ORIGINAL ARTICLE

Multicentre Study of Preoxygenation Practices by Anaesthesia Providers

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Summary

A total of 155 consecutive anaesthetics in three public Malaysian hospitals were prospectively studied to assess preoxygenation practices by their anaesthesia providers. Preoxygenation was practised in 96.1% of patients. Specialist and non-specialist anaesthesiologist did not preoxygenate 8.8% and 2.3% of their patients, respectively. Overall incidence of arterial oxygen desaturation during induction was 15.5%. Arterial oxygen desaturation occurred more frequently with emergency surgery (30.2%) in comparison to elective surgery (9.8%). Arterial oxygen desaturation occurred more frequently with non-specialist (18.9%) than specialist anaesthesia providers (3.0%).

Key Words : Anaesthesia, Induction : Arterial desaturation, Preoxygenation

Introduction

The development and subsequent routine use of pulse oximetry have demonstrated that arterial oxygen desaturation is a frequent occurrence during induction of general anaesthesia. About 60% of patients who do not receive any preoxygenation desaturate during induction of general anaesthesia [1]. Consequently, preoxygenation is a recommended practice for all patients undergoing general anaesthesia regardless of type of surgery, i.e. elective or emergency. However, preoxygenation is still not routinely practised by all anaesthesia providers. In a survey of anaesthetic practice in Great Britain, only 21% of anaesthetics were preceded by preoxygenation [2]. Major obstacles to pre-oxygenation include patient dislike for the anaesthetic mask, and the "lack of time" to perform the procedure.

To assess the practice of preoxygenation in Malaysia, we surveyed anaesthetics administered in three major hospitals. We also investigated the incidence of arterial oxygen desaturation during induction of general anaesthesia.

Materials and Methods

We studied consecutive general anaesthetics given in three major hospitals in Malaysia, i.e. the Kuala Lumpur Hospital (KLH), Ipoh Hospital (IGH) and the Seremban Hospital (SGH). The survey was done in such a manner that the anaesthetic provider was "blinded" and unaware that he/she was subjected to the study. This was to reduce the probability of bias as the anaesthesia provider may change his/her technique upon realization of the survey. Survey information included patient characteristics (age, sex, ASA physical status, weight); type of surgery (elective vs' emergency); status of anaesthesia provider (non-specialist vs specialist); and the preoxygenation technique.

Only general anaesthesia induced via the intravenous route were studied. All patients were monitored with continuous electrocardiography, a non-invasive automated blood pressure monitor, a capnograph, and a pulse oximeter. As there were three survey centres involved, a single make and model of the pulse oximeter could not be standardized. Among the pulse

oximeters used include those by Nellcor®, Criticare®, Ohmeda®, and Datex-Engstrom®. All the pulse oximeters' time averaging interval were adjusted to a maximum of 3 seconds. The highest pulse oximetry reading prior to induction was taken as the baseline arterial oxygen saturation. The induction period commenced with the administration of an intravenous agent until after the airway was secured with an endotracheal tube. The lowest pulse oximetry reading was recorded during this period. Arterial oxygen desaturation was defined as a pulse oximetry reading of less than 95%.

The results were statistically analyzed by analysis of variance of parametric data, and by Chi-square or Fisher exact test for non-parametric data. The presence of

Table I
Distribution of Patients Surveyed in the Three Centres According to Age, Sex and ASA Physical Status

Centre	KLH n=53	IGH n=51	SGH n=51
Age (years)	mean=36.5	mean=36.6	mean=38.5
<13	1	1	2
13-20	9	7	9
21-30	8	19	9
31-40	17	7	4
41-50	11	5	14
51-60	2	7	8
61-70	2	4	3
71-80	2	1	1
81-90	1	0	1
ANOVA:p=0.811			
Sex			
Male	21 (39.6%)	27 (52.9%)	19 (37.3%)
Female	32 (60.4%)	24 (47.1%)	32 (62.7%)
Chi-Square:p=0.225			
ASA Physical Class			
I	35 (66.0%)	36 (70.6%)	28 (54.9%)
II	16 (30.2%)	10 (19.6%)	18 (35.3%)
III	2 (3.8%)	5 (9.8%)	5 (9.8%)
IV	0	0	0
Chi-Square:p=0.333			
Weight	60.6±12.4	59.2±4.4	63.9±5.3
ANOVA:p=0.1808			

confounding factors were subjected to a stratified analysis and the Mantel-Haenszel summary Chi-square obtained.

