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Case Report

Increased requirement for minute ventilation and negative arterial to end-tidal carbon dioxide gradient may indicate malignant hyperthermia

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Abstract

Characteristic signs of malignant hyperthermia (MH) include unexplained tachycardia, increased end-tidal carbon dioxide ($Etco_2$) concentration, metabolic and respiratory acidosis, and an increase in body temperature above 38.8°C. We present the case of a patient with highly probable MH. In addition to sinus tachycardia and metabolic and respiratory acidosis, this patient also had a negative arterial to $Etco_2$ gradient and an increased requirement for minute ventilation to maintain a normal $Etco_2$ concentration, with signs of increased CO_2 production. Despite these signs of MH, the patient's rectal temperature monitoring equipment did not show an increase in temperature, although the temperature measured in the mouth was increased. This case illustrates the unreliability of measuring rectal temperature as a means of reflecting body temperature during MH and the usefulness of increased CO_2 production signs in helping to diagnose MH.

Keywords: blood gas analysis; body temperature; capnography; malignant hyperthermia; pulmonary ventilation

1. Introduction

A rapid increase in end-tidal carbon dioxide ($Etco_2$) is one of the earliest signs of an episode of malignant hyperthermia (MH).[1] However, increased $Etco_2$ may not present with an increased minute ventilation (MVe)[2,3] or may be neglected due to normal arterial carbon dioxide concentrations ($Paco_2$).[4] Under these circumstances, a negative gradient between $Paco_2$ and $Etco_2$ [(a-Et)Pco_2], another early sign of MH, can be used as an additional diagnostic indication.[4] We present here a clinically "almost certain" case of MH. An earlier diagnosis of MH could have been made if we had used an increased MVe and negative (a-Et)Pco_2 as signs of MH.

2. Case report

A 71-year-old woman weighing 64 kg with a body mass index of 26 and of American Society of Anesthesiologists physical status II was scheduled for the excision of a thoracic spine T1–2 neurogenic tumor. The patient had no previous exposure to general anesthesia. There was no known family history of MH or myopathies. She had a history of asthma with no recent attack and drug treatment had been stopped 2 years previously. A preoperative pulmonary function test showed mild restrictive ventilatory impairment with a forced expiratory volume in the 1st second of expiration of 1.47 L (78% of predicted value).

Anesthesia was induced with fentanyl, propofol, and cisatracurium. After uneventful endotracheal intubation, a radial arterial catheter, a central venous catheter via the internal jugular vein, and a rectal temperature probe were inserted. Anesthesia was maintained with isoflurane in an oxygen and air mixture. The patient's temperature was 36.0°C and her

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$Etco_2$ was 39 mmHg with an MVe of 4.3 L/minute immediately after induction (Fig. 1). The airway pressure was 24 cmH_2O and the dynamic respiratory compliance was 25.33 mL/cmH_2O.

The patient was placed in a prone position about 1 hour after the induction of anesthesia. After the change to a prone position, her airway pressure increased and the ventilator was switched to pressure control mode, with the inspiratory pressure set at 24 cmH_2O; respiratory compliance dropped to 20.48 mL/cmH_2O. During the next hour, MVe was gradually increased from 4.7 L/minute to 8.0 L/minute by increasing the inspiratory pressure setting to 28 cmH_2O and increasing the respiratory rate to 14 per minute to keep the $Etco_2$ around 40 mmHg. The patient's respiratory compliance was 22.80 mL/cmH_2O and her temperature remained at 36.1°C during this period.

In the next 30 minutes, the $Etco_2$ gradually increased to 47 mmHg with an increase in heart rate to 100 beats per minute (bpm) and decreased blood pressure (systolic blood pressure around 90 mmHg). At this time, the patient's temperature was 36.5°C. There was an estimated concurrent blood loss of 1200 mL. Colloid and blood products were used for replacement. Arterial blood gas (ABG) analysis showed metabolic acidosis (base excess, BE = −10 mmol/L) with a pH of 7.27, $Paco_2$ 37.7 mmHg, and a negative (a-ET)Pco_2 gradient (Table 1; Fig. 1). Sodium bicarbonate was given to correct acidosis. Over the next 20 minutes the $Etco_2$ continued to increase to 57 mmHg. MH was highly suspected, although the rectal temperature was only 36.8°C. Subsequent ABG analysis showed a more significant negative (a-ET)Pco_2 gradient, with pH 7.24, $Paco_2$ 44.7 mmHg, and BE −8 mmol/L (Table 1). We checked whether the temperature probe was in the correct position. The gas analysis machine, CO_2 absorber, and breathing circuit were checked to exclude equipment error. During the checking, the breathing circuit was found to be very warm and humid and the $Etco_2$ was increased rapidly to 92 mmHg. The ABG results were pH 7.108 and $Paco_2$ 75.3 mmHg (Table 1; Fig. 1). Her heart rate was 130 bpm. The diagnosis of MH was made and treatment commenced immediately. At this time, the patient's rectal temperature still showed 36.8°C despite correct positioning having been confirmed.

