CASE REPORT

Carbon dioxide embolism during laparoscopic hepatectomy in a patient with an iatrogenic atrial septal defect : a case report

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Abstract : Background : Laparoscopic hepatectomy has advantages including shorter hospital stay, lesser blood loss, and lower complication rates. Carbon dioxide gas embolism is a life-threatening complication associated with laparoscopic hepatectomy. During catheter ablation, the standard treatment for atrial fibrillation, an iatrogenic atrial septal defect (ASD) is developed when performing a septal puncture from the right to the left atrium. Case presentation : Carbon dioxide embolism occurred during laparoscopic liver resection in a 70-year-old male patient with a history of catheter ablation for atrial fibrillation. Transesophageal echocardiography detected iatrogenic ASD. The surgery was converted into an open procedure after consulting with the surgeon. Postoperatively, the patient exhibited no evidence of poor arousal nor obvious neurological abnormalities. Conclusion : In patients with a history of catheter ablation, particular attention should be paid to the bubble inflow into the left ventricular system in the event of gas embolism during laparoscopic hepatectomy. J. Med. Invest. 71 : 320-322, August, 2024

Keywords **:** *atrial fibrillation, carbon dioxide embolism, catheter ablation, iatrogenic atrial septal defect, laparoscopic hepatectomy*

BACKGROUND

Laparoscopic hepatectomy has advantages including shorter hospital stay, lesser blood loss, and lower complication rates (1). However, complications have been reported, among which carbon dioxide gas embolism is serious and life-threatening (2). Catheter ablation is the standard treatment for atrial fibrillation during which a septal puncture is performed from the right to the left atrium, creating an iatrogenic atrial septal defect (ASD) (3). We report a case of carbon dioxide embolism during laparoscopic hepatectomy in a patient with a history of catheter ablation for atrial fibrillation and an iatrogenic ASD found on transesophageal echocardiography.

CASE PRESENTATION

A 70-year-old male (height, 168 cm ; weight, 65 kg) was scheduled to undergo laparoscopic partial hepatic S8 resection for hepatocellular carcinoma. The patient underwent two ablations for atrial fibrillation, the first one done 3 years ago while the second, just 15 days prior to surgery. Other relevant medical history included hypertension and nonalcoholic hepatitis. Preoperative electrocardiography and chest radiography showed no abnormalities. Preoperative blood test results indicated mild hepatic dysfunction (glutamic-oxaloacetic transaminase, 47 U/L) and anemia (hemoglobin, 11 g/dL). Pre-operative transthoracic echocardiography showed no abnormalities ; transesophageal echocardiography performed immediately prior to the first ablation did not show any foramen ovale or ASDs. Subsequent follow-up using transesophageal echocardiography, including at the time of the second ablation, was not performed.

General anesthesia and peripheral nerve blocks were administered. Anesthesia was induced with propofol, remifentanil, and rocuronium and maintained with desflurane, remifentanil, fentanyl, and rocuronium. Rectus abdominis sheath and transverse abdominis fascia plane blocks were administered before initiating surgical procedure. An arterial line was inserted into the radial artery to monitor blood pressure over time. Additionally, peripherally inserted central catheter (PICC) was placed into the ulnar cutaneous vein preoperatively to measure central venous pressure (CVP).

The patient was placed in a reverse Trendelenburg left semi-supine position. During the liver surgery, the surgeon requested that the infusion volume be limited to maintain a low CVP ; therefore, the infusion volume was restricted. Insufflation pressure was initiated at 12 mmHg. Ventilator settings during hepatectomy were set as follows : positive end-expiratory pressure, <4 cm H_2O ; peak inspiratory pressure, <15 cm H_2O. Respiratory rate was maintained at 10-20 breaths/minute, and the expiratory CO_2 concentration was kept as low as possible at 40 mmHg. At the time of hepatectomy, SpO_2 decreased from 99% to 90% and systolic blood pressure decreased from 120 mmHg to 90 mmHg. In addition, $EtCO_2$ and $PaCO_2$ dissociated at 24 mmHg and 71 mmHg, respectively ; CO_2 embolism was suspected. The patient was immediately placed on pure oxygen and administered a boosting agent and infusion load. The team attempted aspiration using a PICC, but no aspirate was

Abbreviation list :
ASD, atrial septum defect ; CVP, central venous pressure ; LR, left to right ; PICC, peripherally inserted central catheter

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obtained. They discontinued insufflation, and performed a transesophageal echocardiogram after vital signs improved. At that point, no right heart load findings were noted. Additionally, a color Doppler scan showed left-to-right shunts through the ASD (Figure 1). Following consultation with the surgeon, the surgery was converted to an open procedure and surgery was continued. Postoperatively, the patient was extubated in the operating room, with no evidence of poor arousal nor obvious neurological abnormalities. Although the lactate level was mildly elevated at 3.9 mmol/L a few hours after surgery, it recovered to its normal level the day after surgery.

