

# The Effect of Heat and Moisture Exchanger and Gas Flow on Humidity and Temperature in a Circle Anaesthetic System

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## ABSTRACT

**Objective:** The aim of the study was to measure the humidity and temperature of the inspired gas in a circle absorber system at fresh gas flows of 1 l/min and 3 l/min and assess the need of a heat and moisture exchanger (HME).

**Methods:** This prospective randomised controlled study received the Hospital Ethics Committee approval and informed consent. Forty adult ASA I and II patients were randomised into four groups to receive with or without HME fresh gas flow of 1 l/min or 3 l/min. Temperature and the relative humidity readings were taken at the start and every 10 minutes for the first hour of anaesthesia.

**Results:** There was a significantly higher relative humidity, absolute humidity and temperatures of the inspired gases at fresh gas flow of 1 l/min and 3 l/min with a HME compared to 3 l/min without HME. Patients receiving fresh gas flows of 1 l/min had higher relative and absolute humidity than patients with fresh gas flows of 3 l/min. However, the addition of the HME improved the absolute and relative humidity of the inspired gas in patients receiving fresh gas flow of 3 l/min to a comparable level. However, the addition of a HME to a fresh gas flow of 1 l/min did not significantly improve the humidity of the inspired gas.

**Conclusion:** This suggests that the inherent humidifying property of the circle system at low fresh gas flow of 1 l/min was sufficient in short surgeries lasting less than one hour and that the addition of a HME may not be necessary.

**Keywords:** Humidity, low flow anaesthesia, heat and moisture exchanger, circle anaesthetic system

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## INTRODUCTION

In patients who are intubated, the natural mechanism of heating and moisturising the inspired gas by the nose and the upper airway is bypassed. The problem

is confounded by the delivery of cold and dry anaesthetic gases, which lead to the drying of the respiratory tract and heat loss<sup>(1)</sup>. This deleterious effect causes damage to the tracheobronchial epithelium and retardation of the mucociliary action<sup>(2,3)</sup>. It may lead to microatelectasis resulting in intrapulmonary shunt and increased risk of infection. These changes are particularly important in patients undergoing long anaesthesia and in patients with pulmonary disease.

The minimum absolute humidity required to prevent these deleterious changes remains controversial. Kleemann suggested an absolute humidity of 20 mg/l would be able to reduce the risk associated with dehydration of the respiratory tract<sup>(4)</sup>. However, a more recent study by Branson et al suggested a lower 12-15 mg/l would be adequate<sup>(5)</sup>.

The aim of the study was to measure the humidity and temperature of the inspired gas in a circle absorber system at gas flows of 1 l/min and 3 l/min and assess the need of a heat and moisture exchanger (HME) at these flows.

## METHODS

This was a prospective randomised controlled study. After obtaining approval from the Hospital Ethics Committee and informed consent, 40 adult ASA I and II patients aged between 20 and 65 undergoing elective surgery were included in the study. Patients with lung pathology or those who were febrile were excluded from the study.

The patients were induced with fentanyl 2 µg/kg as well as propofol 2 mg/kg and maintained using a volatile anaesthetic with oxygen-nitrous oxide mixtures. A non-depolarising muscle relaxant was used as needed to facilitate tracheal intubation and surgery. The patients were then randomised into four groups with different gas flow and the use of the heat and moisture exchanger Portex Thermovent HEPA.

Group 1 HME : Gas flow set at 1 l/min with HME  
 Group 1 : Gas flow set at 1 l/min without HME  
 Group 3 HME : Gas flow set at 3 l/min with HME  
 Group 3 : Gas flow set at 3 l/min without HME

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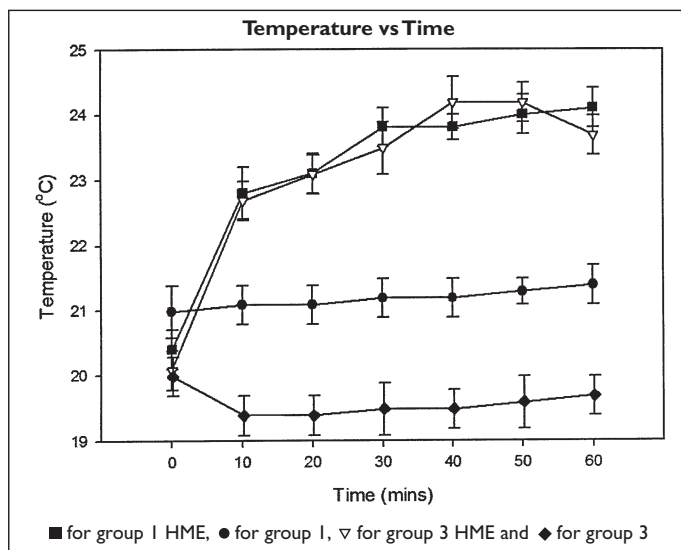


Fig.1 Temperature recorded every 10 minutes over the first hour. Values given are mean (SEM).

