Basal segmental auto-transplantation after pneumonectomy for advanced central lung cancer

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Abstract
In patients with central lung cancer that extensively involves the bronchus/pulmonary artery, a double-sleeve lobectomy is often difficult to perform. We describe a case of post-pneumonectomy basal segmental auto-transplantation using a lung preservation technique that uses cold low-potassium dextran glucose solution to protect the lung graft from ischaemia–reperfusion injury during the ex situ division of the segmental graft and the pathological investigations for the clearance of the surgical margins. A right basal segmental auto-transplantation procedure was performed in a patient with stage-III A squamous cell lung cancer. This technique could allow extensive pulmonary resection while minimizing the loss of pulmonary reserve.

Keywords: Lung transplantation • Pneumonectomy • Organ preservation • Lung cancer surgery • Ischaemia-reperfusion

INTRODUCTION
Pneumonectomy for central lung cancer is associated with a high postoperative mortality, especially with right-sided lesions. A bronchovascular double-sleeve lobectomy has been reported as an alternative technique that preserves the lung function [1]. However, in patients with central lung cancer that extensively involves the bronchus and the pulmonary artery, the double-sleeve lobectomy is difficult to perform. There are few English-language articles describing lung auto-transplantation, which is a technique that involves a lower lobe replantation after the in situ sleeve lobectomy with systemic heparinization [2–4]. Moreover, no report describing a basal segmental auto-transplantation has been published (Fig. 1). We describe a case involving the post-pneumonectomy basal segmental auto-transplantation using a lung preservation technique that uses the cold low-potassium dextran glucose solution to protect the lung graft from ischaemia–reperfusion injury during the ex situ division of the segmental graft and pathological investigations for the clearance of the surgical margins.

CASE
The patient in this case had squamous cell lung cancer involving the proximal right main stem bronchus and the pulmonary artery from the level of the right main to the middle lobe artery with right upper lobe atelectasis (cT4N1M0, Fig. 2A). A sleeve resection of the right upper/middle lobes and the superior segment was considered to be too difficult because, after the resection of the involved bronchus/pulmonary arteries, the gap between the proximal and distal bronchovascular structures would be impossible to bridge due to a tethering effect caused by the intact inferior pulmonary vein. Therefore, the patient was scheduled to undergo a right basal segmental auto-transplantation after the pneumonectomy followed by adjuvant chemotherapy. This procedure was approved by the Okayama University Institutional Review Board.

A median sternotomy and a fourth intercostal right thoracotomy were performed for improved access to the central pulmonary artery and the main bronchus. After the mediastinal and hilar lymph node dissection (ND2a), intravenous heparin (1 mg/kg) was administered. The pulmonary artery and vein were clamped and the pneumonectomy was completed. Prior to the basal segmental auto-transplantation, the pulmonary arteries were dissected as proximal as possible for the upper pulmonary vein and as proximal as possible for the lower pulmonary vein. On another table in the operating room, antegrade followed by retrograde pulmonary arterial flushes were performed with 2 l of cold low-potassium dextran glucose solution for lung preservation. The main bronchus was re-intubated and ventilated with room air to facilitate the pulmonary arterial flushes. To obtain sufficient surgical margins, the ex situ resection of the basal segment of the lower lobe was performed and negative bronchial/arterial surgical margins were verified. Prior to the basal segmental auto-transplantation, the intra-atrial groove was dissected for the better mobilization of the remaining right upper pulmonary venous stump. To overcome the size disparity between the proximal and distal anastomoses, the bronchial cuff was obliquely trimmed relative to the lower lobe branch to obtain a bronchial stump with a larger...
diameter. The proximal pulmonary artery was also trimmed in a similar manner, and the anastomosis was performed, reducing the diameter of the proximal pulmonary artery stump. Access to the arterial anastomosis site was achieved through the window between the superior vena cava and the ascending aorta (Fig. 2B). The basal segmental pulmonary vein was anastomosed to the remaining upper pulmonary venous stump. The total ischaemic time was 120 min. The postoperative course was uneventful, and ischaemia–reperfusion injury was not observed (Fig. 2C and D). Computed tomography (CT) angiography revealed a patent vascular anastomosis, and a ventilation/perfusion scan confirmed adequate ventilation/perfusion of the segmental graft. The preserved volume of the basal segment/ remnant contralateral whole lung estimated with CT volumetry was 1197/2467 ml. The %FEV1 pre- and postoperation was 96.8 and 78.3%, respectively. The patient was discharged from the intensive care unit 2 days after the operation and returned to normal life without recurrence of the primary disease (follow-up period: 19 months).

**DISCUSSION**

Centrally located lung cancer can involve structures that preclude an isolated lobectomy and require a more extended resection. In this condition, the pneumonectomy is usually performed;
however, the pneumonectomy results in a greater loss of functioning lung tissue compared with a lobectomy. The bronchovascular double-sleeve lobectomy has been reported as an alternative procedure that both preserves the lung function and provides an equally curative resection compared with the pneumonectomy [1]. However, after the extensive sleeve resection of the bronchus and the pulmonary artery, the gap between the proximal and the distal bronchovascular stump is often difficult to bridge because of the tethering effect caused by the inferior pulmonary vein. Reardon et al. [2] reported a case in which the lower pulmonary vein was disconnected and then reconnected to the upper pulmonary vein after the in situ double-sleeve resection of the right upper and middle lobes. In that case, the lobar graft underwent ischaemia–reperfusion injury after the operation. Jiang et al. [3] reported seven cases of the in situ double-sleeve lobectomy and the replantation of the lower lobe with a single-lung flushing with heparin solution (500 ml of normal saline with 12,500 U heparin at 20°C). Both authors noted the importance of preventing ischaemia–reperfusion injury with the lung preservation solution. In the lung transplant reports, proper lung preservation was recommended in cases in which the warm ischaemic time would exceed 1 h [5]. In fact, the average ischaemic time in the cases described by Jiang et al. [3] was 153 min; the ischaemic time in our case was 120 min. In our case, 2 l of cold low-potassium dextran glucose lung preservation solution was used for antegrade followed by retrograde pulmonary arterial flushes. Appropriate lung preservation may provide less ischaemic damage and sufficient time to perform the pathological examination of the bronchial and arterial surgical margins.

In addition, we believe that the ex situ segmental graft resection may be safer and easier than the in situ resection. It can be performed with a favourable visual field without excessive bleeding and tumour manipulation, because the cancerous lung is completely removed from the patient’s body.

In conclusion, basal segmental auto-transplantation after the ex situ division of the segmental graft is technically feasible and allows the extensive pulmonary resection while minimizing the loss of pulmonary reserve. The lung preservation technique can help protect the lung grafts from ischaemia–reperfusion injury caused by the ischaemic period.

Conflict of interest: none declared.

REFERENCES