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A Prospective, Controlled, Randomised Comparison of Preoxygenation in 20° Headup Position Versus Supine Preoxygenation

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ABSTRACT

Preoxygenation before anaesthesia is traditionally achieved by administering 100% oxygen to patients in supine position for 3 to 5 minutes. Varying methods of enhancing preoxygenation have been tried including fast techniques like 4-8 vital capacity breaths, preoxygenation with reverse Trendelenburg position or use of noninvasive ventilation. The efficacy of preoxygenation has been monitored using transcutaneous PO2 (tcPO2) , expired fraction of oxygen(FeO2), arterial oxygen content (PaO2) or pulseoximetry(SpO2). We decided to compare the efficacy of preoxygenation in 20° head up position versus supine position using pulseoximetry. We decided to study the time to desaturation, lowest saturation attained during the recovery phase, time required to regain a saturation of 100%, any change in haemodynamic parameters and complications, if any. 60 ASA status I/II adult patients of either sex were studied using ethics committee approved protocol and data obtained was statistically analyzed. We found that that 3 minute of preoxygenation with tidal volume technique with patient in the 20° head up position is superior to preoxygenation in supine position. Patients positioned 20° head up had a longer mean time to desaturation as monitored by pulse oximetry than those in the supine position (311.36±29.21seconds , 215.76±12.77seconds, $p < 0.001$) which is statistically very highly significant. An additional 96 seconds of apnoea time was gained with no detrimental effect on ease of intubation. An increase in the time available for airway manoeuvres thus obtained may prove to be the difference between hypoxia and safe induction of anaesthesia

KEYWORDS PREOXYGENATION, APNOEA, REVERSE TRENDELENBURG, HEADUP,SUPINE

INTRODUCTION

Preoxygenation which involves administration of oxygen prior to induction of anaesthesia is a time honoured ritual carried out in all patients about to undergo general anaesthesia. The induction of anaesthesia is associated with a variable period of apnoea, which lasts until mechanical ventilation of the lungs begins or until the patient resumes spontaneous ventilation. During this time the body's continuing requirements of oxygen are supplied from the functional residual capacity. The aim of preoxygenation is to saturate this capacity with oxygen and increase the oxygen stores. Dillion and Darsie[1] in 1955 were the first to note significant desaturation occurring during thiopental apnoea. They recommended 5 minutes of preoxygenation before induction to prevent this desaturation.

Preoxygenation and denitrogenation depends on the inspired fraction of oxygen (FiO_2), inspired volume and respiratory rate. It has been carried out using various techniques: a slow technique of tidal volume breathing for 2-5 min or fast techniques involving 4 to 8 deep vital capacity breaths at FiO_2 = 100% in 30 to 60 seconds. [2,3,4,5] The efficacy of preoxygenation can be improved by changing the patient position from supine to head up. This has been proved by various investigators in pregnant, obese and female patients in a range of degrees of head-up positioning from 15° to 45° [6,7,8,9,10,11].

An angle of 45°-60 ° may produce more efficient preoxygenation; however, this angle may be associated with more practical difficulties, like hypotension after induction, intubation in headup position or repositioning prior to intubation and increased chance of aspiration pneumonia should regurgitation occur. An angle of 20° -25° is readily achievable, and similar physiologic gains may be possible at these lesser angles while allowing intubation to take place in a more familiar position. Also the desaturation point in various previous studies ranged from 90% to 95%.

Different markers have been used to measure the primary outcome i.e. efficacy of preoxygenation; like the transcutaneous oxygen tension($tcPO_2$), expired fraction of oxygen(FeO_2) or arterial oxygen content (PaO_2). However speific expensive monitor or gas analyzer or invasive monitoring may not be available or required in every set up. Thus oxygen saturation (S_pO_2) which can be measured non invasively with easily available monitor like the pulse oximeter may be used.