Results

The study was terminated when it was apparent that the anaesthesia providers became aware of the survey. In the end, a total of 155 general anaesthetics were studied, 53 in KLH, and 51 each in IGH and SGH, respectively.

There were no significant differences with regard to the age, sex, ASA physical class, or weight of the patients studied in all three centres (Table I). There was a difference in the distribution of class of surgery surveyed in the three centres.

In KLH, 92.5% surveyed were elective surgery compared to 62.7% and 60.8% in IH and SH, respectively (Table II). There were more anaesthetics given by specialist anaesthesia providers in KLH (41.5%) compared to IGH (5.9%) and SGH (15.7%).

Specialist anaesthetist staffing is much higher in KLH than the two other hospitals. However, there were no differences in the number of elective or emergency cases handled by either specialist or non-specialist anaesthetists (Table III).

Overall, preoxygenation was practised in 96.1% of the anaesthetics. 8.8% and 2.3% of specialist and non-specialist anaesthetists, respectively, did not provide any preoxygenation (Table IV). Only 26.5% of specialist anaesthetists provided the full 3-5 minutes of preoxygenation compared to 46.3% of non-specialist anaesthetists. There were no differences with the technique of anaesthetic mask application between specialist and non-specialist anaesthetist.

All patients had a saturation above 98% prior to induction of anaesthesia. Gross incidence of arterial oxygen desaturation was 15.5%. There was no relationship between age, sex, and ASA physical status to the incidence of arterial oxygen desaturation (Table V). Anaesthesia provided by non-specialist anaesthetists had a higher incidence of arterial oxygen desaturation (18.9%) compared to specialist anaesthetists (3.0%). Furthermore, 38.2% of anaesthetics given for emergency surgery by non-specialist anaesthetists developed arterial oxygen desaturation (Table VI) compared to none by specialist anaethetists.

Table II
Distribution of Class of Surgery and Status of Anaesthesia Provider in Each Centre. KLH surveyed more anaesthetics provided for elective surgery compared to other 2 centres

Centre	KLH	IGH	SGH
Class			
Elective	49 (92.5%)	32 (62.7%)	31 (60.8%)
Emergency	4 (7.5%)	19 (37.3%)	20 (39.2%)
Status			
Specialist	22 (41.5%)	3 (5.9%)	8 (15.7%)
Non-specialist	31 (58.5%)	48 (94.1%)	43 (84.3%)

Chi-square (Yates corrected) : KLH vs IGH p = 0.0064; KLH vs SGH p = 0.0003; IGH vs SGH p = 1.0. More anaesthetics in KLH were performed by specialist anaesthetists. Chi-square (Yates corrected): KLH vs IGH p<0.0001; KLH vs SGH p = 0.0072; IGH vs SGH p = 0.2017

Table III
Class of Surgery Managed by Status of Anaesthesia Provider. No significant difference between class of surgery performed by specialist or non-specialist anaesthetists

Class	Specialist (%)	Non-specialist (%)	Total
Elective	24 (72.7)	88 (72.1)	112
Emergency	9 (27.3)	34 (27.9)	43
Total	**33**	**122**	**155**

Chi-square (Yates corrected) p = 0.6466

Table IV
Preoxygenation Practice by Status of Anaesthesia Provider

	Specialist	Non-specialist
Preoxygenation Technique	**n(%)**	**n(%)**
None	3 (8.8)	3 (2.5)
Full 3-5 mins	9 (26.5)	56 (46.3)
Few tidal breaths	9 (26.5)	39 (32.2)
Vital capacity breaths	13 (38.2)	23 (19.0)
Total	**34**	**121**
Mask Application	**n(%)**	**n(%)**
None	3 (8.8)	3 (2.5)
Firmly	23 (67.6)	99 (81.8)
Loosely or held above	2 (5.9)	8 (6.6)
Intermittently removed	6 (17.6)	11 (9.1)
Total	**34**	**121**

