

A randomised control study comparing the efficacy of 2 techniques of preoxygenation - tidal volume breathing for one minute and 8 deep breaths in one minute

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Received: 19th July, 2018

Accepted: 23rd November, 2018

Abstract

Introduction: The aim of preoxygenation is to replace nitrogen in the Functional Residual Capacity (FRC) with oxygen. This increases body oxygen store and increases tolerance to apnoea significantly.

Materials and Methods: This study was conducted in PESIMSR, Kuppam between July 2012 and November 2013 in a selected population of 60 adults of either sex scheduled posted for elective surgery. The patients were distributed into 2 groups, Group Tidal Volume Breathing, T and Group Deep Breathing, D. Each group had 30 patients. Group T patients were preoxygenated with Tidal Volume Breathing and group D patients were preoxygenated with 8 deep breaths in 1 minute. The measured variables were SpO₂, Heart rate, inspired oxygen concentration, Endtidal Oxygen concentration, End tidal Carbon Dioxide and Duration of Apnoea without desaturation (DAWD).

Results: There were no statistically significant differences between both the groups in age, gender, height, weight and BMI. All the patients in both the groups attained ETO₂ values of above 90 at the end of preoxygenation. The mean ETCO₂ value in T group was 32.16 ± 1.51 and 27.36 ± 1.73 in Group D. This value was statistically significant with a p value of < 0.001 . In Group T, the mean DAWD was 6.84 ± 1.094 min whereas the DAWD time in Group D was 7.88 ± 1.255 min, with a p value of 0.0011.

Conclusion: Preoxygenation with 8 deep breaths in 1 minute is a more effective method of preoxygenation because there is a significant increase in the time taken for desaturation. This method will be more effective in patients with full stomach posted for emergency surgery.

Keywords: Tidal volume breathing, Deep breathing technique, Preoxygenation, Safe duration of apnoea.

Introduction

Preoxygenation before anaesthetic induction and tracheal intubation is a widely accepted. It increases the oxygen reserve in the lungs and delays the onset of desaturation of oxygen during apnea.¹ Some have referred to this procedure as “denitrogenation” because the nitrogen in functional residual capacity (FRC) is replaced by oxygen. Preoxygenation is a more appropriate term because our primary goal with this technique is to provide oxygen and not to remove nitrogen from the lungs. Preoxygenation increases oxygen reserve, therefore the duration of apnoea without desaturation (DAWD) is increased.² This additional time is very valuable for the anaesthesiologist at the time of securing the airway. Preoxygenation is complete when the alveolar, arterial, tissue, and venous compartments are all filled with oxygen.²

After preoxygenation, patients tolerate a longer period of apnoea. There is an increased margin of safety between induction of anaesthesia and the time at which airway is secured. In situations like rapid sequence induction of anaesthesia or when difficult tracheal intubation and/or difficult ventilation are suspected, this additional time is important as patients are not/cannot be manually ventilated.

Unanticipated difficulties with tracheal intubation are encountered by Anaesthesiologists in clinical practice. Preoxygenation is necessary for all patients before induction of general anaesthesia to help in such unanticipated difficulties. The American Society of Anaesthesiologists’ (ASA) difficult airway algorithm did not mention preoxygenation but the recent report by the ASA Task Force

on Management of the Difficult Airway (2003) recommends facemask preoxygenation as mandatory before induction.³

The purpose of preoxygenation is to increase the period of apnoea without hypoxia. Thus, the most direct method to evaluate effectiveness is to measure DAWD. DAWD is defined as the time for oxygen saturation to decrease to less than 90%.⁴ There are many indicators of the completeness of preoxygenation like end-tidal nitrogen fraction (FEN₂) or end-tidal oxygen fraction (FEO₂). They are used as indicators because they are reflections of the alveolar fraction of nitrogen and oxygen respectively.⁵

Various techniques of preoxygenation are described 1, 2. Slow techniques like tidal volume breathing (TVB) and fast techniques like taking deep breaths and vital capacity breaths have been proposed. In our study we chose to compare the efficacy of 2 techniques of preoxygenation -slow technique of tidal volume breathing for 3 minutes and fast technique of 8 deep breaths in 1 minute.

