PREDICTIVE FACTORS REDUCING ARTERIAL OXYGENATION (PaO_2) DURING ONE LUNG ANAESTHESIA: A CROSS-SECTIONAL STUDY

Ezhil Rajan V[1], Suresh Rajkumar[2]

[1]Professor, Department of Anaesthesiology, Aarupadai Veedu Medical College, Puducherry.
[2]Associate Professor, Department of Anaesthesiology, Aarupadai Veedu Medical College, Puducherry.

ABSTRACT

BACKGROUND

One Lung Anaesthesia (OLA) is used in thoracic surgery for prevention of spillage of blood and pus into the healthy lung to facilitate surgical exposure. During OLA since the collapsed lung continues to be perfused, there will be large right to left shunt which leads to hypoxaemia.

Objective- To find out the potential factors that reduce arterial oxygenation (PaO_2) during OLA and to find out the possibility of predicting the PaO_2 during OLA based on these potential factors.

MATERIALS AND METHODS

A cross-sectional study was conducted among 34 patients who came for lung or non-lung surgery in the CMC Vellore during a period of 2 years. All the ASA grade I and II patients who needed OLA were included. Preoperative PaO_2, TLV PaO_2, PaO_2 at 10 mins. and 25 mins. after starting OLA were assessed. Alteration in PaO_2 related to side, smoking and gender was measured by mean±SD and multiple linear regression was done to assess the independent contribution of each of 9 predictors with OLA PaO_2 at 25 min.

RESULTS

Three factors were of significance in predicting the PaO_2 which were gender, side of surgery and smoking. Women had significantly ($p=0.04$) higher PaO_2 as compared to men. Similarly, left side had significantly ($p = 0.01$) higher PaO_2 as compared to right side and non-smokers had significantly lower PaO_2 compared to smokers ($p = 0.03$). A predictive equation was constructed for PaO_2 on OLV at 25 mins. by using the significant predictors in this study.

CONCLUSION

Our study was an attempt to show that it is possible to predict preoperatively the patient who is likely to suffer from hypoxaemia during OLA. The ability to predict the subsequent arterial oxygenation allows the anaesthetists/surgeons to assess and rationalise risk/benefits regarding the use of OLA during thoracic surgery and permits more controlled intraoperative management of oxygenation.

KEYWORDS

One Lung Anaesthesia (OLA), Arterial Oxygenation (PaO_2), Predictors Predictive Factors Reducing Arterial Oxygenation (PaO_2) during One Lung Anaesthesia - A Cross-Sectional Study.

HOW TO CITE THIS ARTICLE: Rajan EV, Rajkumar S. Predictive factors reducing arterial oxygenation (PaO_2) during one lung anaesthesia: a cross-sectional study. J. Evolution Med. Dent. Sci. 2016;5(86):6375-6378, DOI: 10.14260/jemds/2016/1442

BACKGROUND

One Lung Anaesthesia (OLA) is used in thoracic surgery for a variety of indications.[1] It ranges from prevention of spillage of blood and pus into the healthy lung, as in lung abscess and haemorrhage to facilitation of surgical exposure as in oesophageal surgery.

During one lung anaesthesia, the non-dependent lung is collapsed and the dependent lung is selectively ventilated using a double lumen tube. Since the collapsed lung continues to be perfused, there is a large right to left shunt at this level which is the major cause of hypoxaemia[2] in OLA. In addition, the ventilation of the dependent lung is hampered by the weight of the mediastinum, collection of secretions and the wedge under the lower thorax. The other probable factors affecting OLA PaO_2 are age, obesity and smoking. All these factors also contribute to the hypoxaemia.

During OLA when there is arterial desaturation, various measures can be initiated to increase the oxygenation. These measures are increasing the FiO2, non-dependent lung CPAP and dependent lung PEEP.[3,4] To carry out this, we need an additional oxygen source and circuit in the case of CPAP and a retard valve for PEEP. CPAP is not desirable in all the patients prophylactically, as it may interfere with the surgery. Therefore, if we can predict which patients will have the need for these measures it will enable us to be prepared to use them before hypoxaemia occurs without having to use it for all patients as routine. This study was an attempt to find out the predictive factors for decreasing PaO_2 and to find out if it was possible to predict which patient will have a clinically important decrease of PaO_2 during OLA for thoracic surgery based on these factors.[5,6,7]

Objectives of the study are to find out the potential factors that reduce arterial oxygenation (PaO_2) during One Lung

Financial or Other, Competing Interest: None.
Submission 12-08-2016, Peer Review 06-09-2016,
Acceptance 12-09-2016, Published 26-10-2016.
Corresponding Author:
Dr. Ezhil Rajan V,
Professor, Department of Anaesthesiology,
Aarupadai Veedu Medical College, Puducherry.
E-mail: ezhilrajan96@gmail.com
DOI: 10.14260/jemds/2016/1442

Anaesthesia (OLA) and to find out the possibility of predicting the PaO_2 during One Lung Anaesthesia (OLA) based on these potential factors.