Arterial oxygen desaturation occurred more frequently with emergency (30.2%) compared to elective surgery (9.8%). Of those who had emergency surgery, 27.6% of patients who had a full 3-5 minutes of preoxygenation had desaturation compared to over 40% of patients who had either tidal or vital capacity breaths. However, this did not reach statistical significance (p=0.4686). Analysis of desaturation without preoxygenation was not possible with the small numbers surveyed. There was no significant difference in arterial oxygen desaturation between various anaesthetic mask application techniques.

Table V
Incidence of Arterial Oxygen Desaturation According to Age, Sex And ASA Physical Status

	SATURATION		
Age (years)	**<95%**	**≥ 95%**	**Total**
<13	0	4	5
13-20	1	24	25
21-30	11	25	36
31-40	3	25	28
41-50	4	26	30
51-60	2	15	17
61-70	2	7	9
71-80	1	3	4
81-90	0	2	2
Total	**24**	**131**	**155**

Chi-Square:p=0.12678050

Sex			
Male	8 (5.2%)	59 (38.1%)	67
Female	16 (10.3%)	72 (46.5%)	88
Total	**24**	**131**	**155**

Chi-Square:p=0.225

ASA Physical Status			
I	15 (9.7%)	84 (54.2%)	99
II	7 (4.5%)	37 (23.9%)	44
III	2 (1.3%)	10 (6.5%)	12
Total	**24**	**131**	**155**

Chi-Square:p=0.98646023

Discussion

Arterial oxygen desaturation is a frequent occurrence during induction of general anaesthesia [1,2]. A variety of causes contribute to desaturation during induction. These include apnoea, respiratory depression, decreased functional residual capacity, decreased cardiac output, and if the induction process was complicated by airway obstruction or difficulties. To minimize the occurrence of hypoxia, 100% oxygen is often administered to the patient prior to induction of anaesthesia. The functional residual capacity is the principal oxygen store during apnoea. In a normal adult it is about 3.5 litres. Assuming an alveolar ventilation of 3.5 litres/min, this would give a time constant of 1 min. As filling of the lung represents an exponential function, three times the time constant will be required for 95% filling. Therefore, a 3 min period of preoxygenation has often

Table VI
Incidence of Arterial Oxygen Desaturation According to Class of Surgery and Status of Anaesthesia Provider

	Specialist (n=33) Saturation (%)		Non-specialist (n=122) Saturation (%)		
Class	**<95**	**≥95**	**<95**	**≥95**	**Total**
Elective	1 (3.0)	23 (69.7)	10 (8.2)	78 (63.9)	112
Emergency	0 (0)	9 (27.3)	13 (10.7)	21 (17.2)	43
Total	**1 (3.0)**	**32 (97.0)**	**23 (18.9)**	**99 (81.1)**	**155**

There were significantly more arterial oxygen desaturations in emergency surgery compared to elective (Yates corrected Chi-square:p=0.0038). Non-specialist anaesthetists managed anaesthetic for emergency surgery had higher occurrence of desaturation (Mantel-Haenszel summary Chi-square:p=0.0036). No significant difference in desaturation in anaesthetics performed by specialist anaesthetists (Fisher exact test p=0.7273)

been recommended to ensure an adequate reserve of oxygen during induction of anaesthesia. This received validation by Hamilton's [3] observation that denitrogenation of the lungs was more than 95% complete in 3 minutes in patients breathing oxygen through a circle system with a fresh gas flow of 4 litres/min. Other workers have shown that a four vital capacity breath technique was almost similar to 3 mins tidal breathing of 100% oxygen [4,5,6]. It appears that the provision of oxygen in lower concentrations also provided similar benefits [7,8,9]. Nevertheless, it is recommended that preoxygenation should be of at least 3 minutes to offer better protection against hypoxia [10].

