Pre-Oxygenation: A Comparison of Three Techniques

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ABSTRACT

Background: Pre-oxygenation is a time honoured ritual carried out in a variety of circumstances. Various methods of pre-oxygenation have been proposed and followed world wide with variable success. The purpose of this study was to evaluate the need for pre-oxygenation prior to the induction of general anaesthesia and also compare the effects of three techniques of pre-oxygenation, on peripheral oxygen saturation and vital parameters.

Patients and Methods: Hundred ASA grade I and II patients in the age group of 20-40 years were studied under four equal groups. Group I did not receive any pre-oxygenation, group II received pre-oxygenation in the form of four vital capacity breaths, group III and group. IV received pre-oxygenation for 3 and 5 minutes respectively.

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, 96.84 ± 1.972% in group III and 99.28 ± 0.737% in group IV. It was also observed that vital parameters at the end of 1 min of apnea were close to baseline values in group III and group IV. The results were analysed using the "Analysis of Variance" (ANOVA) method.

Conclusion: Pre-oxygenation for 5 minutes prior to induction of general anaesthesia is the best technique among the three, as it provides maximum safe period before the hypoxia sets in after induction of general anaesthesia and also the vital parameters remain closer to baseline.

KEYWORDS: Pre-oxygenation, General Anaesthesia, Induction, Oxygen saturation.

Pre-oxygenation with 100% oxygen replaces nitrogen in the functional residual capacity & increases oxygen stores, thus prolonging the safe duration of apnea after induction of general anaesthesia & administration of muscle relaxants. The anaesthesiologist often faces situation in which intubation is difficult & mask ventilation is inadequate. Prolongation of the safe period after the hypoxemia sets in after induction of general anaesthesia is therefore desirable.

Several studies have demonstrated various techniques and have used different methods to determine the adequacy of pre-oxygenation. We used pulse oximeter to evaluate the need of pre-oxygenation, to compare effect of varying durations of pre-oxygenation on oxygen saturation and arrive at a value of optimal duration of pre-oxygenation to tide over the period of hypoxia that occurs during the process of securing airway.

PATIENT AND METHODS

After obtaining approval from our institutional ethics committee and written consent from hundred ASA grade I and II adult patients aged between 20 and 40 yrs of either sex were randomly allocated into four groups of twenty five each.

All patients included in the study were Mallampati Class I on airway examination and were scheduled for surgeries under general anaesthesia. Patients with cardiorespiratory diseases, large abdomen/ thorax/ neck tumour, pregnancy and 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 our vital capacity breaths in 30 secs with oxygen flow of 10 L/min through Bain system.

Group III – Pre-oxygenation in the form of 3 min tidal volume breathing using an oxygen flow of 10 L/min through Bain system.

Group IV - Pre-oxygenation in the form of 5 min tidal volume breathing using an oxygen flow of 10 L/ min through 3 min system.

All patients were pre-medicated with Tab. Diazepam 0.2mg kg⁻¹ body weight and Tab Ranitidine 3 mg kg⁻¹ body weight orally on the night before and in the morning, one hour before surgery. After recording baseline heart rate, peripheral oxygen saturation, systolic and diastolic blood pressure, depending on the group the patient belonged to the pre-oxygenation was instituted using Bain system prior to the induction of general anaesthesia. General anaesthesia was induced with Inj thiopentone sodium.
5mgkg⁻¹ Succinylcholine 1.5 mgkg⁻¹ was given to facilitate orotracheal intubation with a cuffed tube and time noted. The patients were not oxygenated for a period of one minute. 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%. Following this nitrous oxide was administered and the surgery was commenced.

Results were analysed statistically by application of analysis of variance (ANOVA) technique.

RESULTS
Four groups were similar with respect to age, weight, height and ASA physical status.

It was observed that the increase in HR (Table 1), SBP (Table 2) and DBP (Table 3) after one minute of apnoea as compared to the base line mean values in respective groups was statistically significant. The values in group III and group IV were close to mean baseline values.

The reduction in SpO₂ in group IV (Table 4) was found to be statistically insignificant and that in group III significant, but values were very close to baseline values, differences in mean SpO₂ being 2.56%. Group I and II showed a significant reduction in SpO₂ at the end of one minute of apnoea but the fall in group II was significantly less than that in group I, the difference in mean SpO₂ being 7.32%.

