RESEARCH ARTICLE

Preoxygenation in surgical patients undergoing general anaesthesia – A cross sectional survey

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Abstract

Objective: To determine the frequency of preoxygenation practice among anaesthesiologists, the reason for skipping preoxygenation, and the endpoint chosen to stop preoxygenation.

Method: The prospective, cross-sectional study was conducted from April to September 2018 at the Department of Anaesthesiology, Aga Khan University, Karachi, and comprised anaesthesiologists with at least two years of experience. Data regarding preoxygenation practice was collected through structured interviews. Data was analysed using SPSS 19.

Results: Of the 76 subjects, 43(56.6%) were females and 33(43.4%) were males. The overall mean age was 35.1±7.4 years. A total of 30(39.5%) sujects performed preoxygenation in all elective surgical patients undergoing general anaesthesia. The most common instance for not performing preoxygenation was healthy adults and anxious patients in 19(41.3%) cases. The technique most preferred was tidal volume breathing for 3-5 minutes 34(44.74%). Four deep breaths in 30 seconds were used by 25(32.89%) anaesthesiologists, and the technique least preferred was 8 deep breaths in 1 minute by 17(22.37%). Besides, 69(90.8%) anaesthesiologists chose to end tidal oxygen at >90% as their endpoint of preoxygenation, and 7(9.2%) performed it for three minutes.

Conclusion: The standard technique to perform preoxygenation was found to be the most preferred technique used by anaesthesiologists. The preoxygenation was skipped mainly in young healthy and anxious adults. The endpoint chosen by anaesthesiologists was almost always the end tidal oxygen >90%.

Key Words: Pre-oxygenation, De-nitrogenation, Practice, Endpoint, Anaesthetist.

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Introduction

Preoxygenation is a straightforward and efficient method to prolong apnoea duration during the initiation of general anaesthesia (GA). The primary goal of preoxygenation involves eliminating nitrogen from the functional residual capacity while infusing it with oxygen, leading to a notable increase in the body's oxygen reservoir and consequently extending the period of apnoeic ventilation significantly.[1]

The effectiveness of preoxygenation, or de-nitrogenation, can be gauged by monitoring the end-tidal oxygen status, which should ideally exceed 80%.[2] However, it is important to note that a 100% saturation of peripheral oxygen (SpO2) reading does not indicate the cessation of preoxygenation, as the lungs might not have undergone sufficient de-nitrogenation. Conversely, a lack of significant increase in SpO^2 does not necessarily imply a failure in the de-nitrogenating process.[2]

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Studies have demonstrated the rapid development of hypoxaemia in individuals with good health and fitness, revealed that one minute after the induction of anaesthesia, the mean SaO2 dropped to 85.5% when preoxygenation was inadequate compared to a mean arterial oxygen saturation (SaO2) of >90% when preoxygenation was properly conducted, even if momentarily and imperfectly.[3]

In clinical practice, various methods of preoxygenation are employed, such as the traditional approach of breathing in 100% oxygen with a well-fitted mask either for 3 minutes using tidal volume breaths, or for 0.5 minutes with four deep breaths, or for 1 minute with eight deep breaths.[4] A comparative analysis of these preoxygenation techniques concluded that 3-5 minute tidal volume breathing achieved optimal preoxygenation, whereas the shorter intervals of deep breaths resulted in suboptimal preoxygenation, suitable only in time-sensitive situations. It was observed that increasing the fresh gas flow from 5L/min to 10L/min did not enhance preoxygenation with either tidal volume breathing or the shorter deep breaths, and maximal preoxygenation was only achieved when deep breathing was extended to 1.5 or 2 minutes, coupled with a high fresh gas flow of 10L/min.[4]

Ensuring adequate haemoglobin (Hb) saturation during airway management is critical for patient safety. A Hb saturation level <70% poses significant risks, including dysrhythmia, haemodynamic instability, hypoxic brain injury, and even mortality.[5,6] Research demonstrated significantly prolonged time to desaturation when patients received preoxygenation with 100% oxygen as opposed to 21% (room air) prior to tracheal intubation.[7,8] However, to our knowledge, there is currently no comprehensive study outlining the preoxygenation techniques predominantly employed by anaesthesiologists, or the circumstances under which they choose to proceed without preoxygenation in elective cases.

The current study was planned to fill the gap in literature by determining the frequency of preoxygenation practice among anaesthesiologists, the reason for skipping preoxygenation, and the endpoint chosen to stop preoxygenation.

