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CLINICAL REPORT

A case of congenital central hypoventilation syndrome

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Abstract We encountered a 2-year-old female infant with congenital central hypoventilation syndrome (CCHS) who underwent an abdominal operation for strangulated ileus. Prior to the surgery, at home, the infant had been receiving non-invasive positive-pressure ventilation (NPPV) support only during sleep. However, after postoperative extubation, the blood oxygen saturation (SpO_2) decreased to approximately 90 % with NPPV during sleep alone, necessitating the use of biphasic cuirass ventilation (BCV) along with NPPV for 2 days. The infant was weaned from the BCV on hospital day 9, and was discharged from the intensive care unit (ICU) on hospital day 13. Although it has been said that CCHS is not under the control of the respiratory center, there are no reports of the true CO_2 response curves in these patients. Therefore, during respiratory management in the ICU post-surgery, we examined (with the consent of the mother) the relationship of the end-tidal carbon dioxide ($ETCO_2$) to the tidal volume and respiratory rate, for a period of 6 min in the absence of sedation, using a respiratory profile monitor. Electrocardiographic and SpO_2 monitoring was also conducted at the same time, to ensure the patient's safety. In this patient, while the $ETCO_2$ increased, the tidal volume and respiratory rate remained unchanged. No relationship was found between the tidal volume and the respiratory rate. Various modalities have been used for the treatment of CCHS (tracheotomy, NPPV, and diaphragmatic pacing). Treatment of these patients in the ICU should be tailored to the needs of individual patients and their families.

Keywords Congenital central hypoventilation syndrome · $ETCO_2$ · Tidal volume

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Introduction

Congenital central hypoventilation syndrome (CCHS) is a rare respiratory disorder characterized by a diminished drive to breathe (apnea) during sleep. The condition occurs at an incidence of approximately 1 in 50,000–200,000 live births. In fact, CCHS can develop as a result of damage to the neural crest [1]. In children with CCHS the respiratory center usually shows no sensitivity to hypercapnia . These children appear to breathe well while awake, such as during the day, because of the higher control of respiration from the cerebral cortex; however, during nocturnal sleep, in the absence of respiratory stimulation from the higher centers, they manifest hypoventilation.

Herein, we report a patient with CCHS in whom an abdominal operation was necessitated for the treatment of strangulated ileus. Although it has been said that respiration in patients with CCHS is not under the control of the respiratory center, there are no reports of the true CO_2 response curves. We took the opportunity to determine the relationship of the end-tidal carbon dioxide ($ETCO_2$) to the tidal volume and respiratory rate during the postoperative respiratory management of the patient.

Case report

A 2-year-old female infant (body height 98 cm, body weight 15 kg) was diagnosed as having CCHS based on the clinical manifestations immediately after birth. Non-invasive positive-pressure ventilation (NPPV) support only during sleep was instituted. At the end of November 2008, she developed watery diarrhea and white stool with vomiting. She was admitted to another hospital in December 2008 with the diagnosis of acute gastroenteritis and dehydration. Bloody stool and abdominal distension were noted later, both of which continued to worsen progressively despite symptomatic treatment. She was admitted to our intensive care unit (ICU) after having undergone endotracheal intubation at the other hospital because of poor ventilation caused by diaphragmatic elevation associated with abdominal distension. We performed resection of the small intestine with a colostomy, based on the diagnosis of strangulated ileus. General anesthesia was induced and maintained with a mixture of 1.5–2 % sevoflurane and oxygen (fraction of inspired oxygen [FiO_2] 0.7), intermittent doses of fentanyl (total dose 14 μg/kg), and administration of rocuronium bromide (10 mg at the start of the operation). After the surgery, respiratory management was initiated because of a decrease in the postoperative PaO_2/FiO_2 (P/F) ratio to 181 mmHg, and sedation was maintained with dexmedetomidine (0.6–0.8 μg/kg/h) and midazolam (0.25 mg/kg/h). As the oxygenation improved thereafter, extubation became possible on hospital day 6. Oxygen was administered at 3–5 L/min through a face mask, with the blood oxygen saturation (SpO_2) maintained at 99–100 % while the patient was awake. However, the use of biphasic cuirass ventilation (BCV) using an RTX respirator (Medvent, London, England) became necessary along with the NPPV during sleep on the night of extubation, because the SpO_2 decreased to approximately 90 % with NPPV alone and we thought that the cause of hypoxia was dorsal pulmonary atelectasis. The infant was weaned off the BCV on hospital day 9, after confirming that adequate oxygenation was maintained for 2 days. She was discharged from the ICU on hospital day 13.

