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Case report - Thoracic oncologic
Lung lobectomy in a patient with an implantable left ventricular assist device

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Abstract
Non-cardiac surgical procedures in patients with left ventricular assist devices (LVADs) pose a special challenge given the hemodynamic and hematologic considerations in these patients. During pulmonary procedures in patients with LVADs, special attention should be paid to hemodynamics because lung resection surgery requires a lateral decubitus position, single-lung ventilation and postoperative decrease in the pulmonary vascular bed, all of which may lead to inadequate preload to the LVAD. We present a case of lower lobectomy of the left lung for an adenocarcinoma found in a patient with an implantable continuous-flow LVAD.

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1. Introduction
Left ventricular assist devices (LVAD) have become an important option in the treatment of end-stage heart failure, and surgeons are more frequently required to perform non-cardiac operations on these patients. In pulmonary procedures in such patients, special attention should be paid to hemodynamics because pulmonary procedures require the lateral decubitus position, single-lung ventilation and postoperative decrease in the pulmonary vascular bed, all of which may lead to inadequate preload to the LVAD. With the emergence of second-generation, continuous-flow LVADs, hemodynamic and hematologic considerations may become more critical [1–3].

2. Case presentation
A 58-year-old female patient with a LVAD was referred for diagnosis and treatment of an undiagnosed small nodule in the lower lobe of the left lung (Fig. 1a,b,c). She suffered from non-ischemic dilated cardiomyopathy and had undergone cardiac resynchronization therapy with a defibrillator Concerto C154DKW CRT-D (Medtronic, Minneapolis, MN, USA) device two years earlier. Due to deteriorating cardiac function, she underwent a HeartMate II LVAD (Thoratec, Pleasanton, CA, USA) implantation as a bridge-to-transplantation six months earlier.

At the time of LVAD implantation, a moderate amount of bilateral pleural effusion existed and the bilateral pulmonary lower lobes became atelectatic. Adjacent to the atelectasis, an indeterminate small nodule, 8 mm in diameter, was found by computed tomography (CT)-scan (Fig. 1a,b,c). Possible differential diagnoses were organizing pneumonia or bronchioloalveolar carcinoma (BAC), however, an invasive approach was impossible due to her severe congestive heart failure and the small size of the nodule. As her heart condition was deteriorating, the VAD team decided to do a LVAD implantation due to the high possibility of organizing pneumonia.

Although a fluorine-18 fluorodeoxyglucose-positron emission tomography (FDG-PET) scan showed no accumulation to this nodule (d), a CT-scan taken four months after LVAD implantation showed a gradual increase in the size of the nodule, slight enlargement of the solid component of the nodule and the emergence of slight pleural indentation (e,f). BAC was suspected again. Serum carcinoembryonic antigen was 2.5 ng/ml. To determine the indication for heart transplantation and to make a definite diagnosis and treatment plan for the indeterminate lung nodule, she was referred to the general thoracic department.

The pulmonary function test showed reduced vital capacity and diffusing capacity of the lung to carbon monoxide (DLCO): 70% and 58%, respectively, of predicted values. Right heart catheter examination with a 15-min left pulmonary artery occlusion test showed no pulmonary hypertension and no significant change in pulmonary artery pressure. End-diastolic pressure of the right ventricle (RVEDP) remained constant at approximately 9 mmHg. Notably,
von Willebrand factor levels decreased to 26% of normal. A week prior to lung surgery, coumadin and aspirin were discontinued, and heparin infusion was started with a partial thromboplastin time of 40–60 s.

During the operation, arterial line, Swan-Ganz catheter and transesophageal echocardiography were used for monitoring hemodynamics. The rotation speed of HeartMate II was adjusted to allow proper left ventricular size to warrant appropriate preload to LVAD. The pacing mode of CRT-D was changed to fix ventricular pacing. The patient’s position was carefully changed to the right decubitus position and single-lung ventilation was started. Due to dense fibrous adhesion of the left lung to the chest wall, open thoracotomy was performed. Adhesiotomy was accompanied by a tendency for severe bleeding, and gauze packing was necessary to control oozing bleeding. Notably, the mediastinal surface of the left lung adhered severely to the pericardium, especially around the inflow cannula of the LVAD (Fig. 2). Special attention was carried out so as not to injure the inflow cannula. The nodule was identified and resected with wedge resection. The frozen section revealed an adenocarcinoma, and lower lobectomy of the left lung and systemic lymphadenectomy were done. To reduce the risk of postoperative intrapulmonary bleeding, we did not choose a sublobar resection, relying on the preoperative 15-min left pulmonary artery occlusion test. To obtain optimal hemostasis, gauze packing and transfusion of eight units of fresh frozen plasma and 20 units of platelet concentration were necessary. The estimated blood loss was 3400 ml and 18 units of packed red blood cells were transfused. The operative time was 3 h and 20 min. Two chest tubes were inserted and the wound was closed. The patient was transferred to the intensive care unit (ICU) and was extubated on postoperative day 1. Chest tubes were removed on postoperative day 4. To control right heart failure symptoms, oral furosemide and pimobendan were started. Intravenous dobutamine and olprinone hydrochloride were tapered off on postoperative days 3 and 25, respectively. Coumadin and aspirin were restarted on postoperative day 3. Right heart catheter examination performed on postoperative day 18 revealed no pulmonary hypertension. RVEDP was 6 mmHg. The patient was discharged on postoperative day 30.
Pathologic evaluation revealed an adenocarcinoma with mixed subtypes (mainly non-mucinous bronchioalveolar carcinoma, with a minimal papillary component) 9 mm in maximal diameter without lymph node metastasis.

