Peri-operative echocardiography for lung transplantation in a critical patient with COVID-19

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Abstract

Critical patients with coronavirus disease 2019 (COVID-19) suffer from severe illness and have a high mortality rate. Lung transplantation may be the final option for a subset of these patients. Herein we report the important role of peri-operative echocardiography in a COVID-19 patient who underwent bilateral lung transplantation because of severe respiratory failure. The precise evaluation provided by echocardiography enabled the prevention of anastomotic complications and the successful management of haemodynamic instability. Echocardiographers should be familiar with the complications of lung transplantation and the haemodynamics under extracorporeal membrane oxygenation support to achieve a more accurate interpretation of cardiac parameters.

Keywords: echocardiography, lung transplantation, extracorporeal membrane oxygenation

Case report

A 66-year-old woman with COVID-19 was transferred to our hospital owing to deterioration from pneumonia, with progressive shortness of breath, diarrhoea, fever and cough after two days of treatment in a local hospital. The patient had a body mass index of 31 kg/m², with no clinical history except appendectomy, which had taken place 34 years earlier.

After admission, she received an oral tracheal cannula when the blood gas analysis showed a PO₂ value of 56.5 mmHg, with oxyhaemoglobin saturation decreased to 74% under light activity, even with high nasal flow oxygen (FiO₂ 100%). An X-ray demonstrated continuous aggravation of pneumonia after treatment involving lopinavir–ritonavir and umifenovir antiviral therapy, interferon α-2b, immunoglobulin, methylprednisolone, piperacillin–tazobactam and nutritional support. Veno-venous ECMO was performed to reduce the pulmonary burden. A tracheostomy tube was used after hospitalisation for three weeks.

The patient had respiratory failure with lung consolidation seen on the X-ray but showed no clinical improvement after aggressive treatment, even after the COVID-19 test was continuously negative for one week (Fig. 1). Transthoracic echocardiography (TTE) showed a gradual increase of pulmonary artery systolic pressure (PASP) up to 80 mmHg and a slight decline in the right heart function, with the tricuspid annular plane systolic excursion (TAPSE) decreasing to 17 mm. No abnormality was

Fig. 1. Chest X-ray showing consolidation of the lung.
found in the left heart, with a left ventricular ejection fraction of 60–68%. The brain natriuretic peptide level gradually increased up to 1,012 pg/ml, and the serum cardiac troponin I level was up to 0.322 ng/ml. The other organ functions were well maintained.

Blood count revealed a white blood cell count of 9.8 × 10^9 cells/l, haemoglobin level was 87 g/l and platelet count was 72 × 10^9 cells/l. Serum creatinine level was 49 µmol/l and blood glucose was mainly between 9 and 10.5 mmol/l. She had no history of hypertension, hyperlipidaemia or diabetes.

Lung transplantation was decided upon as a course of treatment after multidisciplinary consultation. The procedure was performed after four weeks of mechanical ventilation and two weeks after initiating veno-venous ECMO support.

In the operation room, pre-operative transoesophageal echocardiography (TEE) showed mild dilation of the right ventricle (RV) with a fractional area change (FAC) of 30% and moderate tricuspid regurgitation (TR) with a peak pressure gradient (PPG) of 64 mmHg (Fig. 2A). No other structural or functional abnormalities were observed.

Implantation of an allograft was uneventfully completed under cardiopulmonary bypass support. After reperfusion of the allograft, the TEE showed laminar flow across the pulmonary vascular anastomoses and mild TR with a PPG of 30.5 mmHg. Additionally, the TEE revealed right heart dilation with a RV FAC of approximately 20% (Fig. 2B). Persistent RV failure required the initiation of veno-arterial ECMO (VA-ECMO) with cannulation of the left femoral artery and retention of the right femoral vein cannula. Subsequently, the TEE confirmed normal systolic cardiac function on VA-ECMO support. The patient was transferred to an isolated room in the intensive care unit (ICU) and received the standard post-transplantation therapeutic protocol.