We decided to compare the efficacy of preoxygenation in supine position versus 20° head up position in general population of adults of ASA physical status I and II who were to undergo procedures under general anaesthesia with endotracheal intubation. We decided to study the time to desaturation, lowest SpO_2 attained during the recovery phase (after breathing system was attached and ventilation commenced) , time required to regain a saturation of 100% , any change in haemodynamic parameters and complications, if any.

MATERIALS AND METHODS

Based on a previous study by Ramkumar V et al[6], a sample size of 26 patients was needed to gain approximately 90 seconds delay to desaturation with 5 mins of pre-oxygenation and desaturation to 93%. However with our pilot study of 10 cases with the traditional 3 mins pre-oxygenation and desaturation point 95%, a sample size of 50 was needed to gain approximately 60 seconds increase in desaturation time with an alpha error of 5% and with power of study 80%. Assuming a dropout percentage of 10% and for better statistical analysis a total of 60 patients were studied.

The study was approved by institutional ethics committee and postgraduate review board. We studied 60 patients, aged 18-60 years, both male and female, of ASA I & II posted for surgery under general anaesthesia with endotracheal intubation. Patients with significant respiratory disease (asthma, obstructive or restrictive airway disease etc.), cardiovascular disease (ischemic heart disease, etc.), history of failed or difficult intubation or features of difficult airway or at risk of aspiration and patients showing SpO_2 of < 95% on room air were excluded. Written informed valid consent was obtained from all patients. Thirty patients were assigned to each group randomly by chit block method. One group was preoxygenated in the 20° head up position (Group H) and other in supine position (Group S).

After standard preoperative assessment and confirmation of starvation, patients were taken on table. Baseline heart rate, blood pressure and oxygen saturation (SpO_2) on room air as measured with pulse oximeter (Datex Engstrom Satlite Trans, 3581699) were noted. Standard pre-medication consisting of glycopyrrolate 0.004 mg/kg IV, ranitidine 1mg/kg IV, ondansetron 0.08 mg/kg IV, midazolam 0.03 mg/kg IV and fentanyl 2μg/kg IV was administered.

All the patients received preoxygenation with 100% oxygen for 3 minutes and all patients were asked to breath normally during this period. SpO_2 reading on the pulse oximeter was noted just before the start of preoxygenation. Preoxygenation was achieved with tight fitting face mask with no air leak with closed circle system breathing apparatus with oxygen flow of 8 L/min. Tight fit of the face mask was confirmed with adequate movement of the reservoir bag and square waveform on Capnometer.

After 3 minutes of preoxygenation anaesthesia was induced with inj propofol 2-3 mg/kg till centralisation of eyeballs. After checking ventilation with 1 tidal volume breath, intubating dose of muscle relaxant succinylcholine 1.5 mg/kg IV was given with each subject in their assigned position. Face mask was kept in position for 60 seconds after giving succinylcholine. Then Propofol infusion was started at rate of 4mg/kg/hr to ensure absence of awareness and maintenance of apnoea during the whole procedure. Under direct laryngoscopic vision trachea was intubated with appropriate size PVC(poly vinyl chloride) cuffed endotracheal tube after completion of 60 seconds of giving succinylcholine. Breathing system was not connected till saturation dropped to 95%. When oxygen saturation dropped to 95%, breathing system was connected immediately and positive pressure ventilation with 100% oxygen was commenced and SpO_2 was brought up to 100%.

The following parameters were noted. Time to desaturation defined as the time taken to reach an oxygen saturation of 95% from the time mask was taken off the face was noted. Lowest oxygen saturation during the recovery phase and duration of recovery phase defined as time for oxygen saturation to reach 100% after initiation of ventilation was recorded. Full routine monitoring including blood pressure, pulse rate, pulse oximetry, electrocardiography and end tidal carbon dioxide monitoring was done throughout the procedure and changes were noted. We also studied the occurrence of complications, if any during the procedure.

