# A new nasal cannula-based nitrous oxide system. Does it work?

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## Aim

The goal was to evaluate a new technology (Silhouette, Parker Instrument, Hatfield, PA) for inhalational sedation with nitrous oxide ($N_2O$). First, we investigated the system's capability to deliver precise dentist-controlled gas concentrations, which is of critical importance to patient safety [1]. Secondly, we assessed the system's ability to deliver 100% oxygen ($O_2$) – essential in an emergency or to terminate a procedure, as specified by the American Dental Association and the American Academy of Pediatric Dentistry [2, 3].

## Introduction

Dentists have achieved an unparalleled level of patient safety by combining a high level of technical precision and skill in choosing the appropriate $N_2O$ concentration and thus protecting the patient from potentially life-threatening adverse effects [4, 5]. Nasal cannula systems are used outside of dentistry to apply medical $O_2$, but they are known to deliver unpredictable gas concentrations [6]. To date, dentistry has avoided nasal cannulas instead employing nasal hoods that deliver reliable gas concentrations that are not dependent on factors outside of the dental practitioner's control [7].

Fig.1 Sampling probe to determine applied gas concentrations

## Methods

24 volunteers (12 male, 12 female, 26-61 y/o) participated. Body weight and actual corresponding resting respiratory minute volume (MV) were recorded for each subject (Tab. 1 and 2). As per manufacturer's instructions, the Silhouette system was properly fitted with the nasal cannula positioned in the right nostril. The hood size was determined as described in the package insert and a disposable nasal mask was placed over the nose and sealed with the attached adhesive. The flowmeter was set to 6 LPM which is the maximum safe flow rate [8]. A probe was inserted through the wall of the nasal hood to monitor the inhaled gas mixture (Fig. 1.). Gas sampling was performed at 50ml/min using a calibrated General Electric Datex Ohmeda s/5 monitor. Inhalational sedation was performed with $N_2O$ set at 70% for 10 minutes and followed by 100% $O_2$ for 5 minutes to terminate the procedure. The maximum $N_2O$ concentration was measured during the sedation phase. The maximum $O_2$ concentration was measured following the washout of $N_2O$.

| | Mean | SD | Median | min-max |
|---|---|---|---|---|
| Age | 39.3 | 10.1 | 36.5 | 26.0-61.0 |
| Height [cm] | 172.3 | 10.4 | 169.0 | 157.0-192.0 |
| Weight [kg] | 71.5 | 14.3 | 67.0 | 52.0-101.0 |
| BMI | 23.8 | 2.1 | 23.6 | 20.6-27.8 |
| MV [L/min] | 5408 | 1126 | 5200 | 4000-7800 |
| $N_2O$ [%] | 25.1 | 6.9 | 24.5 | 13.0-35.0 |
| $O_2$ [%] | 31.0 | 3.5 | 30.0 | 26.0-39.0 |

Tab. 1 Parameters obtained in all subjects [n=24]

| | | N | Mean | SD | Median | min-max |
|---|---|---|---|---|---|---|
| Age | Male | 12 | 44.2 | 10.7 | 43.5 | 29.0-61.0 |
| | Female | 12 | 34.3 | 6.8 | 33.5 | 26.0-50.0 |
| Height [cm] | Male | 12 | 180.8 | 7.2 | 182.0 | 169.0-192.0 |
| | Female | 12 | 163.8 | 4.0 | 164.5 | 157.0-169.0 |
| Weight [kg] | Male | 12 | 83.5 | 9.9 | 82.0 | 68.0-101.0 |
| | Female | 12 | 59.5 | 4.0 | 59.5 | 52.0-66.0 |
| BMI | Male | 12 | 25.5 | 1.5 | 25.4 | 23.0-27.8 |
| | Female | 12 | 22.2 | 1.2 | 22.2 | 20.6-24.5 |
| MV [L/min] | Male | 12 | 6325 | 789 | 6350 | 5200-7800 |
| | Female | 12 | 4492 | 440 | 4350 | 4000-5200 |
| $N_2O$ [%] | Male | 12 | 20.0 | 4.6 | 20.0 | 13.0-29.0 |
| | Female | 12 | 30.2 | 4.8 | 31.5 | 21.0-35.0 |
| $O_2$ [%] | Male | 12 | 29.8 | 3.6 | 29.5 | 26.0-38.0 |
| | Female | 12 | 32.1 | 3.3 | 32.0 | 27.0-39.0 |

Tab. 2 Parameters by gender

## Results

MV is dependent on lean body mass, which is reflected by the significantly lower MV generally found in females as opposed to males. Lower MV leads to lower levels of admixing room air and thus to higher max. $N_2O$ levels. While the dentists applied the same concentration of $N_2O$ to all subjects, females with their lower body weight inhaled significantly higher concentrations of $N_2O$ (mean: 30.2 %) than the heavier males (20.0 %). The Spearman's Rank Correlation Coefficients (rho) also show a negative correlation between MV and $N_2O$, where patients with lower respiratory minute volumes receive higher concentrations of $N_2O$ (Tab. 3 and Fig. 2).