The earlier studies 4 comparing preoxygenation with 8 deep breaths in 1 minute and tidal volume breathing for 3 minutes were done conducted in healthy volunteers. Our study was conducted in a clinical setting in patients posted for elective surgeries. The time to desaturation was taken as the end point.

Materials and Methods

This study was conducted in PESIMSR, Kuppam between July 2012 and November 2013. Approval from the ethical committee of the institution and informed consent from all the patients participating in the study was obtained.

The 60 patients participating in the study were selected randomly and allocated into 2 groups of 30 patients. The selection to the group was decided by computer.

Inclusion Criteria: ASA physical status 1 and 2 patients in the age group 20 – 50 years for elective surgery under general anaesthesia

Exclusion Criteria: Patients with difficulty in mask ventilation / predicted difficult airway, BMI > 30, patients with recent respiratory infection, cardiac, respiratory, renal, neurologic and endocrine functions, patients with Haemoglobin less than 10gm/dL, patients with smoking history and pregnant and lactating women

Methodology

The 60 patients were divided into 2 groups 30 each.

Group T Preoxygenated with Tidal volume breathing of oxygen 100% for 3 minutes

Group D Preoxygenated with 8 deep breaths within 1 minute

During the Pre-Anaesthetic evaluation, the SpO₂ on room air was recorded. Only patients who had SpO₂ more than 98% on breathing room air were included in the study. Patients who met all the criteria were and explained about the procedure and consent obtained. All patients were premedicated with oral Diazepam 5mg night before the surgery.

In the operation theatre, the patients were reminded about the technique of preoxygenation as per the group allocation. Intravenous access was secured. The monitors to record Non Invasive Blood Pressure (NIBP), SpO₂ and electrocardiogram (ECG) were connected. The baseline readings of pulse rate, heart rate and blood pressure were recorded.

The closed circuit of the anaesthesia workstation was flushed with oxygen at flow rate of 10L/min and the reservoir bag filled before preoxygenation.

Preoxygenation was accomplished with appropriately sized face mask connected to semi-closed circle absorber system with the patients in supine position. The oxygen flow rate was set at 10L/min.

Patients in T group continued to breathe normally after application of face mask for 3 minutes. Patients in D group were asked to breathe deeply at 7.5 sec intervals to complete 8 deep breaths in 1 minute.

Immediately after completing preoxygenation, anaesthesia was induced with injection Propofol 2mg/kg, injection Fentanyl 2µg/kg and Succinyl choline 1.5mg/kg. As the patients may be aware during the apnoeic period, a bolus dose of 10 mg of Propofol was administered 2 min after the induction dose and then every minute until the completion of the study. With the onset of anaesthesia and muscle relaxation, patient's trachea was intubated under direct vision. Only after successful intubation was visually confirmed, the endotracheal tube was left open to air.

The study was completed when the SpO₂ reached 90%. The lungs were then ventilated with 100% oxygen until the SpO₂ reached values 97%.

The measured variables were SpO₂, Heart rate, inspired oxygen concentration, End tidal Oxygen concentration and

End tidal Carbon Dioxide and DAWD (Duration of apnoea without desaturation) time were noted in the multi channel monitor with the respiratory gas analyser. DAWD was defined as the time from the end of preoxygenation to the time when spo₂ to reached 90% Data was collected at 0.5 min intervals during the study period.

Results

The data was analysed using SPSS Statistical Software version 20.0 for Windows. All the quantitative data were expressed in mean+/- 2SE, ANOVA and chi square test was used to compare the standard error of mean. p<0.05 was considered significant. The Demographic data of the patients is shown in Table 1. There were no statistically significant differences between the groups, T and D in age, gender, height, weight and BMI. The mean weight in group T was 63.06+/-5.7Kg and the mean weight of group D was 63.26+/-5.72Kg. The mean age in the group T was 28.06+/-4.85yrs and in the D group was 28.4 ± 5.19yrs.