### Table 1

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<th>SD</th>
<th>P</th>
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### Table 2

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<td>148.000</td>
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<td></td>
<td>1 minute 25</td>
<td>125.280</td>
<td>6.079</td>
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The statistics clearly prove that the technique of pre-oxygenation used in group IV is supreme into other techniques. Group III statistics are very close to those of group IV, and the technique used for this group saves two minutes of valuable time for anesthesiologist. Group II statistics though are far worst than those of group IV, they are significantly better than those of group I. Therefore this technique of pre-oxygenation has definitely a role in rapid sequence induction where anaesthesiologist has less time in hand.

### DISCUSSION

In 1955, Hamilton and Eastwood demonstrated that denitrogenation is 95% complete within 2-3 minutes, if a subject is breathing at normal tidal volume from a circle anaesthesia system with an oxygen flow of 5L/min. These studies lead to the recommendation that pre-oxygenation should last for 3-5 minutes.

Given that the aim of pre-oxygenation is actually denitrogenation, the end tidal oxygen is probably the best “surrogate marker”. PaO₂ may also be taken as surrogate marker for pre-oxygenation, because PaO₂ is proportional to the alveolar PO₂ in the functional residual capacity, which is the main oxygen store. However, the only reason that we perform pre-oxygenation maneuvers is to attempt to increase the oxygen content of the body and to prevent desaturation. If we observe the equation of oxygen content of arterial blood:

\[ \text{Oxygen Content} = H_b \times C_b H_b + \text{HbO}_2 + \text{HHb} + \text{COHb} \]

where:
- \( H_b \) is the concentration of hemoglobin
- \( C_b \) is the content of oxygen bound to hemoglobin
- \( HbO_2 \) is the concentration of oxygenated hemoglobin
- \( HHb \) is the concentration of deoxyhemoglobin
- \( COHb \) is the concentration of carboxyhemoglobin
\[ \text{CaO}_2 : (\text{SaO}_2 \times \text{Haemoglobin\%} \times 1.34) + (0.003 \times \text{PaCO}_2) \]
\[ \text{CaO}_2 : \text{Oxygen content of the blood} \]
\[ \text{SaO}_2 : \text{Oxygen saturation of haemoglobin} \]
\[ \text{PaO}_2 : \text{Partial pressure of oxygen of arterial blood in mmHg} \]
\[ 0.003 : \text{Solubility coefficient of oxygen} \]
\[ 1.34 : \text{Oxygen binding capacity of haemoglobin.} \]

By this equation it is very clear that the contribution of saturation is more important than the contribution of PaO\(_2\) on oxygen content of the blood. Thus the time to desaturate is a more appropriate outcome measure for efficiency of pre-oxygenation.

Thorpe C. M. et al\(^4\) determined the incidence of hypoxia using pulse oximetry during induction of anaesthesia. It was concluded that 98% of the patients not preoxygenated developed hypoxia during intubation. Skea et al\(^9\) observed that in pre-oxygenated patients the SpO\(_2\) values remained at a mean of 98% during apnoeic period of intubation whereas it reduced to a mean of 81% in the non-oxygenated group. Hett et al\(^4\) observed that 97% of patients in whom no pre-oxygenation was done had a reduction in saturation to a mean of 84% and in patients in whom three minutes of pre-oxygenation was done had a mean saturation of 98% during the apnoic period of intubation.

In our study, we found that group I in whom no pre-oxygenation was given, a minute of apnoea in the post induction phase resulted in a reduction of saturation to a mean 79.92 ± 3.328% as compared to 87.24 ± 2.368% in the group II, to whom pre-oxygenation was instituted in the form of four vital capacity breaths. This was in sharp contrast to the groups in whom pre-oxygenation was given for three and five minutes respectively. In these latter groups, the saturation reduced to a mean of 96.84 ± 9.72% and 99.28 ± 0.732% respectively. We also found the variation in vitals to be very minimal in group III and group IV as compared to that in group I and group II.

The results of our study correlate well with those obtained in the study conducted by Hett et al.\(^4\) Our results also were in accordance with the study done by Skea et al.\(^9\).

In conclusion pre-oxygenation for 5 minutes prior to induction of general anaesthesia is the best technique among the three, as it provides maximum safe period before the hypoxia sets in after induction of general anaesthesia and also the vital parameters remain closer to baseline.

## REFERENCES