

# Denitrogenation: A Comparison Between Two Techniques

MASHFAQUE MAKRAM

Department of Anaesthesia, Lahore General Hospital, Lahore  
Correspondence To: Dr. Muhammad Ashfaq

Denitrogenation of the lungs with 100% oxygen before or during induction of anaesthesia is now routine practice. It helps to prolong the duration of safe apnoea by maintaining acceptable SpO<sub>2</sub> values. We have compared three groups of patients each comprising of 25 patients. Group A patients breathed room air during induction whereas group B received preoxygenation for 3 minutes (8 liters/minutes O<sub>2</sub>) and group C patients were given five tidal volume puffs after injection of suxamethonium. The mean SpO<sub>2</sub> in group A at endotracheal intubation was significantly different from group B and C (P=0.000001). We conclude that five tidal volume puffs during the apnea after injection of suxamethonium are equally safe and practicable compared to 3 minutes preoxygenation in fasting patients undergoing elective surgery.

**Key Words:** Denitrogenation, technique, preoxygenation, five tidal volume puffs.

Oxygen stores of human body are very limited<sup>1</sup>. The apnoea occurring during induction of anaesthesia and intubation of trachea is, therefore, likely to result in hypoxia and hence hemoglobin desaturation in patients where a clear airway is not established within 1 to 2 minutes<sup>2,3</sup>. The hypoxia such produced may reach critical proportions in patients in which intubation is difficult or prolonged and in those who may not withstand hypoxia due to concurrent medical conditions like ischaemic heart disease. Increase in the oxygen reserves of the body by denitrogenation of lungs avoids the possible sequelae of hypoxia<sup>4</sup>.

Pulmonary denitrogenation by administration of oxygen increases oxygen stores in the lungs and reduces the risk of hypoxia during the period of apnea during induction of anaesthesia and tracheal intubation<sup>5</sup>.

Complete denitrogenation of lungs takes about 7 minutes while the earlier part to this time period is more effective due to exponential nature of the phenomenon. The effectiveness of denitrogenation has been studied by various methods such as mass spectrometry and, end tidal oxygraphy (FEO<sub>2</sub>)<sup>7,8</sup> and pulse oximetry<sup>9,10</sup>. Out of these pulse oximetry is a rapid and practical method of monitoring adequacy of oxygenation in the modern day operation rooms and is an important tool in early detection and reduction of hypoxaemia during anaesthesia<sup>11,12</sup>. A three-minute tidal breathing technique is useful. But a more rapid and effective technique is likely to have advantages. In this study we have compared preoxygenation for 3 minutes to 5 tidal volume puffs of 100% or after injection of suxamethonium before intubation of the trachea.

## Patients and methods

Seventy five healthy adult patients (ASA-I) of either sex and age range 18-50 years, and body weight 50-70 Kg were randomly divided into three groups of twenty five patients each. On preoperative visit the procedure was explained to the patients and a written informed consent obtained. All the patients in the study sample were undergoing elective surgery. Pregnant patients and obese patients (Body weight >70kg) were excluded from study

(none of the patients were premedicated). On arrival in the operation room baseline readings of systolic, diastolic and mean blood pressure and pulse rate were recorded. SpO<sub>2</sub> was continuously monitored using a pulse oximeter (Nellcor, N100) and the baseline SpO<sub>2</sub> while breathing room air was recorded. A continuous ECG monitor (Lead II) was applied. A free flowing i/v line was established and induction of anaesthesia was done with i/v thiopentone sodium 4-6mg/kg body weighty followed by i/v suxamethonium 1.5mg/kg body weight prior to endotracheal intubation. The Group A patients (n=25) breathed room air until intubation was complete and breathing circuit was attached. For group B and C patients the breathing circuit (Semiclosed circle system) was flushed and the breathing bag filled with 100% O<sub>2</sub>.

The Group B (n=25) patients were preoxygenated for three minutes using 8 liters/minute of oxygen. Group C patient breathed room air initially, but after the injection of suxamethonium and before intubation five tidal volume puffs of oxygen using 8 liters/minute O<sub>2</sub> flow were administered and intubation performed.

