

A Novel Method for Percutaneous Insertion of a Right Ventricular Assist Device

Dimitrios V. Avgerinos, MD; William DeBois, CCP; Linda Mongero, CCP;
Karl Krieger, MD; Arash Salemi, MD

Department of Cardiothoracic Surgery, New York Presbyterian–Weill Cornell Medical Center, Weill Cornell Medical College, Columbia University Medical Center New York, New York

Presented at the 51st International Conference of the American Society of Extracorporeal Technology (AmSECT), March 6–9, 2013, Las Vegas, Nevada.

Abstract: Right heart failure is a rare but often fatal complication both in the pre- and postoperative setting. Right heart support with a ventricular assist device inserted in the operating room through median sternotomy can be a time-consuming procedure that requires a reoperation for removal. In cases of urgent need of right heart support, a percutaneous technique option may be of benefit. We present our initial experience with a percutaneously inserted right ventricular assist device (RVAD) in an elderly patient with severe right heart failure. An 81-year-old female patient underwent combined aortic and mitral valve replacement at our institution. During the first postoperative evening, the patient sustained sudden cardiovascular collapse and a bedside transesophageal echocardiogram revealed severe right heart failure. A coronary angiogram showed thrombosis of the right coronary artery, which was cleared with a suction device. As a result of the patient's critical condition, it was decided that an RVAD was

needed as a bridge to recovery. The patient's condition improved significantly almost immediately. Her right heart function recovered over the next few days and the RVAD was removed at the bedside. She made a complete recovery and was discharged home. This patient is a prime example that a totally RVAD can be inserted in urgent situations easily and safely under fluoroscopic and echocardiographic guidance. More clinical experience with percutaneous RVADs is required to establish this technique as an alternative equivalent to the traditional open method. Right heart failure complicates many heart diseases both in the pre- and the postoperative setting. In cases of urgent need of right heart support, a percutaneous technique of a RVAD is needed for a successful outcome. We present our initial experience with a percutaneously inserted RVAD in an elderly patient with severe postoperative right heart failure. **Keywords:** right ventricular assist device, percutaneous, CentriMag. *JECT. 2013;45:136–138*

An 81-year-old female patient with a medical history significant only for nonobstructive coronary artery disease presented to our hospital with the primary complaint of dyspnea on exertion of a few months' duration. She was admitted to the cardiology service for further work-up. Transthoracic echocardiogram revealed severe aortic stenosis and moderate to severe mitral regurgitation with a left ventricular ejection fraction of 60%, whereas cardiac catheterization showed no progression of her known coronary artery disease. The patient was referred to cardiac surgery for definitive management of her valvular disease.

The Institutional Review Board of our hospital granted permission for publication of this case.

The patient underwent combined aortic and mitral valve replacement with porcine valves. The operative procedure was uneventful and postoperatively she was transferred to the intensive care unit on support with minimal doses of inotropes and vasopressors. During the first postoperative evening, the patient sustained sudden cardiovascular collapse with profound hypotension and borderline cardiac output per Swan-Ganz measurements. Because cardiac tamponade was highly suspected, an emergent bedside transesophageal echocardiogram was performed after the patient was stabilized with high doses of inotropes. The echocardiogram revealed severe right heart failure with almost complete akinesis of the right ventricle. A coronary event was suspected and the patient was emergently taken to the hybrid operating room for a coronary angiogram. The right coronary artery was found to be obstructed

Received for publication March 21, 2013; accepted May 29, 2013.
Address correspondence to: William DeBois, CCP, Department of Cardiothoracic Surgery, Weill Cornell Medical College, Suite M422, New York, NY 10065. E-mail: wdebois@nyp.org
The senior author has stated that the authors have reported no material, financial, or other relationship with any healthcare-related business or other entity whose products or services are discussed in this paper.

by thrombus and then cleared with a suction device (Angiojet; Medrad Inc., Warrendale, PA).