The haemodynamic data before preoxygenation, at end of preoxygenation and at end of apnoea are shown in Table 2. There were no significant differences in heart rate and systolic blood pressure between the two groups at the beginning of preoxygenation, end of preoxygenation and at the end of apnoea. The mean heart rate in the group T at beginning of preoxygenation was 87.76 ± 3.4/min and 87.9 ± 3.67/min in D group.

Table 3 and Fig. 1 shows the end tidal concentration of oxygen in both the groups. There was no significant difference in ETO₂ values at end of preoxygenation in both the groups. All the patients, in both the groups had an ETO₂ of above 90. This reading was noted in the multi channel monitor with Respiratory Gas Analyser.

Table 4 shows the end tidal concentration of carbon dioxide at end of preoxygenation in both the groups. The mean ETCO₂ value in T group was 32.16 ± 1.51 and 27.36 ± 1.73 in Group D. This value was statistically significant with a p value of < 0.001.

The duration of apnoea without desaturation (DAWD) is shown in Table 5 and Fig. 2. In Group T, the mean DAWD was 6.84 ± 1.094 min whereas the DAWD time in Group D was 7.88 ± 1.255 min. This was statistically highly significant with a p value of 0.0011.

Table 1

	Group TVB	Group DB	P value
Age	28.06 ± 4.85	28.4 ± 5.19	0.798
Gender M:F	16:14	17:13	
Height (in cm)	158.03 ± 4.28	157 ± 3.89	0.85
Weight (in Kg)	63.06 ± 5.7	63.26 ± 5.72	0.892
BMI	25.183 ± 1.67	25.31 ± 1.47	0.746

Table 2

	Before	Preoxygenation	At end of	Preoxygenation	At end of	Apnoea
	HR	SBP	HR	SBP	HR	SBP
Group TVB	87.76 ± 3.4	122.96 ± 4.99	99.66 ± 3.71	121.46 ± 4.67	109.13 ± 5.99	131.06 ± 4.34
Group DB	87.9 ± 3.67	123.26 ± 5.24	101.66 ± 5.77	125.76 ± 5.44	109.06 ± 6.06	128.83 ± 4.89

Table 3

	Group TVB	Group DB	P value
ETO2 at end of preoxygenation	94.96 ± 1.92	94.33 ± 1.88	0.202

Table 4

	Group TVB	Group DB	P value
ETCO2 at end of preoxygenation	32.16 ± 1.51	27.36 ± 1.73	<0.001

