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# Is four vital capacity breath pre-oxygenation technique useful?: A study

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## Abstract

**Background:** Many techniques of pre-oxygenation have been proposed and followed world-wide. 3–5 minutes of tidal volume pre-oxygenation is the most preferred technique of choice for pre-oxygenation. This technique may not be feasible in emergency situations. Hence this study was conducted to evaluate the efficacy and utility of four vital capacity breath pre-oxygenation technique, as its less time consuming.

**Methods:** Fifty American Society of Anesthesiologists grade I and II patients in the age group of 20–40 years were studied under two groups of 25 each. Group I did not receive any pre-oxygenation and group II received pre-oxygenation in the form of four vital capacity breaths in 30 seconds. Rescue breaths with 100% oxygen were administered to all those patients whose oxygen saturation dropped below 75%.

**Results:** It was observed that after one minute of post induction apnea, patients in group I had a reduction in oxygen saturation to a mean of 79.92±3.328%, in comparison to 87.24±2.368% in group II. It was also observed that vital parameters at the end of 1 min of apnea were close to baseline values in group II. The results were analysed using the "Analysis of Variance" (ANOVA) method.

**Conclusions:** Pre-oxygenation with four vital capacity breaths does prolong the onset of desaturation and thus can be useful in emergency situations where time is precious.

**Keywords:** Pre-oxygenation, Oxygen saturation, General anaesthesia, Four vital capacity breaths, Desaturation.

## Introduction

Pre-oxygenation with 100% oxygen has been proved very beneficial in any case of general anesthesia.[1-4] Maximal pre-oxygenation is achieved when alveolar, arterial, tissue and venous compartments are filled with oxygen. However, patients with a compromised oxygen carrying capacity, like those with decreased functional residual capacity, anaemia, poor alveolar ventilation, decreased cardiac output and or an increased oxygen extraction, become hypoxic during apnoea much faster than healthy individuals.[2] Consequently, in patients with poor oxygen transport and in any patients who have difficult airway, maximal pre-oxygenation is indicated. Moreover, because of the difficult airway, situation is largely unpredictable, hence the need to pre-oxygenate is present in all patients. American society of Anaesthesiologists difficult airway algorithm[1] makes no mention of pre-oxygenation and it should include a requirement of pre-oxygenation before the induction of general anesthesia wherever possible.

When oxygenation is interrupted by apnoea, existing oxygen stores are consumed for cellular metabolism, if the stores are exhausted, hypoxia and cellular death occurs.[1] Normal oxygen store in an adult is approximately 1550ml.[2] This is the amount of oxygen remaining in lungs, that binds to haemoglobin and that gets dissolved in body fluids. Haemoglobin has a high affinity towards oxygen and oxygen in solution is very meagre, which restricts the availability of these stores. The oxygen content of functional residual capacity in lungs becomes main source of oxygen and of which only 80% is usable.

Apnoea in any patient who is breathing room air leaves approximately 450ml[2] of oxygen in lungs (Functional residual capacity, FRC- 2300ml, oxygen concentration in air, FiO2- 21%, oxygen present in lungs = FiO2xFRC). The tissue metabolism rapidly uses up these stores and severe hypoxia usually occurs in 90-120 seconds. The onset of this systemic deoxygenation can be delayed by increasing FiO2 prior to apnoea.[2] On ventilation with 100% oxygen, FRC contains 3,000 ml[2] of oxygen. This delays development of hypoxia, following apnoea for 4-5mins. This is the basis on which pre-oxygenation prior to induction of general anesthesia prevents tissue hypoxia.

The anaesthesiologists often face difficult intubation and ventilation situations. Prolongation of the safe period after induction and prior to intubation in general anaesthesia is therefore desirable. Nitrogen is replaced by oxygen in the functional residual capacity during pre-oxygenation and this increases oxygen stores, thus prolonging the safe duration of apnoea after induction of general anesthesia & administration of muscle relaxants.[1,3]

Study conducted by Hamilton and Eastwood[3] and Dillon and Darsi[4] in 1955 found that administration of oxygen pre-operatively avoided significant desaturation of arterial blood and recommended pre-oxygenation in all patients for procedures under general anesthesia. Many Studies done in the past have found four vital capacity breath pre-oxygenation technique equally effective as compared to different other techniques. In

