

Original Research Article**Comparison of Carboxyhaemoglobin Concentrations between Low-flow and Minimal-flow Anaesthesia with Desflurane**Nazarudin B¹, Khairulmir Z², Azarinah I², Jaafar MZ², Karis M³, Esa K²¹Department of Anaesthesiology, Hospital Nora Ismail, Jalan Korma, 83000 Batu Pahat, Johor, Malaysia.²Department of Anaesthesiology and Intensive Care, Faculty of Medicine, Universiti Kebangsaan Malaysia Medical Centre, Jalan Yaacob Latif, Bandar Tun Razak, 56000 Cheras, Kuala Lumpur, Malaysia.³Department of Anaesthesiology, Faculty of Medicine, Universiti Teknologi MARA, Sungai Buloh Campus, Jalan Hospital, 47000 Sungai Buloh, Selangor, Malaysia.**Abstract**

This was a prospective randomised study comparing carboxyhaemoglobin concentrations between low-flow anaesthesia (fresh gas flow 1.0 L/min) and minimal-flow anaesthesia (0.5 L/min) using desflurane. Sixty (ASA 1 or 2) adult patients undergoing elective surgery under general anaesthesia were randomly allocated to receive either low-flow (Group 1) or minimal flow anaesthesia (Group 2). Venous blood samples for carboxyhaemoglobin levels were taken at baseline and at 10 mins intervals for 40 mins. Both groups showed significant increase in carboxyhaemoglobin concentrations within the first 10 mins when fresh gas flow of 4.0 L/min was used. Reduction in carboxyhaemoglobin levels was seen after 20 mins of minimal or low flow anaesthesia. However, there was no significant difference in the magnitude of reduction of carboxyhaemoglobin concentrations between the groups. The fractional inspired of oxygen (FiO₂) showed no significant changes in either group. In conclusion, desflurane usage in anaesthesia with either low-flow or minimal-flow was not associated with increased carboxyhaemoglobin concentrations.

Keywords: Low-flow, desflurane, soda lime, circle system, carboxyhaemoglobin**Correspondence:**

Dr. Esa Kamaruzaman, Department of Anaesthesiology and Intensive Care Unit, Faculty of Medicine, Universiti Kebangsaan Malaysia Medical Centre, Jalan Yaacob Latif, Bandar Tun Razak, 56000 Cheras, Kuala Lumpur, Malaysia. Tel: 006-03-91455785 Fax: 006-03-91737826 Email: ek4776@hotmail.com

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Introduction

Low-flow anaesthesia is a technique in which the rebreathing system is used resulting in at least 50% of the exhaled air being returned to the lungs after carbon dioxide absorption (1,2). Low-flow anaesthesia can be subdivided into low-flow, minimal-flow and metabolic flow. Low-flow anaesthesia is used when the fresh gas flow (FGF) below 1.0 L/min while minimal-flow anaesthesia when the FGF is between 0.25 to 0.5 L/min. Both low and minimal flow anaesthesia provide many advantages which include conservation

of body heat and airway humidity, economical and less pollution of the operation theatre (2,3).

Desflurane is a volatile agent of fluorinated methyl ethyl ether that has rapid emergence during anaesthesia (4). This property is due to its low solubility and negligible metabolism (5). Desflurane has been reported to interact with dry carbon dioxide absorbents producing carbon monoxide (CO), similar to other halogenated volatile agents (6). The main effect of CO toxicity is cellular hypoxia which is due to impairment of the delivery and utilisation of

oxygen. This effect is most profound in the brain and heart as the oxygen consumption in these organs is high (7). Carbon monoxide has higher affinity to bind reversibly with haemoglobin as compared to oxygen, therefore a small amount of CO may produce a significant concentration of carboxyhaemoglobin (COHb) in the blood.

Desflurane produces the highest CO concentration compared to other volatile agent (8). Low-flow anaesthesia has been used as one of the method to reduce the production of COHb in patients receiving desflurane (9). Factors that affect CO production during anaesthesia include the type of anesthetic agent used, the inspired anaesthetic concentration delivered, temperature of CO₂ absorbent and the degree of dryness of the CO₂ absorbent (10). Desflurane is known to have the lowest blood-gas solubility with its partition coefficient at 37°C of 0.42 (4). Low blood-gas solubility allows low FGF to be used, because of the decreased dilution of the high expired concentration of volatile agent (5). As FGF is reduced, less volatile agent is consumed therefore the overall operating cost is lower.

