CARBON DIOXIDE GAS PULMONARY EMBOLISM DURING LAPAROSCOPIC ADRENALECTOMY. A CASE REPORT

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Abstract

A 33-year-old female patient with right sided pheochromocytoma scheduled for laparoscopic adrenalectomy under general anesthesia. In the course of initial abdominal insufflation with carbon dioxide through upper right abdominal quadrant using Verres needle, patient presented sudden decrease of end-tidal carbon dioxide pressure and severe oxygen desaturation accompanied with bradycardia and hypotension. The suspicion of carbon dioxide gas embolism led to stoppage of further insufflation. The abdomen was opened through a right subcostal incision, an injured area through which gas is entrained was found on the surface of the liver, it was repaired and the tumor was successfully excised. Patient hemodynamics improved gradually, while end-tidal carbon dioxide came back to normal after about one hour. Vigilance and high degree of suspicion during insertion of the Veress needle along with elaborate communication between the anesthetist and surgeon can prevent this potentially catastrophic complication.

Keywords: Carbon dioxide, embolism, laparoscopy, adrenalectomy

Introduction

Since it was reported in 1992 laparoscopic adrenalectomy is now regarded as the technique of choice for most benign adrenal lesions because of the decreased blood loss, lower morbidity, shorter hospitalization, faster recovery, and overall cost-effectiveness in comparison with the open approach[1]. Carbon dioxide (CO2) is currently the most frequently used insufflation gas for laparoscopy, since it fulfills most of the requirements for an ideal insufflation gas, being noninflammable, chemically inert, inexpensive, colorless and highly soluble in the blood that allows rapid absorption into the blood stream and rapid excretion from the circulation[2,3]. However, its use during laparoscopic procedures may be associated with adverse cardiorespiratory effects and though uncommon with major complications like CO2 embolism[4].

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Although the incidence of clinically apparent CO2 embolism is only 0.001-0.59 %, it is a serious complication of laparoscopy, with an associated high mortality rate of 28%[4]. The mechanism of embolism is thought to be via intravascular injection of gas through direct needle or trocar placement, or as a consequence of parenchymal injury[4].

We report a case of CO2 gas embolism during laparoscopic adrenalectomy for pheochromocytoma. The early detection of gas embolism with prompt and effective resuscitation resulted in a favorable post-operative outcome.

Case Report

A 33-year-old female patient presented to the hospital emergency room with headache, palpitation and sweating. The diagnosis of pheochromocytoma was made and confirmed with radiologic and laboratory studies. Alpha receptor blocking medications were started followed by beta receptor blockers and the patient was scheduled for laparoscopic right adrenalectomy.

On the morning of surgery the patient was premedicated with diazepam 5 mg orally. In the operating room standard monitoring was applied, with electrocardiogram, pulse oximetry, and noninvasive blood pressure. Midazolam 1 mg was given intravenously and an arterial line was inserted in the left radial artery under local anesthesia. General anesthesia was induced intravenously with propofol 140 mg, fentanyl 100 mcg, and rocuronium 50mg. After tracheal intubation, a triple-lumen central venous catheter was inserted in the right internal jugular vein. Anesthesia was maintained with sevoflurane in 50% air/oxygen mixture, remifentanil infusion, and intermittent top-up boluses of rocuronium. The lungs were mechanically ventilated with tidal volume of 500 ml, at the rate of 12-15/min keeping an end-tidal CO2 partial pressure (EtCO2) 30-35 mmHg, and peak airway pressure 13 cm H2O. The patient was positioned for surgery in a left lateral position; the surgeon introduced the Veress needle through the upper right quadrant of the abdomen. Insufflation of CO2 was started to reach an intra-abdominal pressure of 15 mmHg. During the insufflation, there was a rapid decrease in the EtCO2 from 33 to 11 mmHg, rapid oxygen desaturation from 99% to 70%, arterial blood pressure hypotension from 122/83 mmHg to 70/40 mmHg, bradycardia with heart rate from 75/min to 50/min, and increased peak airway pressure from 13 to 33 cm H2O.

