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CASE REPORT

Using inhaled nitric oxide for a patient with pulmonary hypertension during biventricular assist device surgery in the operating room

I-Chun Hou [a,*], Fan-Yen Lee [b,c], Su-Fang Wang [a], Szu-Hui Wu [a], Mei-Ling Hsueh [a], Mei-Lein Tu [a]

[a] *Department of Respiratory Therapy, Kaohsiung Chang Gung Memorial Hospital, Kaohsiung, Taiwan*
[b] *Department of Cardiothoracic and Vascular Surgery, Kaohsiung Chang Gung Memorial Hospital, Kaohsiung, Taiwan*
[c] *Department of Respiratory Therapy, Chang Gung University of Science and Technology, Chiayi, Taiwan*

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Abstract Many patients experience hemodynamic collapse associated with severe heart failure despite receiving an optimal medical therapy. Therefore, mechanical circulatory assist devices, such as the intra-aortic balloon pump (IABP), extracorporeal membrane oxygenation (ECMO) device, and ventricular assist device (VAD), are used. In this paper, we report the successful treatment of a 59-year-old male patient with heart failure awaiting heart transplantation. Medication therapy, IABP, and ECMO failed to stabilize his advanced heart failure; therefore, he was suggested to undergo biventricular assist device (BiVAD) implantation surgery as a "bridge" to transplantation. However, the blood flow generated by the VAD was inadequate due to elevated pulmonary artery pressure during surgery. Therefore, we used inhaled nitric oxide to treat pulmonary hypertension and to successfully increase the pulmonary blood flow during BiVAD-implantation surgery.

Conflicts of interest: The authors declare no conflicts of interest.

* Corresponding author. Department of Respiratory Therapy, Kaohsiung Chang Gung Memorial Hospital, Number 123, Dapi Road, Niaosong District, Kaohsiung City 833, Taiwan.
E-mail address: wa1012@adm.cgmh.org.tw (I.-C. Hou).

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1. Introduction

Heart failure is a major and escalating public health problem. Treatments for heart failure, such as medication therapy, use of implantable cardioverter defibrillators, and cardiac resynchronization therapy, have improved the survival rate[1]; however, several patients still experience hemodynamic collapse associated with severe heart failure and exhibit poor prognosis despite receiving an optimal medical therapy. Therefore, mechanical circulatory assist devices, such as the intra-aortic balloon pump (IABP), extracorporeal membrane oxygenation (ECMO) device, and ventricular assist device (VAD), are used to support such patients.

Pulmonary vascular resistance (PVR) is frequently elevated in patients with left ventricular failure due to dysregulation of the vascular smooth-muscle tone and structural remodeling, resulting in pulmonary hypertension (PH), which directly affects right ventricular function.[2] Inhaled nitric oxide (iNO) has been used therapeutically to treat severe PH, to selectively dilate pulmonary vessels in well-ventilated regions of the lungs, and to increase pulmonary blood flow; however, trial data on the use of iNO during complicated cardiac surgery are inadequate.[3]

In this paper, we report the successful treatment of a patient with heart failure awaiting heart transplantation. Since the administered optimal medical therapies, IABP and ECMO, could not stabilize his advanced heart failure, he was suggested to undergo biventricular assist device (BiVAD) implantation surgery as a "bridge" to transplantation. However, the blood flow generated by the VAD was inadequate due to elevated pulmonary artery pressure (PAP) during surgery. Therefore, we used iNO to treat PH and to successfully increase the pulmonary blood flow during BiVAD-implantation surgery.

2. Case Report

A 59-year-old male presented with dilated cardiomyopathy (New York Heart Association Class IV) and PH. He was intubated because of dyspnea and hypoxemic respiratory failure and PH (pulmonary capillary wedge pressure = 41 mmHg). Cardiac inotropic agents were administered, supported by an IABP and a venoarterial (VA) ECMO device, after the diagnosis of cardiogenic shock while he awaited cardiac transplantation in the intensive care unit. Chest radiography revealed bilateral infiltration and opacification of the left side of the lungs. Transthoracic echocardiography revealed severe mitral regurgitation, left ventricular dilatation with an ejection fraction of 18%, and impaired right-ventricular function.

