PREOXYGENATION IN PARTURIENTS: A COMPARISON OF 4, 6 AND 8 VITAL CAPACITY BREATHS TO 5 MINUTES OF TIDAL VOLUME BREATHING

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ABSTRACT

We compared the difference in denitrogenation (by intermittent measurement of arterial tension, $Pa0_2$) in 45 parturients at term when preoxygenated with 4, 6 or 8 rapid vital capacity breaths and 5 minutes of tidal volume breathing. Oxygen, at 8 litres min-1, was delivered through a facemask via a circle absorber with a 2 litre reservoir bag. Higher $Pa0_2$ was produced with 5 minutes of tidal volume breathing. This differed significantly from the $Pa0_2$ produced by 4, 6 or 8 rapid vital capacity breaths ($p < 0.01$).

Keywords: Preoxygenation, Parturients.

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INTRODUCTION

Preoxygenation aims to increase oxygen reserves in order to increase the duration of apnoea that will be possible before the onset of hypoxia. The need to preoxygenate all patients prior to the induction of balanced anaesthesia has been firmly established for the last three and a half decades. Traditionally, this consisted of tidal volume breathing of 100% 0_2 for 3-5 minutes (1, 2).

A new method, the four rapid vital capacity breaths which can be performed within 30 seconds was advocated to be just as effective by Gold et al (3). This was demonstrated to allow three minutes of apnoea without arterial desaturation of greater than 6% by Drumond et al (4) and to be safe in the parturient by Norris et al (5).

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However, recent studies (6, 7) utilizing the mass spectrometer, which measures concentration of gases continuously, demonstrated suboptimal oxygenation with 4 vital capacity breaths and suggest that 8 vital capacity breaths may be required to provide maximum oxygenation.

In view of the conflicting evidence, it is necessary to re-examine "the 4 rapid vital capacity breaths" technique of preoxygenation. We compared the efficacy of different techniques of preoxygenation in parturients at term as they were most at risk. Pregnancy being associated with a 20% decrease in functional residual capacity (FRC) and a 20% increase in oxygen consumption (8). Furthermore most of the published work on preoxygenation has concerned the nonpregnant general surgical patient.

Study design took into consideration the limitations and constraints faced during the conduct of anaesthesia in the operation theatre. In addition, patients were preoxygenated for 5 minutes as we were interested in maximum oxygen reserves.

The objective of this study was to ascertain (from among the methods studied) which method of preoxygenation in pregnant patients provided maximum oxygen reserves with reference to arterial oxygen tension ($Pa0_2$).

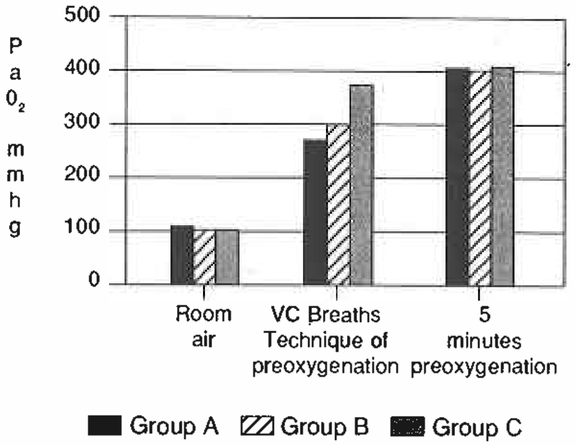
METHOD

After approval from the Medical Clinical Research Committee, informed consent was obtained from 45 patients between the age of 18-40 years, normal and healthy (ASA I) and non-smokers. They had been scheduled for elective caesarean section at term. All pregnancies were singleton and uncomplicated. Patients were randomly assigned to one of the three groups which differed only in the number of rapid vital capacity breaths administered:

Group A : 4 rapid vital capacity breaths

Group B : 6 rapid vital capacity breaths
Group C : 8 rapid vital capacity breaths

Fig I
The mean PaO_2 mmhg achieved for the various techniques of preoxygenation in groups A, B and C



After premedication with 15ml 0.3M sodium citrate the patient was brought to the operation theatre and positioned in the left lateral position. The radial artery was cannulated percutaneously with a #20G critikon catheter of 1 1/4 inch length under local anaesthesia. A baseline value of arterial blood was taken while the patient breathed room air (sample 1).

