Ann Thorac Cardiovasc Surg 2022; 28: 298–301
Online November 3, 2020
doi: 10.5761/atcs.cr.20-00230

Case Report

Exacerbation of Secondary Pulmonary Hypertension by Flat Chest after Lung Transplantation

Haruhiko Shiiya, MD, PhD,[1,2] Masaaki Sato, MD, PhD,[1] Aya Shinozaki-Ushiku, MD, PhD,[3] Chihiro Konoeda, MD, PhD,[1] Kentaro Kitano, MD, PhD,[1] and Jun Nakajima, MD, PhD[1]

A 40-year-old woman with idiopathic pleuroparenchymal fibroelastosis (IPPFE) and flat chest underwent left single lung transplantation (SLT). Although she had developed over-systemic pulmonary arterial pressure (PAP) at transplantation, it was alleviated. However, her PAP gradually increased again. Her transplanted lung was well-inflated, but progression of fibrosis in her right native lung appeared to have caused a mediastinal shift, and her flat chest caused obstruction of the outflow tract of the pulmonary vein. She died of heart failure and associated infection 1.5 years after transplantation. An autopsy confirmed irreversible pulmonary arterial and venous changes in the transplanted lung, suggestive of chronic pressure overload. The flat chest associated with IPPFE can affect pulmonary circulation after SLT.

Keywords: chest wall, pulmonary arteries/veins, pulmonary vascular resistance/hypertension, interstitial lung disease, transplantation, lung

Introduction

Idiopathic pleuroparenchymal fibroelastosis (IPPFE) is a relatively new entity of idiopathic interstitial pneumonia (IIP) that was first included as a specific clinicopathologic entity in the updated classification of IIPs in 2013.[1)] IPPFE is characterized by upper lobe-predominant fibrosis involving the pleura and subpleural lung parenchyma. Patients with IPPFE reportedly have a characteristic chest wall deformity known as flat chest.[2)] Chest computed tomography (CT) in patients with flat chest often shows a mediastinal shift or displacement of the heart. However, its impact on hemodynamics after lung transplantation remains unclear.

In this report, we describe a fatal case of pulmonary hypertension that was exacerbated after single lung transplantation (SLT) in association with flat chest in a patient with IPPFE.

Case Report

A 40-year-old woman with a diagnosis of IPPFE was evaluated for lung transplantation. She showed flat chest typical of IPPFE. Although she had a history of surgical fixation of her funnel chest in childhood, she still showed funnel chest. Because no evidence of pulmonary arterial hypertension was demonstrated (mean pulmonary arterial pressure [PAP], 16 mmHg by right heart catheterization; right ventricular systolic pressure [RVSP], 30 mmHg by echocardiography), she was listed for lung transplantation with SLT as the primary procedure because of the severe donor shortage in Japan. At 1.5 years later, she

[1]*Department of Thoracic Surgery, The University of Tokyo Graduate School of Medicine, Tokyo, Japan*
[2]*Department of Cardiovascular and Thoracic Surgery, Hokkaido University Graduate School of Medicine, Sapporo, Hokkaido, Japan*
[3]*Department of Pathology, The University of Tokyo Graduate School of Medicine, Tokyo, Japan*

Received: July 21, 2020; Accepted: August 25, 2020
Corresponding author: Masaaki Sato, MD, PhD. Department of Thoracic Surgery, The University of Tokyo Graduate School of Medicine, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8655, Japan
Email: satom-sur@h.u-tokyo.ac.jp