Because of rapidly progressive pulmonary edema with hemoptysis, the cardiovascular surgeon suggested that the patient undergo BiVAD-implantation surgery as soon as possible. The PAP values before surgery and after anesthetic induction were 100/59 mmHg and 125/70 mmHg, respectively. Intraoperative transesophageal echocardiography revealed a good left VAD (LVAD) inflow cannula position in the left ventricular cavity and no pulmonary valve regurgitation. The surgeon noted that the blood flow generated by the LVAD was inadequate due to high PVR during BiVAD-implantation surgery.

Therefore, iNO (NO: 1000 ppm with balanced nitrogen; Jing De Gas Co., Ltd., Kaohsiung, Taiwan) was administered using a Servo 300 ventilator (Siemens Elema, Solna AB, Sweden). Furthermore, iNO treatment was administered at 20 ppm, and the patient was ventilated in the pressure-control mode at a peak inspiratory pressure/positive end-expiratory pressure of 17/5 and tidal volume of approximately 8–10 mL/kg. The PAP decreased to approximately 68/42 mmHg in 30 minutes, and systolic PAP was maintained at approximately 50 mmHg (Figure 1). The patient was weaned from iNO after the implantation procedure with a PAP of 59/35 mmHg and an acceptable BiVAD support status. Figure 2 shows the chest radiographs before and after BiVAD surgery, which indicate improved bilateral infiltration and opacification of the left side of the lungs. Finally, the patient received cardiac transplantation 7 days after the BiVAD surgery and was extubated successfully.

3. Discussion

In patients with heart failure and for whom medical therapy is ineffective, the use of mechanical circulatory assist devices, such as a IABP, ECMO, and VAD, might be necessary. The IABP supports left ventricular failure by increasing diastolic blood pressure to enhance coronary perfusion pressure and decrease left ventricular afterload, but the circulatory support provided might be inadequate for patients with severe heart failure. Therefore, such patients might need to be supported by the use of advanced circulatory assist devices, such as an ECMO and VAD. Although the ECMO provides both respiratory and hemodynamic support, it is unsuitable for long-term use due to the high incidence rate of several potential hemorrhagic complications.[4] Moreover, VA ECMO may increase the left ventricular afterload, leading to deterioration of left ventricular function, severe pulmonary edema, and lung hemorrhage. Therefore, if patients with advanced heart failure exhibit a deteriorating clinical status, intermediate- and long-term VAD therapies can be used as a bridge to transplantation (to sustain life until a donor heart becomes available).[5] The

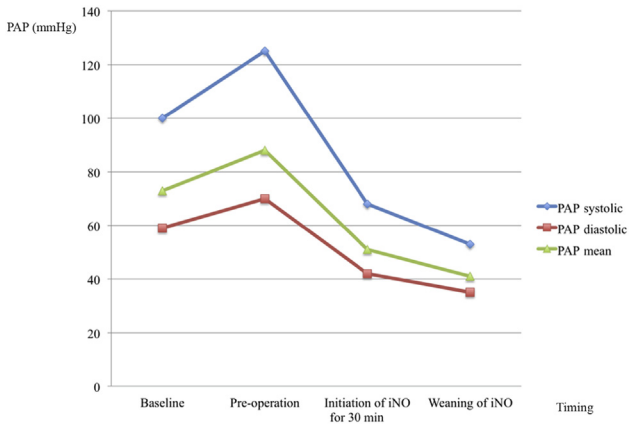

Figure 1 PAP variation before and after iNO therapy. iNO = inhaled nitric oxide; PAP = pulmonary artery pressure.