Table 5

	Group TVB	Group DB	P value
DAWD	6.84 ± 1.094	7.88 ± 1.255	0.0011

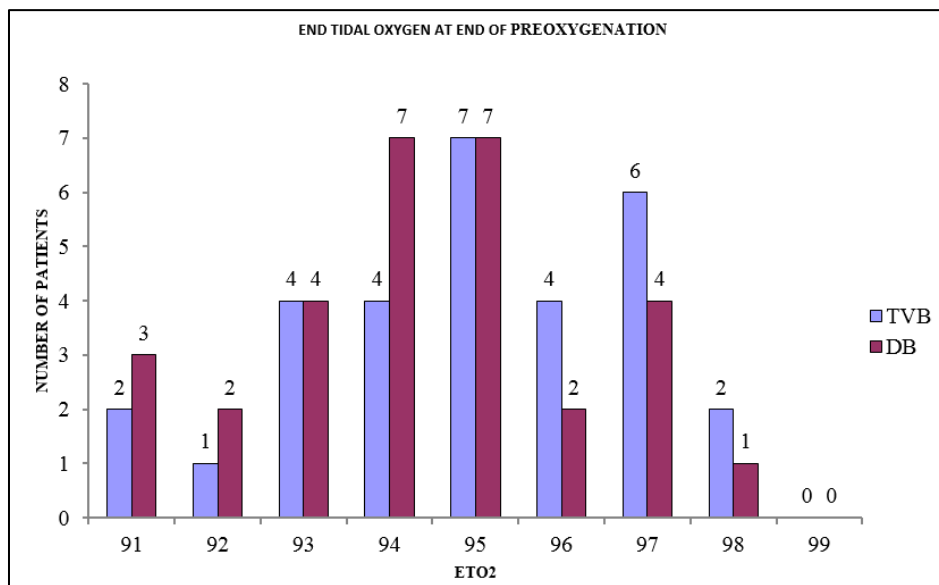


Fig. 1

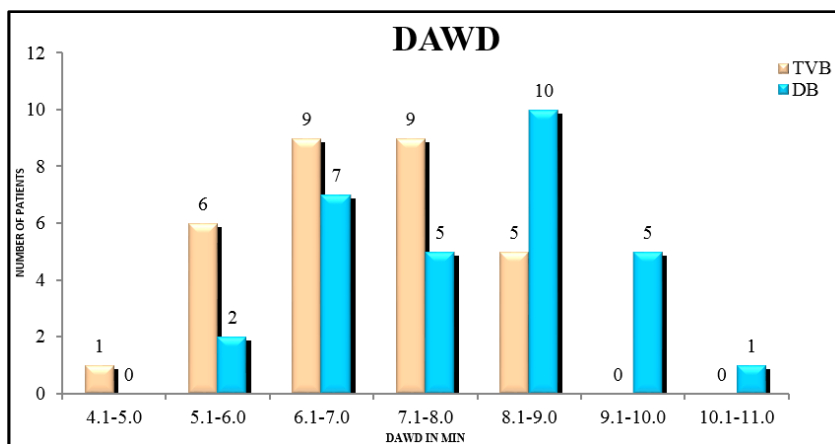


Fig. 2

Discussion

The safety and wellbeing of the patient are fundamental goals for the anaesthesiology specialty. There has been a recent talk for preoxygenation to be considered essential in avoiding adverse outcomes when faced with difficulty with ventilation. Several studies have shown that patients reach ETO₂.

of 90 % after 3 minutes of normal tidal volume breathing of 100%O₂ using O₂ flow of 5 L/min through standard breathing systems. This is the traditional technique of preoxygenation. In certain clinical situations like full stomach posted for emergency surgery, foetal distress and un co-operative patients, it may not be possible to pre-oxygenate for 3 minutes. In these situations, a shorter method of preoxygenation would be useful and a better alternative. This study was conducted to compare the traditional preoxygenation technique of 3 minutes with the fast technique of preoxygenation - 8 deep breaths in 60 secs.

In 1981, Gold⁶ et al showed that mean PaO₂ after four deep breaths of 100% oxygen at 5 L/min within 30 seconds is not significantly different from those obtained after 3 minutes of normal tidal volume breathing. So, we chose 3 minutes for the traditional technique of preoxygenation. The fast technique of preoxygenation was not initially accepted. Gamber⁷ and Mc Carthy⁸ who showed that four deep breaths technique of pre-oxygenation was inferior to the traditional 3 minutes technique. Later, Baraka et al⁹ increased the time of deep breathing from 30 sec to 60 secs and performed a study. Eight deep breaths were taken in 1 minute. The conclusion was that 8 deep breaths in 60 seconds produced PaO₂ values comparable to that achieved by traditional preoxygenation technique. They had the O₂ flow set at 10 L/min. So, we chose to compare the traditional technique of tidal volume breathing of 3 minutes with the fast technique of 8 deep breaths in 60 sec technique. These studies were not done in hospital settings with the patients posted for elective surgeries.

In elderly people, the functional residual capacity (FRC) falls below closing capacity. The change in the relationship between functional residual capacity and closing capacity causes an increased V/Q mismatch, which in turn leads to

lower oxygen stores in elderly patients than in young adults. To overcome this problem, we included only patients in the age group 20 – 50 years. Maximum number of patients were in the age group 20 – 30 years (20 patients in each group). The mean age in group T was 28.06 ± 4.85 years and in group D was 28.4 ± 5.19 years. There was no significant difference in the age of patients in both groups (p value 0.798).