Hypoxia was classified according to the SpO<sub>2</sub> value. Mild hypoxia is the one in which SpO<sub>2</sub> is 86 to 90%, moderate hypoxia 1 to 85% and in severe hypoxia SpO<sub>2</sub> is less than 81%.

Patients who had a drop in SpO<sub>2</sub> during the induction and intubation to < 81% were excluded from the study and 100% oxygen was immediately administered to bring SpO<sub>2</sub> back within normal limits.

The subjects were lying supine during the induction and intubation. The face mask being held by one of the two 'investigators', both of them consultant anesthesiologist with 6 years of clinical experience. Laryngoscopy and intubation were completed within 30 seconds. The readings of pulse rate, systolic BP, diastolic BP, mean BP, SpO<sub>2</sub> were again recorded at the time of connection of endotracheal tube to the breathing circuit, and the findings were analysed by applying Bonferroni's test for analysis of variance (ANOVA) and Chi-square test for comparison of ratios. Comparison of mean SpO<sub>2</sub> values was made between baseline and OETT (Oral endotracheal intubation) values both within the groups and between the

groups. A value of  $P < 0.05$  was considered to be statistically significant.

**Results**

One way analysis of variance (ANOVA) was used to compare groups for baseline as well as OETT parameters. Chi-square test was used for comparison of ratios. Analysis of variance with Bonferroni's and LSD tests was utilized as *post-hoc*. age, weight and baseline  $SpO_2$  were similar in all three groups. One patient from Group A was excluded from study because it took longer than 30 seconds for laryngoscopy and intubation due to failure of the light of laryngoscope and hence was not included in the statistical analysis. In group B males were significantly larger in number as compared to females. However, in group A and C the difference was not significant ( $P=0.009$ ) (Table 1).

**Table 1** Demographic profile

	Mean	P value
Age (Years)		
Group A	27.83 ± 2.05	0.08748
Group B	29.60 ± 2.61	
Group C	29.04 ± 2.22	
Weight (Kgs)		
Group A	58.71 ± 2.06	0.3448
Group B	61.76 ± 19.68	
Group C	63.88 ± 1.20	
Sex		
Group A	24(M=14, F=10)	0.4142
Group B	25(M=19, F=6)	0.009
Group C	25(M=12, F=13)	0.8415

The mean ±  $SpO_2$  values at OETT for group A were significantly different from Group B and C value ( $P=0.000001$ , Table 2, Fig.1). The mean  $SpO_2$  at OETT in all groups was, however always > 94%.

**Table 2**  $SpO_2$  values

	Baseline	OETT
Group A	99.29 ± 0.14	94.67 ± 0.9221
Group B	99.64 ± 0.127	98.28 ± 0.5432
Group C	99.32 ± 0.1705	99.08 ± 0.2996

There was a significant change in systolic (SBP), diastolic (DBP), mean (MBP), blood pressure and pulse rate (PR) from baseline values at the time of OETT within the groups but the change was comparable between the groups (Table 3).

**Discussion**

Significant arterial desaturation can occur in patients induced with thiopentone sodium. This can be further enhanced by administration of suxamethonium to facilitate tracheal intubation which results in further fall in  $SpO_2$ . On top of these factors an unanticipated difficult intubation can complicate the situation<sup>12</sup>.

Apnea during induction and intubation may attain harmful proportions by leading to extreme degrees of

desaturation due to high metabolic demands e.g. in pregnant patients<sup>14</sup> and the massively obese patients who maintain  $SpO_2$  with difficulty in the supine position<sup>15</sup>.

**Table 3** Comparison of cardiovascular parameters

		A	B	C	P value
B	SBP	125.8333	135.32	129.00	0.1716
A	(mmHg)	±4.1951	±4.1951	±3.1948	
S					
E	MBP	93.4167	97.76004	95.88	0.5067
L	(mmHg)	±2.0807	±3.0382	±2.6015	
I					
N	DBP	75.8333	78.32	78.560	0.6311
E	(mmHg)	±1.4202	±2.66	±2.2877	
O					
E	Pulse rate	91.7082	89.00	90.48	0.8389
T		±7083	±3.4862	±2.6865	
T					
T	SBP	146.5833	155.16	147.76	0.3198
	(mmHg)	±4.462	±4.6718	±3.8084	
	MBP	109.7083	116.160	112.24	0.3457
	Female	±3.1170	±3.3900	±2.8392	
				9	
	DBP	90.5833	95.28	94.44	0.4808
	(mmHg)	±2.7838	±3.2216	±2.6294	
	Pulse	115.1667	106.32	104.24	0.0308
	Rate	±3.9345	±2.5828	±2.3673	

