Abstract. – During a retroperitoneoscopic adrenalectomy in the prone position, a sudden increase in end-Tidal CO₂ (EtCO₂) (from 42 to 68 mmHg) followed by an abrupt decrease (from 68 to 35 mmHg) was observed, concomitantly with a right adrenal vein laceration. Heart rate decreased to 30 bpm, and the systolic blood pressure decreased to 40 mmHg. The patient was slightly turned in the left lateral and Trendelenburg position and vasoactive drugs were administered. The systemic blood pressure, EtCO₂, CO₂ elimination (VCO₂) and pulse oximetry (SpO₂) progressively improved within 10 minutes and, at the end of the surgery, the blood pressure recovered from hypotension. ECG returned to normal, with sinus rhythm and heart rate ~70 bpm. The patient was extubated and moved to the Intensive Care Unit (ICU). This case suggests that gas embolisms may occur during retroperitoneoscopic adrenalectomy, and acute changes in EtCO₂ should alert the clinicians to these rare but potentially lethal complications. EtCO₂ monitoring is essential during laparoscopy, as it may help an early detection of CO₂ embolism, characterized by a transient and rapid increase in EtCO₂, followed by an abrupt decrease.

Key Words: Carbon dioxide, Embolism, Retroperitoneoscopic adrenalectomy, Prone position.

Introduction

Retroperitoneoscopic adrenalectomy is a new surgical technique that can be performed in either prone or lateral positions1,2. The prone position is preferred during conventional adrenalectomy for tumours < 10 cm in terms of reduced blood loss, postoperative morbidity and length of hospital stay2,3. Moreover, this surgical procedure carries less important haemodynamic changes than conventional transperitoneal laparoscopic adrenalectomy4,5.

Up to now no case reports about gas embolism during retroperitoneoscopic adrenalectomy exist. We report a suspect unusual complication of CO₂ embolism, causing haemodynamic failure, in a 43 years old man during retroperitoneoscopic adrenalectomy in the prone position.

Case Report

A male patient (aged 43, 98 kg, ASA II), who suffered from a mild hypertension and thyroiditis, in treatment with an antihypertensive drug (irbesartan 150 mg 1 cp/die) and levothyroxine, was admitted for elective retroperitoneoscopic right adrenalectomy in the prone position for an adrenal “incidentaloma”. Abdomen CT scan showed an inhomogeneous adrenal mass (55 mm in diameter) with a hyper-uptake of the tracer at PET-CT scan. No hormonal hypersecretion was found at the preoperative laboratory evaluation, with the exception of a high upright plasma aldosterone level (524.0 pg/ml [7.5-150]). Urinary aldosterone was within the normal range. The preoperative routine laboratory testing values were within the normal range.

After premedication in the operating room with midazolam (3 mg intravenous), anaesthesia was induced with propofol (2 mg/kg), fentanyl (2 mcg/kg), cisatracurium (0.2 mg/kg) for muscle relaxation, and was maintained with sevorane in 50% oxygen/air, titrated on a BIS (bispectral index) value of 30-40, and fentanyl (up to 5 mcg/kg). An infusion of lactated Ringer’s solution (8-10 ml/kg/h) was started and modified according to clinical needs.

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Mechanical ventilation (MV) was adjusted to maintain an end-Tidal CO₂ (EtCO₂) between 35 and 45 mmHg throughout surgery. Monitoring consisted of ECG, invasive blood pressure (radial
arterial catheter), pulse oximetry (SpO\textsubscript{2}), EtCO\textsubscript{2}, BIS (bispectral index, Aspect Medical System Inc., Newton, MA, USA), urine output and blood gas analysis.

Moreover, as usual in our institution, O\textsubscript{2} consumption (VO\textsubscript{2}) and CO\textsubscript{2} elimination (VCO\textsubscript{2}) were monitored by computerized indirect calorimetry (Deltatrac II, Datex-Ohmeda, Finland). After the induction of the anaesthesia, arterial blood gas analysis was normal (Table I).