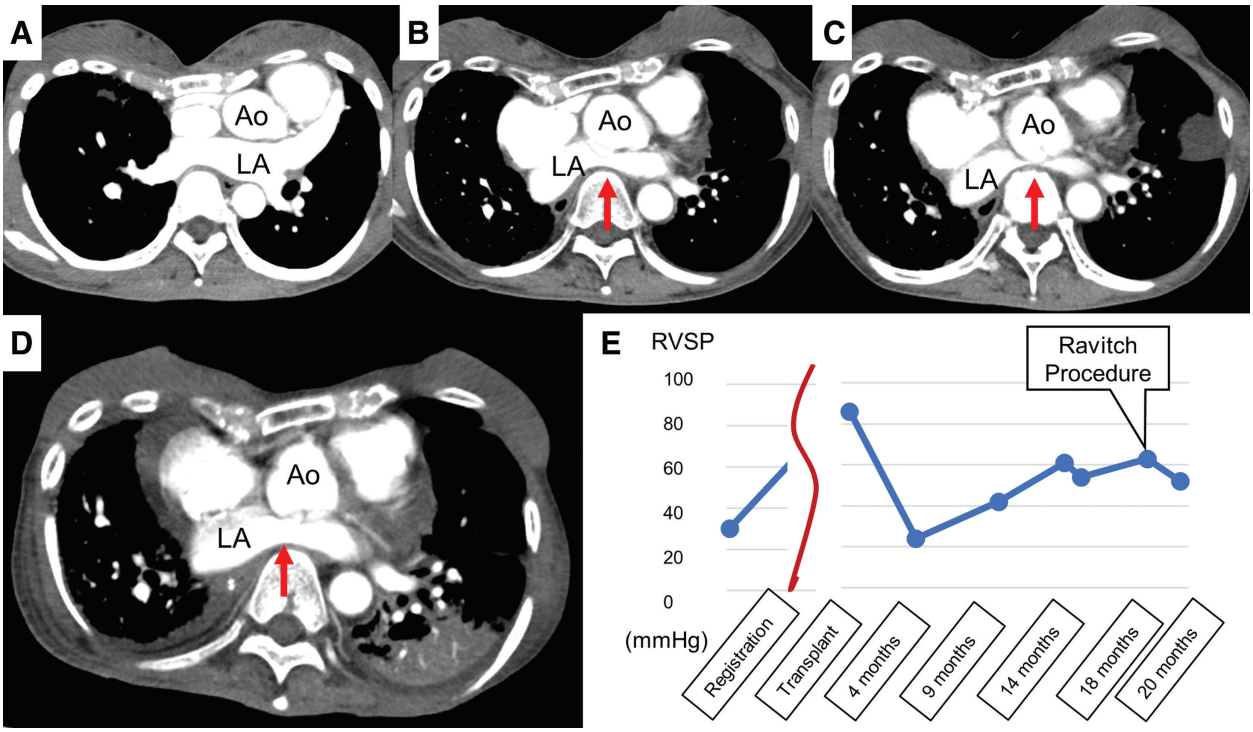

Fig. 1 Mediastinal shift and associated change in RVSP. (**A**) Chest CT before transplantation showed that the patient had a flat chest and the mediastinum was deviated to the left. (**B**) Chest CT 5 months after transplantation showed that the transplanted left lung was well-inflated, resulting in a mediastinal shift to the right. The flat chest caused deformation of the left atrium, which narrowed the outflow tract of the pulmonary vein (red arrow). (**C**) Chest CT 14 months after transplantation. Progression of the mediastinal shift and flattened chest wall resulted in obstruction of the outflow tract of the pulmonary vein (red arrow). (**D**) Chest CT 3 months after the sternal elevation procedure. Successful decompression of the left atrium was demonstrated (red arrow). (**E**) The initially low RVSP was increasing by the time of transplantation. After lung transplantation, the RVSP decreased to almost the normal range. However, it gradually increased again in association with symptoms of right heart failure. After the Ravitch procedure, the RVSP decreased slightly. Ao: aortic arch; CT: computed tomography; LA: left atrium; RVSP: right ventricular systolic pressure

underwent left SLT from a brain-dead donor. Her flat chest had become more pronounced during the waiting period. An echocardiogram on admission showed that the RVSP was high at 84 mmHg and Swan–Ganz catheterization showed over-systemic PAP, indicating an exacerbation of right heart failure. The total ischemic time of the graft was 6 hours 48 minutes. She was discharged home 4 months after SLT.