Subjects and Methods

The prospective, cross-sectional study was conducted from April to September 2018 at the Department of Anaesthesiology, Aga Khan University, Karachi, After approval from the institutional ethics review committee. The sample size was calculated using the standard formula[9] for estimating a single proportion with ±9% margin of error, 95% confidence interval (α=0.05) and on the assumption that 80% of anaesthesiologists routinely use preoxygenation (p=0.80). The sample was raised using non-probability consecutive sampling technique. Those included were anaesthesiologists of either gender who were medical school graduates with at least two years of professional experience. The rest were excluded. Informed consent was taken from all the anaesthesiologists.

Data was collected using a predesigned structured questionnaire to evaluate the practice trend of preoxygenation, the preferred technique, the reasons for skipping preoxygenation, and the endpoint chosen by the anaesthesiologists. The questionnaire was filled up during interviews by the primary researcher. Prior to the study, the questionnaire was pilot-tested on 3 individuals, and minor adjustments were made to improve clarity and relevance based on the feedback.

Data was analysed using SPSS 19. Data was expressed as frequencies and percentages for gender, designation, professional experience, practice, technique of preoxygenation and reason for skipping preoxygenation. Mean ± standard deviation was estimated where appropriate. Cross-tabulation was performed to control effect-modifiers to observe the difference in practice and technique of preoxygenation. Chi-square test was used to assess the significance of differences. P≤0.05 was considered statistically significant.

Results

Of the 76 subjects, 43(56.6%) were females and 33(43.4%) were males. The overall mean age was 35.1±7.4 years (range: 25-68 years). The mean length of experience was 7.17±6.07 years, and 28(36.8%) of the subjects were consultants by designation (Table 1).

Table-1: Professional profile of the participants (n=76).

Variables	Point Estimates Mean ± SD
Years of Experience	7.17±6.07
Designation	
Consultant	28 (36.8%)
Medical Officer	19(25%)
Resident	29(38.2%)

SD: Standard deviation.

Table-2: Practice and preferred preoxygenation technique of the participants.

Practice And Technique of Pre oxygenation	Frequency n	Percentages %
Do you perform preoxygenation in every patient (all age groups) undergoing general anaesthesia for elective surgery? (n=76)		
Yes	30	39.5%
No	46	60.5%
If no, in which patients do you avoid preoxygenation? (n=46)		
Anxious Patients	7	15.2%
Healthy Adults	9	19.6%
Anxious + Healthy	19	41.3%
Healthy + Daycare	2	4.3%
Anxious + Healthy + Daycare	9	19.6%
Which technique do you prefer? (n=76)		
Tidal volume breathing for 3-5mins	34	44.7%
Four deep breaths in 30secs	25	32.9%
8 Deep breaths in 1min	17	22.4%
Which endpoint do you choose to stop pre oxygenation? (n=76)		
Three minutes from when pre oxygenation was started	7	9.2%
When end tidal oxygen concentration reaches above 90%	69	90.8%

Of the total, 30(39.5%) subjects performed preoxygenation in all surgical patients undergoing GA for elective surgery, while 46(60.5%) did not. The most common instance for not performing preoxygenation was while managing healthy adults and anxious patients 19(41.3%). The technique most preferred was tidal

Table-3: Comparison of practice and techniques of preoxygenation with respect to professional standing.

Practice And Technique of Preoxygenation	Resident and Medical Officer (Trainees) n=48	Consultant n= 28	P-Value
Do you perform preoxygenation in every patient (all age groups) undergoing general anaesthesia for elective surgery? (n=76)			
Yes	24(50%)	6(21.4%)	0.014
No	24(50%)	22(78.6%)	
If no,in which patients do you avoid preoxygenation? (n=46)	24	28	
Anxious Patients	3(12.5%)	4(18.2%)	0.344
Healthy adults	4(16.7%)	5(22.7%)	
Anxious + Healthy	12(50%)	7(31.8%)	
Healthy + Daycare	2(8.3%)	0(0%)	
Anxiou + Healthy + Daycare	3(12.5%)	6(27.3%)	
Which technique do you prefer? (n=76)			
Tidal volume breathing for 3-5mins	27(56.3%)	7(21.6%)	0.029
Four deep breaths in 30secs	27(56.3%)	13(46.4%)	
Deep breaths in 1min	9(18.8%)	8(28.6%)	
Which endpoint do you choose to stop preoxygenation? (n=76)			
Three minutes from when preoxygenation was started	4(8.3%)	3(10.7%)	0.729
When end tidal oxygen concentration reaches above 90%	44(91.7%)	25(89.3%)	

Table-4: Comparison of practice and technique of preoxygenation with respect to professional experience.

