

Carbon dioxide embolism with severe hypotension as an initial symptom during laparoscopy: a case report

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Abstract

Laparoscopy is widely used because it induces minimal postoperative pain and facilitates rapid recovery. However, carbon dioxide (CO₂) embolism is a rare but potentially fatal complication of laparoscopic surgery. Earlier reports have shown that decreased end-tidal CO₂ (ETCO₂) and increased partial pressure of CO₂ might be useful indicators of CO₂ embolism. We herein report a case of CO₂ embolism after the freed bladder neck was released during laparoscopic radical prostatectomy. Sudden hemodynamic disorder and increased ETCO₂ combined with immediate arterial blood gas analysis led us to suspect CO₂ embolism, which was confirmed by the aspiration of foamy blood from the central venous catheter. The patient was successfully resuscitated and recovered well. This case illustrates that hemodynamic collapse accompanied by increased ETCO₂ can indicate CO₂ embolism.

Keywords

Carbon dioxide embolism, end-tidal carbon dioxide, laparoscopy, case report, blood gas analysis, hemodynamic disorder

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Introduction

Laparoscopy is widely used in the diagnosis and treatment of gynecological and intra-abdominal diseases. Advantages of this technique include minimal postoperative pain and rapid recovery. However, a serious complication of this technique is gas embolism caused by insufflation, which has a

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high mortality rate of approximately 28%.¹ A small amount of carbon dioxide (CO₂) may enter the circulation through any opening in the injured vessels either at the abdominal wall or the operative site during laparoscopic surgery. Previous reports have shown that decreased end-tidal CO₂ (ETCO₂) and increased partial pressure of CO₂ (PaCO₂) might be useful indicators of gas embolism under general anesthesia.² We herein report a case of CO₂ embolism with hemodynamic collapse as an initial sign during laparoscopic radical prostatectomy. The complication was diagnosed rapidly and managed appropriately.

Case report

A 71-year-old man with a body mass index of 19 kg/m², American Society of Anesthesiologists physical status of II, medical history of hypertension well managed with nifedipine, and no surgical history was scheduled to undergo laparoscopic radical prostatectomy in March 2018. His echocardiogram showed slight bicuspid and tricuspid regurgitation and decreased left ventricular systolic function. His electrocardiogram showed that the electrical axis had shifted to the left and that the ST-T segment had changed. Other preoperative examinations, including hematological and serum biochemical studies, chest radiography, and pulmonary function tests, revealed no obvious abnormalities.

Therefore, the patient was scheduled for surgery and transferred to the operating room after admission. The radial artery was cannulated and a central venous catheter was placed in the right internal jugular vein. The patient underwent monitoring of his pulse oximetry, tidal volume, airway pressure, body temperature, and urinary output. His blood pressure was 180/80 mmHg and heart rate was 100 beats/minute. The patient was given 1 mg of midazolam intravenously to relieve his anxiety.

His blood pressure and heart rate soon dropped to 140/70 mmHg and 90 beats/minute, respectively. General anesthesia was induced with 20 mg of etomidate, 45 µg of sufentanil, and 100 mg of lidocaine; a neuromuscular blockade was achieved with 50 mg of rocuronium bromide. After intubation, the patient received mechanical ventilation under the volume-controlled mode with a respiratory rate of 12 breaths/minute, tidal volume of 6.8 mL/kg, and ETCO₂ of 35 to 45 mmHg. Anesthesia was maintained with continuous infusion of propofol (4–7 mg/kg per hour) and remifentanyl (0.1–0.2 µg/kg per minute). The patient showed no adverse reactions, and the surgery was initiated.

Several minutes after freeing the bladder neck, the patient's blood pressure decreased from 140/80 to 100/60 mmHg. Thus, 40 µg of phenylephrine was administered intravenously to improve his blood pressure; however, his hemodynamics remained unstable. The fall in blood pressure was accompanied by tachycardia, with an increase in his heart rate from 80 to 120 beats/minute. Because his ETCO₂ remained at 35 mmHg, pulmonary embolism was not taken into consideration. To maintain hemodynamic stability, adrenaline (40 µg) and methylprednisolone (80 mg) were administered intravenously.

Other conditions, such as hemorrhage, heart failure, and pneumothorax, were initially considered. However, there was no evidence to confirm their diagnosis. The estimated blood loss was 100 mL and the urine output was 100 mL, whereas the total fluid infusion volume was 2250 mL. Auscultation confirmed bilateral breath sounds.