Rapid vital capacity breathing was explained and demonstrated to the patient prior to preoxygenation. (This approximates the routine sequence of events in the operation theatre where the lack of proper understanding or fear of impending surgery could prevent full cooperation produced by rapid vital capacity breathing.)

After maximum exhalation, a snugly fitting facemask was applied. This was connected to a semi-closed circle circuit with a carbon dioxide absorber and a 2 litre reservoir bag which had been prefilled with oxygen. This was chosen as it is a commonly used anaesthesia circuit, despite the fact that the vital capacity of parturients has been reported to be 4 litres (5). Oxygen was supplied at 8 litres min-1 as it is the maximum possible in many anaesthesia machines.

After the requisite number of rapid vital capacity breaths, a second sample of arterial blood was obtained (sample 2).

This was followed by normal tidal volume breaths with parturients breathing room air for 5 minutes. (This was determined after preliminary trials showed that blood gases approximate baseline values within 5 minutes of breathing room air.) The face mask was reapplied and the patient asked to breathe normally for 5 minutes, after which a third blood sample was obtained (sample 3).

All samples of arterial blood were immediately placed on ice and analysed within 30 minutes using the AVL 945 automatic blood gas analyser.

The various values of PaO_2 obtained from analysis of arterial blood gases were subjected to one way analysis of variance. Subsequently they were reanalysed using either the student's t test or paired t test whichever as appropriate (Bonferroni inequality was applied so that the risk of committing a type I error was less than 1%). A probability of $p < 0.01$ was considered to be significant.

RESULTS

There were no significant differences ($p > 0.05$) between the three groups of patients in terms of age, height and weight (Table I).

Table I
Characteristics of the Study Sample Illustrating Age (Mean ± SD), Height (Mean ± SD) and Weight (Mean ± SD)

	Group A (n=15)	Group B (n=15)	Group C (n=15)	p value*
Age(yrs)	30.5±6.1	30.9±4.6	32.2±4.6	p>0.05
Height (cm)	152.9±5.3	154.4±5.5	154.4±5.3	p>0.05
Weight(kg)	63.1±5.6	65.1±11.5	59.4±9.1	p>0.05

* One way analysis of variance used for comparing the means of each variable between groups A, B and C.

One way analysis of variance revealed no significant differences ($p > 0.05$) between groups A, B and C when baseline values of PaO_2, obtained when breathing room air (sample 1), were compared (Table II).

Table II
Arterial tension of oxygen (mmhg) achieved by Breathing Air (Mean ± SD), Rapid Vital Capacity Breaths (Mean ± SD) and 5 minutes of Tidal Volume Breathing (Mean ± SD)

	Group A (n=15)	Group B (n=15)	Group C (n=15)	p value*
Breathing Air	108.9±15.9	104.1±12.0	106.7±11.5	p>0.05
Rapid Vital Capacity Breaths	263.9±63.7	303.3±77.4	359.0±73.8	p>0.01**
5 minutes of Tidal Volume Breathing	402.6±80.1	397.0±112.0	409.0±81.6	p>0.05
p value #	p<0.01	p<0.01	p<0.01	

* One way analysis of variance used for comparing the mean PaO_2 of groups A, B and C.

** Analysis of these values with t test with bonferroni inequality showed that only mean PaO_2 of groups A and C were significantly different.

\# Paired t test used to compare the means of PaO_2 obtained by rapid vital capacity and 5 minutes of tidal volume breathing for groups A, B and C.

No significant differences were detected by analysis of variance between PaO_2 achieved after 5 minutes of tidal volume breathing (sample 3) between the three groups A, B and C (Table II).

Significant differences were detected by one way analysis of variance between the PaO_2 achieved in groups A, B and C by 4, 6 and 8 rapid vital capacity breaths respectively (sample 2) ($p < 0.01$). When these results were reanalysed using t test (with Bonferroni inequality applied to these results), no significant differences were detected between groups A and B, and between groups B and C. However the $Pa0_2$ of groups A and C were found to be significantly different ($p < 0.01$) (Table II p value**).

When the paired t test was used to compare $Pa0_2$ obtained by 4, 6 and 8 rapid vital capacity breaths (sample 2) to their respective $Pa0_2$ obtained by 5 minutes of tidal volume breathing (sample 3), statistically significant differences ($p < 0.01$) were found between these two values of $Pa0_2$ in each of the three groups (Table II p value#).