The data thus obtained was statistically analyzed using student paired and unpaired t test for intra-group and intergroup comparison of demographic data, time to desaturation, lowest oxygen saturation, duration of recovery phase and haemodynamics respectively. A p value of < 0.05 was considered significant.

OBSERVATIONS AND RESULTS

The 2 groups were comparable as regards age (31.16±9.1, 35.43±10.61, p=0.1), weight (54.8±7.8, 54.53±6.9, p=0.88), sex distribution (M: F 11:19, 12:18, p=0.79) and ASA physical status class(I/II, 25/5, 22/8,p=0.34).

TABLE 1. DESATURATION PARAMETERS

Parameters	Group H	Group S	P value
Time to desaturation (seconds)	311.36±29.21 (388-270)	215.76±12.77 (242-190)	<0.001*
Lowest SpO_2 (%)	91.23±1.22	90.83±1.2	0.20
Recovery phase in seconds	21.6±3.91	22.06±3.99	0.64

As seen in Table 1, our results showed that patients positioned 20° head up had a longer mean time to desaturation than those in the supine position; 311.36±29.21 seconds versus 215.76±12.77 seconds respectively; the difference between the means 95.6 seconds ; p < 0.001 which is statistically very highly significant. We found that change of position did not affect the lowest SpO_2 and duration of recovery phase.

TABLE 2. HAEMODYNAMIC COMPARISON BETWEEN TWO GROUPS

	Heart Rate beats per minute			Systolic Blood Pressure in mmHg		
Time	Group H	Group S	P value	Group H	Group S	p value
Baseline	81.73±7.24	84.5±8.77	0.18	113.2±7.32	110.4±6.08	0.11
T0 (Time of mask removal)	88.26±7.76	93.1±8.99	0.02	111.26±7.78	112.8±6.94	0.42
T1 (Time of desaturation)	97.5±11.31	100.43±10.07	0.29	117.73±5.53	116.06±5.86	0.26

Apart from a statistically significant but clinically insignificant difference in the heart rate at T0, p = 0.02, the heart rate and systolic blood pressure was comparable for both groups (Table 2). However on comparison of haemodynamics between baseline and the time of desaturation, we found that there was clinically and statistically very highly significant (p<0.001) difference in the heart rate and statistically significant but clinically insignificant difference in blood pressure at time of desaturation as compared to preoperative values(Table 3). There were no complications reported in either group.

Table 3.COMPARISON OF HAEMODYNAMIC PARAMETERS WITHIN GROUP

	Heart Rate beats per minute			Systolic Blood Pressure in mmHg		
	Baseline	T1	P value	Baseline	T1	p value
Group S	84.5±8.77	100.43±10.07	<0.001	110.4±6.08	116.06±5.86	0.005
Group H	81.73±7.24	97.5±11.31	<0.001	113.2±7.32	117.73±5.53	0.008

DISCUSSION

Preoxygenation being a vital component of anaesthesia protocol has been traditionally achieved by administering 100% oxygen to patients in supine position for 3 to 5 minutes. Varying methods of enhancing preoxygenation have been tried in cases of anticipated difficulty in securing airway , patients with decreased reserves like pregnant, elderly or obese patients or patients requiring rapid sequence intubation.[6,7,8,9,10,11] These include fast techniques like 4-8 vital capacity breaths[3] or preoxygenation with varying degrees of reverse Trendelenburg position[10,11] or use of positive end expiratory pressure, continuous positive airway pressure.[6,12,13] Various monitoring techniques have also been used to measure the efficacy of preoxygenation like the transcutaneous PO_2 ($tcPO_2$)[14] , expired fraction of oxygen(FeO_2)[14], arterial oxygen content (PaO_2)[12] or pulseoximetry(SpO_2)[15]. We decided to compare the efficacy of preoxygenation in supine position versus 20° head up position in general population of adults of ASA physical status I and II who were to undergo procedures under general anaesthesia with endotracheal intubation. We decided to study the time to desaturation, lowest SpO_2 attained during the recovery phase (after breathing system was attached and ventilation commenced) , time required to regain a saturation of 100% any change in haemodynamic parameters and complications, if any.

