Fighting Disease with Electronics
NIHON KOHDEN

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Vol.2

Ensure Quality of Care under Sedation

- Accurate respiratory monitoring with optimal oxygen supply -

Efficient Monitoring for Safer Pediatric Sedation

— Don't miss signs of respiratory depression —

Pediatric sedation may involve serious risks including hypoventilation, apnea, airway obstruction and cardiopulmonary dysfunction[1]. Also, it has been shown that depth of sedation can be deeper than the intended level in pediatric patients[2]. For safer patient management, it is essential to closely observe patients while administrating sedation. According to an analysis of adverse events related to pediatric sedation in the US, the most commonly observed adverse event is respiratory depression. It also reports that these adverse events can lead to serious incidents including death and permanent dysfunction in the absence of appropriate monitoring[3].

— Fast, accurate detection of respiratory depression while oxygen is supplied —

Nihon Kohden has developed an extremely small mainstream CO_2 sensor (cap-ONE) that can accurately measure oral as well as nasal exhaled CO_2 in non-intubated patients[4]. After further development and evolution, the cap-ONE is now available as the world's smallest mainstream CO_2 sensor weighing only 4 g with an original open face oxygen mask (cap-ONE mask). Cap-ONE mask is easily used for pediatric patients who are receiving supplemental oxygen, and the cap-ONE CO_2 sensor reliably detects respiratory depression including apnea and hypoventilation while oxygen is supplied (Fig. 1).

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Using this ultra-small mainstream CO_2 sensor together with cap-ONE mask, the sensor can accurately catch oral and nasal exhaled CO_2 and reliably detect respiratory variation.

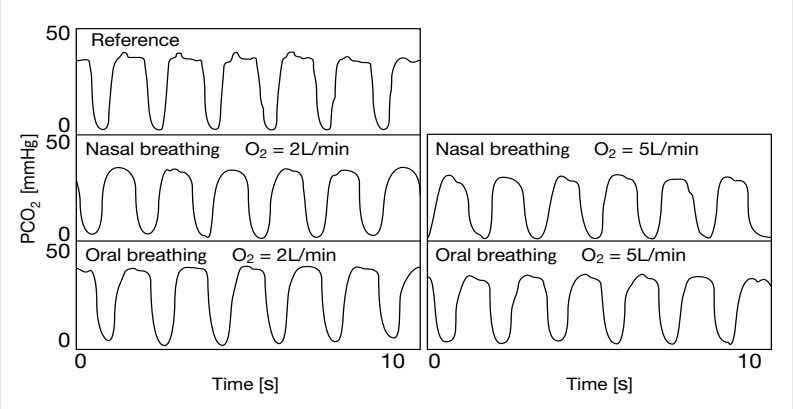


Figure 1.
The exhaled CO_2 waveform (capnogram) simulated by a pediatric model mannequin and spontaneous breathing lung simulator in the presence of oxygen supplement. The cap-ONE sensor reliably detects exhaled CO_2 during oxygen administration and presents a quality capnogram which agrees with a reference capnogram. (From Reference 5, with permission)

— Gentle oxygen supply from a mask with a wide opening —

cap-ONE mask

- Gentle stream of oxygen from both sides of the mask
- Consistent and stable oxygen concentration
- Less rebreathing of exhaled CO_2 even with low oxygen flow
- Lighter, freer, less oppressive feeling

It is recommended that oxygen flow should be more than 6L/min when using an oxygen mask in order to prevent the patient from rebreathing exhaled gas which is retained in the mask[6]. Cap-ONE mask has a wide opening in the front to let oral and nasal exhaled gas out of the mask. This design prevents exhaled gas from remaining in the mask even when oxygen flow is low (**Fig. 2**). Also, well dispersed oxygen is supplied from the sides of cap-ONE mask, so oxygen concentration inside the mask remains consistent and stable[7].

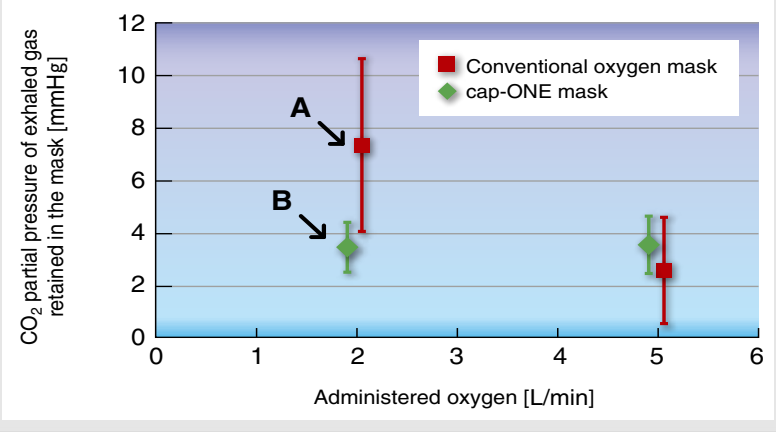


Figure 2.
Comparison of CO_2 partial pressure in exhaled gas while administrating oxygen using a conventional oxygen mask and cap-ONE mask (pediatric patients aged 1 to 8, CO_2 partial pressure measured 5 minutes after the oxygen administration). Point A shows retained exhaled gas and increased CO_2 partial pressure in the conventional mask. Point B shows that CO_2 partial pressure remains low and rebreathing of exhaled gas is reduced. (From Reference 7, with permission)