Practice and Technique of Preoxygenation	Years of Experience			P-Value
	≤5 Years n=44 n (%)	Years n=16 n (%)	10 Years n=16 n(%)	
Do you perform preoxygenation in every patient (all age groups) undergoing general anaesthesia for elective surgery? (n=76)				
Yes	23(52.3%)	5(31.3%)	2(12.5%)	0.015
No	21(47.7%)	11(68.8%)	14(87.5%)	
If no, in which patients do you avoid preoxygenation? (n=46)				
Anxious Patients	3(14.3%)	0(0%)	4(28.6%)	0.139
Healthy adults	4(19%)	2(18.2%)	3(21.4%)	
Anxious + Healthy	11(52.4%)	5(45.5%)	3(21.4%)	
Healthy + Daycare	2(9.5%)	0(0%)	0(0%)	
Anxious + Healthy + Daycare	1(4.8%)	4(36.4%)	4(28.6%)	
Which technique do you prefer? (n=76)				
Tidal volume breathing for 3-5mins	25(56.8%)	5(31.3%)	4(25%)	0.060
Four deep breaths in 30secs	11(25%)	5(31.3%)	9(56.3%)	
Deep breaths in 1min	8(18.2%)	6(37.5%)	3(18.8%)	
Which endpoint do you choose to stop preoxygenation? (n=76)				
Three minutes from when preoxygenation was started	4(9.1%)	0(0%)	3(18.8%)	0.186
When end tidal oxygen concentration reaches above 90%	40(90.9%)	16(100%)	13(81.3%)	

volume breathing for 3-5minutes 34(44.74%). The method of four deep breaths in 30 seconds was used by 25(32.89%) anaesthetists, and the technique least preferred was 8 deep breaths in 1 minute 17 (22.37%).

A total of 69 (90.8%) anaesthetists chose to end tidal oxygen >90% as their endpoint of preoxygenation, whereas 7(9.2%) performed it for a total of three minutes (Table 2).

The practice and preferred technique of preoxygenation as well as the reasons for skipping preoxygenation and the chosen endpoint were compared with respect to professional standing (Table 3) and the length of experience (Table 4).

Discussion

Preoxygenation aims at bolstering the body's oxygen reserves, thereby delaying the onset of arterial Hb desaturation during periods of apnoeic ventilation, playing a crucial role in extending the duration of safe apnoea, defined as the period until a patient's saturation level reaches 88-90%, allowing for the secure placement of a definitive airway. As patients transition below this critical threshold, they navigate the steep segment of the oxyhaemoglobin dissociation curve, and their oxygen saturation levels can rapidly plummet to precarious levels (<70%) within seconds.[10] Preoxygenation effectively elevates the alveolar oxygen fraction of oxygen (FAO2) while concurrently reducing the fraction of nitrogen (FAN2).

In the current study, only 30 out of 76 anaesthetists (39.5%) consistently administered preoxygenation to all elective surgical patients undergoing GA, while the remaining 46(60.5%) did not. In contrast, a prospective study conducted in three public hospitals in Malaysia revealed that preoxygenation was administered to 96.1% of all patients.[11] Tanoubi et al. also strongly recommended the universal implementation of preoxygenation in all patients undergoing anaesthesia, emphasising its critical role in ensuring patient safety.[12]

The functional residual capacity (FRC) represents a pivotal reservoir of oxygen within the body. A larger FRC enables a more prolonged endurance of apnoea before the onset of critical hypoxia. In the case of an adult with a normal FRC and maximal oxygen consumption (VO2), the lung's oxygen reserves will be depleted within approximately one minute (approximately 290ml), elucidating the rapid progression towards critical hypoxia after this timeframe. Patients with diminished FRC due to underlying conditions, such as lung disease, kyphoscoliosis, pregnancy or obesity, experience an even more accelerated onset of critical hypoxia.[13] Therefore, the significance of preoxygenation in such cases should be duly acknowledged, emphasising the vital role it plays in preserving patient safety. The current study underscores the pressing need for reinforcing this safety protocol.

