TITLE: A novel mainstream capnometer system for non-intubated children requiring oxygen administration

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INTRODUCTION:
Detection of respiratory depression in non-intubated pediatric patients who undergo procedural sedation poses a significant clinical problem as pulse oximeters are not sensitive respiratory monitors, especially when oxygen is being administered. Capnometers can be very sensitive respiratory monitors in pediatric patients, however stable application on non-intubated patients can be problematic, especially when oxygen is administered. We devised a novel mainstream capnometer system, which enables stable monitoring of exhaled CO2 while administering oxygen, and tested its usefulness on selected pediatric patients in PICU.

Methods:
A specially designed open facemask type furnace (Figure 1), which is designed to hold a lightweight mainstream capnometer (cap-One® OLG-2800, Nihon Kohden, Tokyo) was studied. It has a unique current plate structure to let expiratory gas flow be exposed to the capnometer sensor from either the nose and/or mouth. It also has a structure to let oxygen flow effectively to patients without expiratory gas exposure interfering with the capnometer sensor. The mask type furnace is designed to have a big enough opening to facilitate observation and allow such manipulations as oral suctioning. At the same time the outer limb of the furnace is designed to effectively retain oxygen flow without causing rebreathing.

The basic performance and stability of this capnometer/furnace system (C/F system) were compared with a standard type facemask (Pedimask OX-130, Atom Medical, Tokyo) in a child face mannequin in a supine position connected to a spontaneous respiration simulator at a tidal volume of 80 ml and rate of 40/min (TTL 1603, Michigan Instrument, MI). The C/F system was also tried on pediatric patients who still had arterial lines immediately after extubation in PICU. Arterial blood gas samples were withdrawn when ETCO2 appeared stable for at least 5 minutes. The research protocol was approved by the IRB of Nagano Children’s Hospital.

RESULTS:
This C/F system showed appropriate capnograms even at relatively high (6L/min) oxygen flow and yielded better inspiratory oxygen concentrations with the same oxygen flow rate when fitting was appropriate compared to a standard facemask (55% vs 40%). The C/F system was found to have less fluctuation in inspiratory oxygen concentration when the mask was moved away from the standard position (45-50% vs 30-60%). Inspiratory PCO2 never rose above 7 mmHg when there was no oxygen flow, but it rose as high as 21 mmHg when a standard facemask was applied.

This C/F system was tried on 6 pediatric patients ranging from 28 days to 4 years (2.2kg-12.8kg) with 2l/min or 5l/min of oxygen. ETCO2 agreed well with PaCO2 and differences ranged 2-7 mmHg (total of 12 samples), although no statistical analysis was made due to the non-uniformity of the patients.

DISCUSSION:
Capnometry on non-intubated pediatric patients is usually performed with a sampling of expired gas via nasal cannula, which is prone to frequent measurement interruptions from repeated clogging with secretions and humidity, dilution of sampled gases by aspiration of environmental gas or oxygen, and inevitable measuring time delay. Apnea may not be accurately detected due to artificially made inspiration (lowering CO2). A mainstream capnometer is better than a mask, however it is too heavy, bulky and difficult to hold in place. The C/F system we developed was designed to overcome these problems. The furnace structure has the added advantage of effectively delivering oxygen without compromising nursing care. This novel C/F system has a potential of contributing to the safety of infants and children who undergo procedural sedation.

REFERENCES: