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CASE REPORT
Heart failure

A stent for branch pulmonary artery stenosis after double-lung transplantation in a patient with COVID-19: a case report

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Background Coronavirus disease 2019 (COVID-19) continues to be a pandemic worldwide. Lung transplantation is the last option to increase life expectancy of end-stage COVID-19 patients. Branch pulmonary artery stenosis (PAS) is a rare complication after lung transplantation with an extremely poor prognosis. The current trend in the management of branch PAS is percutaneous balloon angioplasty and/or stent implantation, rather than high-risk reoperation with a lower success rate.

Case summary The subject was a 54-year-old male with severe acute respiratory syndrome coronavirus 2 infection who underwent a double-lung transplantation. He suffered hypoxaemia and right heart dysfunction following the operation. Right cardiac catheterization and pulmonary angiography examination revealed severe stenosis of the right branch pulmonary artery. Due to immunosuppression and reduced coagulation function, the patient underwent pulmonary artery balloon dilatation and stent implantation, and ultimately recovered well.

Discussion The combination of balloon dilatation and stent implantation is a good alternative to reoperation for patients with COVID-19.

Keywords COVID-19 • Lung transplantation • Branch pulmonary artery stenosis • Immunosuppressed • Balloon pulmonary dilatation and stent implantation • Case report

Learning points

- Lung transplantation is the last option for end-stage coronavirus disease 2019 (COVID-19) patients with severe irreversible pulmonary fibrosis to increase life expectancy.
- Balloon pulmonary dilatation combined with stent implantation can improve hypoxaemia and heart function in COVID-19 patients with branch pulmonary artery stenosis after lung transplantation.

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Introduction

In December 2019, an outbreak of coronavirus disease 2019 (COVID-19) emerged in Wuhan, PRC.[1,2] The patients first developed atypical pneumonia, followed by acute lung injury (ALI) and acute respiratory distress syndrome, which evolved into lung fibrosis.[3] Lung transplantation is the last option for end-stage lung disease patients to increase life expectancy.[4]

Branch pulmonary artery stenosis (PAS) is an unusual complication after lung transplantation, which is defined as a minimal anastomotic diameter of <75% that of neighbouring vessels.[5] Severe branch PAS might trigger pulmonary hypertension and right heart dysfunction.

The current trend in the management of branch PAS is percutaneous balloon angioplasty and/or stent implantation rather than high-risk reoperation with a lower success rate.[6] Here, we describe a successful endovascular procedure experience in the treatment of branch PAS after double-lung transplantation in a patient with COVID-19.

Timeline

Date	Events
Early January 2020	A 54-year-old male was infected with severe acute respiratory syndrome coronavirus 2
Late April 2020	The patient underwent double-lung transplantation following the ethical principles of international organ transplantation
6 days after lung transplant (LTX)	Extracorporeal membrane oxygenation (ECMO) was discontinued for the first time
7 days after LTX	The patient suffered from hypoxaemia, respiratory acidosis, and circulation instability. Venous–venous ECMO was performed again
12 days after LTX	ECMO was discontinued for the second time
17 days after LTX	Tracheal intubation was weaned successfully
More than 3 months after LTX	The patient complained of progressive dyspnoea. Echocardiography revealed right ventricular enlargement, moderate to severe tricuspid regurgitation, and severe pulmonary hypertension of 70 mmHg. There was no improvement of respiratory or right heart functionality after almost 1 month of symptomatic therapy
Five months after LTX	Right heart catheterization and pulmonary angiography revealed severe stenosis of the right branch pulmonary artery with a pressure gradient of 44 mmHg, and stent implantation was performed
Present (7 months after LTX)	The patient recovered well

Case presentation

The subject of this case study was a 54-year-old male with medium build (body mass index: 21 kg/m^2) who had been infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in January 2020 and diagnosed with critical COVID-19. To the best of our knowledge, the patient had enjoyed good health without any previous lung or cardiovascular conditions, except for a history of smoking for over 20 years. Symptomatic medical treatment, including antiviral treatment (umifenovir), was administered from January 29 to February 20. However, during hospitalization, the patient developed atypical pneumonia followed by ALI and severe hypoxaemia on February 12. Extracorporeal membrane oxygenation (ECMO) was initiated on February 22. The patient developed acute kidney injury requiring haemodialysis on April 1. On April 3, the patient tested negative in the SARS-CoV-2 nucleic acid test and was diagnosed to be in the recovery stage of critical-type COVID-19. Following refractory hypoxaemia after 73 days, different slices of chest computed tomography (CT) scan revealed severe pulmonary fibrosis (*Figure 1*), which was confirmed by pathological examination after lung transplantation. The patient was treated with umifenovir, convalescent plasma, alpha-interferon, corticoids, and other supporting therapy. However, there was no clinical improvement after 73 days on ECMO or active medical treatment, the patient suffered progressive dyspnoea, and progressive respiratory failure continued. In order to increase the patient's life expectancy, double-lung transplantation was performed.

The patient underwent double-lung transplantation in late April 2020, following the ethical principles of international organ transplantation. The allocated lungs were harvested from the donor after brainstem death and donated through the China Organ Transplant Response System.

Extracorporeal membrane oxygenation was discontinued 6 days after double-lung transplantation for the first time, but the patient suffered from hypoxaemia, respiratory acidosis, and circulation instability 7 days after double-lung transplantation. Hence, venous–venous ECMO was used again. In addition, biological tests showed D-dimer levels of 12.38 μg/mL, ultrasound indicated pulmonary hypertension and right heart failure, and minor levels of right pulmonary stenosis and embolism were found by CT angiography. Therefore, we administered intravenous heparin for anticoagulant therapy and inhaled nitric oxide to dilate the pulmonary arteries. The respiratory and circulation status improved during the following days. The patient was weaned from ECMO 12 days after double-lung transplantation, and tracheal intubation was removed 17 days after double-lung transplantation.

However, more than 3 months after double-lung transplantation, the patient complained of progressive dyspnoea again. Branch PAS was confirmed by pulmonary artery CT angiography, which revealed stenosis in the right lower pulmonary branch, including a minor level of pulmonary embolism. Electrocardiography (ECG) results showed sinus rhythm at 79–116 b.p.m. with right bundle branch block. Echocardiography revealed right ventricular enlargement, moderate to severe tricuspid regurgitation, and an estimated right ventricular systolic pressure (RVSP) of 76 mmHg. Considering clinical presentation, ECG, echocardiography, and CT angiography findings, the

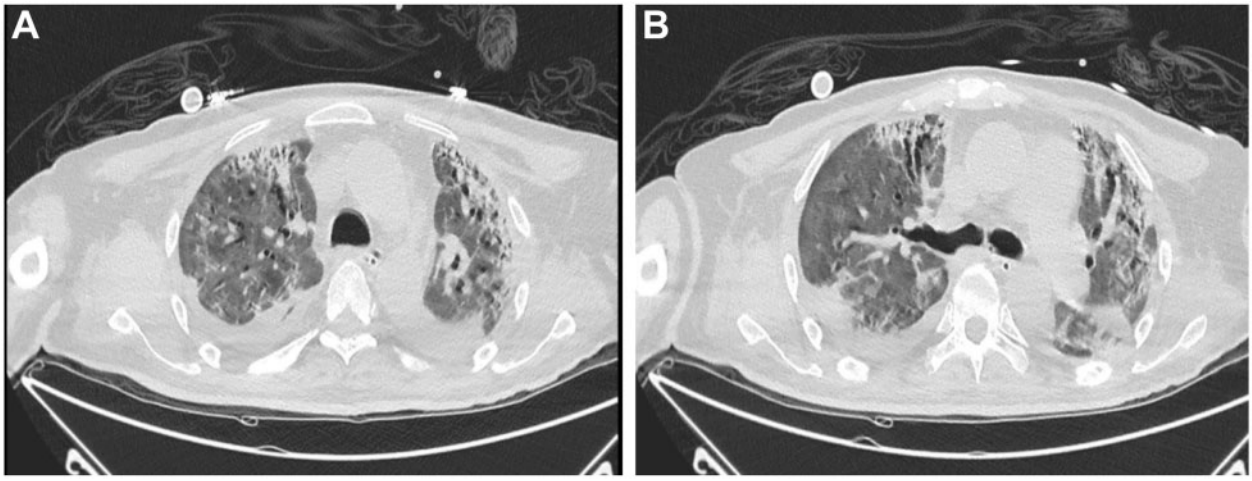

Figure 1 Chest computed tomography scan prior to lung transplantation at tracheal and bronchial bifurcation (*A* and *B*, respectively).