The patient was positioned in a jack-knife prone position with the trunk-thigh hinge of Wilson’s bridge table used as a flexion joint, augmented by placing a pillow under the pelvis. A leg intermittent pneumatic compression device (Kendall 7325 SCD Response Compression System, Kendall Healthcare Products Co Mansfield, MA, USA) was applied.

The first step was a 2 cm transverse incision at the tip of the 12\textsuperscript{th} rib. A blunt finger-guided dissection of the retroperitoneal space prepared a safety insertion of the other two 10-mm trocars laterally and medially to the first trocar site. After creating a retroperitoneal space by introducing CO\textsubscript{2} at a pressure of 20 to 24 mm Hg, a 10 mm/0\textdegree endoscope was introduced into it through the middle trocar site. Retroperitoneal pressure was maintained automatically at 15 or 20 mmHg using a CO\textsubscript{2} insufflator. As previously described\textsuperscript{2}, the classic surgical steps of this technique were performed. While cutting the main adrenal vein, the clip on the inferior cava vein was dislodged and this provoked a sudden bleeding of the main adrenal vein, very close to its point of entry into the inferior cava vein.

The patient was stable during the adrenal dissection, but during the bleeding of the right adrenal vein (blood losses ~300 ml), a rapid increase in EtCO\textsubscript{2} (from 42 to 68 mmHg) was observed (Table I). MV was consequently increased, by changing the respiratory rate, to control this parameter.

After a few minutes, a sudden decrease in EtCO\textsubscript{2} (from 68 to 35 mmHg) and in VCO\textsubscript{2} (from 270 ml/min to 135 ml/min) was observed, combined with a decrease in SpO\textsubscript{2} (from 100\% to 54\%). Simultaneously, the heart rate abruptly decreased to 30 bpm and the systolic blood pressure decreased to 40 mmHg. A gas embolism was suspected, and the surgeon was informed. The patient was slightly turned in the left lateral and Trendelenburg position. The FiO\textsubscript{2} was changed from 0.4 to 1, and 0.5 mg atropine and 1 mg epinephrine were administered, along with a load of fluids (500 ml of colloids). A few minutes later, the onset of a supraventricular tachyarrhythmia (142 bpm) was treated with amiodarone (continuous i.v. infusion after a bolus dose of 300 mg). The systemic blood pressure, EtCO\textsubscript{2}, VCO\textsubscript{2} and SpO\textsubscript{2} progressively improved within 10 minutes. Blood gas analysis showed a PaCO\textsubscript{2} of 48 mmHg and a PaO\textsubscript{2} of 128 mmHg. At this time, the surgeon, after completely removing the gland, immediately performed the clamping of the lateral surface of the inferior cava vein, by using metallic clips, stopping the venous bleeding.

At the end of the surgery (230’ minutes after the first skin incision), blood pressure was recovered from hypotension without any vasoactive drugs, and ECG returned to sinus rhythm and heart rate ~70 bpm.

A transesophageal echocardiography (TEE) was performed intraoperatively as soon as possible (at the end of surgery) and showed no valve abnormalities and a normal cardiac contractility. Gas bubbles were not seen, probably due to the elapsed time from the onset of the symptoms.

The patient was extubated and moved to the Intensive Care Unit (ICU). A chest X-ray showed a mild interstitial pulmonary oedema, with a minimal impairment of pulmonary gas exchange. In the first postoperative day, the patient was transferred to a surgical ward. The clinical course was uneventful, and 1 week later he was successfully discharged from hospital.

The final histology report was consistent with an adrenocortical carcinoma. The patient is presently undergoing to a close postoperative follow-up (1 year) by his endocrinologist. A first computed tomography (CT) scan control showed no persistence or recurrent disease.

