Nitrous Oxide Pollution in the Operating Room. A Comparison of Two Modes of Ventilation

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SUMMARY

The use of laryngeal mask airway (LMA) as an alternative to the endotracheal tube (ETT) is becoming more popular in the practice of anesthesia. It is undeniable that this device has numerous advantages over endotracheal tube, however it does not provide an airtight seal between the airway and atmospheric gases. This may lead to pollution of the operating room environment with nitrous oxide. One hundreds adult patients undergoing general anaesthesia were divided into two groups. The airway in Group I was maintained with LMA with spontaneous ventilation and ETT with intermittent positive pressure ventilation (IPPV) was used for Group II. The result demonstrated that the ETT group recorded concentrations of nitrous oxide that were well above the NIOSH recommended eight hour time weighted average of 25ppm throughout the duration of surgery when compared to patients using LMA.

KEY WORDS:
Nitrous oxide pollution, Laryngeal mask airway, Endotracheal tube, Spontaneous ventilation, Intermittent positive pressure ventilation

INTRODUCTION

The use of numerous airway devices as an alternative to the endotracheal tube in providing positive pressure ventilation is becoming more popular in the practice of anaesthesia[1,2]. Laryngeal mask airway is widely used as a supraglottic airway management device during general anaesthesia today. It is undeniable that this device has numerous advantages over the ETT, however it does not provide an airtight seal between the airway and atmospheric gases especially during positive pressure ventilation. Therefore the likelihood of anaesthetic and inhalational agents such as nitrous oxide, sevoflurane or isoflurane escaping from the breathing circuit is higher than when an endotracheal tube is used[3,4,5]. This would lead to pollution of the operating room environment with nitrous oxide and anaesthetic vapours. Chronic exposure to traces of nitrous oxide can cause decreases in mental performance, reduced fertility and spontaneous abortion[6,7,8]. The National Institute for Occupational Safety and Health (NIOSH) recommends a time weighted average (TWA) of no more than 25 parts per million (ppm) over an eight hour period in the operating room.

The aim of this study was to determine if there was a difference in the OT pollution by nitrous oxide when LMA was used during spontaneous ventilation when compared to ETT usage during mechanical ventilation.

MATERIALS AND METHODS

This was a prospective randomized double blinded study conducted in Hospital Universiti Kebangsaan Malaysia. Following approval of the Hospital's Research and Ethical Committee and patient's informed consent, a total of 100 adult patients undergoing general anaesthesia with surgery not involving the airway were recruited and randomly divided into two groups using toss of a coin. Airway maintenance in Group I was using LMA while patients in Group II was using ETT. The study was conducted in five operation theatre (OT) in the same OT complex. All five OTs have the same ventilation characteristic. Similar anaesthetic machine (Falcon MIE), breathing circuit (closed system with PVC tubing's) and scavenging system (active scavenging) were utilized in all five OTs. Patients undergoing laparoscopic surgery, children and obese patients were excluded from the study.

Prior to starting each case, the anaesthetic machine was checked to ensure it was leak free and that the scavenging system was functioning. All patients were induced with intravenous propofol 2mg/kg and fentanyl 2microgram/kg. Patients in Group II were also given atracurium 0.5mg/kg to facilitate laryngoscopy and endotracheal intubation whilst this was omitted in Group I.

The patients were then manually ventilated for 3 minutes with 5 L/min of 100% oxygen and 3% sevoflurane until adequate depth of anesthesia was achieved. The selected airway device was then inserted. The size of the airway devices and the amount of air used for cuff inflation followed the manufacturer's recommendation. Correct placement was confirmed by equal chest expansion, adequate presence of breath sounds on auscultation, an end-tidal CO2 maintained between 35-40 mmHg and SpO2 of above 95%. An air sample was then collected, at a distance of 20cm (vertically) from the patient mouth. The air sample was aspirated directly into the gas analyzer **(EDIN-GUARDIAN PLUS Nitrous Oxide Gas Monitor)** which utilizes an infrared spectrophotometer, through a 30 centimeters plastic tubing. This first sample was

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Table I: Demographic data

	LMA (n= 49)	ETT (n=51)
Gender (M / F)	27 / 22	25 / 26
Race (M / C / I)	25 / 16 / 8	24 / 18 / 9
Weight (kg)	59.8	55.3
Airway size		
LMA 3 / 4	22 / 27	0
ETT 7 / 7.5 / 8	0	28 / 20 / 3