As a result of the patient's critical condition and continuous right heart failure, it was decided that an assist device was urgently required as a bridge to recovery. A ventricular assist device (VAD) was preferred over an intra-aortic balloon pump (IABP) to offer maximum support. This was inserted with a totally percutaneous technique. After heparinization with 5000 unites of heparin and achieving an activated clotting time of 200 seconds, under fluoroscopic guidance, an Amplatz Super Stiff (Boston Scientific, Natick, MA) 0.035-inch \times 180-cm wire was inserted in the Swan-Ganz lumen and the pulmonary artery catheter was removed. A long flexible 17-French venous cannula, #CB96605-17 (Biomedicus; Medtronic, Minneapolis, MN) was inserted over the stiff wire to the pulmonary artery through the right internal jugular vein and was used as the outflow cannula; the inflow cannula was 25 French in size, #96880-25 (Biomedicus; Medtronic) and was inserted in the inferior vena cava through the femoral vein with its tip in the right atrium. Correct position placement of the cannulas was achieved with the use of transesophageal echocardiogram and fluoroscopy (Figure 1). The two cannulae were connected to a CentriMag (Thoratec Corporation, Pleasanton, CA) centrifugal pump and flows up to 4 L/min were achieved. This way the right heart was decompressed effectively.

The right VAD was kept in for 48 hours, and a repeat echocardiogram showed dramatic improvement in the right ventricular function. Thus, on the second postoperative day the assist device was weaned and finally the cannulas were removed. During the weaning process, anticoagulation was increased to a celite activated clotting time of 300 seconds. Over a 2-hour period, adequate hemodynamics were maintained with particular attention to rapid rise in central venous pressure. The patient's heart managed to sustain normal cardiac output. Her recovery from that point was uneventful and she was discharged home 2 weeks after the operation. Today, 1 year after, she is in good health and her heart function remains normal.

COMMENT

Acute right heart failure can occur as a complication of myocardial ischemia, postcardiotomy syndrome, heart transplantation, pulmonary embolism, and left VAD insertion (1,2). This condition can have increased morbidity and mortality for the patient. The first-line management is usually medical; however, in extreme situations, insertion of a right VAD is required to avoid further deterioration and death.

Recent advances in technology have made feasible the percutaneous insertion of left VAD (LVAD) such as

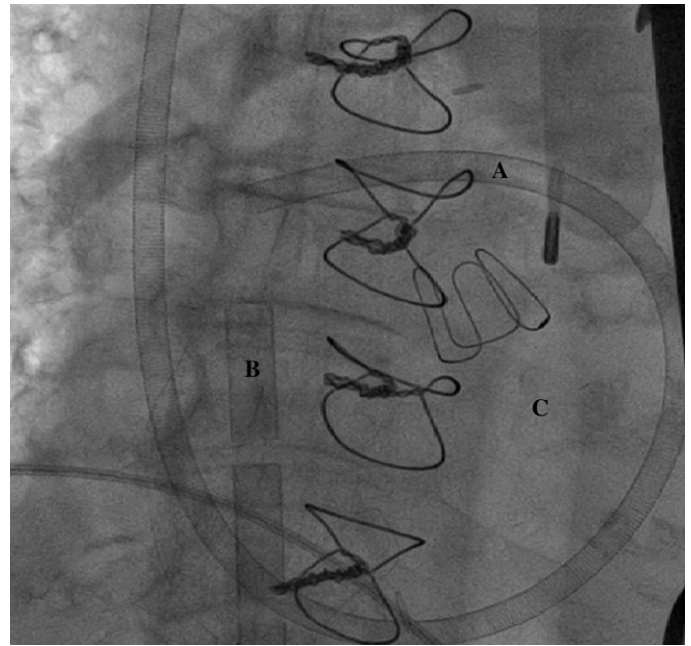


Figure 1. (A) The outflow cannula in the pulmonary artery. (B) The inflow cannula in the right atrium. (C) Intra-aortic balloon pump.