There is 18% reduction in FRC during pregnancy. The reduced FRC diminishes oxygen reserve within the lung and the patient is able to withstand only very short periods of apnoea. Pregnant patients were excluded from our study. There were 16 male patients and 14 female patients in group T and 17 male and 13 female patients in group D. the male: female ratio was similar in both the groups.

Obesity is one of the most important clinical factor associated with hypoxemia. The lungs are major oxygen store of the body and lung volume decreases in obese subjects on induction of anaesthesia. Goldberg¹⁰ et al in a study on morbidly obese patients demonstrated that obese patients in traditional method of pre-oxygenation group hypoventilated significantly during pre-oxygenation and by the end of induction and intubation, had developed a decrease in pH and significantly elevated PaCO₂. Rapaport S¹¹ et al further reaffirmed this while comparing 8 deep breathing and tidal volume breathing preoxygenation techniques in morbid obese patients, found that patients in 8 deep breaths group had ET CO₂ (end tidal CO₂) of 29.0±1 mm of Hg while traditional group had ET CO₂ of 36±5 mm of Hg at the end of pre-oxygenation thus showing that 8 deep breath patients did not hypoventilate. In our study, we excluded obese patients with BMI >30 and restricted the study for patients with BMI between 25 and 30. The height of the patients in both the groups were compared. The mean height in group T was 158.03 ± 4.28cm and 157.0 ± 3.89 cm in group D. The values in both the groups were not statistically significant (p value 0.85). Weight of the patients included in our study was compared and there was no statistically significant difference. The mean weight in group T was 63.06 ± 5.7 Kg and in group D was 63.26 ± 5.72 Kg (p value 0.892). The Body Mass Index was also calculated for all the patients included in our study. Mean BMI in group T was 25.183 ± 1.67 and in group D was 25.31 ± 1.47. The p value was 0.746

which is not statistically significant. Most of the patients had a BMI between 25.1–26.0.

The maximum effects of preoxygenation are achieved when the alveolar, arterial, tissue and venous compartments are filled with oxygen. Patients who have reduced Haemoglobin concentration desaturate much faster during apnoea than a healthy patient. Patients with Hb < 10gm/dL were excluded from the study. The haemoglobin values of the patients in our study was comparable. The mean Hb was 12.78 ± 1.63 gm/dL in group T and 12.59 ± 1.603 gm/dL in group D (p value 0.683).

Various end points have been used to compare different techniques of preoxygenation – minimum end tidal nitrogen fraction,⁷ maximum arterial oxygen tension,⁶ maximum end tidal oxygen fraction⁵ and pulse oximetry.¹² Reaching SpO₂ of 100% as measured by pulse oximetry does not mean that preoxygenation is complete. The most useful indicators of the completeness of preoxygenation are ETN₂ or ETO₂ fractions as they reflect the alveolar fraction of N₂ and O₂ respectively. In our study we compared the ETO₂ Values at the end of preoxygenation technique to check the adequacy of both the techniques. Only patients who had ETO₂ of above 90% at the end of preoxygenation were allowed to complete the study. The mean ETO₂ in group T was 94.96 ± 1.92 and in group D was 94.33 ± 1.88 (p value 0.202). The ETO₂ values were not statistically significant.

The most common cause of failure of preoxygenation is an incomplete seal with the facemask. The shape of the face or patients having beard or uncooperative patients are some of the contributing factors. To ensure that the preoxygenation was complete, we noted the ETO₂ values at the end of the preoxygenation technique. ETO₂ of above 90% indicates that preoxygenation is complete. Gagnon¹³ showed that any leak in the system leads to breathing room air and the final result is deoxygenation. Gagnon¹³ et al in their study concluded that ETO₂ decreases significantly with both preoxygenation techniques (Vital capacity or TVB) to approximately 60%.

We used a large tidal volume for preoxygenation in the patients to prevent rebreathing. Nimmagadda¹⁴ et al showed that when circle absorber system was used, the nitrogen rebreathing with increasing fresh gas flow had no discernible impact on preoxygenation during TVB. During the Deep breathing technique, there are chances of rebreathing which lead to incomplete preoxygenation. The high flow rates help to prevent rebreathing and compensate for any existing leak around the face mask. In our study we used the circle absorber system for preoxygenation technique. We flushed the circuit with 100% oxygen before starting the procedure and maintained a fresh gas flow at 10L/min for both the techniques. All our patients, in both the groups had ETO₂ of above 90 at the end of preoxygenation.