Materials and Methods

This was a prospective randomised, single blinded study to compare the COHb concentration during low-flow anaesthesia and minimal-flow anaesthesia with desflurane. Prior to the study, an approval was obtained from the Research and Ethics Committee, Universiti Kebangsaan Malaysia Medical Centre. Written informed consent was obtained from the patients before the commencement of this study.

A total of sixty patients with ASA physical status I or II, aged between 18 and 65 years who underwent elective surgery under general anaesthesia were enrolled. Patients with chronic respiratory disease and haemoglobinopathies were excluded from the study. All patients were fasted overnight for six hours and oral midazolam was prescribed as night sedation as well as premedication when patients were transferred to the operation theatre.

The anaesthetic machine was checked to meet the requirements for low-flow anaesthesia technique prior to induction of anaesthesia which included:

1. Flowmeter with graduation for low-flow rates at 100 ml/min.
2. Circle system with functioning carbon dioxide absorber containing fresh soda lime.

3. Anaesthetic machine with multi-gas analyzer, low pressure and disconnection alarms, airway pressure gauge and oxygen sensor.

The anaesthetic machine was checked for leak by automated leak test. The breathing circuit was also tested for leak. The expiratory valve was closed and the breathing circuit was pressurized to 50 cmH₂O while the circuit at the patient's end was occluded. The pressure was maintained with minimum flow of 0.1 L/min.

Standard anaesthesia monitoring which included the electrocardiogram, pulse oximetry, non-invasive blood pressure, anaesthetic gas and oxygen analyzer, capnography and spirometry were used. Intravenous (IV) cannula was inserted and venous blood samples were taken for baseline measurements. Subsequent venous blood samples were withdrawn for measurement 10 mins after induction and repeated every 10 mins for 40 mins. These samples were analysed by using ABL 800TM machine for COHb concentration.

Patients were pre-oxygenated with 5.0 L/min of 100% oxygen for at least three minutes before induction with intravenous fentanyl 2.0 µg/kg, propofol 2.5- 3.0 mg/kg and rocuronium 0.6 mg/kg or atracurium 0.5 mg/kg. After the patients had loss of consciousness, desflurane concentration was set at 6% initially. After 2-3 breaths of manual ventilation, the concentration of desflurane was increased by 1% until its end-tidal concentration reached 1 minimal alveolar concentration (MAC) and then endotracheal intubation was performed. After intubation, anaesthesia was maintained with 4.0 L/min fresh gas flow (FGF) with oxygen flow of 2.0 L/min, air 2.0 L/min and desflurane at 1 MAC for 10 mins.

In low-flow group, after initial FGF of 4.0 L/min, the FGF was reduced to 1.0 L/min with 100% oxygen and desflurane was maintained at 1 MAC. In minimal-flow group, the FGF was reduced to 0.5 L/min with 100% oxygen and desflurane maintained at 1 MAC. Blood samples were taken accordingly during the study period. After 40 mins, the FGF and choice of volatile agent were decided by the anaesthetist in-charge of the operating theatre.

Data analysis was done using SPSS 15 for Windows (LEAD Technologies, Inc). Student's t test was used for parametric demographic data such as age, weight and baseline COHb concentration. Qualitative demographic data was analyzed by Chi-square test.

Table 1: Demographic data. Values are expressed as mean \pm SD, number, (n) and percentage (%) where appropriate.

	Low-flow group (n=30)	Minimal-flow group (n=30)
Age (years)	41.7 \pm 13.0	45.7 \pm 13.9
Weight (kg)	67.0 \pm 10.0	69.0 \pm 13.5
Gender		
Male	18 (60)	17 (56.7)
Female	12 (40)	13 (43.3)
Race		
Malay	19 (63.3)	19 (63.3)
Chinese	6 (20.0)	9 (30.0)
Indian	4 (13.3)	1 (3.3)
Others	1 (3.3)	1 (3.3)
Baseline COHb (%)	0.88 \pm 0.24	0.87 \pm 0.26
Haemoglobin concentration (gm/dl)	13.5 \pm 2.1	13.4 \pm 1.4

Paired sample T test was used to analyze COHb concentration. 'p' value of < 0.05 was considered statistically significant.

