Dual-outflow extracorporeal membrane oxygenation support in secondary right ventricular failure

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Abstract

Acute-on-chronic right ventricular failure has a tremendously high mortality rate and pulmonary artery hypertension plays a major role in the progression of secondary right ventricular failure. Here, we report a case of drug-refractory acute-on-chronic right ventricular failure due to primary artery hypertension and a two-step approach of a percutaneous dual-outflow extracorporeal membrane oxygenation support set-up implanted under on-going mechanical resuscitation for immediate biventricular support with a consequent downgrade to right ventricular assist device after left ventricular recompensation.

Title page:

Title: Dual-outflow extracorporeal membrane oxygenation support in secondary right ventricular failure

Running Head: Percutaneous dual-outflow ECMO with RVAD

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Acute-on-chronic right ventricular failure has a tremendously high mortality rate and pulmonary artery hypertension plays a major role in the progression of secondary right ventricular failure. Here, we report a case of drug-refractory acute-on-chronic right ventricular failure due to primary artery hypertension and a two-step approach of a percutaneous dual-outflow extracorporeal membrane oxygenation support set-up implanted under on-going mechanical resuscitation for immediate biventricular support with a consequent downgrade to right ventricular assist device after left ventricular recompensation.

Text:

Introduction

Drug-refractory right ventricular failure (RVF) is mostly caused by pressure and volume overload of the right ventricle (RV) due to its limited muscular pump function. Pulmonary artery hypertension (PAH) is an important contributing factor leading to the progression of secondary RVF (s-RVF).[1] Especially acute-on-chronic s-RVF has a tremendously high mortality rate with up to 40%.[2]Mechanical circulatory support of the RV may be the only therapeutic strategy facing this rapidly progressive syndrome and was reported to be successful with various percutaneous cannulation techniques in cases of RVF due to myocardial infarction, after left ventricular assist device implantation and prior lung transplantation.[3, 4]

Herewith, we describe our experience with a percutaneously implanted right ventricular assist device (RVAD) combined with a regular veno-arterial extracorporeal membrane oxygenation (ECMO) set-up in a patient with acute s-RVF due to PAH under on-going resuscitation.

This case report does not require Institutional Review Board approval at our institution and the informed consent was obtained from the patient.

This case report does not require IRB review at our institution and the

patient has given consent for their case to be used for educational

purposes.

Case report

A 65-year-old male patient was admitted to the hospital presenting with acute coronary syndrome. The coronary angiography showed a hemodynamically relevant in-stent re-stenosis of the left anterior descending and ramus intermedius artery. The first intervention was done 23 years ago, followed by multiple re-interventions due to recurrent in-stent re-stenosis in all three coronary vessels. Echocardiography revealed preserved left ventricular function with reduced RV function. The tricuspid annular plane systolic excursion (TAPSE) was at 14 mm without dilatation of the tricuspid valve anulus (28 mm) but signs of RV dilatation. The approximated systolic pulmonary artery pressure (PAP) over the tricuspid valve was measured with 100 mmHg plus central venous pressure. The patient underwent a right heart catheterization which confirmed the elevated systolic PAP of 90 mmHg with a regular pulmonary capillary wedge pressure and, following supplementary CT-angiography, was diagnosed with a precapillary idiopathic type I PAH. Due to his coronary state with unstable angina but subclinical PAH, the patient has been indicated for coronary treatment. Without an

option for interventional therapy, the patient was scheduled for urgent minimally invasive direct coronary artery bypass surgery.