MATERIALS AND METHODS

A cross-sectional study was conducted among 34 patients who came for lung or non-lung surgery in the CMC Vellore during a period of two years. All the ASA grade I and II patients who needed One Lung Anaesthesia (OLA) during the study period either for lung or non-lung surgery were included in this study. The exclusion criteria were patients less than 15 years, presence of cardiovascular disease, anticipated difficult intubation and inability to isolate the lungs properly after double lumen tube insertion. On the patient arrival in the operating room peripheral and central intravenous cannulations and percutaneous arterial line insertion were done under local anaesthesia. Blood samples for preoperative PaO_2, PaO_2 during two lung ventilation (TLV), PaO_2 at 10 mins. and 25 mins. after starting OLA were taken and assessed. Alteration in PaO_2 related to side, smoking and gender was measured by mean±SD. The data were analysed by multiple linear regression to assess the independent contribution of each of these 9 predictors with OLA PaO_2 at 25 mins.

RESULTS

Total number of patients in this study were 34. Out of this 22 (64.7%) were males and 12 (35.29%) were females. Patients undergone right thoracotomy was 13 (38.23%) and left thoracotomy was 21 (61.76%). Among the 34 patients 24 (70.59%) underwent lung surgery, while 10 (29.41%) underwent non-lung surgery. Mean PaO_2 at different stages of surgery is described in Table No. 1. Table No. 2 shows that there is a significant increase in the PaO_2 at 25 minutes in patients who had their left lung collapsed during surgery. Under the same conditions, PaO_2 with the right lung collapsed shows a drop. In Table No. 3 non-smokers showed a lower PaO_2 at 25 minutes of one lung ventilation when compared to smokers. The females in the study showed a significantly higher PaO_2 at 25 minutes of one lung ventilation (Table No. 4). Multiple linear regression analysis was done to assess the independent contribution of each of the 9 predictors in explaining the variability in the drop in PaO_2 at 25 minutes of OLA. These predictors or potential factors affecting PaO_2 are the side of operation, FEV_1% vital capacity; PaO_2 on age, sex, weight and age of the patient, effect of smoking and whether the patient had undergone lung or non-lung surgery. From the Table No. 5, it was noted that only 3 factors were of significance in predicting the PaO_2. These were the side of the surgery, sex of the patients and smoking. When the operative procedure was done on the left sided lung, PaO_2 at 25 mins. had significantly ($p = 0.01$) increased. Women had significantly ($p = 0.04$) higher PaO_2 at 25 mins. as compared to men. The non-smokers had lower PaO_2 at 25 minutes ($p = 0.03$) compared to smokers. Based on this data, the following regression equation could be used for predicting PaO_2 at 25 mins. This method was used to construct a predictive equation for PaO_2 on OLV at 25 mins. by using the most highly significant predictors.

The Predictive Equation

The predictive equation may be derived as follows:

PaO_2 (25 mins.)

=65.0 (constant) + 25.6 (side) + 27.7 (sex) – 26.1 (smoking).

Points being given in relation to significance of predictors.

For side-1 for Right Thoracotomy, 2 for Left Thoracotomy.

For sex-1 for males, 2 for females.

For smoking-1 for smokers, 2 for non-smokers.

Example of Prediction of PaO_2 during One Lung Anaesthesia at 25 mins.

Patient Age - 20 yrs., Sex - Male, Side of Thoracotomy – Left, Non-Smoker.

By substituting out equation.

Predicted PaO_2 at 25 mins in this patient = 65+25.6 (side) + 27.7 (sex) – 26.1 (smoking).

= 65+ 25.6 (left) + 27.7 (male) – 26.1 (non-smoker).

= 65 +_25.6 (2) + 27.7(1) – 26.1 (2).

= 65 + 51.2 + 27.7 – 52.2.

PaO_2 at 25 mins. = 91.70.