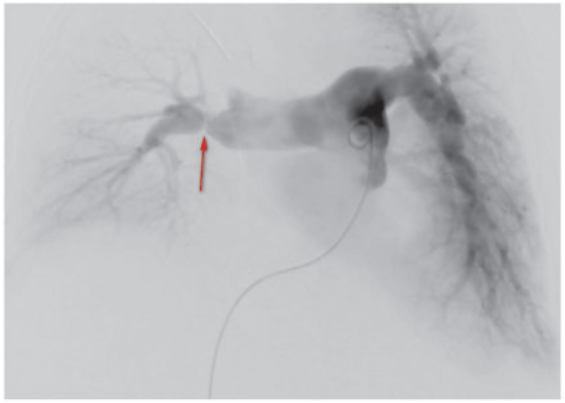

Figure 2 Right cardiac catheterization demonstrated a narrowing of the right pulmonary artery before endovascular procedure.

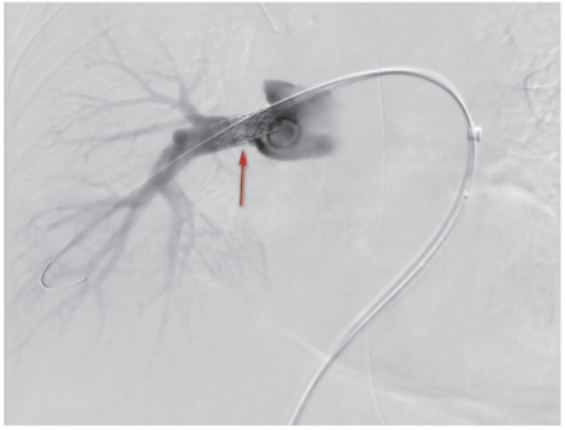

Figure 3 After stent implantation, right cardiac catheterization revealed a reduction in right pulmonary artery stenosis.

patient was diagnosed with branch PAS. Later, Treprostinil injection was continuously administered for pulmonary vasodilation. However, biological tests showed that brain natriuretic peptide (BNP) and N-terminal pro-B-type natriuretic peptide (NT-proBNP) levels were not improved. The patient underwent further right cardiac catheterization examination and pulmonary angiography under general anaesthesia and mechanical ventilation. Pulmonary angiography revealed the main pulmonary artery was at a pressure of 60/20 mmHg, severe stenosis was present in the right branch pulmonary artery with a pressure of 17/9 mmHg (*Figure 2*), and mild stenosis was present in the left branch pulmonary artery with a pressure of 50/20 mmHg.

The MPA1 catheter (Cordis, USA) was delivered to the distal end of the right pulmonary artery after right heart catheterization and exchanged for Amplatz Super Stiff Wire (BostonScientific Corporation, USA). A 14-Fr guiding sheath (Cook Medical, Bloomington, USA) was introduced into the right pulmonary artery so as to ensure the previously preloaded 25-mm long Pul-Stent™ (Med-Zenith Company, Beijing, China) could pass through the lesion smoothly. The stent was expanded step by step with a 12-mm Balloon-in-Balloon (Numed Company, USA) after accurate location was confirmed by angiography.

After the endovascular procedure, pulmonary angiography revealed the main pulmonary artery was at a pressure of 54/17 mmHg, the right branch stenotic lesion diameter improved and its estimated pressure was 45/17 mmHg (*Figure 3*), and the pressure gradient decreased from 43 to 9 mmHg. The percutaneous interventional procedure went smoothly, and the vital signs of the patient remained stable during catheterization. After treatment, echocardiography estimated the RVSP decreased from 76 to 34 mmHg. The patient's BNP and NT-proBNP levels decreased distinctly (*Figure 4*). Additionally, the mean level of the postoperative oxygenation index

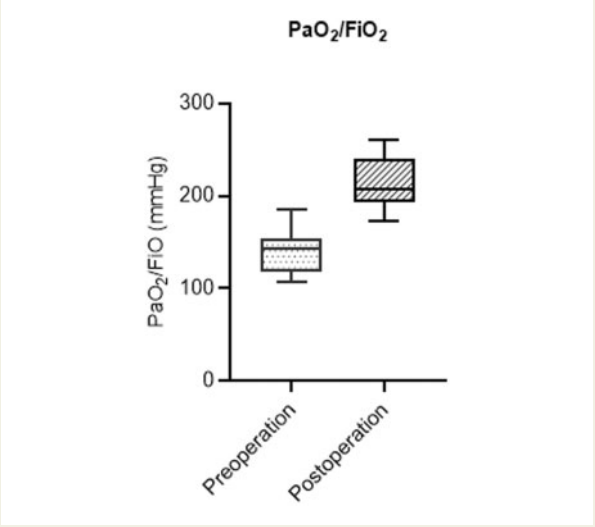

Figure 4 Column diagram of oxygenation index level before and after operation.