The same holds true for $O_2$. Tab. 4 and Fig. 3 show the negative Spearman's Rank Correlation Coefficients (rho) for MV and $O_2$. It is noteworthy that there is a less negative correlation between $O_2$ and MV reflecting lower $O_2$ concentrations than might be clinically expected. No subject was able to receive 100% $O_2$ which might be needed in an emergency situation and is required at the end of any inhalational sedation.

| | MV | rho | p-value |
|---|---|---|---|
| Total (n=24) | $N_2O$ | -0.93 | <0.001 |
| Male (n=12) | $N_2O$ | -0.83 | <0.001 |
| Female (n=12) | $N_2O$ | -0.86 | <0.001 |

Tab. 3 Spearman's Rank Correlation Coefficient (rho) for MV and $N_2O$

| | MV | rho | p-value |
|---|---|---|---|
| Total (n=24) | $O_2$ | -0.60 | 0.002 |
| Male (n=12) | $O_2$ | -0.55 | 0.064 |
| Female (n=12) | $O_2$ | -0.58 | 0.047 |

Tab. 4 Spearman's Rank Correlation Coefficient (rho) for MV and $O_2$

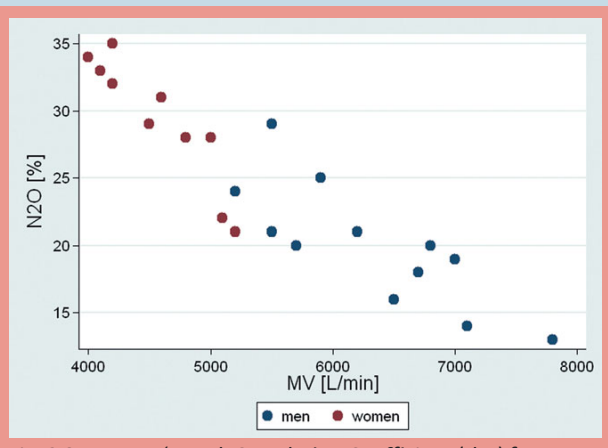


Fig. 2 Spearman's Rank Correlation Coefficient (rho) for MV and $N_2O$

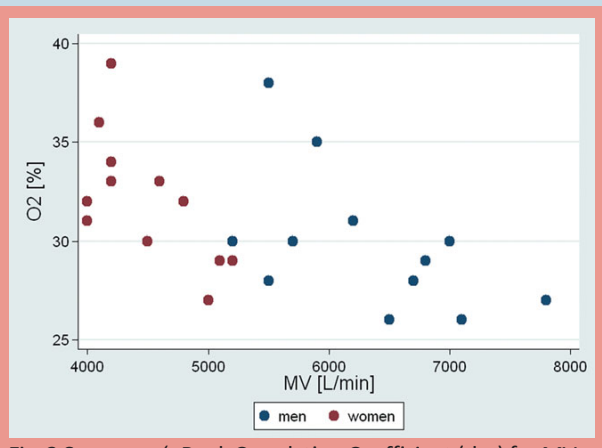


Fig. 3 Spearman's Rank Correlation Coefficient (rho) for MV and $O_2$

## Conclusion

For many years, nasal cannulas have been used outside of dentistry to administer $O_2$, but they are known to deliver unpredictable gas concentrations [9]. This study, based on the new Porter Silhouette nasal cannula system, shows similarly inconsistent results with regard to both $O_2$ and $N_2O$ delivery. Especially in women, lower body weight and correspondingly lower respiratory minute volumes cause an increase in inhaled $N_2O$ which is difficult for the dentist to quantify and can potentially lead to deeper levels of sedation than anticipated. The application of 100% $O_2$ was not possible with the Silhouette system.

Further studies are required to determine whether dentists can inadvertently apply dangerously high levels of $N_2O$ with this system. Also, further investigation will show if the Silhouette's inability to supply high concentrations of $O_2$ could leave the doctor without recourse in an emergency situation or during the occurrence of diffusion hypoxia.

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