Once detected, the surgeon was informed about the possibility of gas embolism. The CO2 insufflation was immediately discontinued and pneumoperitoneum was deflated. The patient was positioned in Trendelenburg position and manually ventilated with 100% oxygen. One liter normal saline was given through a pressure bag to increase the central venous pressure. About 20 ml of gas bubbles were aspirated from the central venous catheter which confirmed the diagnosis of gas embolism. The abdomen was opened through a subcostal incision, a small hole was seen on the anterior surface of the right lobe of the liver from which the gas was entrained. Bilateral adequate air entry was detected by chest auscultation with no mill-wheel murmur on cardiac auscultation. In the following 10 minutes oxygen saturation increased to 100%, peak airway pressure decreased to 15 cm H2O, heart rate increased to 70/min, blood pressure increased to 110/70 mmHg with phenylephrine boluses and end-tidal CO2 increased gradually and reached 30 mmHg after one hour. Arterial blood gas analysis parameters were within normal range except mild metabolic acidosis.

An open right adrenalectomy was performed successfully and the patient was shifted to intensive care unit with stable hemodynamics on minimal dose of norepinephrine infusion. Transthoracic echocardiography revealed no residual air in the heart or pulmonary arteries. Next day the patient was transferred to the ward.

Discussion

Carbon dioxide embolism is a rare but serious complication during laparoscopic procedures[4-6]. Like in our case, the majority of symptomatic cases of CO2 embolism occurred during initial CO2 insufflation due to the misplacement of trocar or the Veress needle directly into a vein or a parenchymal organ[4-6]. In these occasions when a CO_2 bolus enters the local venous circulation, subsequently traveling through the inferior

vena cava into the right atrium where a "gas lock" may occur, dropping the venous return and cardiac output, leading to hemodynamic collapse[4-6]. However, due to the physical characteristics an inflow of small volume of CO_2 into the systemic circulation does not always cause such significant clinical symptoms[8].

If a gas embolism is created, the clinical symptoms and degree of the hemodynamic impact of the gas embolism depend on the bubble size and amount or speed of the intravenous administration of the gas[9]. The absolute diagnosis depends on the detection of CO_2 emboli in the right side of the heart; however, due to its rapid elimination, it may be diagnosed based on physiological parameters[10]. The associated changes include a rapid decrease in the EtCO2, cardiac arrhythmias, hypotension, hypoxia, increased central venous pressure, presence of "millwheel" murmur and electrocardiogram changes[10].

Many diagnostic modalities have been used to detect gas embolism like transesophageal echocardiography (TEE), transesophageal Doppler and precordial Doppler. Although TEE is considered a sensitive tool, allowing detection of smaller CO2 emboli[5,11], the need for rapid detection and management, requires TEE to be placed prior to insufflation[11]. Moreover, TEE can distract the anesthesiologist due to increased incidence of non clinically significant gas emboli that do not require intervention[12,13]. In patients who underwent laparoscopic cholecystectomy, TEE assessment revealed CO2 gas emboli in most cases, without significant changes in the cardiorespiratory variables[12]. Additionally, using TEE gas embolism was detected in all patients undergoing laparoscopic total hysterectomy, and 37.5% of patients had significant amounts of CO2. However, no patient in this study showed hemodynamic instability or electrocardiogram changes at the time of venous air embolism occurrence[13]. Therefore, the use of TEE is not absolute and is not intended for every patient, but is an option that can be considered should a patient be evaluated to be a higher risk for CO2 emboli. The above confirms that the clinical effects of carbon dioxide embolism depend on the balance between the volume of carbon dioxide entering circulation and the amount of carbon dioxide removed from circulation[3].

In our case, the diagnosis of CO2 embolus was made based on the documented rapid decrease in EtCO2, hypotension, and hypoxemia. Under the current standard, a rapid decrease in EtCO2 detected by capnography is an acceptable, sensitive and noninvasive method[2,5] which can provide an early detection of as low as 0.25-0.5 ml/kg/min of gas entrainment in the venous circulation and is regarded as mandatory monitoring during laparoscopic procedures[5,14]. However, other causes of decreased EtCO2 should also be considered and excluded, such as monitoring error, position change of endotracheal tube, and pneumothorax[7]. Comparative study with TEE revealed that EtCO2 monitoring is sensitive enough to detect hemodynamically significant venous gas emboli episodes[14].