DISCUSSION

The need for preoxygenation with 100% oxygen to increase oxygen stores in the body to prevent hypoxia during the apnoeic interval following an induction sequence with intravenous anaesthetics and neuromuscular blockers in patients with full stomach is firmly established (2). However the choice of technique to achieve maximum oxygen reserves is controversial. The gold standard for preoxygenation, tidal volume breathing for 3 to 5 minutes, was questioned by Gold et al (3) when he demonstrated a comparable increase in $Pa0_2$ in twenty two ASA I and II patients when preoxygenated with 4 rapid vital capacity breaths.

They were further supported by Drumond et al, who demonstrated similiar desaturation in normal healthy cooperative patients preoxygenated with either one minute of tidal volume breathing or three vital capacity breaths. Additionally, Norris et al (5) also demonstrated comparable increase in $Pa0_2$ in twenty ASA I and II parturients preoxygenated with either three minutes of tidal volume or 4 rapid vital capacity breaths.

However, more recent studies utilising the mass spectrometer, (6, 7) suggest that 4 rapid vital capacity breaths is inferior to 3-5 minutes of tidal volume breathing in producing larger oxygen reserves.

Larger oxygen reserves is intuitively correlated with an increased ability to withstand the adverse effects of hypoxia; the greater the oxygen reserves the longer the time before hypoxic cerebral damage occurs. Parturients at term are particularly prone to hypoxia during the apnoeic interval, as they have an increased basal oxygen consumption and a reduced oxygen reserve secondary to a decrease in functional residual capacity. This predisposition assumes greater clinical relevance when difficult intubation is anticipated.

In this study, which used $Pa0_2$ as an index of oxygenation, comparison of the various techniques of oxygenation showed that highest $Pa0_2$ was achieved in parturients only after five minutes of tidal volume breathing and that four rapid vital capacity breaths advocated by Gold et al (3) for preoxygenation of nonpregnant was the least effective technique and produced the lowest $Pa0_2$ in our patients. This is in agreement with the findings obtained by Russell et al (7). Using the mass spectrometer, they demonstrated lower alveolar oxygen content in twenty ASA I parturients when preoxygenated with four slow vital capacity breaths when a Magill circuit with an oxygen flow of 8 litres min-1 was used when compared to 2 minutes of tidal volume breathing.

The $Pa0_2$ produced by 4, 6 and 8 rapid vital capacity breaths in our patients were significantly lower to $Pa0_2$ produced by 5 minutes of tidal volume breathing ($p < 0.01$). This finding was similiar to to the result obtained by Cruise et al (6) even though their work was on nonpregnant ASA I healthy volunteers. They demonstrated, using the mass spectrometer, that at least eight rapid vital capacity were required to produce an equivalent denitrogenation of lungs to two minutes of tidal volume breathing in these volunteers breathing from a circle absorber with with oxygen flowing at 10 litres min-1.

The results obtained from this study and the Russell study are contradictory to those obtained by Norris et al (5) in that 4 rapid or slow vital capacity breaths do not oxygenate parturients to the same degree as 2-5 minutes of tidal volume breathing.

The $Pa0_2$ achieved after 3 minutes of tidal volume (385 ± 23 mmHg) in the Norris study, appears to be similiar to the $Pa0_2$ achieved by 5 minutes of tidal volume in this study (402 ± 80, 397 ± 112 and 409 ± 81 mmHg) when the two different time intervals were considered. However the $Pa0_2$ achieved by 4 rapid vital capacity were significantly greater in the Norris study ($Pa0_2$ 404 ± 15 mmHg) when compared to the results of this study ($Pa0_2$ 269 ± 63 mmHg).

Perhaps it could be considered that patients in this study were less cooperative, or instructions to patients were inadequate when compared to those in the Norris study. It should also be remembered that this study was designed to mimic the real life situation in the operation theatre and this could also have adversely affected results.

However, in view of similiar results obtained by the Russell and Cruise studies, earlier results may have been flawed.

Additional evidence to support this statement is the report by Gambee et al (9) who demonstrated earlier desaturation in ASA I nonpregnant patients who were preoxygenated with four rapid vital capacity breaths as compared to those who were preoxygenated with 3 minutes of tidal volume breathing.

In conclusion, parturients at term achieve significantly greater oxygen reserves with five minutes of tidal volume breathing as compared to 4, 6 and 8 rapid vital capacity breaths, while breathing through a circle absorber with a 2 litre reservoir bag with an oxygen flow of 8 litres min-1 ($p < 0.01$).

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