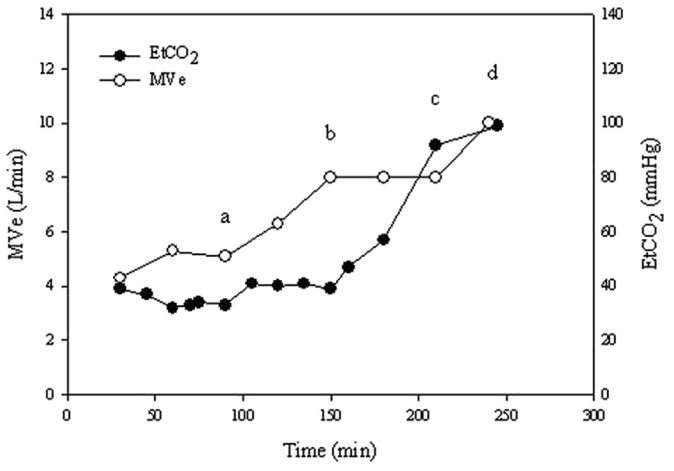

Fig. 1. Minute ventilation and end-tidal CO_2 ($Etco_2$) versus time. Time starts at induction of anesthesia. The patient was relatively stable for about 80 minutes, but minute ventilation (MVe) was gradually increased to maintain $Etco_2$ (point a to b). Increasing $Etco_2$ was then noted in spite of the increased MVe (8.0 L/minute), whereas the arterial CO_2 concentration remained normal (point b). $Etco_2$ increased rapidly later, and malignant hyperthermia was diagnosed (point c). Dantrolene was infused and the patient remained hemodynamically stable, whereas $Etco_2$ stayed at the high extreme (point d).

Table 1
Sequential data at different time points for this patient.

	Time after induction of anesthesia (min)					
	70	160	180	210	240	290
pH	7.381	7.266	7.240	7.108	7.004	7.467
$Paco_2$ (mmHg)	36.4	37.7	44.7	75.3	107.7	33.5
$Etco_2$ (mmHg)	33	47	57	92	99[a]	NA
(a-Et)Pco_2 (mmHg)	3.4	−9.3	−12.3	−16.7	NA	NA
K^+ (mmol/L)	3.43	4.19	3.93	3.93	4.92	5.0
Temperature[b] (°C)	36.0	36.5	36.8	36.8	37.2,[b] 38.4[c]	37.1[d]
MVe (L/min)	5.3	8.0	8.0	8.0	10.0	9.0

(a-Et)Pco_2 = gradient between $Paco_2$ and end-tidal CO_2; $Etco_2$ = end-tidal CO_2; MVe = minute ventilation; NA = not applicable; $Paco_2$ = arterial carbon dioxide concentrations.

[a] Upper measurement range of capnography.
[b] Rectal temperature.
[c] Oral temperature.
[d] Tympanic membrane temperature.

Isoflurane was withdrawn immediately. Anesthesia was maintained with propofol infusion. The anesthetic machine was replaced and the patient's lungs were hyperventilated with 100% O_2. Rapid infusion of dentrolene was started at a dose of 2 mg/kg. The operation ended 30 minutes later and the patient was returned to a supine position. Her oral temperature was 38.4°C, whereas the rectal temperature equipment still read 37.2°C. Her heart rate decreased progressively from 145 bpm to 115 bpm after the dantrolene infusion. Nevertheless, the $Etco_2$ was more than 99 mmHg (the upper measurement limit of the capnograph), with blood gas analysis showing pH 7.004 and $Paco_2$ 107.7 mmHg (Table 1; Fig. 1). The patient was admitted to the intensive care unit (ICU) under stable hemodynamic conditions.

On arrival in the ICU, the patient's tympanic temperature was 39.0°C. Ice water irrigation via a nasogastric tube and an alcohol bath were used to cool the patient. Her temperature and $Paco_2$ shortly returned to normal. ABG analysis showed pH 7.467, $Paco_2$ 33.5 mmHg, BE 0.3 mmol/L and K^+ 5.0 mmol/L. Her tympanic temperature was 37.1°C 45 minutes after being admitted to the ICU. Her creatinine kinase peaked at 107 U/L during the morning of the 1st postoperative day. The patient was extubated on the 1st postoperative day and was closely monitored for another 24 hours. There was no further sign of MH and no additional dantrolene was given in the ICU. The patient was discharged from hospital 6 days later with an uneventful postoperative course. The patient and her family had been informed of possible MH during anesthesia and surgery, but she had not undergone a muscle biopsy test. According to the clinical grading scale of MH, the patient's