In the current literature, there is only one case report of CO2 embolism during laparoscopic adrenalectomy[15], while other five cases reported during retroperitoneal laparoscopic nephrectomy[16]. Cases of cardiac arrest have been reported after CO2 embolism with successful cardiopulmonary resuscitation or lethal outcome[16-20].

Treatment of CO2 embolism includes immediate discontinuation of insufflation and release of the pneumoperitoneum[5]. The patient may be placed in a left-lateral decubitus position (Durant's maneuver) and Trendelenburg position to relieve the 'gas lock' in the right side of the heart, though this has been refuted in animal studies[21]. In our case the patient was already in left-lateral decubitus position. Ventilation with 100% oxygen washes out entrained gas and improves V/Q mismatch and hypoxemia[22,23]. Aggressive volume expansion may reduce further gas entry by elevating central venous pressure[7,22,23]. Volume optimization prevents wide pressure gradients between the right atrium and the entraining vein. Aspiration of air from right atrium through the central venous catheter (especially Bunegin-Albin multi-orifice catheter) provide a quicker diagnosis, and significantly improves hemodynamic status by relieving 'gas lock'[5,24]. Circulatory support and maintenance of coronary perfusion pressure is essential to prevent further deterioration of the right ventricular function[22-24]. Norepinephrine can significantly improve cardiac functions without constricting the pulmonary vessels and also it can combat the abrupt fall in blood pressure

that may occur after pheochromcytoma excision[25,26]. Vasodilators like nitrates can be used to reduce right ventricular afterload and are also useful in treating any intraoperative hypertensive episodes in the course of tumor excision[25].

High dose remifentanil has been also used to control blood pressure fluctuations during pheochromocytoma excision[26,27]. In case of cardiac arrest, cardiopulmonary resuscitation should be performed according to the Advanced Cardiac Life Support protocol. External cardiac compression may help in the breakdown of the gas lock and its passage into pulmonary circulation[5]. Hyperbaric oxygen therapy has been found to be a useful treatment, especially in the neurologic deficits caused by paradoxic cerebral gas emboli[28].

In summary, we present a case of CO2 venous gas embolism during laparoscopic adrenalectomy, which was presented with sudden fall in EtCO2, hypoxia and hypotension. It helps to remind clinicians of this potentially fatal complication during laparoscopic surgery and the importance of early detection of gas embolism with prompt resuscitation that may result in a favorable post-operative outcome.

