Nitrous Oxide Inhalation Sedation Through a Nasal High-Flow System: The Possibility of a New Technique in Dental Sedation

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High-flow nasal cannula (HFNC) systems are increasingly used for patients with both acute and chronic respiratory failure because of the clinical effectiveness and patient comfort associated with their use. Recently, HFNC has been used not only as a respiratory support device, but also as a drug delivery system. HFNC is designed to administer heated and humidified inspiratory oxygen flows (100% relative humidity at 37°C). Therefore, HFNC can provide high flows (up to 60 L/min) without discomfort. Moreover, HFNC improves oxygenation by exerting physiologic effects such as (a) dead-space washout and (b) moderate positive airway pressure. These characteristics and physiologic effects of HFNC may permit administration of high-flow nitrous oxide sedation while ensuring patient comfort and adequate sedative effect.

Key Words: Nasal high-flow system; Nitrous oxide inhalation sedation; Sedation.

Many dental patients subconsciously feel a certain amount of anxiety because of the anticipated pain or discomfort often associated with dental treatment. Nitrous oxide in oxygen (N₂O) inhalation sedation is the most commonly used technique for management of anxious dental patients of all ages. It is especially useful for dental patients with needle phobia to aid in initiating intravenous access prior to intravenous sedation. Nitrous oxide can provide conscious sedation in most patients. However, the sedative effect of N₂O may not achieve adequate levels in some patients. For these patients, increasing the total flow rate is a common technique for providing adequate sedation, as is increasing the N₂O concentration. In general, N₂O is administered by dedicated dental N₂O/

O₂ nasal inhalation systems in the dental setting. A typical N₂O inhalation system can supply a maximum total flow rate of 20 L/min (O₂ 10 L/min, N₂O 10 L/min). However, these higher flows through the N₂O inhalation system can cause mouth/nasal dryness or deterioration of airway mucociliary clearance because the gases cannot be adequately humidified. This is one reason a flow rate of less than 5–6 L/min is generally administered by the N₂O inhalation system.¹

High-flow nasal cannula (HFNC) systems are increasingly used for patients with both acute and chronic respiratory failure because of their clinical effectiveness and the associated patient comfort with their use.² Recently, Sago et al³ reported the utility of the HFNC system in dental patients under intravenous sedation. Moreover, HFNC is used not only as a respiratory support device, but also as a drug delivery system.⁴ Inhaled nitric oxide using an HFNC is also used in the management of pediatric patients with respiratory distress.⁵

An HFNC system is designed to administer heated and humidified inspiratory gases (100% relative humid-

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Figure 1. A nasal high-flow cannula system (AIRVO, Fisher & Paykel Healthcare, Auckland, New Zealand) and nasal cannula (Optiflow, Fisher & Paykel Healthcare) for nasal high-flow nitrous oxide delivery.

ity at 37°C).² Therefore, HFNC can provide high gas flows (up to 60 L/min) without discomfort.

It is conceivable that actual inspired N_2O concentrations with a conventional dental N_2O inhalation system are much lower than actual delivered concentrations because of (a) dilution with inspired air from the atmosphere and (b) rebreathing of expired air in the anatomical dead space, which probably attenuates actual inspired N_2O concentrations. The actual inspired gas concentration with HFNC is closer to actual delivered concentrations because of high flow without dilution from air from in the atmosphere.^{6,7} Moreover, HFNC exerts physiologic effects, such as (a) anatomical dead-space washout and (b) a moderate positive airway pressure.^{7–9} Therefore, HFNC may permit the actual inspired concentrations of N_2O to be closer to the actual delivered concentrations, thereby allowing better titratability and ensuring adequate sedative effects.

AIRVO 2 (Fisher & Paykel Healthcare, Auckland, New Zealand) is one of the most commonly used HFNCs in the world (Figure 1). Although several

Figure 2. Oxygen delivery inlet of the nasal high-flow cannula system.

HFNC devices are now available, we consider AIRVO 2 as being most applicable to N_2O inhalation sedation through an HFNC system. Because AIRVO 2 has an oxygen delivery inlet (Figure 2), the gaseous mixture of N_2O and O_2 for N_2O inhalation sedation can be provided using the oxygen delivery inlet of the HFNC.

First, a nasal cannula (Optiflow, Fisher & Paykel Healthcare) for NHFC is inserted into the patient's nostrils and connected to the NHFC system (AIRVO, Fisher & Paykel Healthcare). Next, the NHFC system is activated and set to deliver an oxygen concentration of 50%, a temperature of 37°C, and a total flow rate of 20 L/min. Simultaneously, a conventional N_2O sedation system is set to deliver oxygen at a flow rate of 10 L/min and N_2O of 10 L/min. The outlet of the conventional N_2O sedation system and the inlet of the NHFC system are connected using a polyvinyl chloride tube. This combination system allows provision of heated, humidified 50% N_2O (in oxygen) at a total inspiratory flow rate of 20 L/min.

One of the drawbacks of N_2O inhalation sedation is exposure of dental personnel to N_2O . N_2O inhalation sedation through an HFNC system produces a large amount of excess gas. Therefore, when using this technique, external scavenging such as a fan to direct excess delivered gas away from dental personnel, likely in combination with a room air circulation system, is necessary to reduce environmental exposure to N_2O . Furthermore, a nasal cannula for NHFC would likely have to be covered with a mask scavenger to retrieve excess gas. Before clinical application, additional basic research will be required to ensure protection of dental personnel from unwanted N_2O exposure. Our initial focus in the use

of this modality is for initiation of intravenous access, which should be a relatively short exposure time that might limit environmental concerns.

In addition to basic studies for environmental contamination, human volunteer studies and clinical studies are needed to determine the appropriate N₂O concentrations to achieve the optimal sedative level. Total flow rates for the clinical application of this technique also need to be determined. It may be that lower total flow rates of 10–15 L/m may be acceptable. We believe that N₂O inhalation sedation through a nasal high-flow system may become a useful technique for the management of anxious dental patients with needle phobia if the above concerns can be addressed.

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