1981, Martin I. Gold et al[5] found a similar PaO2 after four maximal deep breaths with 100% oxygen taken in 30 seconds compared to that achieved after 5 minutes of tidal volume breathing with 100% oxygen, in the same group of patients. Mark et al,[6] in 1985 found that there was no significant statistical difference between four vital capacity breath technique and 3 minutes tidal volume technique in pregnant patients subjected for caesarean sections. Similarly, in 1989 Goldberg M et al[7] compared PaO2 in four vital capacity technique and 3 minute tidal volume technique in morbidly obese individuals and found both techniques equally effective and in year 1994, M. J. Rooney(8) also found four or more vital capacity breath technique of pre-oxygenation to be as reliable as traditional 3 minute tiadal volume pre-oxygenation technique. Several other studies have demonstrated various techniques[9-14] and have used different methods[15-18] to determine the adequacy of pre-oxygenation. Though traditionally 3 mins tidal volume oxygenation is considered the best technique, this technique cannot be used in certain emergency situations where time is valuable. Hence four vital capacity breath technique becomes the technique of choice in such situations. Hence this study was undertaken to determine its feasibility in emergent situations.

## Materials and Methods

After getting the Institutional ethics committee approval, along with Informed and written consent from fifty American Society of Anesthesiologists grade I and II adult patients, aged between 20 and 40 yrs of either sex were randomly divided into two groups each of twenty five patients. All the patients with Mallampati Class I airway status and those scheduled for surgeries under general anaesthesia were included. Patients with cardiorespiratory diseases, large abdomen/ thorax/ neck tumour, pregnancy, obesity, neuromuscular disorders, hemoglobinopathies and smokers were excluded from the study.

Group I – Patients did not receive any pre-oxygenation.

Group II – Patients received pre-oxygenation in the form of four vital capacity breaths in 30 seconds at a flow of 10L/min through Bain system.

All patients received pre-medication with Tab. Diazepam0.2mg/kg body weight and Tab Ranitidine 3 mg/kg body weight orally on the night before and in the morning, one hour before surgery. Baseline heart rate, peripheral oxygen saturation, systolic and diastolic blood pressure of all patients were recorded. All group II patients received pre-oxygenation with four vital capacity breaths using Bain system prior to the induction of general anaesthesia. Inj.Thiopentone sodium 5mg/kg was used to induce general anesthesia, Inj.Succinylcholine 1.5 mg/kg was given to facilitate orotracheal intubation with a cuffed tube and time noted. For subsequent one minute, the patients did not receive any oxygen. Rescue breaths with 100% oxygen were given when saturation dropped below 75%. At the end of one minute, heart rate (HR), peripheral oxygen saturation (SPO2) systolic blood pressure (SBP) and diastolic blood pressure (DBP) were noted, laryngoscopy was done and the trachea was intubated with an adequate sized endotracheal tube. The lungs were ventilated with 100% oxygen and 0.5% Halothane, till peripheral oxygen saturation reached 100%. Subsequently Nitrous oxide was administered and the surgery was commenced. Results were analysed statistically by application of analysis of variance (ANOVA) technique.

## Results

All the data is presented as mean +/- standard deviation. Based on p - value, the result is stated as significant or not significant.

p - value: < 0.05 - significant

<0.01 - highly significant

<0.001 - very highly significant

>0.05 - not significant

Two groups were similar with respect to age [Table 1], weight [Table 2], height [Table 3] and American society of Anaesthesiology physical status.

It was observed that the increase in heart rate [Table 4], systolic [Table 5] and diastolic blood pressure [Table 6] after one minute of apnea as compared to the baseline mean values in both the groups was statistically significant. However the values in group 2 remained closer to the baseline values.

Rescue breaths were not given to any patient as the saturation in all the patients remained above 75%. Though both groups showed statistically significant reduction in oxygen saturation [Table 7] at the end of one min of apnea, fall in group 2 was far less than that in group 1, the difference in mean oxygen saturation between two groups being 7.32%.