A sudden increase in the ETCO₂ from 35 to 58 mmHg was accompanied by a decrease in the blood pressure to 52/20 mmHg, and the central venous pressure was 25 cmH₂O. Rapid arterial blood gas analysis showed that the fraction of

inspired oxygen was 60%, pH was 7.14, and PaCO₂ was 91.3 mmHg. The partial pressure of oxygen (PaO₂) was 423 mmHg, and the base excess was 2 mmol/L. Considering the above findings, the most probable cause of the hemodynamic collapse and tachycardia in this case was CO₂ embolism. The patient was immediately turned to the head-down left-lateral position, and 22 mL of foamy blood was aspirated from the central venous catheter, confirming our diagnosis.

Given his hemodynamic instability, the patient was immediately administered 100% oxygen and continuously infused with high-dose epinephrine (0.1–0.2 µg/kg per minute). Pneumoperitoneum was decreased from 14 to 10 mmHg, and the ruptured vessel was promptly closed.

Five minutes later, a stable hemodynamic condition was achieved with a blood pressure of 130/70 mmHg and decreased ETCO₂ of 50 mmHg accompanied by central venous pressure of 14 cmH₂O. Another arterial blood gas analysis performed at the end of the surgery showed a pH of 7.33, PaCO₂ of 52.3 mmHg, PaO₂ of 257 mmHg, and base excess of 1.7 mmol/L. The patient’s heart rate, oxygen saturation, ETCO₂, and arterial blood pressure before, during, and after resuscitation are shown in Table 1. The patient was then transferred to the post-anesthesia care unit with an improved condition and stable vital signs. He was extubated in the post-anesthesia care unit with no complications.

Discussion

Laparoscopic techniques are widely used in radical prostatectomy. However, such techniques can damage Santorini’s venous plexus and the blood vessels on the side of the bladder during the surgery, providing access for CO₂ to enter the systemic circulation. Thus, laparoscopic surgery may result in CO₂ embolism.³ In 2009, Kim et al.⁴ reported the incidence of CO₂ embolism during total laparoscopic hysterectomy using transesophageal echocardiography (TEE). The authors observed gas emboli in all patients, and 37.5% of these emboli occupied more than half the diameter of the right atrium, right ventricle, and right ventricular outflow tract.⁴ Moreover, many cases of CO₂ embolism have been reported in the past,^{5–7} indicating an underestimated incidence of CO₂ embolism by anesthesiologists and surgeons.

CO₂ embolism obstructing the right chamber of the heart and pulmonary artery can be a potentially fatal anesthetic complication during laparoscopic surgery. The clinical manifestations of CO₂ embolism depend on the rate and volume of CO₂ entrapment and the patient’s condition. According to case reports of accidental intravascular air delivery, the lethal volume for adults is 200 to 300 mL or 3 to 5 mL/kg. Additionally, as shown in this case, the heart might be able to withstand a larger quantity of air over a prolonged period as long as the entrainment is slow.⁸

Table 1. Heart rate, SpO₂, ETCO₂, and arterial blood pressure before, during and after resuscitation.

Time	11:40	11:45	11:50	11:55	12:00	12:05	12:10	12:15	12:20	12:25	12:30
Heart rate (beats/minute)	100	100	99	90	80	82	121	121	119	92	90
SpO ₂ (%)	100	100	100	100	100	100	100	100	100	100	100
ETCO ₂ (mmHg)	35	35	35	35	35	35	58	55	50	47	39
Arterial blood pressure (mmHg)	100/60	85/52	82/50	75/42	90/50	80/42	52/20	61/20	130/70	110/61	105/58

SpO₂, oxygen saturation; ETCO₂, end-tidal carbon dioxide.

Indicators of gas embolism during general anesthesia are decreased ETCO₂, hypoxemia, hypercapnia, high airway pressure, and hemodynamic change. The initial manifestation in the present case was hemodynamic deterioration and tachycardia; however, the ETCO₂ did not simultaneously decrease. Therefore, CO₂ embolism was not initially considered. A significant increase in PaCO₂ detected by arterial blood gas analysis leads to a rapid and accurate diagnosis of CO₂ embolism and appropriate hemodynamic management.