After transplantation, her RVSP temporarily decreased to an almost normal range, but it then gradually increased again in association with symptoms of right heart failure, necessitating medical treatment including diuretics and a phosphodiesterase-5 inhibitor. However, the effects of this treatment were limited. Chest CT showed progression of fibrosis of the native right lung and inflation of the transplanted left lung, resulting in mediastinal shift. Furthermore, the flat chest wall in combination with the mediastinal shift resulted in obstruction of the outflow tract of the pulmonary vein (**Figs. 1A–1C**). This dynamic anatomical change in the thorax seemed to have caused the pulmonary hypertension. To resolve the problem, the patient underwent the sternal elevation (Ravitch) procedure. After the operation, her PAP as measured by the Swan–Gantz catheter temporarily decreased. A chest CT taken after the operation demonstrated successful decompression of the left atrium, which persisted thereafter in follow-up CT (**Fig. 1D**). However, echocardiography showed that its effect on the RVSP was limited (**Fig. 1E**). She was unable to be weaned from oxygen therapy thereafter. Her right heart failure persisted and her respiratory condition gradually deteriorated. She developed recurrent right pneumothorax, pneumonia, and acute rejection. She died of respiratory and cardiac failure 1.5 years after SLT.

An autopsy revealed progression of IPPFE in the native right lung compared with the extracted lung at transplantation. Although the transplanted left lung showed no signs of chronic rejection such as bronchiolitis

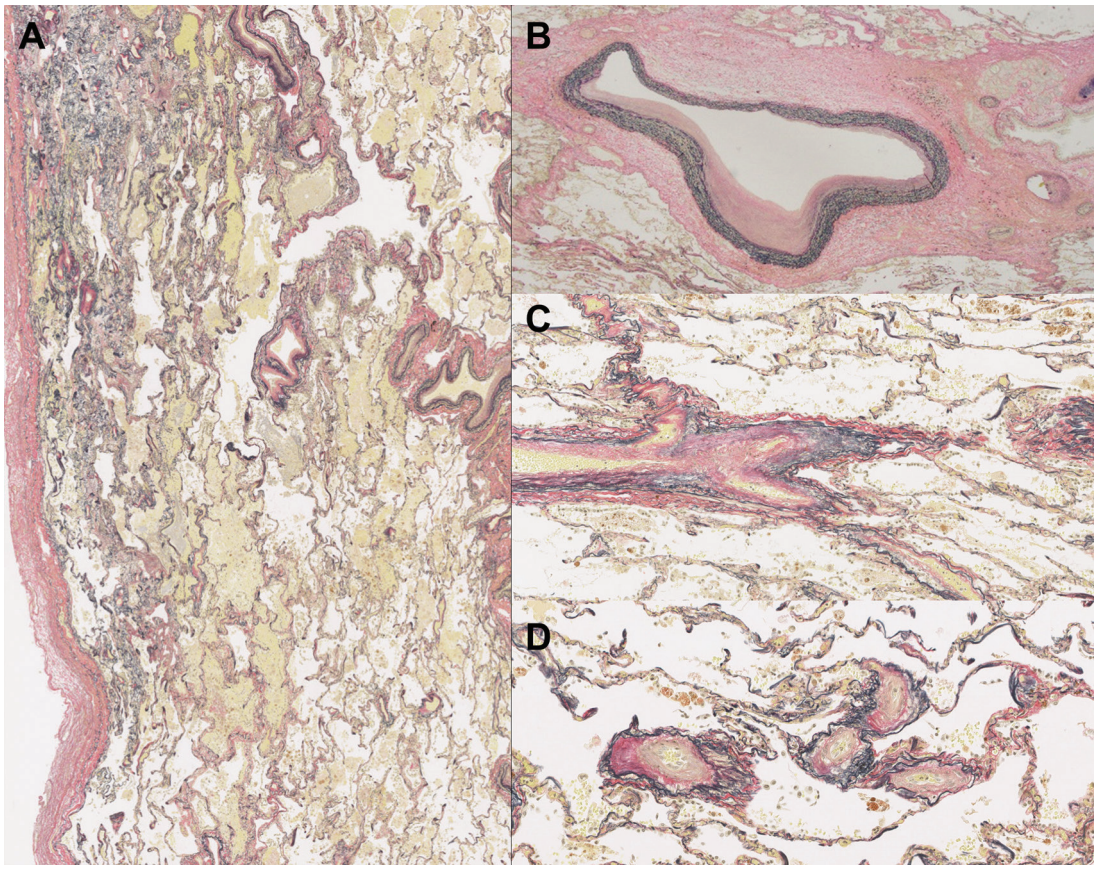

Fig. 2 Autopsy findings. (**A**) The transplanted lung showed congestion and edema without any signs of chronic rejection (Elastica van Gieson staining, ×10 at original magnification). (**B**) Intimal proliferation of pulmonary artery in the transplanted lung (Elastica van Gieson staining, ×40 at original magnification). (**C**) Pulmonary veins in the transplanted lung also exhibited intimal proliferation (Elastica van Gieson staining, ×100 at original magnification). (**D**) Muscularization of arterioles (Elastica van Gieson staining, ×200 at original magnification).

