WHITE PAPER

$CAPNO_2$*mask* –
A viable alternative to nasal cannulae

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INTRODUCTION

Supplemental oxygen is widely used for the long-term treatment of chronically ill patients suffering from various respiratory diseases such as Chronic Obstructive Pulmonary Disease (COPD) and emphysema. Additionally, in emergency situations, supplemental oxygen is administered on a short-term basis to relieve acute symptoms, such as shortness of breath and lowered oxygen saturation. Supplemental oxygen is also commonly administered throughout the hospital setting, such as in the operating room during surgery and during post-operative recovery, and in the intensive care units to critically ill patients.

Conventional practices for administering supplemental oxygen to a patient include nasal cannula and face masks. The nasal cannula consists of tubing with a pair of prongs that are situated within the nostrils of the patient and through which oxygen flows. The nasal cannula provides more freedom of movement for the patient than other methods, but drawbacks of using a conventional nasal cannula are well known and include unknown and/or limited delivered fractional inspired oxygen (FiO_2), potential irritation of the nose and dislodgment of the cannula from the patient's nostrils. Moreover, a cannula including a gas monitoring capability exhibits a recognized inability to reliably detect both oral and nasal gas exchange as well as a tendency to dilute the measured gas. Thus, while the nasal cannula with CO_2 sampling provides a monitoring capability combined with oxygen delivery, the delivery may be somewhat less efficient than is possible with a mask. In addition, the use of a mask provides an enclosure that can alleviate problems in dealing with oral vs. nasal breathing, and maintaining smooth flow through the sample line tubing.

Oxygen masks, which are simple, inexpensive to use, and not subject to easy dislodgment, have also been employed to reliably administer oxygen levels of 40–60% O_2 to the patient. Oxygen mask designs vary based upon intended use of the particular mask. Oxygen masks include a body that is sized to cover the nose and mouth of the patient. With conventional mask designs, oxygen is introduced through an oxygen inlet, and expiratory gases are vented from the mask through apertures.

Disadvantages of conventional oxygen mask delivery systems are that some patients may not tolerate a mask for more than short periods of time and no quantitative monitoring of the end-tidal carbon dioxide is performed. Such monitoring would allow for the diagnosis of hypercapnia, which indicates inadequate oxygen delivery and the need for a more aggressive treatment strategy. While some designs have addressed these disadvantages, such as gas measurement, separately, an apparatus providing these features would be advantageous.

Figure 1 - $CAPNO_2$*mask*

The patented $CAPNO_2$*mask* (1) provides a face mask which includes a mainstream gas monitoring capability for improved patient management in combination with supplemental oxygen delivery to the patient.

The face mask is configured to direct all of the inspiratory and expiratory gas streams to and from the patient through a mainstream airway adapter and to deliver supplemental oxygen. As such, contrary to a nasal cannula, the face mask allows for efficient measurement of both oral and nasal gas exchange.

The supplemental oxygen delivery inlet is located distal to the airway adapter so that it does not mix with the expiratory gases prior to their measurement but is still available to enrich the gas stream during inhalation. An adapter proximal to the oxygen delivery inlet provides a reservoir of oxygen for the next inhalation cycle. The placement of this adapter (i.e. reservoir) proximal to the location of oxygen delivery increases the amount of oxygen which would be inspired by the patient. Provided the flow rate of oxygen is sufficient, the added volume of the reservoir will not result in any significant CO_2 rebreathing. Thus, the portion of the inspiratory gases within this reservoir will contain primarily end-expiratory gas mixed with 100% O_2. Table 1 provides guidance on the FiO_2 range that may be achieved with different oxygen flow rates.

Unlike conventional oxygen delivery systems, this face mask does not contain any additional apertures or valves for venting the expiratory gases. Because one purpose of this face mask is to provide accurate gas monitoring, a proper seal between the peripheral rim of the mask and the patient's face is created to prevent dilution of the inspiratory gases by ambient gases. Thus, the gas measuring device associated with the face mask can provide quantitative information on the expiratory gases such as end-tidal values and respiratory rate as well as qualitative values. Also, the face mask is designed with minimal deadspace within the mask volume as placed on the patient to more accurately reflect the patient's carbon dioxide output.

In operation, the face mask traps CO_2 upon exhalation (whether oral, nasal or combined) and pressure forces it out of the mask. Upon inhalation, enriched ambient air is easily entrained into the face mask. This bi-directional gas exchange allows the attached CO_2 sensor to easily track the patient's capnogram while avoiding problems associated with sidestream gas sampling systems.

Table 1 - Oxygen Delivery Table

O_2 (LPM)	FiO_2 Range
6	25-45%
7,8,9	30-60%
10,11,12	40-65%
13,14,15	45-75%

Note: Delivered FiO_2 is dependent on patient's minute ventilation and inspiratory flow rate.

Figure 2 - Subject with CAPNO$_2$*mask*

One significant advantage of the CAPNO$_2$*mask* is that it enables effective detection of both oral and nasal gas exchange without dilution, enabling among other capabilities, an accurate measurement of end tidal CO_2. The CAPNO$_2$*mask* is particularly suitable for non-intubated gas exchange monitoring where oxygen delivery and CO_2 monitoring are needed. This includes patient transport, conscious sedation, critical care and emergency medicine.

REFERENCE

(1) United States Patent #7004168, Face mask for gas monitoring during supplemental oxygen delivery, Issued February 28, 2006.

FOR FURTHER READING ON CAPNOGRAPHY

Gravenstein JS, Jaffe MB, Paulus DA. Capnography: Clinical Aspects. Cambridge University Press, London, 2004.