CO₂ embolism can occur during peritoneal insufflation in laparoscopic radical prostatectomy. Embolization should always be suspected when CO₂ insufflation is followed by abrupt hemodynamic disorder and increased PaCO₂, regardless of any change in ETCO₂ (which may initially increase). The monitoring is nonspecific.⁹ Furthermore, the changes in ETCO₂ can be easily missed in the operating room because they occur rapidly within a short duration.¹⁰ Apart from ETCO₂ monitoring, TEE is the most sensitive method for detecting CO₂ embolization.¹¹ TEE can detect a minimum of 0.02 mL/kg of intravenously injected CO₂.¹² Additionally, in patients with cardiac diseases or hemodynamic instability, a central venous catheter should be inserted to monitor hemodynamics and remove gas emboli from the right atrium when suspected.¹³

Prompt diagnosis and accurate treatment are imperative to improve the prognosis in cases of CO₂ embolization. The basic treatments include immediate cessation of CO₂ insufflation, hyperventilation with an inspired oxygen fraction of 1.0, and inotropic support of hemodynamic function.¹⁴

In conclusion, this case shows that co-occurrence of severe hypotension and tachycardia may indicate CO₂ embolism even if the ETCO₂ does not decrease. Hence, we recommend intraoperative arterial blood gas analysis in cases of

hemodynamic collapse and tachycardia during laparoscopy. Prompt diagnosis and accurate treatments are imperative for improving the prognosis if CO₂ embolism occurs.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Ethics

The patient provided written informed consent, and the study was approved by the First Affiliated Hospital, Zhejiang University, School of Medicine.

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References

1. De Jong KI and De Leeuw PW. Venous carbon dioxide embolism during laparoscopic cholecystectomy a literature review. *Eur J Intern Med* 2019; 60: 9–12.
2. Mao Y, Wen S, Chen G, et al. Management of intra-operative acute pulmonary embolism during general anesthesia: a case report. *BMC Anesthesiol* 2017; 17: 67.
3. Ikegami T, Shimada M, Imura S, et al. Argon gas embolism in the application of laparoscopic microwave coagulation therapy. *J Hepatobiliary Pancreat Surg* 2009; 16: 394–398.
4. Kim CS, Kim JY, Kwon JY, et al. Venous air embolism during total laparoscopic hysterectomy: comparison to total abdominal hysterectomy. *Anesthesiology* 2009; 111: 50–54.
5. Kawahara T, Hagiwara M, Takahashi H, et al. Cerebral infarction by paradoxical

- gas embolism during laparoscopic liver resection with injury of the hepatic vessels in a patient without a right-to-left systemic shunt. *Am J Case Rep* 2017; 18: 687–691.
6. Abraham MA, Jose R and Paul MJ. Seesawing end-tidal carbon dioxide: portent of critical carbon dioxide embolism in retroperitoneoscopy. *BMJ Case Rep* 2018; 2018: bcr-2017-219397.
 7. Kale RD, Sarwar MF and Sopchak A. Intraoperative massive carbon dioxide embolism captured with transesophageal echocardiography in a patient with a rare vena cava anomaly. *J Cardiothorac Vasc Anesth* 2019; 33: 157–161.
 8. Mirski MA, Lele AV, Fitzsimmons L, et al. Diagnosis and treatment of vascular air embolism. *Anesthesiology* 2007; 106: 164–177.
 9. Gutt CN, Oniu T, Mehrabi A, et al. Circulatory and respiratory complications of carbon dioxide insufflation. *Dig Surg* 2004; 21: 95–105.
 10. Fors D, Eiriksson K, Arvidsson D, et al. Gas embolism during laparoscopic liver resection in a pig model: frequency and severity. *Br J Anaesth* 2010; 105: 282–288.
 11. Couture P, Boudreault D, Derouin M, et al. Venous carbon dioxide embolism in pigs: an evaluation of end-tidal carbon dioxide, transesophageal echocardiography, pulmonary artery pressure, and precordial auscultation as monitoring modalities. *Anesth Analg* 1994; 79: 867–873.
 12. Furuya H, Suzuki T, Okumura F, et al. Detection of air embolism by transesophageal echocardiography. *Anesthesiology* 1983; 58: 124–129.
 13. Haroun-Bizri S and ElRassi T. Successful resuscitation after catastrophic carbon dioxide embolism during laparoscopic cholecystectomy. *Eur J Anaesthesiol* 2001; 18: 118–121.
 14. Martineau A, Arcand G, Couture P, et al. Transesophageal echocardiographic diagnosis of carbon dioxide embolism during minimally invasive saphenous vein harvesting and treatment with inhaled epoprostenol. *Anesth Analg* 2003; 96: 962–964.