obliterans, morphologic changes associated with pulmonary hypertension were noted: intimal proliferation of pulmonary arteries and veins, medial hypertrophy of pulmonary arteries, and muscularization of arterioles (**Fig. 2**). These autopsy findings suggested that the vessels in the transplanted lung had been affected by chronic pressure overload.

Discussion

In this report, we have described a fatal case of pulmonary hypertension after SLT associated with a flat chest in a patient with IPPFE. Intimal thickening of the pulmonary artery and vein in the graft lung without pathologic findings of chronic rejection suggested the occurrence of chronic pressure overload of the graft lung. The well-inflated transplanted left lung and progression of fibrosis in the native right lung led to mediastinal shift, and the flat chest associated with IPPFE compressed the left atrium; this resulted in obstruction of the outflow tract of the pulmonary vein, which elevated the PAP in the transplanted lung. If the patient had undergone right lung transplantation, she would not have had compression of the left atrium. The laterality of lung transplantation should be carefully considered when the patient has flat chest and pretransplant mediastinal shift. Although the flat chest was fixed by the sternal elevation procedure, it is likely that chronic pressure overload had already caused irreversible vascular changes in the lung. The funnel chest may have also affected the compression of the left atrium; however, the progression of the flat chest shortened the anteroposterior diameter of the thoracic cage and exacerbated the obstruction of the outflow tract of the pulmonary vein.

Nasir et al.[3] recently reported that a pretransplant mean PAP of >40 mmHg is associated with reduced survival after SLT. The reported theory is that increased native lung pulmonary pressure causes hyper-perfusion

of the transplanted lung, resulting in primary graft dysfunction.[4] Likewise, an extremely high pretransplant PAP in our case may have affected the initial blood flow in the transplanted lung. However, this was not the main cause of mortality because the RVSP temporarily decreased to the normal range after lung transplantation and increased again in the long term. Native lung complications after SLT also reportedly impact post-transplant survival.[5] In our case, post-transplant complications including pneumonia and pneumothorax in the native lung may have affected the blood flow and vascular pressure in the transplanted lung. The present case suggests that a severe flat chest can affect hemodynamics in complex ways and further complicate problems of the native lung in SLT.

Conclusion

The laterality and the indications for SLT in patients with IPPFE and a flat chest should be carefully considered, especially when these patients have pretransplant mediastinal shift and pulmonary hypertension.

Acknowledgment

We thank Angela Morben, DVM, ELS, from Edanz Group (https://en-author-services.edanzgroup.com/), for editing a draft of this manuscript.

Disclosure Statement

Dr. Nakajima reports grants from Astellas Pharma Inc, outside the submitted work.

The other authors declare no conflict of interest to disclose.

References

1) Travis WD, Costabel U, Hansell DM, et al. An official American Thoracic Society/European Respiratory Society statement: update of the international multidisciplinary classification of the idiopathic interstitial pneumonias. Am J Respir Crit Care Med 2013; **188**: 733–48.
2) Harada T, Yoshida Y, Kitasato Y, et al. The thoracic cage becomes flattened in the progression of pleuroparenchymal fibroelastosis. Eur Respir Rev 2014; **23**: 263–6.
3) Nasir BS, Mulvihill MS, Barac YD, et al. Single lung transplantation in patients with severe secondary pulmonary hypertension. J Hear Lung Transplant 2019; **38**: 939–48.
4) Julliard WA, Meyer KC, De Oliveira NC, et al. The presence or severity of pulmonary hypertension does not affect outcomes for single-lung transplantation. Thorax 2016; **71**: 478–80.
5) King CS, Khandhar S, Burton N, et al. Native lung complications in single-lung transplant recipients and the role of pneumonectomy. J Hear Lung Transplant 2009; **28**: 851–6.