We conducted a randomized controlled comparative clinical trial of sixty patients, between age group of 18-60 years (male and female) of ASA physical status I and II who were to undergo procedures under general anaesthesia with endotracheal intubation. Patients with significant respiratory disease (asthma, obstructive or restrictive airway disease etc.), cardiovascular disease (ischemic heart disease, etc.), history of failed or difficult intubation or features of difficult airway or at risk of aspiration and patients showing SpO_2 of < 95% on room air were excluded. Written informed valid consent was obtained from all patients. After standard preopeartive assessment and confirmation of nil per oral status, patients were taken on opeartion table. Patients were monitored with electrocardiography, non invasive blood pressure monitor, pulseoximetry and capnometry. Baseline vital parameters and oxygen saturation were measured and noted. Standard pre-medication was administered and all the patients were preoxygenated with 100% oxygen for 3 minutes at normal tidal volume breaths with a tight fitting face mask with no air leak with closed circle system breathing apparatus with oxygen flow of 8L/min. Efficacy of the face mask ventilation was confirmed with adequate movement of the reservoir bag and square waveform on capnometer. We decided to preoxygenate our patients with the traditional 3 minute tidal volume breathing technique, because it has been found by many investigators to be superior[2,5] and more convenient.

SpO_2 reading on the pulse oximeter was noted just before the start of preoxygenation. Anaesthesia was induced with inj propofol 2-3 mg/kg after 3 minutes of preoxygenation and intubating dose of muscle relaxant succinylcholine 1.5 mg/kg IV was given with each subject in their assigned position after checking ventilation with 1 tidal volume breath. Face mask was kept in position for 60 seconds after giving succinylcholine. Then propofol infusion was started at rate of 4mg/kg/hr to ensure absence of awareness and maintenance of apnoea during the whole procedure. Trachea was intubated with appropriately sized PVC(poly vinyl chloride) cuffed endotracheal tube with direct laryngoscopy after completion of 60 seconds of giving succinylcholine. Breathing system was not connected till saturation dropped to 95%. We took 95% as end point value because in many of the previous studies various authors have taken values ranging from 90% to 95% as lower limit to measure the desaturation safety period.[7,9,11] The arterial PaO_2 also remains on the plateau portion of the oxyhaemoglobin dissociation curve at 95% saturation. So patient is safe within this limit. When oxygen saturation dropped to 95%, breathing system was connected immediately and positive pressure ventilation with 100% oxygen was commenced and SpO_2 was brought up to 100%.

The following parameters were noted. Time to desaturation defined as the time taken to reach an oxygen saturation of 95% from the time mask was taken off the face; lowest oxygen saturation during the recovery phase; and duration of recovery phase defined as time for oxygen saturation to reach 100% after initiation of ventilation. Full routine monitoring including blood pressure, pulse rate, pulse oximetry, electrocardiography and end tidal carbon dioxide monitoring was done throughout the procedure and changes were noted. We also studied the occurrence of complications, if any during the procedure.

The data thus obtained was statistically analyzed using student paired and unpaired t test for intra-group and intergroup comparison of demographic data, time to desaturation, lowest oxygen saturation, duration of recovery phase and haemodynamics respectively. A p value of < 0.05 was considered significant.

We found that patients positioned 20° head up had a longer mean time to desaturation than those in the supine position (311.36±29.21 seconds , 215.76±12.77 seconds, p < 0.001) which is statistically very highly significant. We found that change of position did not affect the lowest SpO_2 and duration of recovery phase.