Denitrogenation of the lungs by administration of oxygen avoids the desaturation occurring during induction and intubation and prolongs the duration of safe apnea. Preoxygenation by different techniques has been used in this regard. Traditionally 3-5 minutes of preoxygenation have been used but over last ten years there has been emphasis on reduction in the duration of preoxygenation without harming the patients<sup>13</sup>. It has been shown that 1 minutes of normal tidal breathing or several vital capacity breaths were sufficient to maintain  $SpO_2$  more than 93% for an apnoeic period of three minutes<sup>10,15</sup>.

Recently attention has also been drawn to the fact that although preoxygenation added little in terms of a rise in  $SpO_2$ , the duration of safe apnoea was prolonged from just over 3 minutes to about 10 minutes after preoxygenation for more than one minute or by several vital capacity breaths. In this regard tissue oxygen stores are very important<sup>2</sup>. Although complete denitrogenation of lungs takes about seven minutes<sup>16</sup>. The half life for change of alveolar  $PO_2$  ( $PAO_2$ ) is 26 seconds while breathing 100%. Oxygen in an adult of 70kg body weight. According to Mapleson (1973)<sup>17</sup> the process of denitrogenation is 80% complete at one minute showing that very little change in alveolar  $PO_2$  occurs during later part of denitrogenation. The  $SpO_2$  reaches 100% in 15 seconds while breathing 100% oxygen, whereas only 36ml of extra oxygen is added to arterial blood. However, total tissue stores of Oxygen increase from 1.2 liters in adults before

oxygenation to 3.2 liters at 1 minute. Over next two minutes further 1.6 liters are added thus prolonging the duration of tolerable apnoea from 1.5 minutes without preoxygenation to more than five minutes after three minutes of preoxygenation provided oxygen consumption does not increase.

More rapid oxygenation techniques have also been practised to tide the patients over the apnea of induction and these include preoxygenation for one minute, four vital capacity breaths and breathing 100% O<sub>2</sub> from the beginning of induction to the point of apnoea<sup>7,18</sup>.

In the present study we have compared two techniques of oxygenation with a control in which the patients breathed room air, oxygen being administered if the SpO<sub>2</sub> fell < 81%. The two experimental groups i.e. B and C received 100% Oxygen after injection of suxamethonium respectively. There was a significant drop in SpO<sub>2</sub> during induction and intubation in the control group whereas the experimental groups exhibited no significant fall in SpO<sub>2</sub> during the same period both within the groups and between the groups. The SpO<sub>2</sub> drop in control group breathing room air was not only significantly different from baseline SpO<sub>2</sub> value but also from SpO<sub>2</sub> values for other two groups at the time of tracheal intubation.

The results of this study are in partial agreement with those of an earlier study performed by Haynes et al<sup>18</sup> (1992), in which preoxygenation for 3 minutes resulted in a higher SpO<sub>2</sub> during apnoea than SpO<sub>2</sub> value in patients, in a group breathing room air. Four vital capacity breaths in the same study resulted in a fall in mean SpO<sub>2</sub> to significantly lower value at 95% confidence (CI) limits. The SpO<sub>2</sub> values in the patients given five tidal volume puffs in our study were comparable before and after induction to SpO<sub>2</sub> values with preoxygenation for three minutes. The difference can be explained on the basis of induction agent used and leaks in the circuit. The induction agent used by Haynes et al<sup>18</sup>(1992) was propofol which has loss of eyelash reflex as an endpoint a bit later than is the case with thiopentone. In addition fentanyl used simultaneously with propofol and premedication with temazepam could have influenced the outcome. In our study no premedication was used. Although the induction profile of propofol is similar to that of thiopentone regarding apnoea experience by patients, the simultaneous use of an opioid and premedication lead to significantly longer duration of apnea with propofol. There is significant decrease in minute volume, tidal volume, inspiratory flow rate and functional residual capacity for at least first four minutes after induction with propofol<sup>19</sup>.