Limitations of the Pulse Oximeter

— Desaturation can be delayed during oxygen administration —

The pulse oximeter is widely used to monitor vital signs in various clinical settings since it provides oxygen saturation and pulse rate non-invasively and continuously with just a probe on the patient's finger. However, it is important to understand the limitations of pulse oximeters especially when using it as a respiratory monitoring tool. It has been shown that when fraction of inspiratory oxygen (FiO_2) is high, saturation level remains high and does not decrease promptly even when pulmonary function is deteriorated[8] (**Fig. 3**). This can lead to failure to detect respiratory depression and hypoventilation for a long time. There has been a reported case where a post-operative patient who received high concentration oxygen developed serious and fatal hypercapnia and acidosis in the recovery room[9]. Monitoring respiration only with a pulse oximeter can have potential risks. It is important to understand that the pulse oximeter can be an excellent index of oxygenation only when a patient breathes room air[10].

In June 2011, the Anesthesia Patient Safety Foundation held a meeting titled "Essential Monitoring Strategies to Detect Clinically Significant Drug-Induced Respiratory". Different monitoring methods were compared (**Table 1**) and capnography (monitoring of exhaled CO_2) was reported to be the most suitable method for detecting respiratory depression during oxygen administration[10].

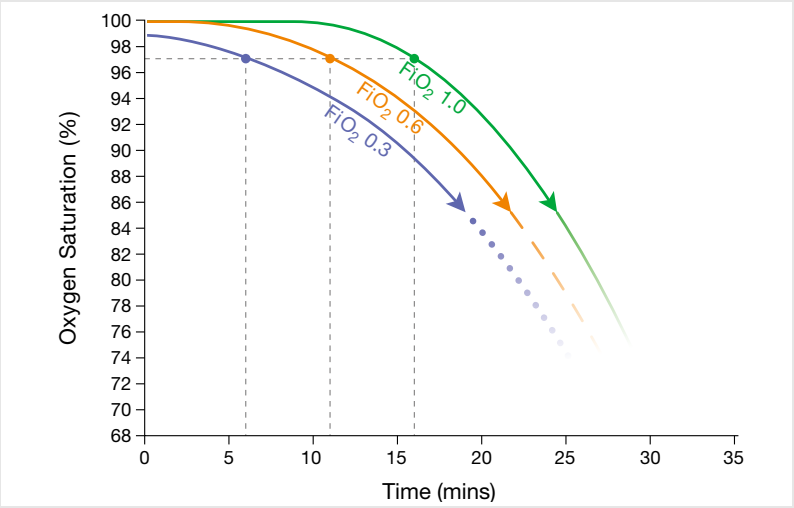


Figure 3.
Change of oxygen saturation plotted as a function of increasing intrapulmonary shunt from 0% at a rate of 2%/min. With fraction of inspiratory oxygen (FiO_2) of 1.0, 0.6, and 0.3, it takes 16, 11, and 6 minutes for oxygen saturation (SaO_2) to decrease from 100% to about 97%, respectively. (From Reference 8 with permission, partly modified)

Monitoring method	Sensitivity	Specificity	Reliability	Response time
$P_{et}CO_2$ (intubated)	High	High	High	Fast
$P_{et}CO_2$ (not intubated)	High	Moderate-High	Moderate	Fast
S_pO_2 (no O_2 supplement)	High	Moderate-High	High	Fast
S_pO_2 (with O_2 supplement)	Moderate	Moderate	High	Slow
Clinical assessment by skilled clinician	Moderate	Moderate-High	Moderate	Slow
Thoracic impedance	Low-Moderate	Low	Low	Moderate

Table 1.
Monitoring methods for detecting opioid induced respiratory depression in the postoperative period. (From Reference 10, with permission)

Exhaled CO_2 Monitoring Recommended by Anesthesia Guidelines

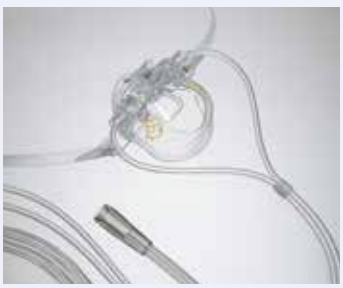
Reflecting serious concerns about pediatric sedation outside the operating room, the American Academy of Pediatrics and the American Academy of Pediatric Dentistry updated their "Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic and Therapeutic Procedures"[1)] in 2006. This guideline describes recommendations regarding monitoring of exhaled CO_2 as well as monitoring of common vital signs including heart rate and oxygen saturation. Also, the "Standards for Basic Anesthetic Monitoring" (revised July 2010 and effective July 2011) mandated that the adequacy of ventilation should be evaluated by exhaled CO_2 in moderate to severe sedation[11)]. Now, capnography is strongly recommended as a means to continuously assess patients' respiratory condition during procedures using sedation and anesthesia which may be associated with risks of respiratory depression.

cap-ONE Product Line

cap-ONE CO_2 sensor
P909 (TG-970P)

For non-intubated pediatric patients

cap-ONE mask
V933 (YG-232T)
For child weighing 20-40kg



cap-ONE mask
V935 (YG-242T)
For child weighing 7-20kg

For intubated patients

Airway adapter
R805 (YG-211T) A
For adult and child weighing over 7kg

R806 (YG-213T) B
For infant weighing 2-7kg

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11) American Society of Anesthesiologists. Standards for Basic Anesthetic Monitoring. http://www.asahq.org/For-Members/Standards-Guidelines-and-Statements.aspx

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