study. They were divided into two groups group A, and group B respectively.

In this study, it was found out that in group A (zero PEEP) there was no significant increase in oxygen tension after the initiation of one lung ventilation, there arterial oxygen tension remained in the abnormal levels (PaO_2 <80 mmHg) however hypercapnia was prevented by increasing respiratory rate. On the other hand group B that were subjected to positive end expiratory pressure of 5cmH_2O showed a definitive improvement in arterial oxygen tension. There is much controversy in the literature over the efficacy of PEEP in controlling PaO_2 during one lung ventilation. Cohen et al. demonstrated that the application of a PEEP level of 10 cmH_2O to patients with low PaO_2 increased the functional residual capacity to normal values, thereby reducing the pulmonary vascular resistance, improving the ventilation-perfusion ratio and increasing PaO_2[13].

On the other hand, Capan et al. provided evidence that oxygenation did not improve in the presence of PEEP. In patients with no previous history of lung disease, arterial oxygenation, shunt fraction and cardiac rate were satisfactory when PEEP levels similar to those of auto-PEEP were used[14].

Therefore, in order to apply an ideal PEEP level, it is recommended that auto-PEEP levels be determined[15].

This is an important clinical benefit, because improved oxygenation decreases postoperative morbidity & mortality in one lung ventilation patients and reduces their in hospital stay. There are various important effects that application of PEEP during one lung physiology. First, PEEP decreases the amount of atelectasis[16], and this increases the functional residual capacity (FRC) which is the main oxygen store of the body[17]. Second, decreasing atelectasis also decreases intrapulmonary shunt[18]. Indeed, the higher Pao_2 seen in the PEEP group may reflect a lower level of intrapulmonary shunt. Therefore, increasing the oxygen store of the body and decreasing the intrapulmonary shunt may prolong the duration of nonhypoxic apnea and the margin of safety during anesthesia induction. Earlier observations[19] from the intensive care setting established that the use of adequate levels of PEEP[20] throughout the respiratory cycle could greatly improve oxygenation in patients with acute lung injury (ALI) or acute respiratory distress syndrome (ARDS) by increasing functional residual capacity and recruiting alveoli to improve lung compliance. It is known that significant reduction in lung volume and functional residual capacity occurs in the dependent lung during OLV due to the effects of anaesthesia, the weight of the mediastinum and abdominal contents. Applying PEEP would help to splint the alveoli throughout the respiratory cycle and thus improve oxygenation. However, several studies on the effects of PEEP during OLV produced conflicting evidence, some showing improvement[16] and others no benefit or worsening of PaO_2[16].

CONCLUSIONS

The execution of one-lung ventilation still constitutes a challenge in clinical and surgical practice. Many techniques have been developed with the aim of minimizing the related complications. However, further studies are warranted in order to find the ideal way to employ and monitor this technique.

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