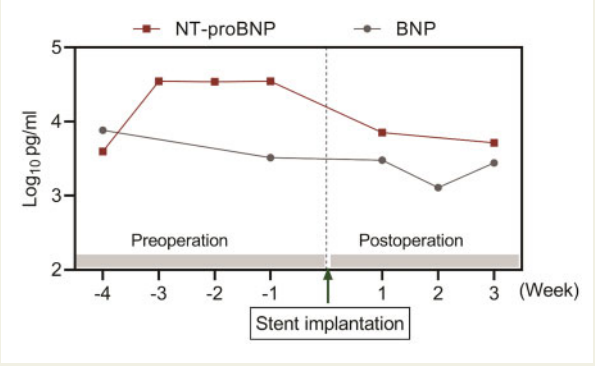

Figure 5 Timeline of brain natriuretic peptide and N-terminal pro-B-type natriuretic peptide levels in plasma. The *Y*-axis shows the brain natriuretic peptide and N-terminal pro-B-type natriuretic peptide loads (solid lines). The *X*-axis represents the days of illness. The time when the stent implantation was performed is marked by vertical broken lines and a green arrow. BNP, brain natriuretic peptide; NT-proBNP, N-terminal pro-B-type natriuretic peptide.

was also significantly improved compared with the preoperative oxygenation index (*Figure 5*).

Discussion

Branch PAS is an unusual postoperative complication with a reported incidence varying from 0.03% to 1%, and it has a very poor prognosis that can significantly affect the outcome of patients who have undergone lung transplantation.[7] It can have significant clinical consequences, such as pulmonary hypertension and right heart dysfunction. In the presented case study, several echocardiography findings revealed right ventricular enlargement, and pulmonary arterial pressure was maintained above 60 mmHg. On top of this, the patient suffered from pneumonia, acute kidney injury, and severe malnutrition. Therefore, it was essential to provide balanced pulmonary blood flow and to decrease right ventricular pressure.

There are various therapeutic methods for branch PAS, including surgical treatment, balloon dilations, and the use of various types of stents. As a percutaneous treatment, balloon dilations and stent implantation are performed by inflating the device in the narrowed blood vessel, after inferring that it has been successfully expanded. The stents were implanted to achieve good surgical results. O'laughlin *et al.*[8] were the first to report endovascular treatment using a stent. Since then, pulmonary stent therapy has been widely used in the treatment of PAS, and it offers a higher success rate than surgical reoperation.[9,10] After lung transplantation, the lifelong use of immunosuppressive agents is required, which makes patients prone to lung infection, transplant rejection, and hypoxaemia. Moreover, it has been recently reported that COVID-19 may contribute to thrombotic complications.[11] Surgical reoperation may heighten these risks. Moreover, balloon dilatation alone may not achieve satisfactory results. Therefore, a combination of balloon dilatation and stent implantation was selected in this case study to reduce the risks to the patient.

A novel domestic stent made of cobalt alloy and specifically indicated for PAS was used in this case. To the best of our knowledge, no similar case has been reported to date. Compared with the closed-loop design of the Palmaz bracket and CP bracket, the chosen stent has good flexibility and a small axial shortening rate, which is helpful during positioning and release. Hence, it can reduce both the difficulty of operation and the operation time. In the present case, PAS stenting was effective in improving the patient's clinical condition and haemodynamic parameters. Although the novel domestic stent has shown promising results in this patient, future prospective trials are still needed to prove the feasibility of this method.

Conclusion

We report a COVID-19 patient with a dysfunctional immune system and thrombosis who underwent lung transplantation and then developed branch PAS. For this patient, balloon dilatation and implantation of a novel domestic stent were a good alternative to a high-risk, second open chest surgery.

Lead author biography

Jiawei Shi, MD, PhD, was born in January 1974. She is from the Department of Cardiovascular Surgery at Union Hospital affiliated to Huazhong University of Science and Technology in Wuhan, P.R. China. She began to work in the field of intensive care medicine in 1999 and became a chief physician in 2017.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

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Conflict of interest: None declared.

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