Despite maximal PAH specific preventive measures during induction of anesthesia, the patient became hemodynamically unstable requiring cardiopulmonary resuscitation. Return of spontaneous circulation was achieved shortly using high doses of inotropic agents. Due to no signs of new acute ischemic heart abnormalities the surgery was postponed, and due to circulatory instability despite maximal inotropic support mechanical circulatory support was indicated. Under on-going mechanical resuscitation, a veno-arterial-venous, respectively pulmonary artery (PA) ECMO (V-A-V/PA ECMO) was established **(Fig. 1)** . An inflow cannula was inserted percutaneously via the right femoral vein (Getinge HLS 23F, 55 cm; Rastatt, Germany) into the right atrium and an outflow cannula was inserted into the right femoral artery (Getinge HLS 17F, 23 cm) for initial stabilization. Thereafter, a soft guidewire was placed percutaneously via the right internal jugular vein through the tricuspid- and pulmonary valve, with its tip into the PA common trunk under fluoroscopic control in the catheterization lab. (see**video** demonstration for the percutaneous deployment of the 21F outflow cannula via internal jugular vein to the pulmonary trunk over an extra-stiff guide wire and the final result after removing the cannula's inner sheath under fluoroscopic vision) The soft guidewire was then exchanged via a pigtail catheter for an extra-stiff wire (Lunderquist?, COOK Medical, Bloomington, IN). Finally, a pre-warmed 21F cannula with a multi-hole tip (Biomedicus? 21F, 50 cm, Medtronic, Minneapolis, MN) was percutaneously inserted over the stiff wire and connected to the outflow line of the ECMO system with a monitored in-line flow-reducer.**(Fig. 2)** Thus, while bypassing the acute failing RV, this cannula acted as a temporary RVAD. Flow rates were optimized by RV appearance in echocardiography and for anticoagulation the patient received standardized heparinization. The femoral arterial outflow cannula could be explanted after 48 h due to the competent left ventricle using a combination of a suture-mediated percutaneous closure device (ProGlide?, ABBOTT Vascular, CA) and a sandwiching bioabsorbable closure device (Angioseal?, ABBOTT Vascular, CA) by reinsertion of a guide wire through the cannula for the needed vessel access. Tricuspid valve and pulmonary valve were without new abnormalities after decannulation. The remaining oxygenated temporary RVAD was successfully explanted at day 8 after implantation. Thereafter, the patient recovered well, was awake and extubated, and could be discharged for further medical therapy on day 21. After establishment of proper medical therapy (sildenafil and macitentan) for precapillary idiopathic type I PAH the patient is doing well, he is currently in NYHA class II one year after the ECMO therapy and the coronary artery disease was decided for conservative treatment at present.

Comment

Functional improvement of the RV after normalization of loading conditions under the support of temporary RVAD systems has been described but were rarely used in cases of isolated acute-on-chronic s-RVF due to rapidly exacerbated PAH and is still controversial.[4, 5] Despite an extremely high PAP in our patient, we saw no signs of pulmonary edema or hemorrhage.

This case demonstrates a successful two-step treatment of a patient with acute-on-chronic RVF due to severe primary PAH with implantation of a percutaneous RVAD system combined with a regular veno-arterial ECMO set-up for biventricular support in on-going resuscitation which may be a safe and feasible treatment for patients with these critical clinical conditions, however, further clinical investigation is required.