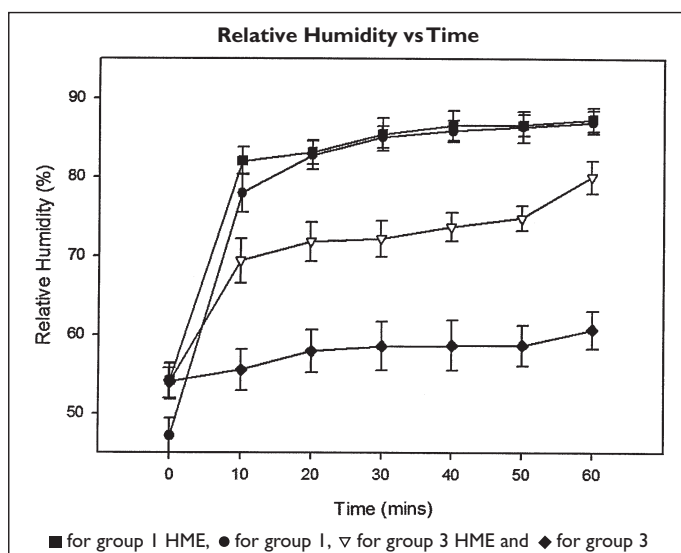


Fig.2 Relative humidity as recorded by the hygrometer every 10 minutes over the first hour. Values given are mean (SEM).

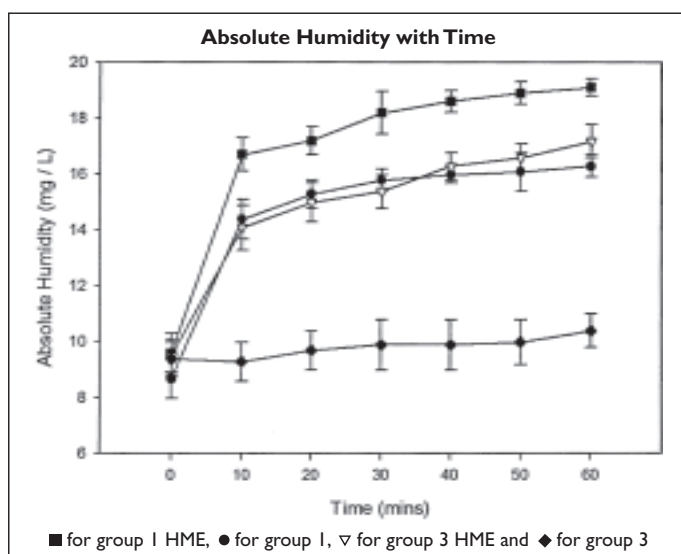


Fig.3 Absolute humidity as calculated every 10 minutes over the first hour. Values given are mean (SEM).

The anaesthetic system used a circle system (Kings System Corporation Adult Anaesthetic Breathing Circuit) with an Ohmeda Excel 210 anaesthetic machine. The ventilator was set at a rate of 10 breaths/min and tidal volume of 10 ml/kg according to the patient's needs. The Extech Instruments 444701 serial number A963466 hygrometer was inserted between the endotracheal tube and the Y piece of the breathing system to detect the temperature and the relative humidity. Baseline readings were taken before the start of the case and every 10 minutes for the first hour of anaesthesia. The absolute humidity was then calculated according to the formula:

$$AH = (3.939 + 0.5019T + 0.00004615T^2 + 0.0004188T^3) \times RH/100$$

(AH - absolute humidity, T - temperature, RH - relative humidity)

The data were analysed using the analysis of variance.  $P < 0.05$  was taken to be statistically significant.

## RESULTS

The demographic profile of the patients in the four groups was similar. The baseline temperature and the relative humidity were also comparable between the groups. The temperature and the relative humidity increased throughout the study period in all the groups (Fig. 1). However, the relative humidity was significantly higher in groups 1HME, 1 and 3HME as compared to group 3. There was no difference in the relative humidity of patients in groups 1HME, 1 and 3HME (Fig. 2). In terms of absolute humidity, again the patients in groups 1HME, 1 and 3HME had significantly higher values than patients did in group 3 (Fig. 3).

## DISCUSSION

The use of low flow anaesthesia has an inherent humidifying property and this is demonstrated in this study. Patients in group 1 with fresh gas flows of 1L/min had higher relative and absolute humidity than patients with fresh gas flows of 3L/min in group 3. However, the addition of the HME was able to improve the absolute and relative humidity of the inspired gas in patients receiving fresh gas flow of 3L/min to a comparable level. This is demonstrated by the fact that there is no significant difference in the humidity levels between patients in groups 1 and 3HME. However, interestingly, the addition of a HME to a fresh gas flow of 1 L/min did not significantly improve the humidity of the inspired gas. Perhaps, the significant difference may only be seen if the anaesthesia proceeded beyond one hour as this study was terminated after one hour. Hence, it may not be necessary to use the HME in patients undergoing

low flow anaesthesia of 1L/min in short surgeries lasting <1 hour. HME in itself adds dead space, resistance, cost and the possibility of occlusion with secretions or leaks in the anaesthetic circuit. However, the anaesthetist may consider using a bacterial filter, which is a cheaper alternative to a HME, in such short cases, especially when the breathing system is not replaced after each case. Neither of the patients in the four groups achieved the minimum value of 20 mg/l as suggested by Kleemann in order to minimise the tracheobronchial changes. Kleemann had demonstrated a 90 min lag time before the absolute humidity reached 20 mg/l even at minimal flows<sup>(4)</sup>. This could also be partially attributed by the low ambient room temperature of 18-20°C in our operating theatre. Nevertheless, the patients in groups 1HME, 1 and 3HME achieved the minimum humidity standard of 12-15 mg/l set by Branson et al within the hour. Patients in group 3 were unable to meet this target. Perhaps, the use of a HME with better moisture-conserving properties would be able to attain absolute humidity of 20 mg/l

within the hour. The use of low flow anaesthesia in a circle system has inherent humidifying properties at flows of 1L/min<sup>(6)</sup>. However, at higher flows of 3 L/min, this humidification may not be sufficient. HMEs may be able to improve on the humidity of the inspired gas in situations where higher fresh gas flow 3 L/min are required even for short surgeries lasting one hour.

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