3. Comment

To date, there have been several reports of non-cardiac procedures in patients with several types of LVAD.

Goldstein et al. reported results of 12 non-cardiac surgical procedures, including four procedures (left pleural decortication, nephrectomy, right lower lobectomy and debridement sacral decubitus ulcer) requiring the lateral decubitus position, in eight patients with pulsatile LVAD [4]. The authors observed that use of the lateral decubitus position resulted in decreased cardiac output as determined by LVAD flow that could be resolved by dobutamine, vasopressor and hydration. Schmid et al. reported results of 20 non-cardiac surgical procedures, including four thoracic procedures in 14 patients with pulsatile-type LVAD [5]. In this report, the most frequent and serious complication was postoperative bleeding. Notably, a patient with empyema operation required redo thoracotomy four times due to uncontrollable bleeding that was finally stopped by temporal towel packing. This patient developed right heart failure as a late complication. Wei et al. described a report of upper lobectomy of the right lung in a patient with a pulsatile-type LVAD [6]. Notably, a dense adhesion of the right upper lobe to the outflow graft of the LVAD was observed. This case and our case represent possible interference by LVAD inflow and outflow tract in lung procedures. Garatti et al. reported results of 12 non-cardiac, non-thoracic surgical procedures for 11 of 77 LVAD recipients: 41 with pulsatile LVAD and 36 with continuous-flow axial-pump LVAD [1]. The authors found that axial-flow pumps as compared with pulsatile-flow pumps were extremely dependent on preload and afterload. They recommended that increases in systemic vascular resistance and hypertension, in particular, must be strictly avoided during axial-flow pump support, because these can result in sudden pump failure and poor peripheral perfusion.

In viewing the literature, the main issues of non-cardiac procedures in patients with LVADs are perioperative anticoagulation protocol and maintenance of hemodynamics during the procedures [1,4–6]. Especially in pulmonary procedures, special attention should be paid to hemodynamics because pulmonary procedures requires the lateral decubitus position, single-lung ventilation and postoperative decrease in the pulmonary vascular bed, all of which may lead to inadequate preload to the LVAD. A clear understanding of the characteristics inherent to LVAD is thought to be important to perform pulmonary lobectomy on patients with LVAD. Right heart catheter examination with a 15-min left pulmonary artery occlusion test done in our case seems to be a valuable evaluation method before lung surgery in a patient with LVAD. As for anticoagulation protocol, oral anticoagulation drugs had preoperatively been replaced to intravenous heparin with a partial thromboplastin time of 60–80 s [5] or discontinued for the patients’ coagulation measurements to be normalized [6]. Postoperative anticoagulation was resumed generally after obtaining sufficient hemostasis under careful measurements of a partial thromboplastin time and international normalization ratio [1, 5, 6].

HeartMate II is reported to be associated with an extremely low thromboembolic risk and with less stringent requirements for anticoagulation. Selected patients with HeartMate II at high-risk for bleeding can be safely followed with either no or extremely low anticoagulation requirements for prolonged periods [2, 3]. Acquired von Willebrand syndrome may explain low thromboembolic risk and unexpected bleeding episodes in patients on HeartMate II [7, 8]. In such a case as we presented, anticoagulation therapy could have been discontinued during the perioperative period. Preoperative heparin treatment was thought to be unnecessary in our case.

This particular case left us an ethical dilemma. To avoid the implantation of an LVAD in a lung cancer patient, precise preoperative evaluation should be done before LVAD implantation because there still remain some doubts about use of LVAD as a destination therapy, however, invasive approach, especially for small size pulmonary nodules, may be often difficult in patients with deteriorating heart failure [6]. At least we have to keep on with a careful patient selection before LVAD implantation.

References