Predicted PaO_2 (25 mins.) during one lung anaesthesia is 91.70.

Observed PaO_2 (25 mins.) during one lung anaesthesia is 91.00.

PaO_2 Levels	Mean	S.D.	Minimum	Maximum
Pre-op PaO_2	91.2	11.21	70.80	112.00
TLV PaO_2	150.69	47.14	63.70	266.80
OLV PaO_2 10 mins.	111.32	42.89	45.60	216.70
OLV PaO_2 25 mins.	100.21	43.71	58.90	199.40

Table 1: PaO_2 Values at Different Stages of Surgical Procedure

TLV = Two lung Ventilation. OLV = One Lung Ventilation.

Variable	No. of Pts.	Pre-op PaO_2	PaO_2 at 25 mins.
Right Side	13	91.3±11.21	86.74±18.00
Left Side	21	91.33±21.22	108.54±39.00

Table 2: PaO_2 Levels and the Side of Thoracotomy

$P < 0.05$, t test 3.43

Variable	No. of Pts.	Pre-op PaO_2	PaO_2 at 25 mins.
Smoker	11	89.98±12.32	98.44±36.43
Non-Smoker	23	94.10±08.25	86.74±18.00

Table 3: PaO_2 Levels and Smoking

$P < 0.05$, t test 2.41

Variable	No. of Pts.	Pre-op PaO_2	PaO_2 at 25 mins.
Males	22	90.71±10.36	94.34±27.23
Females	12	92.42± 33.04	110.95± 44.12

Table 4: PaO_2 Levels and Sex

$P < 0.05$, t test 3.29

Sl. No.	Factors	Unstandardised regr. coeffic	P Value
1	Pre-op PaO_2	-.90	0.13
2	Side of Surgery	34.83	0.01
3	Sex	31.42	0.04
4	Lung Surgery	-14.25	0.41
5	Weight	-1.27	0.10
6	Age	.27	0.64
7	Smoking/Non	-36.00	0.03
8	FEVI	31.91	0.25
9	Vital Capacity	-10.26	0.66

Table 5: Predictive Factors in Altering PaO_2 Levels-Multiple Linear Regression

DISCUSSION

It has been generally appreciated that the side of surgery affects the PaO_2 during OLA. The left lung receives 10% less perfusion than the right lung. In addition, the dependent lung receives 10% more than its usual blood flow. So it seems feasible that patients having left thoracotomy with the left lung collapsed will have better oxygenation than when the right lung is collapsed.[8] Based on the data of this study, a patient having left thoracotomy had a significantly higher PaO_2 at 25 minutes than the patient with right-sided thoracotomy. Therefore, the side of the operation is a statistically significant factor in predicting the PaO_2 during OLA. Slingers in this study[6] also got similar results with regard to the side of the operation. The females (n=12) in our study had a much higher PaO_2 than the males at 25 minutes (Mean increases 16.6 mmHg). This result is statistically significant in this study. Therefore, this would be one of the variables in the predictive equation. We do not have any explanation for this phenomenon. This may be due to having fewer number of females during the study period and larger number will be required to present this evidence as conclusive. The mean pre-operative PaO_2 in smoker was 89.98 mmHg and non-smoker was 94.10 mmHg and PaO_2 at 25 minutes also showed a higher PaO_2 in smokers (Table No. 5). This study has shown a significant negative correlation in the smokers. Even though we expect smokers to have a lower PaO_2, they had higher PaO_2 than the non-smokers. All smokers in this study had stopped smoking for at least two weeks prior to surgery and had bronchodilator therapy and physiotherapy when indicated. Cessation of smoking is considered to reverse the airway abnormalities in smokers. It has been shown that bronchodilators improves not only air flow obstruction and lung mechanism, but also gas exchange abnormalities.[9] The non-smokers did not have any bronchodilators or physiotherapy preoperatively, as their clinical signs did not warrant this line of treatment. This may explain why the smokers in this study had relatively higher PaO_2. Another study may be planned where both smokers and non-smoker received similar bronchodilator and physiotherapy in the pre-operative period and the outcome studied. From this study, pre-operative PaO_2 does not emerge as a significant factor which would help to predict the intraoperative PaO_2 during OLA.[10,11] We should not disregard this factor completely since a larger number of cases in the study could have definitely shown if pre-operative PaO_2 could be significant or not. Similarly, the weight of the patients also has a P value of 0.10. Again, larger numbers in the study may have been more conclusive. The other factors like lung or non-lung surgery, age, FEV_1 and vital capacity did not show any correlation in the ability to predict the PaO_2 at 25 minutes. Clinically, it is often seen that in patients with obstructive lung disease there is surprisingly good oxygenation during OLA.[12] But this study did not establish any predictable change in the PaO_2 of the patients who had surgery for lung disease, i.e. lobectomy or pneumonectomy when compared to the patients who had non-lung surgeries. For example, oesophagectomy where one lung was collapsed to facilitate surgery.[13] The lung function tests that were done, FEV_1 and vital capacity pre-operatively did not give any indication of the PaO_2 levels to be expected at 25 minutes of OLV,[14] even though FEV_1 seemed to be a significant contributory factor in Slinger's study.[6] There was no change in the PaO_2 at 25 minutes whether the lung functions were normal or abnormal. Some studies show that the patients with better pre-operative pulmonary function tends to have a lower PaO_2 value during OLA.[15]

