Percutaneous dual-outflow extracorporeal membrane oxygenation support in secondary right ventricular failure

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Title page:

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

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Informed consent was obtained from patient and no Ethic Committee/Institutional Review Board approval is needed for this report according to the German law.
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Manuscript:

Central Message:

Percutaneous mechanical circulatory support of the right ventricle is a safe and feasible therapy in drug-refractory acute-on-chronic right ventricular failure due to severe pulmonary hypertension.

Abbreviated legend for Central Picture:

Percutaneous canula bypassing the right ventricle, working as a temporary RVAD.

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). Acute on chronic s-RVF is reported to have a high mortality rate, i.e. 40%. Mechanical circulatory support of the RV may be the only therapeutic strategy facing this rapidly progressive syndrome and has been reported successful with various percutaneous cannulation techniques in cases of RVF due to myocardial infarction after left ventricular assist device implantation and prior lung transplantation.

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 ongoing resuscitation.

Case report

Informed consent for the publication of the study data was obtained from patient and no Ethic Committee/Institutional Review Board approval is needed for this report according to the German law.
A 65-year-old male patient was admitted to the hospital presenting with acute coronary syndrome. The first intervention was done 23-years ago, followed by multiple re-interventions due to recurring in-stent re-stenosis in all three coronary vessels. The coronary angiography showed a critical in-stent re-stenosis of the left anterior descending and an ostial stenosis of the ramus intermedius artery. 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 100 mmHg plus central venous pressure. The patient received a right heart catheterization which confirmed the elevated 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 critical coronary state with unstable angina and being inappropriate for an interventional therapy approach, the patient was scheduled for urgent minimally invasive direct coronary artery bypass surgery (MIDCAB).

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. Surgery was postponed, and due to circulatory instability despite maximal inotropic support mechanical circulatory support was indicated. Under on-going mechanical resuscitation, veno-arterial-venous, pulmonary artery (PA) ECMO (V-A-V/PA ECMO) support was established (Fig. 1B). An inflow canula was percutaneously inserted via the right femoral vein (Getinge HLS 23 F, 55 cm; Rastatt, Germany) into the right atrium and an outflow canula was inserted into the right femoral artery (Getinge HLS 17 F, 23 cm) for initial stabilization (Fig. 1A). Thereafter a soft guidewire was placed percutaneously via the right internal jugular vein through the tricuspid- and pulmonary valves, with its tip into the right PA under fluoroscopic control in the catheterization lab. The soft guidewire was then exchanged via a pigtail catheter
for an extra-stiff wire (Lunderquist®, COOK Medical, Bloomington, IN, USA), which was
guided to the PA trunk. Finally, a pre-warmed 21F canula with a multi-hole tip (Biomedicus®
21F, 50 cm, Medtronic, Minneapolis, MN, USA) was percutaneously inserted over the stiff
wire and connected to the outflow line of the ECMO system with a monitored in-line flow-
reducer (Figure 1C and Video). Thus, while bypassing the acute failing RV, this canula acted
as a temporary RVAD.

The femoral arterial outflow canula was explanted by using a percutaneous closure
device after 48 h due to the recovery of the left ventricle. The remaining temporary RVAD
with oxygenator was successfully explanted at day 8 after implantation. Tricuspid and
pulmonary valve were without any possible RV cannula associated alterations. Thereafter the
patient recovered well, was awake and extubated, and could be discharged for further medical
therapy on day 21. After one-year follow-up, the patient is doing well under medication with
sildenafil 20 mg three times daily. His coronary artery disease is under medical therapy and
no further intervention was done.

Discussion
Functional improvement of the RV after normalization of loading conditions under the
support of temporary RVAD systems has been described but has been rarely used in cases of
isolated acute on chronic s-RVF due to exacerbation of PAH, and still remains controversial.4.
Despite an extremely high PAP in our patient, we saw no signs of pulmonary edema or
hemorrhage. Instead of total bypassing the pulmonary circulation, we chose the dual-outflow
concept for a more dynamic and especially faster systemic weaning process. Alternatively, we
could have used the Impella RP system or the LivaNova ProtekDuo cannula for RV support.
Both systems were not in routine use at our center. Furthermore, the ProtekDuo cannula
would have had less effective drainage capacity to support pulmonary and systemic perfusion
parameters and would have prolonged the initial systemic stabilization by VA-ECMO.
This case demonstrates our first and successful 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 circuit in a clinical situation of on-going resuscitation. The approach may be a feasible and safe treatment for patients with these critical clinical conditions, but requires further clinical experience.

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References


Figure legends

Central picture: A – Detailed part of the veno-arterial ECMO delivering systemic perfusion via outflow canula in femoral artery and systemic venous drainage for initial systemic stabilization. B – Total percutaneous dual-outflow ECMO setup delivering oxygenated blood via right femoral artery and pulmonary artery and drains systemic venous blood via femoral vein. C – Detailed part of the 21F outflow canula from the internal jugular vein to the pulmonary trunk. Blood flow is symbolized with arrows, the pinching arrows describe the pulmonary outflow in-line flow reducer. ECMO = extracorporeal membrane oxygenation.

Video:

Percutaneous deployment of the 21F outflow canula from the internal jugular vein to the pulmonary trunk along an extra-stiff guide wire and the final result after removing the canula’s inner sheath under fluoroscopic vision.