On postoperative day two, the oxyhaemoglobin saturation declined markedly while performing an ECMO weaning trial by reducing the ECMO flow from 4 to 2 l/min. X-rays revealed patchy shadows of exudation. On postoperative day three, hypoxaemia was confirmed by blood gas analysis. A fibre bronchoscope revealed a substantial amount of thin, watery secretion in the

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**Fig. 2. Imaging of transoesophageal echocardiography (TEE).**

A. TEE showing tricuspid peak pressure gradient of 64 mmHg before surgery. B. TEE showing dilation of the right heart. C. TEE showing tricuspid peak pressure gradient of 52 mmHg on postoperative day three. D. TEE showing thickening of the right ventricular wall. LA: left atrium, LV: left ventricle, RA: right atrium, RV: right ventricle.
airway. Bedside TEE was performed under transient sedation, and patency of the delicate vascular anastomoses and normal cardiac systolic function was confirmed. Furthermore, the TEE showed moderate TR with a PPG of 52 mmHg (Fig. 2C), which did not markedly change with a change in ECMO flow. An approximate 10-mm thickening of the RV wall was observed (Fig. 2D).

The combination of clinical signs indicated that primary graft dysfunction, mainly caused by allograft rejection, should be considered. The patient received 500 mg methylprednisolone pulse treatment for three days, which was effective, along with complicated treatment involving immunosuppression, anti-infection therapy, continuous renal-replacement therapy and nutritional support. ECMO was successfully weaned off on postoperative day five. COVID-19 viral testing of sputum or broncho-alveolar lavage fluid (when possible) and stool was conducted every postoperative day and remained negative. The patient gradually became well with aggressive follow-up treatment and rehabilitation training and currently remains well.

Discussion

Lung transplantation, as a final option, was an urgently needed salvage therapy for the patient described in our case to prevent certain death because of severe respiratory failure without any signs of respiratory improvement with maximal medical support after consecutive negative COVID-19 nucleic acid tests. The confirmation of irreversible refractory failure and the absence of other organ system dysfunction led to the treatment decision of lung transplantation, which was arranged in accordance with the national organ allocation principles, with the priority of urgency related to disease severity.

Impairment of the heart caused by COVID-19 was not clear to us during the first few months of the pandemic. Precise evaluation of cardiac function using peri-operative echocardiography was requisite in clinical decision making for this lung transplantation patient, especially considering the status of haemodynamic instability. Before the operation, the gradual increase of PASP and the decrease of TAPSE suggested aggravation of the lung lesions and tolerance to sustained pressure overload, which assisted in the clinical strategy in the absence of Swan–Ganz catheterisation owing to the poor condition of the vessels, which was probably related to the high body mass index of 31 kg/m². After lung reperfusion, conversion to VA-ECMO was applied to facilitate offloading of the right heart during persistent RV dysfunction without anastomotic stenosis, as diagnosed by TEE.

TEE was performed again because of an obscure image on initial TTE attributed to postoperative gas interference from a clamshell incision from the lung transplantation. The elevation of PASP, up to nearly 62 mmHg, likely indicated pulmonary small-vessel contraction, which may be attributed to hypoxaemia owing to allograft rejection with concomitant perivascular inflammation and airway inflammation. Furthermore, the thickening of the RV wall may have been a sign of myocardial oedema due to lung rejection, as it was normal before the operation.

Iinciardi et al. reported a COVID-19 patient with cardiac involvement who presented with increased wall thickness and diffuse biventricular hypokinesia confirmed by cardiac magnetic resonance imaging. We speculated that the probability of cardiac impairment caused by COVID-19 in the postoperative period would be very low, as the airway secretion and stool samples all tested negative for COVID-19 after the operation.

Under protective clothing, the performance of bedside echocardiography requires a longer time and consumes more ICU resources, but it is necessary to ensure self-protection. We placed the ultrasonic machine on the left side of the bed and stood at the bedside with our backs to the patient and held the probe in our right hand to perform TTE for patients in the ICU. This is considered to be a good method for avoiding infection while in close contact with patients but requires personnel who are highly experienced in performing echocardiography.

For TEE, a disposable protective cover was used for the probe as usual. A headcover with positive pressure was not used owing to the relatively short time of TEE examination in the operating room. Additionally, echocardiographers should be familiar with the mechanism and complications of ECMO, because it provides indispensable assistance for haemodynamic instability. The left heart systolic function needs to be closely monitored by echocardiography owing to the increased afterload produced by VA-ECMO support.

Conclusion

Peri-operative echocardiography played an important role in the management of an obese patient with lung transplantation because of severe respiratory failure caused by COVID-19. Echocardiographers should be familiar with the complications of lung transplantation and the haemodynamics under ECMO support to achieve a more accurate interpretation of cardiac parameters.

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References