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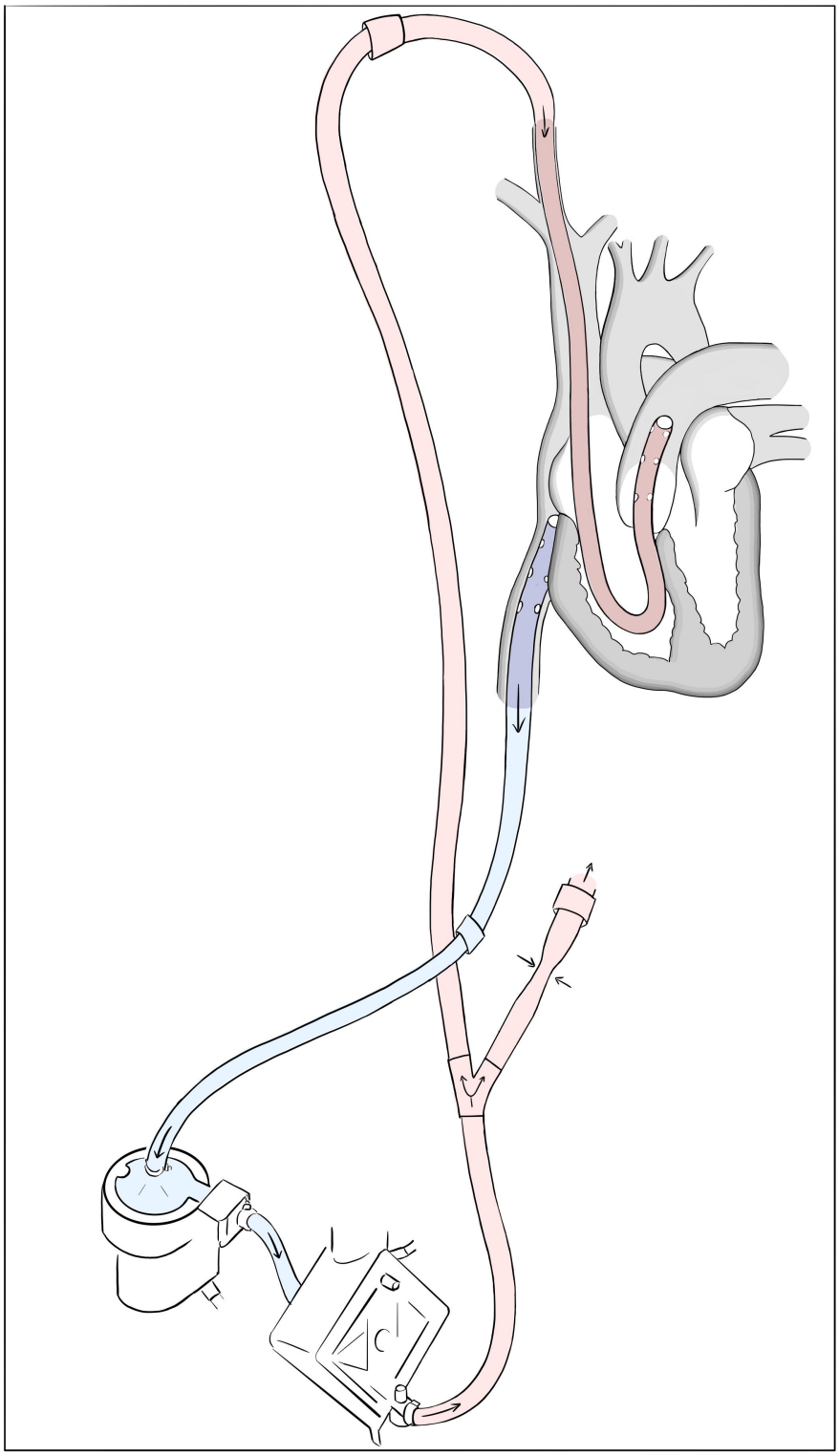
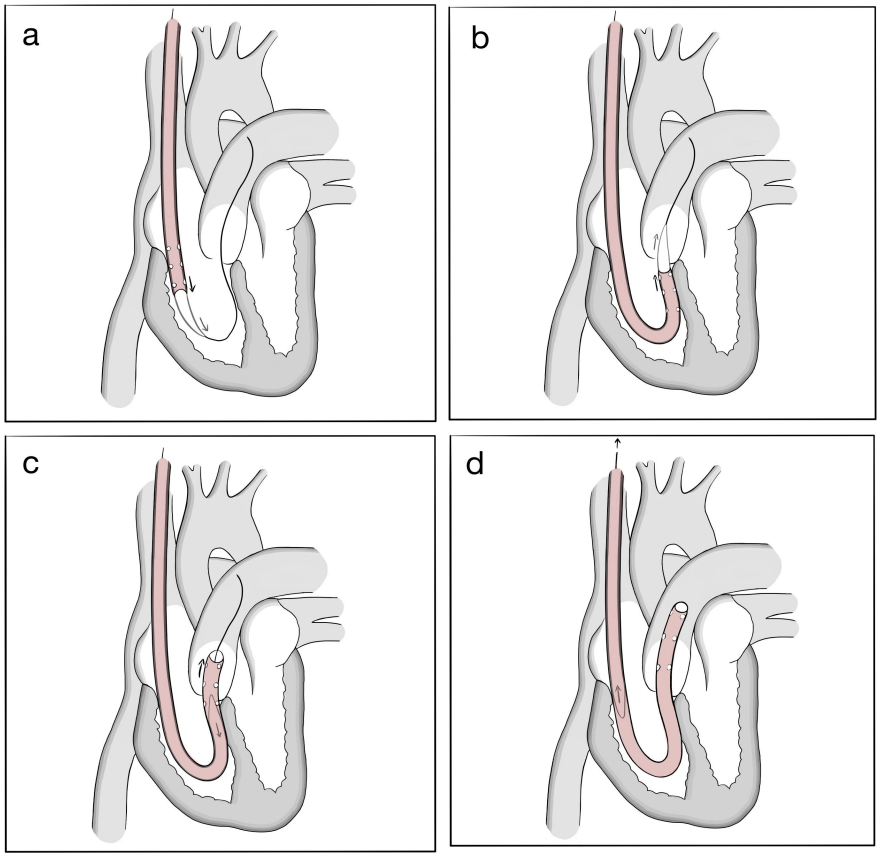
Figure Legends

Figure 1: Initial venous-arterial-venous/pulmonary artery ECMO setup. Inflow: blue line, Outflow: red line.

Figure 2: Step-wise approach of the pulmonary artery cannulation.

Video: Percutaneous deployment of the 21F outflow cannula via internal jugular vein to the pulmonary trunk.





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`Video-Figure.mp4` available at https://authorea.com/users/400224/articles/512561-dual-outflow-extracorporeal-membrane-oxygenation-support-in-secondary-right-ventricular-failure