We found only three predictive factors in altering the PaO_2 were statistically significant. They were the side of the operation, the sex of the patient and history of smoking. The other 6 factors (which were not significant in our study) were pre-op PaO_2, lung or non-lung operation, age and weight of the patient, FEV_1 and vital capacity. In this study, a predictive equation was formulated from the parameters which are available routinely which would tell us the patients at risk of hypoxaemia with OLA on FiO_2 of 0.5. Here, the side of the operation, sex and the smoking were the significant predictors for predicting hypoxaemia at 25 minutes. Therefore, the predictive equation was based on these factors. The equation derived in this study can be applied reliably only to patients undergoing similar anaesthetic. The usefulness of this equation for other anaesthetic techniques has to be studied. The accuracy of the predictive equation in this study is 40% as compared to Slinger's study which was 53%. This may be so because intraoperative PaO_2 with two lung ventilation was a significant variable in the equation in their study. We hoped that using pre-operative PaO_2 levels as a predictive factor, we would be able to predict the degree of hypoxaemia before the patient was anaesthetised. This we felt would help in getting the additional equipment required to provide CPAP or PEP as required. However, we did not find pre-operative PaO_2 value as a good predictor.

ACKNOWLEDGEMENT
I express my heartfelt gratitude for her painstaking efforts in completion of the study in a better way and also to my all other teachers, colleagues in the department.

REFERENCES

1. Benum JL. Anesthesia for thoracic surgery. Philadelphia: WB Saunders Company 1987:227.
2. Kerr JH, Smith AR, Roberts CP, et al. Observation during endobronchial anesthesia II oxygenation. British Journ Anesthesia 1972;46(2):84-92.
3. Benumof JL. Anesthesia for thoracic surgery. Philadelphia: WB Saunders Company 1987:273.
4. Capan LM, Turndorf H, Patel C, et al. Optimization of arterial oxygenation during one-lung anesthesia. Anasth Analg 1980;59(11):847-51.
5. Khanam T, Branthwaite MA. Arterial oxygenation during one-lung anaesthesia. Anesthesia 1973;28(3):280-90.
6. Slinger P, Suissa S, Triolet W. Predicting arterial oxygenation during one-lung anaesthesia. Can J Anesthesia 1992;39(10):1030-5.
7. Thomson DF, Campbell D. Changes in arterial oxygen tension during OLA. British Journal of Anesthesia 1973;45(6):611-6.
8. Marshall BE. Anesthesia for one lung ventilation. Anesthesiology 1988;69(4):630-1.
9. Tinker JH, Morgham EG, Louis (eds). Principles and practice of anesthesiology. Longnecker DE. Mosby year book 1998:529.
10. Eisenkraft JB. Effect of anesthetics on the pulmonary circulation. Br J Anesthesia 1990;65(1):63-78.

11. Milledge JS, Nunn JF. Criteria for fitness for anesthesia in patients with COPD. British Med Journal 1975;3(5985):670-3.
12. Block AJ, Olsen GN. Pre-operative pulmonary function testing. JAMA 1976;235(3):257-8.
13. Lunding M, Fernandes A. Arterial oxygen tension and acid-base status during thoracic anesthesia. Acta Anaesthesiologica Scandinavica 1967;11(1):43-55.
14. Tisi GM. Pre-operative evaluation of pulmonary function. Am Rev Respir Dis 1979;119(2):293-310.
15. Tisi GM. Pre-operative evaluation of pulmonary function. Am Rev Respir Dis 1979;119(2):235-57.