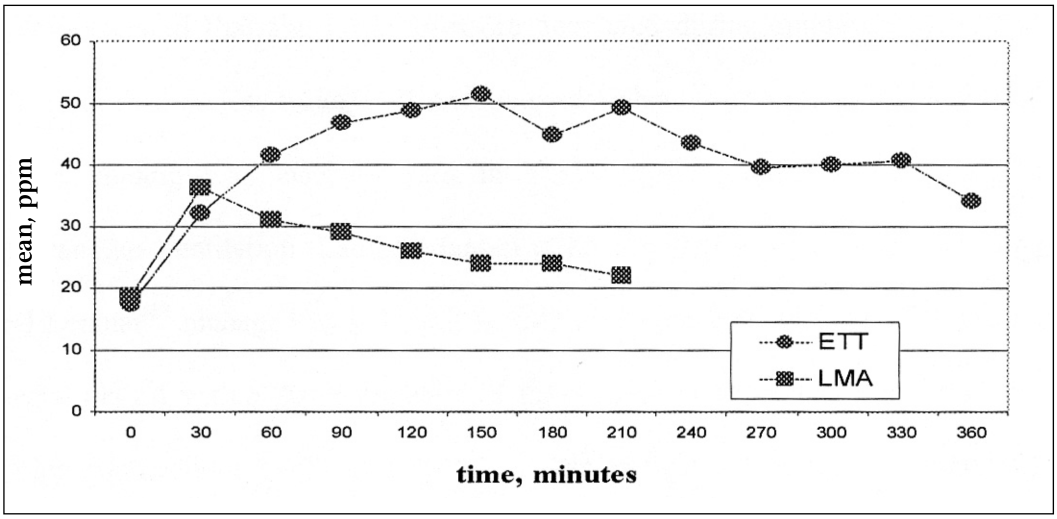

Fig. 1: Graph depicting the changes of nitrous oxide level versus time for both ETT and LMA plotted every 30 minutes. * Only the difference of mean values at 90, 120 and 150 minutes are statistically significant ($p < 0.05$)

considered to be the base line at time 0 minutes. Nitrous oxide was then turned on and anesthesia was maintained with nitrous oxide 1L/min, oxygen 1L/min and sevoflurane 2%.

Patients in Group I were allowed to breathe spontaneously, while periods of apnea was supported by manual positive pressure ventilation till resumption of spontaneous breathing. In Group II however, patients were connected to the ventilator after intubation. The air sampling was repeated every 30 minutes till the end of the surgery and the last sample was taken one minute after the airway device was removed from the patient. At the end of surgery, both nitrous oxide and sevoflurane flows were turned off and the patient was allowed to regain his/hers airway reflexes before the airway device was removed. All patients in Group II were reversed using neostigmine 2.5mg and atropine 1.0mg and the endotracheal tube removed following standard anaesthetic procedures.

RESULTS

The patient's demographic are shown in Table I. There is no difference in terms of sex, age and weight. The changes of nitrous oxide level against time are shown in Figure 1. Our results demonstrated that the ETT group recorded concentrations of nitrous oxide that were well above the recommended eight hour time weighted average of 25ppm by NIOSH throughout the duration of surgery, however with the use of LMA the concentration of nitrous oxide was above the recommended level only during the initial part of surgery. As these devices were used in the same operation theatre complex, room ventilation and scavenging characteristics would not account for any variation in the measured concentration observed with both LMA and ETT.

DISCUSSION

The increase in nitrous oxide concentration during the first half hour in the LMA group exceeded that of the ETT group. This is most likely due to the fact that these patients were manually ventilated with positive pressure ventilation during the initial period of apnoea following induction of anaesthesia and the seal afforded by LMA is not as superior as ETT. However, as the duration of surgery increased, we observed a steady decline in the concentration of nitrous oxide from an initial of 35-40 ppm at 30 minutes to less than 25 ppm at 210 minutes. This decline was not observed in the ETT group which had an average nitrous oxide concentration of more than 45 ppm after 60 minutes.

It is postulated that the lower pressure generated during spontaneous ventilation with LMA resulted in less leakage of nitrous oxide when compared to IPPV with ETT. This similar finding was also reported in a few earlier studies which used LMA and spontaneous ventilation. Lambert-Jansen *et al*[9] reported a mean level of 13 ppm. Sarma and Lenman[10] managed to reduce it further to 5 ppm with the use of closed scavenging device placed within 20 centimeters of the patients' mouth. Cameron *et al*[11] found that during spontaneous ventilation the LMA was as tight as the tracheal tube. O'Hare and Kerr[12] found, in spontaneous breathing patients, an average N2O exposure using face mask of 221 ppm versus 14 ppm using LMA. Jenstrup *et al*[5] found the level of nitrous oxide ranges from 28 to 126 ppm with a median of 60 ppm.

However, more study is needed to show that the differences in the nitrous oxide levels are truly due to the method of ventilation and not the airway devices themselves. We also found that the nitrous oxide levels falls rapidly at the end of surgery and by the time the next case was started which is usually within 5 to 10 minutes, the mean levels of nitrous oxide in the operating room was 14.7 and 17.4 ppm for the ETT and LMA groups respectively. This would indicate the adequacy of ventilation in the operating room. Furthermore in the morning, prior to starting any cases the nitrous oxide level in the operating room was never more than 2 ppm.

CONCLUSION

This study demonstrated that OT pollution with nitrous oxide was less when LMA was used in spontaneously breathing patient when compared to ETT during intermittent positive pressure ventilation.

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