The current study highlighted that the most common scenario where preoxygenation was omitted was among healthy adults and patients exhibiting anxiety (41.3%). A study suggested that with increasing experience and higher professional ranks, fewer anaesthetists tended to routinely administer preoxygenation. Their findings proposed that the hesitancy among anaesthetists in implementing preoxygenation might stem from an overestimation of patient anxiety, despite patients generally exhibiting good tolerance towards the procedure.[14]

The current findings indicate that the most favoured technique among the anaesthetists was the practice of tidal volume breathing for 3-5 minutes (44.74%). Clinical practice incorporates various preoxygenation techniques, including the conventional approach of tidal volume breathing with 100% oxygen for 3 minutes, as well as the utilisation of four deep breaths within 0.5 minutes or eight deep breaths within 1 minute using a tightly fitted mask.[4] A comparative study evaluating these preoxygenation methods revealed that tidal volume breathing for 3-5 minutes effectively achieved maximal preoxygenation, while the application of four deep breaths within 0.5 minute resulted in suboptimal preoxygenation, suitable only in time-constrained scenarios. Also, there was a significant prolonged time to desaturation when patients received preoxygenation with 100% oxygen compared to room air before tracheal intubation.[7,8] Notably, no study has conclusively determined the most preferred technique employed by anaesthetists or the specific circumstances under which they choose to proceed without preoxygenation in elective cases. Tanoubi et al. concluded that the tidal volume breathing for three minutes and the eight deep breaths in 60 seconds techniques are suitable for most patients, highlighting the inadequacy of the four deep breaths in 30 seconds method.[12]

Ensuring a notably high oxygen fraction (FiO2) is crucial in extending the safe duration of apnoea. Elevating the applied oxygen fraction from 90% to 100% approximately doubles the duration before reaching critical hypoxia when the airway remains open.[13]

According to the current results, 69(90.8%) anaesthetists designated an end-tidal oxygen level exceeding 90% as their preoxygenation endpoint, while only 7(9.2%) maintained the practice for a duration of three minutes. The effectiveness of preoxygenation, gauged by its maximum efficacy, is characterised by an end-tidal oxygen concentration of 90% or an end-tidal nitrogen concentration of 5%. This efficacy is reflected in the rate of decline in oxyhaemoglobin desaturation during periods of apnoea.[15] The current study's participants also favoured this specific endpoint. Additional manoeuvres, including proper positioning, continuous positive airway pressure (CPAP), and positive pressure ventilation, are available to extend the effectiveness of preoxygenation, and anaesthesiologists should be well-versed in these techniques, especially for high-risk patients.

The existing literature strongly emphasises the benefits of preoxygenation prior to anaesthesia induction, highlighting its role in delaying the onset of hypoxia and extending safe apnoea time.[15] Consequently, preoxygenation is deemed essential for all patients receiving GA, particularly those undergoing elective procedures. The current findings revealed a tendency to forego preoxygenation in cases involving healthy adults. These results serve to underscore the significance of preoxygenation and establish standardised practices. Notably, preoxygenation should be prioritised in scenarios where a delay in oxygen delivery is anticipated, such as in patients with challenging airways, obesity, pregnancy, during tracheobronchial suctioning, and during awake fibre-optic intubation attempts.

The insights gained from the current study can be utilised to emphasise the significance of preoxygenation, identify the most effective techniques for achieving optimal oxygen concentration, and determine the endpoints that ensure the safety of patients.

The current study has its limitations because non-probability consecutive sampling technique was used to raise the sample. Besides, it was a single-centre study with a relatively large margin of error (9%) during sample size calculation. Finally, the psychometric properties (reliability, validity) of the data-collection questionnaire were not formally assessed. We collected the data for this study back in 2018-2019 however the data analysis and writeup were delayed due to unforeseen disruption caused by the COVID-19 pandemic. This delay in publication is one of the limitation of the study.

Conclusion

The assessment of preoxygenation practices employed by anaesthesiologists Indicated that tidal volume breathing for 3-5 minutes was the preferred technique, and there was a tendency to forego this safety measure in the case of healthy adults and anxious patients undergoing elective surgical procedures. The selected endpoint predominantly centred around the end-tidal oxygen concentration.

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AUTHOR'S CONTRIBUTION:

IJ: Concept, design, data acquisition, analysis, interpretation and agreement to be accountable for all aspects of the work.

GA: Data acquisition, analysis, interpretation, drafting, critical revision, final approval and agreement to be accountable for all aspects of the work