Results

The demographic data was shown in Table 1. Both groups were comparable in terms of age, weight, gender, race, baseline COHb concentration and haemoglobin.

Figure I showed a significant increase in COHb concentration after induction in both low-flow and minimal-flow group when compared with their respective baseline values. However, the difference in COHb concentrations at different time intervals between the two groups was not statistically significant.

Discussion

Close anaesthesia system and low FGF has been used since 1850 (1). This technique was not widely practiced when halothane was introduced in 1954 due to inability of the vaporizer to accurately deliver volatile agent at low FGF (2). Low-flow anaesthesia technique had regained interest among anaesthetists after improvement of vaporizer technology in 1980's and the invention of circle absorber systems (2). Hargesser et al. recommended low-flow anaesthesia with desflurane as a technique of choice to reduce the cost of anaesthesia (5).

This study employed a technique proposed by Baum et al. in which the first 10 mins after induction of

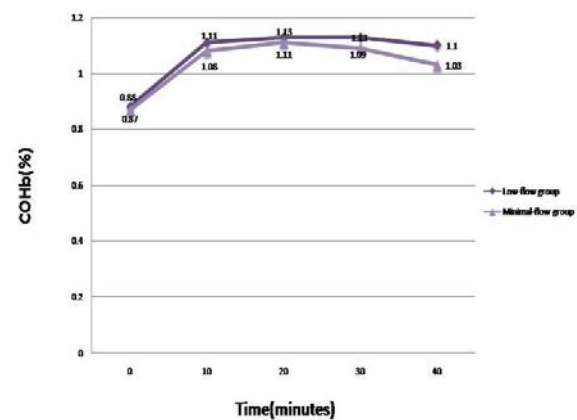


Figure 1: COHb concentrations at different time intervals. Values expressed as mean percentage (%).

anaesthesia, the high FGF of 4.0 L/min at least for 10 minutes need to be delivered to prevent gas volume deficiency (9). This practice had been adopted by Gowrie-Mohan et al. where he suggested the administration of initial high FGF during low-flow anaesthesia technique to establish the desired anesthetic gas composition within the entire patient circuit (11).

Before the induction of anaesthesia, the baseline COHb concentrations were measured. In this study, the baseline COHb concentrations in healthy individual that have no significant respiratory disease was 0.88 \pm 0.24 % in low-flow group and 0.87 \pm 0.25% in minimal-flow group. Sulotto et al. found that the COHb concentration in non-smoker healthy subject without occupational exposure was 1.34 \pm

0.8% with a wide variability (12). In this study, there were significant increase in COHb concentrations after induction in both low-flow and minimal-flow group when compared with respective baseline values in the first 40 mins. The carboxyhaemoglobin concentration declined after 20 mins of induction. Nevertheless, the reduction of carboxyhaemoglobin concentrations was not statistically significant. There was no statistically significance difference in COHb concentration at different time intervals between the two groups.

During low-flow anaesthesia, there was an increased in COHb concentration to reach peak concentration. This was followed by a decline in its concentration after 20 mins under low FGF. Previous study postulated the mechanism for CO formation was due to base-catalyzed difluoromethoxy proton abstraction from the anesthetic agent (13). It had been suggested that desiccated CO₂ absorbent degraded all anesthetics containing the CHF₂-O-moiety, for example desflurane, enflurane, and isoflurane. The desiccation of carbon dioxide occurred with high FGF. This mechanism was suggested by Fan et al. that FGF rate, CO₂ concentration and desflurane partial pressure contributed to CO production during low FGFs using a circle anesthetic breathing system in patient model (14). Other study suggested that the mechanism for the reduction of COHb concentration was the return of the effectiveness of humid CO₂ absorbent to react with CO₂ and effectively removed CO₂ from the circuit (15).

This study showed no significant difference of COHb concentrations in both low-flow group and minimal-flow group. In our opinion, modern anaesthesia machine using circle circuit with soda lime and gas analysers both the technique of low flow and minimal low flow anaesthesia are safe to be used. This anaesthetic technique will also reduce the usage of gases and volatile agent namely desflurane, reduce cost and eliminate operating theatre pollution.

In conclusion, low flow and minimal flow anaesthesia with desflurane was not associated with increased carboxyhaemoglobin concentrations.

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