Letter to the Editor

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Postoperative delayed hypercapnia and respiratory failure after robot-assisted lower anterior resection

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A robotic system is gaining popularity because the tool can overcome the disadvantages of conventional laparoscopic surgery. However, robotic surgery also requires pneumoperitoneum with carbon dioxide, just as in conventional laparoscopic surgery, which can causes various complications, such as air embolism, hypercapnia, subcutaneous emphysema, pneumothorax, and pneumomediastinum [1]. We present here a case involving the unusual and life-threatening complication of delayed hypercapnia and respiratory failure in the postanesthesia care unit (PACU) despite normal anesthesia recovery and tracheal extubation in the operating room.

A 61-year-old, 161 cm tall, 62 kg man underwent robot-assisted lower anterior resection for sigmoid colon cancer. The patient had no specific previous illness history. Anesthesia was induced with 120 mg of propofol, 50 mg of rocuronium, and 60 μg of remifentanil. After tracheal intubation, anesthesia was maintained with 2 L of a mixture of oxygen and air in a ratio of 1 : 1, 1.5–3 vol% of sevoflurane, 5 μg/kg/min of rocuronium, 2.0–5.0 ng/ml of remifentanil (target effect site concentration, Orchestra Base Primea, Fresinius Vial, France). The patient's lungs were ventilated in volume-controlled mode with a tidal volume (VT) of 475 ml, a respiratory rate of 12 breaths per minute, inspiratory/expiratory (I/E) ratio 1 : 2, and an inspired oxygen concentration of 0.6. The initial peak inspiratory pressure was 12 mmHg and the initial $ETCO_2$ was 32 mmHg. During pneumoperitoneum, intraperitoneal pressure was maintained at 12–15 mmHg and peak inspiratory pressure was maintained at 19–22 mmHg.

During surgery, vital signs were stable and the BIS value was within 30–50. After approximately 3 hours, $ETCO_2$ began to rise and reached 44 mmHg, and arterial blood gas analysis (ABGA) demonstrated pH of 7.25, $PaCO_2$ of 58 mmHg, PaO_2 of 257 mmHg, HCO_3 of 25.0 mEq/L, and oxygen saturation (SaO_2) of 100%. Mechanical ventilation was increased to a VT of 500 ml and a respiratory rate of 15, but $ETCO_2$ persisted at 40–42 mmHg. Robotic surgery ended within 30 minutes of reaching the peak $ETCO_2$, and CO_2 insufflation ceased. Continuous rocuronium infusion also ceased immediately after ending of robotic surgery. During the operation through a minimal abdominal incision, $ETCO_2$ was reduced and maintained at 30 mmHg. The operation was completed within 50 minutes of the start of minimal open surgery. The patient began to breathe spontaneously and was given pyridostigmine with glycopyrrolate to prevent residual neuromuscular block. The patient had spontaneous respiratory rate of 15 breaths per minute, VT of 400 ml, $ETCO_2$ of 32 mmHg and opened his eyes on the command. He was extubated in the operating room 15 minutes after discontinuation of anesthesia and transferred to the PACU.

On arrival in the PACU, he received 3 L/min of oxygen via face mask, and SaO_2 was 98%. However, over the next 10 minutes, spontaneous breathing became weak, SaO_2 decreased to < 90%, and his level of consciousness deteriorated. Emergency ABGA (GEM Premier 3000, Instrumentation Laboratory, Bedford, MA, USA) demonstrated pH of 6.88, unmeasurable $PaCO_2$, PaO_2 of 99 mmHg, and unmeasurable HCO_3. The patient was reintubated with 60 mg of propofol and 60 mg of succinylcholine. The patient was then found to have extensive subcutaneous emphysema in the abdomen, chest, inguinal area, shoulder, and

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neck. After 10 minutes of hyperventilation with 100% oxygen, ABGA demonstrated pH 7.31, $PaCO_2$ of 64 mmHg, PaO_2 of 427 mmol/L, and HCO_3 of 32.5. After 30 minutes of hyperventilation, the patient regained consciousness, began breathing spontaneously, and rejected the tracheal tube; ABGA showed pH of 7.37, $PaCO_2$ of 51 mmHg, PaO_2 of 187 mmHg, and HCO_3 of 29.5. He was extubated and given 5 L/min of oxygen via face mask for 15 minutes, and then was transferred to the intensive care unit without other complications. On being notified of the problem, the surgeon mentioned that one of the 12 mm trocars had been placed obliquely with difficulty after three attempts. The patient was returned to the general ward the next day. The remainder of hospital stay was uneventful, and he was discharged 9 days after surgery.

The case presented here illustrates that despite normal anesthesia recovery and tracheal extubation after robotic surgery, delayed severe hypercapnia and respiratory failure can occur during a PACU stay. We believe that the patient's $PaCO_2$ continued to increase from the stores of CO_2 within subcutaneous emphysema. The quantity of CO_2 absorption exceeded excretion capacity. There is a strong correlation between the extent of subcutaneous emphysema and CO_2 absorption. The larger the extent of subcutaneous CO_2 emphysema, the faster the absorption of CO_2 [2]. The risk factors for subcutaneous emphysema are a maximum $ETCO_2$ of ≥ 50 mmHg, six or more surgical ports, surgery duration of > 200 minutes, and age > 65 years [1].

Three situations can induce subcutaneous emphysema directly and independently: First, misplacement of the insufflation needle induces direct administration of CO_2 into subcutaneous tissue. Second, when incision size is excessively larger than trocar size or the trocar is withdrawn partially by excessive movement, subcutaneous infusion of CO_2 can occur through the trocar puncture site. In our patient, when the insufflation needle was placed with difficulty (three attempts), a tunnel might have been formed between the peritoneal cavity and subcutaneous tissue. Third, excessive intraperitoneal pressure can cause subcutaneous emphysema [3].

It is important that the correlation between $ETCO_2$ and $PaCO_2$ is significantly low in robotic or laparoscopic surgery. When the ventilation/perfusion (V/Q) mismatching progresses during pneumoperitoneum, $PaCO_2$ cannot be predicted by $ETCO_2$, owing to increased ventilation in an area with a high V/Q ratio area [4]. As time passes during pneumoperitoneum, the gradient of $ETCO_2$ and $PaCO_2$ increases, and there is no correlation after 30 minutes [5].

In conclusion, although anesthesia and surgery may proceed without problems in robotic or prolonged laparoscopic surgery, it is essential to routinely and repeatedly palpate the trunk, shoulder, and neck to detect massive subcutaneous emphysema. Also, measuring $PaCO_2$ would be safer than depending on $ETCO_2$ before tracheal extubation. Patients with arterial hypercapnia or subcutaneous emphysema should be observed carefully for a prolonged period in the PACU.

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