**Table 1**

| Age | | | | |
|---|---|---|---|---|
| | **N** | **Mean** | **SD** | **P** |
| Group 1 | 25 | 31.4 | 5.36190 | 0.5 |
| Group 2 | 25 | 32.12 | 5.46443 | |

N- Number
SD- Standard deviation
P- p value

**Table 2**

| Weight | | | | |
|---|---|---|---|---|
| | **N** | **Mean** | **SD** | **P** |
| Group 1 | 25 | 59.76 | 6.44386 | 0.803 |
| Group 2 | 25 | 61.40 | 6.78233 | |

**Table 3**

| Height | | | | |
|---|---|---|---|---|
| | **N** | **Mean** | **SD** | **P** |

| | | | | |
|---|---|---|---|---|
| Group 1 | 25 | 159.160 | 6.27615 | 0.788 |
| Group 2 | 25 | 159.000 | 6.35085 | |

**Table 4**

| Heart Rate | | | | | |
|---|---|---|---|---|---|
| | | **N** | **Mean** | **SD** | **P** |
| Group 1 | Baseline | 25 | 78.560 | 5.14846 | 0.001 |
| | 1 minute | 25 | 111.480 | 10.748 | |
| Group 2 | Baseline | 25 | 77.6000 | 5.85947 | |
| | 1 minute | 25 | 109.280 | 6.195 | |

**Table 5**

| Systolic Blood Pressure | | | | | |
|---|---|---|---|---|---|
| | | **N** | **Mean** | **SD** | **P** |
| Group 1 | Baseline | 25 | 121.9200 | 7.60438 | 0.001 |
| | 1 minute | 25 | 148.000 | 9.730 | |
| Group 2 | Baseline | 25 | 119.3600 | 7.29657 | |
| | 1 minute | 25 | 138.400 | 6.083 | |

**Table 6**

| Diastolic Blood Pressure | | | | | |
|---|---|---|---|---|---|
| | | **N** | **Mean** | **SD** | **P** |
| Group 1 | Baseline | 25 | 78.0000 | 4.83046 | 0.001 |
| | 1 minute | 25 | 95.200 | 5.477 | |
| Group 2 | Baseline | 25 | 76.0000 | 5.47723 | |
| | 1 minute | 25 | 91.600 | 4.619 | |

**Table 7**

| Peripheral Oxygen Saturation | | | | | |
|---|---|---|---|---|---|
| | | **N** | **Mean** | **SD** | **P** |
| Group 1 | Baseline | 25 | 99.160 | 0.850 | 0.001 |
| | 1 minute | 25 | 79.920 | 3.328 | |
| Group 2 | Baseline | 25 | 99.120 | 0.833 | |
| | 1 minute | 25 | 87.240 | 2.368 | |

## Discussion

The fact that pre-oxygenation is of great help in delaying the onset of desaturation was first established by Hamilton and Eastwood[2] in their study.

The main goal of pre-oxygenation is denitrogenation and End tidal oxygen is probably the best surrogate marker.[2] Partial pressure of arterial oxygen may also be considered as surrogate marker for pre-oxygenation, as it is proportional to the partial pressure of alveolar oxygen in functional residual capacity, which is the main oxygen store. However the only reason that we perform pre-oxygenation is to prevent desaturation. If we observe the equation of oxygen content in arterial blood:[2]

CaO2: (SaO2 x Haemoglobin % x 1.36) + (0.003 x PaCO2)

CaO2: Oxygen content of the blood

SaO2: Oxygen saturation of haemoglobin

PaO2: Partial pressure of oxygen of arterial blood in mmHg

0.003: Solubility coefficient of oxygen

1.34: Oxygen binding capacity of haemoglobin.

By this equation it is very clear that the contribution of saturation is more important than the contribution of PaO2 on oxygen content of the blood. Hence the time to desaturate is a more appropriate outcome measure for efficiency of pre-oxygenation.

Studies done[8,14,19] in the past have concluded that 97-98% of the patients desaturated without pre-oxygenation, during intubation, stressing the need for pre-oxygenation. Howerver most of the techniques used were time consuming and were avoided during emergency situations, where time was scarce. So a technique which consumed less time would be very useful and valuable in such emergency circumstances.

In our study we found that four vital capacity breath pre-oxygenation technique consumed less than 30 seconds and also increased the duration of safe period before the hypoxia sets in after induction of general anesthesia, as compared to no pre-oxygenation technique. Results of our study correlate well with other studies[5-8] where four vital capacity breaths was used as a technique of pre-oxygenation. Hence we concluded that four vital capacity breath pre-oxygenation technique plays a very vital role in emergency situations where time is precious.

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