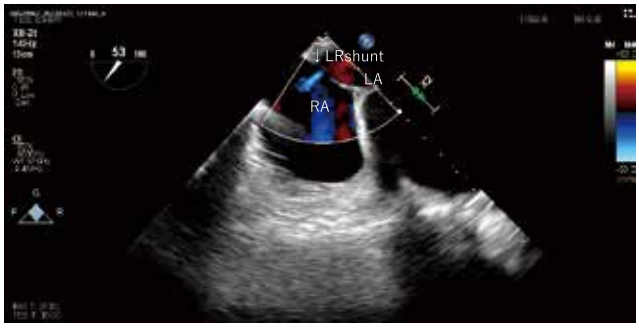

Figure 1. Left to right (LR) shunt of the atrial septal defect on transesophageal echocardiography

DISCUSSION

Owing to establishing pneumoperitoneum, laparoscopic surgery has various effects on the respiratory and circulatory systems. Its complications include hyper-CO_2-emia, subcutaneous emphysema, mediastinal emphysema, and pneumothorax. A more serious complication is gas embolism due to CO_2 gas. Gas embolism is a rare complication of laparoscopic surgery that can be fatal in severe cases, with a reported mortality rate of 28% (4).

In patients with atrial or ventricular short circuits, gas embolism can increase pressure in the right ventricular system, resulting in a right-to-left shunt. This embolus can eventually cause serious complications such as stroke or myocardial infarction (5-7).

Our patient had a history of catheter ablation for atrial fibrillation. During this procedure, a catheter is inserted through a vein, advanced into the right atrium, punctured through the atrial septum, passed through the left atrium, and cauterized around the pulmonary vein. This inevitably leads to the development of an iatrogenic ASD (8, 9). The incidence of iatrogenic ASD varies based on the duration of follow-up and the nature of the procedure (3, 10). Rillig *et al*. reported that 95% of patients had iatrogenic ASDs on transesophageal echocardiography on the day following catheter ablation for atrial fibrillation. However, at the 6-month follow-up, closure of primary ASD was observed in 78.9% of their patients. They further reported that the incidence of odd emboli did not increase with iatrogenic ASDs (8). Nagy *et al*. reported that 18.1% of patients who underwent catheter ablation had iatrogenic ASDs at 3-month follow-up, with a high rate of spontaneous closure observed at 12-month follow-up. No strokes occurred during the study period (11).

Therefore, attention should be paid to iatrogenic ASDs in patients with a history of catheter ablation. In our patient, catheter ablation was performed 15 days prior to surgery, and the possibility of a residual iatrogenic ASD was considered high. The primary ASD is usually small ; herefore, it is rarely a problem and often no follow-up transesophageal echocardiography is performed (10). Moreover, in many cases, a primary iatrogenic ASD closes spontaneously or without symptoms (11). In our case, the preoperative transthoracic echocardiography revealed no iatrogenic ASD or left-to-right shunt. As the patient had no preoperative symptoms, a follow-up transesophageal echocardiography was deemed unnecessary.

Laparoscopic hepatectomy has a higher incidence of gas embolism than other laparoscopic procedures owing to its low CVP, high pneumoperitoneum pressure, the Pringle technique (12), and body position. In the present case, transesophageal echocardiography was performed after an acute response to gas embolism. Fluid loading, administration of a boosting agent, and changing body position was performed when gas embolism occurred ; therefore, there were no right heart load findings and a right-to-left shunt was not observed when the transesophageal echocardiography probe was inserted. However, the sudden increase in right ventricular pressure during gas embolism could have resulted in a temporary right-to-left shunt and bubble inflow into the left ventricular system. Patients with artificial ASDs have a higher risk of arterial embolism due to temporary right-to-left shunts. In addition, this risk could be further increased because the procedure is performed in the left semi-supine, with elevated head, position. If our medical response was delayed, the patient could have been fatally ill.

In summary, we encountered a case of CO_2 gas embolism during laparoscopic liver resection in a patient with a history of catheter ablation for atrial fibrillation. Transesophageal echocardiography revealed an iatrogenic ASD. In patients with a history of catheter ablation, particular attention should be paid to the bubble inflow into the left ventricular system in the event of a gas embolism to prevent paradoxical gas embolism.

DECLARATIONS

Ethics approval and consent to participate : This case report was approved by the institutional Review Board of the Ethics Committee of Tokushima University Hospital (Tokushima, Japan).

Consent for publication : Written informed consent was obtained from the patient and the family for the use of medical records upon hospital admission.

Availability of data and material : Not applicable

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Authors' contributions : YN is the principal author responsible for the conception and design of the case report ; clinical data acquisition, interpretation ; drafting of the manuscript ; and approval for publication. YS helped care for the patient, interpreted and analyzed clinical data, and revised and approved the final version of the manuscript. HY and NK helped care for the patient, and helped design the case reports. KT made substantial contribution to the conception and design of the case reports, interpretation of the data, critical revision of the intellectual content. All authors read and approved the final manuscript.

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