Impella LP and TandemHeart (CardiacAssist, Pittsburgh, PA) (3–7). Although the current main use of these percutaneous LVADs is to support the circulation during high-risk percutaneous coronary interventions, they are valuable in cases of acute hemodynamic compromise. It is obvious that with increased use of percutaneous LVAD for patients with cardiogenic shock, the demand for percutaneous right VAD (RVAD) will increase as well (3).

Takayama et al. reported on eight patients who underwent percutaneous insertion of an RVAD with immediate improvement of hemodynamic parameters. The technique that was used for implantation of the VAD was similar to the one described in the current case report. The patients' cardiac output and mixed venous saturation increased significantly. The authors reported successful outcome in seven of these patients with only one death resulting from multiorgan failure. However, in four patients they had to exchange the RVAD to either biventricular VAD or venoarterial extracorporeal membrane oxygenation (ECMO) (3).

We believe that the best entry site for the pulmonary artery cannula is the right internal jugular vein because it offers the best angle for the stiff wire to access the right ventricle and to thread the cannula. Left-sided access (either internal jugular or subclavian vein) would be a secondary choice, because the cannula would be in danger of getting stuck in the right jugular vein–left innominate vein confluence. We found that the greatest technical challenge of this technique is to make the pulmonary artery cannula turn in the right ventricle and enter the pulmonary artery.

This can be achieved only over a stiff or superstiff wire; otherwise, it will probably get trapped in the ventricular cavity. In case of respiratory failure, the addition of an oxygenator can transform this device into an ECMO. Most possibly, either venoarterial ECMO or biventricular VAD provides better circulatory support than a percutaneous RVAD. This is because the percutaneous RVAD is limited by the left ventricular output. The described technique can be widely applicable. One limitation is in patients with tricuspid valve prostheses, which may make the insertion of a large-bore outflow cannula very challenging.

In summary, percutaneous RVAD was feasible in our patient with acute right heart failure and provided hemodynamic improvement and recovery. This case report gives encouragement that a totally percutaneous RVAD can be inserted in urgent situations easily and safely under fluoroscopic and echocardiographic guidance. Close collaboration and communication between the surgical and perfusion team is essential for a successful outcome. More clinical experience with percutaneous RVADs is required to establish this technique as an alternative equivalent to the traditional open method.

REFERENCES

1. Kapur NK, Paruchuri V, Korabathina R, et al. Effects of a percutaneous mechanical circulatory support device for medically refractory right ventricular failure. *J Heart Lung Transplant*. 2011;30:1360–7.
2. Haneya A, Phillip A, Diez C, et al. Successful use of temporary right ventricular support to avoid implantation of biventricular long-term assist device: A transcatheter approach. *ASAIO J*. 2011;57:274–7.
3. Takayama H, Naka Y, Kodali SK, et al. A novel approach to percutaneous right-ventricular mechanical support. *Eur J Cardiothorac Surg*. 2012;41:423–6.
4. Takayama H, Naka Y, Jorde UP, Stewart AS. Less invasive ventricular assist device placement for difficult re sternotomy. *J Thorac Cardiovasc Surg*. 2010;140:932–3.
5. Cheng JM, den Uil CA, Hoeks SE, et al. Percutaneous left ventricular assist devices vs. intra-aortic balloon pump counterpulsation for treatment of cardiogenic shock: A meta-analysis of controlled trials. *Eur Heart J*. 2009;30:2102–8.
6. Koerner MM, Jahanyar J. Assist devices for circulatory support in therapy-refractory acute heart failure. *Curr Opin Cardiol*. 2008;23:399–406.
7. Seyfarth M, Sibbing D, Bauer I, et al. A randomized clinical trial to evaluate the safety and efficacy of a percutaneous left ventricular assist device versus intra-aortic balloon pumping for treatment of cardiogenic shock caused by myocardial infarction. *J Am Coll Cardiol*. 2008;52:1584–8.