With the consent of the mother, we examined the relationship of the $ETCO_2$ to the tidal volume and respiratory rate just before extubation in the absence of continuous sedation, 2 h after discontinuation of dexmedetomidine and midazolam administration. The tidal volume and respiratory rate were determined using a respiratory profile monitor (CO_2SMO Plus DX8100; Novametrix Medical Systems, Wallingford, CT, USA). The $ETCO_2$ was determined through two flexible connectors (King Systems, Noblesville, Indiana, USA) attached between a Y connector and a sensor of the CO_2 monitor after CO_2 loading by rebreathing for approximately 6 min. The number of respiratory rates was 136, because the method of CO_2SMO Plus is based on breath-by-breath analysis. Electrocardiographic and SpO_2 monitoring was also performed at the same time to ensure the patient's safety.

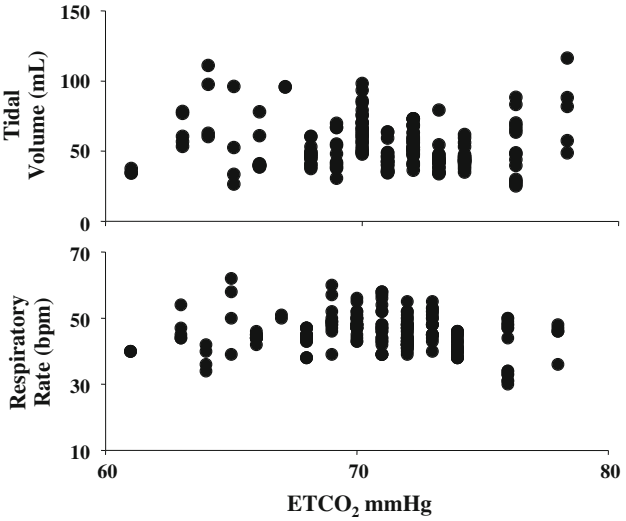

Fig. 1 Relationship of the end-tidal carbon dioxide ($ETCO_2$) to the tidal volume and respiratory rate. The $ETCO_2$ increased to about 78 mmHg for about 6 min, while the tidal volume and respiratory rate remained unchanged (respiratory rates = 136)

In our patient, the $ETCO_2$ increased, while the tidal volume and respiratory rate remained unchanged. No relationship of the $ETCO_2$ was found with the tidal volume or the respiratory rate (Fig. 1). The electrocardiographic and pulse oximetry monitoring also revealed no significant deviations from normal range.

Discussion

Congenital central hypoventilation syndrome (CCHS), a congenital disorder, is reported to be associated mainly with mutation of the *PHOX2B* gene [2]. In patients with CCHS, the bulbar respiratory center shows diminished sensitivity to CO_2; therefore, these patients show impaired responses to hypercapnia. However, while the patient is awake, breathing is maintained by stimulation from the cerebral cortex, whereas during sleep, in the absence of such stimulation, apneustic breathing is noted. When the respiratory center is sensitive to $PaCO_2$, the $ETCO_2$ remains constant even during rebreathing, while the tidal volume and respiratory rate increase. The $ETCO_2$ response curve in our patient was apparently consistent with this notion. This is the first report in the related literature of simultaneous determinations of the $ETCO_2$, tidal volume, and respiratory rate in a patient with CCHS. Inadequate ventilation and sedative drugs are reported as risk factors for prolonged mechanical ventilation [3]. Therefore, we

attempted to avoid continuous sedation to prevent hypoxemia and hypoventilation. However, we could not avoid continuous sedation, because the patient showed no signs of mental depression and cried when she woke up. We measured the relationship of the $ETCO_2$ to the tidal volume and respiratory rate after the discontinuation of continuous sedation.

Furthermore, BCV was instituted in addition to NPPV for 2 days post-surgery, because of the apparent decrease of the functional residual capacity (FRC) caused by the abdominal distension and dorsal pulmonary atelectasis, and the use of BCV improved the outcome of the child.

Some of the most frequently used treatment methods for CCHS include tracheotomy, NPPV, and diaphragmatic pacing [3–6]. In our present patient, for example, NPPV was instituted during nocturnal sleep. Consequently, family members needed to be constantly alert to the child's breathing pattern. Pulse oximetry monitoring must be performed during the night to avoid any decrease of the oxygen saturation caused by any problems, e.g., mask displacement. Tracheotomy, however, has disadvantages, such as limiting oral conversation and movements, and decreasing the patient's quality of life (QOL), besides necessitating the availability of supplies needed for aspiration and lavage during incision.

Other complications of CCHS include Hirschsprung's disease [7], epilepsy, and mental retardation. Our patient was initially suspected to have Hirschsprung's disease; however, the disorder was excluded even without biopsy, because of the delayed onset of strangulated ileus and the absence of dyschezia or paralytic megacolon.

In conclusion, we encountered a patient with the rare disorder of CCHS, characterized by a diminished drive to breathe (apnea) during sleep. We investigated the relationship of the $ETCO_2$ to the tidal volume and respiratory rate in the awake state of the patient. No relationship of the $ETCO_2$ to the tidal volume or respiratory rate was observed. Various modalities have been used for the treatment of CCHS. Treatment of these patients in the ICU should be tailored to the needs of individual patients and their families.

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