## Discussion

Although laparoscopic procedures are associated with a considerably low morbidity and mortality, potentially lethal complications might occur\textsuperscript{6}. Carbon dioxide embolism is a rare complication, but may result in serious morbidity and mortality\textsuperscript{7-9}. Indeed, clinically apparent gas embolism is associated with a mortality rate of 28\%\textsuperscript{10}. Fatal gas embolisms during laparoscopy have been reported in the presence (as well as in the absence) of visible blood vessel lesions. These cases occurred during several surgical la-
Table I. The trends of the main intra-operative parameters are reported in table.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Induction</th>
<th>After 30 min</th>
<th>After 60 min</th>
<th>After 120 min</th>
<th>After 150 min</th>
<th>After 180 min (sudden bleeding)</th>
<th>Suspect carbon dioxide embolism</th>
<th>After 200 min</th>
<th>After 220 min</th>
<th>Desuff</th>
<th>End of surgery</th>
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<tr>
<td>VO₂ ml/min</td>
<td>88</td>
<td>123</td>
<td>100</td>
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<td>110</td>
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<td>VCO₂ ml/min</td>
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<td>172</td>
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paroscopic and retroperitoneoscopic procedures in the supine or lateral position. In the present case, the suspected CO₂ embolism occurred during posterior retroperitoneoscopic adrenalectomy, after a bleeding from the right adrenal vein at its point of entry into the cava vein. Up now, in our knowledge, this is the sole case described during this surgical technique.

The clinical picture was characterized by an abrupt and transient increase in EtCO₂ (from 42 to 68 mmHg), followed by a decrease in EtCO₂ (from 68 to 35 mmHg), with concomitant desaturation and haemodynamic instability (Table I). These clinical findings led us to a suspect of gas embolism, after having ruled out other possible causes, such as pneumothorax and subcutaneous emphysema. Indeed, an increase in EtCO₂ may be due to an increased absorption of CO₂ (emphysema) or to a decreased ventilation (pneumothorax). However, in these cases the increase in EtCO₂ should be slow, while in this patient we observed a rapid increase in the EtCO₂. Moreover, the sudden decrease in EtCO₂ may be caused by an interruption of pulmonary blood flow, as in pulmonary embolism as well as by a decrease in cardiac output. The combination of the two phases (a rapid increase in EtCO₂ followed by an abrupt decrease of this value) prompted us to diagnose a massive absorption of CO₂ during the bleeding and a gas embolism. Two previous case reports of CO₂ embolism describe an initial increase in ETCO₂ followed by an acute decrease. We observed the same pattern, even if a complete diagnosis could not be made in the clinical setting. The circulatory response to CO₂ embolism is caused by the volume of gas and its rate of entry into the venous circulation. In our case, the return to a normal cardiovascular pattern after an adequate vasoactive treatment, confirmed the suspicion of a non-fatal CO₂ embolism, as CO₂ is highly soluble in blood and should dissolve quickly enough. On the other hand, some works show that humoral mechanisms are involved in the pulmonary reactions to microembolism, and in these cases a hemodynamic instability might persist. Diffuse pulmonary CO₂ embolism causes increased pulmonary circulatory resistance, entailing an increase in pulmonary artery pressure, and sometimes it might lead to right heart failure. In the occurrence of an abrupt decrease in EtCO₂ combined with hemodynamic instability, the patient should be quickly positioned in Trendelenburg position and in the left lateral position (Durant’s position), that has proved beneficial as it places the right ventricular outflow tract in a lower position to the embolus and allows resumption of blood flow into the pulmonary circulation. Moreover, to quickly detect the embolism, transesophageal echocardiography may be usefully performed, having been indicated as the most sensitive method for detecting even minor events of CO₂ embolization. However, this device may not be promptly available in every operating room. Therefore, the anesthesiologist should be ready to recognize and treat this sudden event.

In conclusion, this case suggests that gas embolisms may occur during posterior retroperitoneoscopic adrenalectomy, and acute changes in EtCO₂ should alert the clinicians to these rare but potentially lethal complications. EtCO₂ monitoring is essential during laparoscopy, as it may help an early detection of CO₂ embolism, characterized by a transient and rapid increase in EtCO₂, and followed by an abrupt decrease.

References