The SpO<sub>2</sub> values during apnea of induction and intubation after preoxygenation for 3 minutes were not significantly different from baseline values in previous studies<sup>9,10,13</sup>.

The SpO<sub>2</sub> values in group B patients at the time of intubation in our study were significantly lower than baseline values. This can be due to leaks in the mask fit and shallow breathing due to the mask being applied prior

to the loss of consciousness. The ensuing period of apnoea could also have taxed the saturation from the time of loss of consciousness to the time of intubation.

From the results of this study it can be concluded that both the techniques of oxygenation used in this study were equally effective in maintaining SpO<sub>2</sub> within acceptable range but there are certain limitations. Our study was conducted in healthy fasting patients, therefore the techniques cannot be extrapolated to pregnant patients, to those who are massively obese and those patients in which difficulty in intubation is anticipated. However, both techniques can be safely practised in patients undergoing elective surgical procedures after observing preoperative fasting. Furthermore, five tidal volume puffs are aesthetically more acceptable to patients after going to sleep as this avoids putting a mask on the face of a conscious patient.

#### References

1. Nunn JF: Oxygen therapy. In: Nunn JF, Utting JE, Brown Br Jr, eds. *General Anaesthesia* 1989, 5<sup>th</sup> edition. London, Butterworth: 199-209.
2. Editorial: Preoxygenation: Physiology and practice. *Lancet* 1992;339:31-32.
3. Moller JT, Johannessen NW, Berg H, Espersen K, Larsen LE: Hypoxaemia during anaesthesia: An observer study. *Br J Anaesth* 1991;66:437-444.
4. Thorpe CM, Gauntlett IS: Arterial oxygen saturation during induction of anaesthesia. *Anaesthesia* 1990;45:1012-1015.
5. Gold MI: Preoxygenation. *Br J Anaesth* 1989;62:241-242.
6. Carmichael FJ, Cruise CJE, Crayggo PR, Paluck S: Preoxygenation: A study of denitrogenation. *Anaesthesia and Analgesia* 1989;68:406-409.
7. McCrory JW, Matthews JNS: Comparison of four methods of preoxygenation. *Br J Anaesth* 1990;64:571-576.
8. Berry CB, Myles PS: Preoxygenation in healthy volunteers: a graph of oxygen "Washing" using endtidal oxymetry. *Br J Anaesth* 1994;72:116-118.
9. Gambee AM, Hertzka RE, Fisher DM: Preoxygenation techniques: Comparison of three minutes and four breaths. *Anesth Analg* 1987;66:468-470.
10. Valentine SJ, Marjot R, Monk CR: Preoxygenation in the elderly: a comparison of four maximal breath and three minute techniques. *Anesth Analg* 1990;71:516-519.
11. Tremper KK, Barker SJ: Pulse oximetry. *Anesthesiology* 1989;70:98-108.
12. Moller JT, Jensen PF, Johannessen NW, Espersen K: Hypoxaemia is reduced by pulse oximetry monitoring in the operation theatre and in the recovery room. *Br J Anaesth* 1992;68:146-150.
13. McCarthy G, Elliott P, Mirakhor RK, McLoughlin C: A comparison of different preoxygenation techniques in the elderly. *Anaesthesia* 1991;46:824-827.
14. Archer GW, Mark GF: Arterial oxygen tension during apnoea in parturient women. *Br J Anaesth* 1974;46:358-360.
15. Berthoud MC, Peacock JE, Reilly CS: Effectiveness of preoxygenation in morbidly obese patients. *Br J Anaesth* 1991;67:464-466.
16. aCambell IT, Beatty PCW: Monitoring preoxygenation (editorial) *Br J Anaesth* 1994;72:3-4.
17. Maplesond WW: Circulation time models of the uptake of inhaled anaesthetics and data for quantifying them. *Br J Anaesth* 1973;45:319-334.
18. Haynes SR, Allsop JR, Gillies GWA: Arterial oxygen saturation during induction of anaesthesia and laryngeal mask insertion: Prospective evaluation of four techniques. *Br J Anaesth* 1992;68:519-522.
19. Sebel PS, Lowdon JD: Propofol: A new intravenous anaesthetic. *Anesthesiology* 1989;71:260-277.