Heart rate of the patient at the beginning of the preoxygenation technique, end of technique and end of apnoea period was noted. Systolic blood pressure was also compared at the same time as heart rate. The systolic blood pressure at end of preoxygenation technique was 121.46 ± 4.67 mmHg in group TVB but 125.76 ± 5.44 mmHg. The p value was 0.001 which is highly significant. The systolic

blood pressure at beginning of preoxygenation technique and end of apnoea were noted but there was no significant difference in both the groups.

Preoxygenation increases the oxygen reserves and duration of apnoea without desaturation (DAWD), thus it provides valuable additional time to secure the airway. The effectiveness of preoxygenation can be evaluated by measuring DAWD – the time for oxygen saturation to decrease to less than 90%. Clinically, preoxygenation is considered adequate when ETO₂ more than 90%.¹⁵ This was achieved with the 3 min TVB and the 8D B in 60 seconds techniques in our study. To measure the effectiveness of both the techniques we also noted the time taken for saturation to reach 90% during apnoea.

Healthy humans can tolerate periods of relative hypoxia lasting hours to days (SPO₂ <80). However, avoiding SPO₂ < 90% is recommended at induction of anaesthesia because SPO₂ usually diminishes rapidly after the initial decrease is observed. Therefore, we defined the safe duration of apnoea, also termed DAWD as the interval between onset of apnoea and the time SPO₂ reaches a value < 90%. DAWD depends on oxygen reserve at the start of apnoea, oxygen consumption and amount of oxygen required to maintain SPO₂ 90%. The choice of patients included in our study ensured that the above-mentioned factors remain almost similar in all the patients.

The mean DAWD value in group T was 6.84 ± 1.094 min and in group D was 7.88 ± 1.255 min. The DAWD value was statistically highly significant with a p value of 0.0011. This shows that rapid preoxygenation by 8 deep breaths in 60sec resulted in a longer period of apnoea without desaturation.

The reason for better DAWD time in the fast technique was the significantly different ETCO₂ values in both the groups. We observed that the mean ETCO₂ value in group T was 32.16 ± 1.51 and in group D was 27.36 ± 1.73 . The p value was <0.001 which shows statistically highly significant.

Jonathan L. Benumoff² had documented that 8 deep breaths in 60 secs method of pre-oxygenation (hyperventilation for one minute) could result in a significant decrease in PaCO₂ and pH. The change in pH and PaCO₂ changes the position in Oxy Haemoglobin curve and the oxygen consumption. As a result, the rate of Haemoglobin desaturation is altered. In our study the arterial blood gases were not noted. We presume that this is probably the explanation to the results of our study which showed eight deep breaths in sixty seconds method resulted in slower haemoglobin desaturation than the tidal volume breathing method.

Conclusion

We conclude that pre -oxygenation using eight deep breaths within 60 secs at oxygen flow of 10 L/min is an excellent method of rapid pre-oxygenation with regard to both efficacy and efficiency in the hospital setting in patients posted for elective surgeries. This technique provides adequate oxygen saturation in arterial blood (SpO₂) values and End Tidal Oxygen values (ETO₂) of above 90%. There is

a significant increase in the time taken for desaturation after apnoea. This technique can be useful in patients who require rapid sequence intubation during emergency surgeries. We recommend that eight deep breaths technique may be a better alternative to the traditional technique of pre-oxygenation in patients undergoing rapid sequence induction, anticipated intubation / ventilation difficulty and very uncooperative patients.

Conflict of Interest: None.

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How to cite this article: Kaparti L, Sekhar CT, Padmaja R. A randomised control study comparing the efficacy of 2 techniques of preoxygenation - tidal volume breathing for one minute and 8 deep breaths in one minute. *Indian J Clin Anaesth* 2019;6(1):71-76.