References

1. Winfield HN, Hamilton BD, Bravo EL, Novick AC: Laparoscopic adrenalectomy: the preferred choice? A comparison to open adrenalectomy. *J Urol;*160:325-9, 1998.
2. Neuhaus SJ, Gupta A, Watson DI: Helium and other alternative insufflation gases for laparoscopy. *Surg Endosc;* 15:553-560, 2001.
3. Yau P, Watson DI, Lafullarde T, Jamieson GG: Experimental study of effect of embolism of different laparoscopy insufflation gases. *J Laparoendosc Adv Surg Tech A;* 10:211-216, 2000.
4. Park EY, Kwon JY, Kim KJ: Carbon dioxide embolism during laparoscopic surgery. *Yonsei Med J;*53:459-466, 2012.
5. Neudecker J, Sauerland S, Neugebauer E, Bergamaschi R, Bonjer HJ, Cuschieri A, et al: The European Association for Endoscopic Surgery clinical practice guideline on the pneumoperitoneum for laparoscopic surgery. *Surg Endosc;*16:1121-43, 2002.
6. Smith HJ: Carbon dioxide embolism during pneumoperitoneum for laparoscopic surgery: a case report. *AANA J*; 79:371-73, 2011.
7. Cobb WC, Fleishman HA, Kercher KW, Matthews BD, Heniford BD: Gas embolism in laparoscopic cholecystectomy. *J Laparoendosc Adv Surg Tech A*; 15:387-90, 2005.
8. Derouin M, Couture P, Boudreault D, Girard D, Gravel D: Detection of gas embolism by transesophageal echocardiography during laparoscopic cholecystectomy. *Anesth Analg*; 82:119-24, 1996.
9. Mayer KL, Ho HS, Mathiesen KA, Wolfe BM: Cardiopulmonary responses to experimental venous carbon dioxide embolism. *Surg Endosc*; 12:1025-30, 1998.
10. Miller R: 7th edition. Churchill Livingstone; London, UK: Miller's anesthesia, 2009.
11. Joshi GP, Hein HA, Mascarenhas WL, Ramsay M, Bayer O, Klotz P: Continuous transesophageal echo-doppler assessment of hemodynamic function during laparoscopic cholecystectomy. *J Clin Anesth*; 17:117-121, 2005.
12. Park SH, Park CH, Song JE, Kim SH, Lee JY, Kim MH: Transesophageal echocardiographic assessment of venous carbon dioxide embolism during laparoscopic cholecystectomy. *Korean J Anesthesiol*; 50:20-24, 2006.
13. Kim CS, Kim JY, Kwon JY, Choi SH, Na S, An J, et al: Venous air embolism during total laparoscopic hysterectomy: comparison to total abdominal hysterectomy. *Anesthesiology*; 111:50-54, 2009.
14. Pandia MP, Bithal PK, Dash HH, Chaturvedi A: Comparative incidence of cardiovascular changes during venous air embolism as detected by transesophageal echocardiography alone or in combination with end tidal carbon dioxide tension monitoring. *J Clin Neurosci;* 18:1206-9, 2011.
15. Sollazzi L, Perilli V, Punzo G, et al: Suspect carbon dioxide embolism during retroperitoneoscopic adrenalectomy. *Eur Rev Med Pharmacol Sci;* 15:1478-82, 2011.
16. Yu X, Fang X, Fang X: Successful resuscitation after fatal carbon dioxide embolism during laparoscopic nephrectomy. *Chin Med J (Engl)*; 127:2863-4, 2014.
17. Burcharth J, Burgdorf S, Lolle I, Rosenberg J: Successful resuscitation after carbon dioxide embolism during laparoscopy. *Surg Laparosc Endosc Percutan Tech;* 22:e164-7, 2012.
18. Kim IS, Jung JW, Shin KM: Cardiac arrest associated with carbon dioxide gas embolism during laparoscopic surgery for colorectal cancer and liver metastasis - A case report. *Korean J Anesthesiol;* 63:469-72, 2012.
19. Taylor SP, Hoffman GM: Gas embolus and cardiac arrest during laparoscopic pyloromyotomy in an infant. *Can J Anaesth*; 57:774-8, 2010.
20. Shin HY, Kim DW, Kim JD, et al: Paradoxical carbon dioxide embolism during laparoscopic cholecystectomy as a cause of cardiac arrest and neurologic sequelae: a case report. *Korean J Anesthesiol;* 67:425-8, 2014.
21. Geissler HJ, Allen SJ, Mehlhorn U, Davis KL, Morris WP, Butler BD: Effect of body repositioning after venous air embolism. An echocardiographic study. *Anesthesiology;* 86:710-7, 1997.
22. Mirski MA, Lele AV, Lunei Fitzsimmons, Toung TJ: Diagnosis and treatment of vascular air embolism. *Anesthesiology*; 106:164-77, 2007.
23. Shaikh N, Ummunisa F: Acute management of vascular air embolism. *J Emerg Trauma Shock*; 2:180-185, 2009.
24. Colley PS, Artru AA: Bunegin-Albin catheter improves air retrieval and resuscitation from lethal venous air embolism in upright dogs. *Anesth Analg*; 68:298-301, 1989.
25. Angle MR, Molloy DW, Penner B, Jones D, Prewitt RM: The cardiopulmonary and renal hemodynamic effects of norepinephrine in canine pulmonary embolism. *Chest*; 95:1333-1337, 1989.
26. El Kouny A, Al Harbi M, Arif RM, et al: Anesthetic management in unexpected extra-adrenal pheocromocytoma presenting with thoracic spinal cord compression. *Middle East J Anaesthesiol*; 23(4):485-9, 2016.
27. Dimitriou V, Chantzi C, Zogogiannis I, et al: Remifentanil preventing hemodynamic changes during laparoscopic adrenalectomy for pheochromocytoma. *Middle East J Anaesthesiol*; 18:947-54, 2006.
28. Kjeld T, Hansen EG, Holler NG, Rottensten H, Hyldegaard O, Jansen EC: Resuscitation by hyperbaric exposure from a venous gas emboli following laparoscopic surgery. *Scand J Trauma Resusc Emerg Med*; 20:51, 2012.