In this study, the term "preoxygenation" was used liberally. As long as some oxygen supplementation was given prior to induction of general anaesthesia, it was considered as preoxygenation. Different degrees of desaturation have been categorized by various workers [11,12]. Our criterion for deciding what constituted clinically significant desaturation was based on the consideration that all the patients studied had a baseline saturation of 98-100%. Coupled with the accuracy of present day pulse oximeters, a 5% decrease was decided to be significant.

Our objective was to study if anaesthesia providers in this country followed current recommendations for preoxygenation. As such, we did not study the association between disease and arterial oxygen desaturation following induction of general anaesthesia. We also did not directly study the effect of preoxygenation on the incidence of desaturation as these have been well documented.

It was encouraging to note that 96.1% of the patients studied in the three centres did receive some form of preoxygenation. While this appears promising, it is still not ideal as 1 in 25 of patients will have an increased risk of hypoxia following induction of general anaesthesia. Specialist anaesthetists were four times as unlikely to provide preoxygenation for their patients compared to non-specialist anaesthetists in this study. Moreover, fewer specialist anaesthetists adhered to the standard practice of 3 mins preoxygenation compared to non-specialist anaesthetist. As the sample size of patients who did not receive preoxygenation was too small, it was not possible to reliably quantitate the incidence of desaturation within this group. To put this into perspective, even with preoxygenation, 15.5% of patients experienced desaturation.

Table VII
Incidence of Arterial Desaturation Related to Preoxygenation Technique and Class of Surgery

Preoxygenation Technique	Elective		Emergency		Total
	<95 (%)	≥95	<95	≥95	
None	0 (0)	4 (3.6)	0 (0)	2 (4.7)	6
Full 3-5 mins	7 (6.25)	29 (25.9)	8 (18.6)	21 (48.8)	65
Few tidal breaths	1 (0.9)	42 (37.5)	2 (4.7)	3 (7.0)	48
Vital capacity	3 (2.7)	26 (23.2)	3 (7.0)	4 (9.3)	36
Total	**112**		**43**		**155**
Mask Application	**Elective**		**Emergency**		
	<95 (%)	**≥96**	**<96**	**≥96**	**Total**
None	0 (0)	4 (3.6)	0 (0)	2 (4.7)	6
Firmly applied	9 (8.0)	78 (69.6)	12 (27.9)	23 (53.5)	122
Loosely applied	1 (0.9)	7 (6.3)	1 (2.3)	1 (2.3)	10
Int. removed	1 (0.9)	12 (27.9)	0 (2.3)	4 (9.3)	17
Total	**112**		**43**		**155**

There was no statistically significant difference between preoxygenation techniques and desaturation in emergency surgery (Fisher exact test:p=0.4686). There was no statistically significant difference in desaturation with mask application methods (Mantel-Haenszel summary Chi-square:p=0.2141)

Despite diligently following preoxygenation practice guidelines, non-specialist anaesthetist had six times higher incidence of desaturation compared to specialist anaesthetists. The incidence doubled when it involved emergency surgery. This may be due to their inexperience and inadequate skill in maintaining a patent airway and providing satisfactory ventilation. It is worthwhile to highlight that 3 mins of preoxygenation reduced to nearly half the incidence of desaturation for emergency surgery compared to other techniques of preoxygenation.

Although the period of desaturation is short following induction, retrospective studies have shown that oxygenation is an important factor leading to increased morbidity and mortality [13,14,15]. Airway problems may not be recognized and these will result in unanticipated airway and ventilation difficulties. An adequate period of preoxygenation provides a safety reserve that may allow time for a solution to the problem. It has been demonstrated that desaturation still occurred even with a smooth induction by experienced anaesthetists when preoxygenation was not given [16]. This may be related to experience or the lack of it, in maintaining an adequate airway and ventilation prior to tracheal intubation.

In conclusion, preoxygenation reduced significantly the incidence of arterial oxygen desaturation during induction of anaesthesia. This was evident in both elective and emergency surgery as well as different providers of anaesthesia.

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