The value we obtained is comparable to the study by Ramkumar et al[6] who obtained values of 452 ± 71 seconds in 20° head up preoxygenation as compared to conventional position 364 ± 83 seconds (P = 0.030). It was also comparable to the values obtained by Lane et al[11] who obtained 386 seconds in 20° head up and 283 seconds time to desaturation in supine group with difference between means of 103 seconds. The results are also in agreement to the findings in non-pregnant patients in the study done by Baraka A et al[7]. In their study, using the head-up position resulted in an increase in the desaturation time in the nonpregnant group (331 ± 7.2 seconds) from (243 ±7.4 seconds) in the supine group. Dixon BJ et al[9] in 2004 had compared the efficacy of preoxygenation in 25° head-up position with supine position in 42 severely obese patients and achieved similar results. In their study the group randomly assigned to the 25° head-up position took longer to reach an oxygen saturation of 92% (201 ± 55 vs. 155 ±69 s; P = 0.023) which is also reflected in our study.

This extended time to desaturation is especially important in situations where difficulties are anticipated in securing the airway with a tracheal tube, patients with potential danger of regurgitation of stomach contents , patients with compromised respiratory reserves and emergency department intubations[16]. The increase in the time available for airway manoeuvres may prove to be the difference between hypoxia and safe intubation in such patients.

We found that change of position did not affect the lowest SpO_2 or duration of recovery phase. This was also found by Dixon et al[9] 85±3.7 and 85.9±3 in supine and 25° head up group respectively; p value of 0.41 and time for SpO_2 to come up to 97% as 33.9±12.2 seconds in supine group and 37.1±11.6 in 25° head up group; p = 0.39. However Boyce et al[8] in 2003 in their preliminary study of the optimal anaesthesia positioning for the morbidly obese patient found that the SaO_2 of patients in the reverse Trendelenburg position (30°) dropped the least and recovery phase was better in reverse Trendelenburg position (30°) than in supine or 30° Back Up Fowler.

We could not find any previous studies comparing the haemodynamic parameters like pulse rate and blood pressure with preoxygenation in different positions. Our comparative study of these parameters in both the positions found that, at T1 i.e.95% saturation, heart rate was raised to a statistically and clinically significant value in both supine and 20° head up group. It was raised from 84.5 to 100.43 beats per minute in supine and 81.73 to 97.5 beats per minute in 20° head up group(p value < 0.001). A similar finding was also noted with blood pressure. It increased from 110.4±6.08 mmHg to 116.06±5.86 mmHg in supine position and from 113.2±7.32 mmHg to 117.73±5.53 mmHg in 20° head up group. Though statistically significant the rise in blood pressure was not clinically significant. The rise in heart rate and blood pressure might be explained on the basis of sympathetic nervous system stimulation caused by hypercarbia from carbon dioxide(CO_2) build up. This explanation is supported by the end tidal CO_2 values after ventilation was started, which ranged from 48-65 mmHg .Though documented, end tidal CO_2 values were not included in the proforma as it was not a part of our study protocol.

During the study there were no occasions, when difficulty during intubation led to withdrawal of a patient from the study. None of the patient developed any complications during the study phase.

CONCLUSION

The present study showed that 3 minute of preoxygenation with tidal volume technique with patient in the 20° head up position is superior to preoxygenation in supine position. The time to desaturation during subsequent apnoea, as monitored by pulse oximetry, is prolonged and an additional 96 seconds of apnoea time is gained with no detrimental effect on ease of intubation. Thus preoxygenation using this simple, easily implementable technique of placing the patient in 20° head up position is extremely useful. It is especially recommended in anticipated difficult airway (short neck, anterior larynx, limited neck extension, limited mouth opening etc), specific technical issues (e.g. double lumen tracheal tube for thoracic surgery), rapid sequence induction (risk of aspiration-head injury, gastro-oesophageal reflux etc), obesity, pregnancy, bowel obstruction, ascites etc.(when intubation and ventilation difficulties, respiratory dysfunction with a decrease in FRC, and risk of regurgitation are all present) and increased oxygen consumption (febrile patients, pregnant women etc.). An increase in the time available for airway manoeuvres thus obtained may prove to be the difference between hypoxia and safe induction of anaesthesia in such patients.

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