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GRAND ROUND
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Unloading, ablation, bridging and transplant: different indications and treatments using the Impella 5.5 as longer-term circulatory support in one patient—an interdisciplinary case report

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Background In patients with cardiogenic shock the clinical treatment often involves temporary mechanical circulatory support for initial haemodynamic stabilization to enable further assessment of therapeutic strategies. The surgically implanted Impella 5.5 can be used for several indications like ventricular unloading, haemodynamic support during high-risk interventions, and as a bridge-to-transplant strategy.

We present an interdisciplinary managed case of using Impella 5.5 for multiple indications and treatment strategies in one patient.

Case summary A 66-year-old patient with known dilated cardiomyopathy was admitted with non-ST-elevation myocardial infarction and underwent urgent coronary bypass grafting. His native heart function did not recover and he experienced recurrent episodes of sustained ventricular tachycardia (VT) and electrical storm. He was evaluated for heart transplantation (OHT) and received a VT-ablation. However, he suffered an in-hospital cardiac arrest (IHCA) with subsequent implantation of an extracorporeal life support system (ECLS). After surgical placement of an Impella 5.5 due to left ventricular distension and pulmonary congestion, the ECLS was successfully weaned. He showed good neurological outcomes and underwent another high-risk VT-ablation. The patient was further stabilized under Impella 5.5 support in a bridge-to-transplant strategy. After 34 days he underwent a successful OHT.

Discussion In this interdisciplinary case report the surgically implanted Impella 5.5 as temporary mechanical circulatory support was used for multiple different indications and treatment strategies like ventricular unloading, haemodynamic support during high-risk interventions, and as bridge-to-transplant strategy in one patient.

Keywords Cardiac unloading • Bridge to heart transplantation • VT ablation • Mechanical circulatory support • Case report

ESC Curriculum 5.6 Ventricular arrhythmia • 6.2 Heart failure with reduced ejection fraction • 7.1 Haemodynamic instability • 7.5 Cardiac surgery • 7.2 Post-cardiac arrest

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Learning points

- A careful evaluation of therapeutic strategies within a multi-disciplinary team approach is an important aspect of ensuring the best possible management and treatment concept for the patient.
- The Impella 5.5 can be surgically implanted using an axillary approach and can be used for several indications like ventricular unloading, haemodynamic support during high-risk interventions, and as a bridge-to-transplant strategy.
- The implantation and longer-term support of an Impella 5.5 device as a bridging strategy is feasible and safe even in countries with a shortage of donor organs and anticipated longer waiting times.

Primary specialties involved other than cardiology

(1) Cardiothoracic surgery
(2) Electrophysiology
(3) Intensive care medicine
(4) Anaesthesiology
(5) Physiotherapy
(6) Psychology
(7) Heart failure nursing

Introduction

In patients with cardiogenic shock, the clinical treatment often involves temporary mechanical circulatory support (tMCS) for initial haemodynamic stabilization to enable further assessment of therapeutic strategies. In patients with end-stage heart failure, the morbidity and mortality rates remain high.[1] Clinical courses can be complicated by sustained ventricular tachycardia (VT) with an increased risk of ventricular fibrillation and sudden cardiac death. Therefore, the restoration and maintenance of a stable sinus rhythm is crucial in the treatment of patients with end-stage heart failure. Catheter ablations of VT are a widely established treatment strategy to achieve rhythm stabilization but can be challenging in patients with cardiac decompensation and haemodynamic instability.[2]

Transaortic microaxial left ventricular assist devices (Impella 5.5, Abiomed, Danvers, MA, USA) can be surgically implanted using an axillary approach and used for several indications like ventricular unloading, haemodynamic support during high-risk interventions and as bridge-to-transplant strategy.

We present a case of multiple indications and treatment strategies with tMCS in a 66-year-old patient with mixed dilated and ischaemic cardiomyopathy and recurrent electrical storm.

Timeline

Timeline of the clinical course. NSTEMI, non-ST elevation myocardial infarction; MI, myocardial infarction; CI, cardiac index; WU, wood units; VT, ventricular tachycardia; ET, Eurotransplant; IHCA, In-hospital cardiac arrest; ECLS, extracorporeal life support

Days post-MI	Clinical event
Day 0	Submission to the emergency department with ventricular tachycardia and NSTEMI with subsequent urgent coronary bypass grafting
Day 15	Transfer to our University Heart and Vascular Center for heart transplant candidacy evaluation
Day 21	Right heart catheterization: CI of 1.7 l/min/m^2, a pulmonary resistance of 1.4 WU, mixed venous saturation of 49%
Day 22	First VT/premature ventricular contraction ablation in three areas of the RVOT due to sustained electrical storm
Day 34	ET listing for heart transplantation in status "*transplantable*"
Day 47	Implantation of an implantable cardioverter defibrillator
Day 50	ET listing in status *high urgent*
Day 54	IHCA due to ventricular fibrillation with 75 min CPR and ECLS implantation
Day 56	Surgical implantation of an Impella 5.5 (right axillary approach) for LV unloading
Day 62	Explantation of the ECLS and bridge-to-transplant with Impella 5.5
Day 83	Second VT ablation and concomitant stellate ganglion blockade under Impella 5.5 support
Day 90	Orthotopic heart transplantation
Day 103	Discharge to a rehabilitation facility

Case presentation

A 66-year-old patient with mixed dilated and ischaemic cardiomyopathy and a history of myocarditis four years previously was presented to the emergency department with an acute non-ST-elevation myocardial infarction (MI) and sustained hemodynamically instable VT with consecutive haemodynamic compromise. Coronary angiography showed a three-vessel coronary artery disease with relevant stenosis of the left main artery (LCA), the anterior descending artery (LAD), and the dominant right coronary artery (RCA). Subsequently, the patient underwent urgent coronary bypass grafting (CABG) with the left internal thoracic artery (LITA) on the left anterior descending artery (LAD) and the right internal thoracic artery (RITA) as Y-graft on the left circumflex artery (LCx) and right posterior descending artery (PDA). After CABG, Acetylsalicylic acid, and Clopidogrel were added to the initial guideline-recommended heart failure medication as dual antiplatelet therapy.

Over the course of the following 2 weeks after coronary bypass surgery, the patient's clinical condition progressively worsened as he showed no improvement of his native heart function and presented episodes of sustained VT and electrical storm within 1 week after surgery. A coronary angiography showing patent bypass grafts and normal troponin levels ruled out any new ischaemic origin of the recurrent arrhythmias. Due to poor right ventricular (RV) function a durable left

ventricular assist device (LVAD) was deemed not a suitable therapeutic strategy and the patient was transferred to our University Heart and Vascular Center to be evaluated for heart transplantation (OHT).

Echocardiographic examination showed a severely reduced left ventricular ejection fraction of 10–15% as well as a dilation of the right ventricle with reduced function and a severe tricuspid valve regurgitation. The initial right heart catheterization revealed a cardiac index of 1.7 L/min/m^2, a pulmonary resistance of 1.4 wood units (WU), and a mixed venous saturation of 49% despite optimized filling pressures.

The patient received intravenous positive inotropic therapy with the calcium sensitizer Levosimendan and was continuously monitored in the Heart Failure Unit.

Twenty-two days post-MI the patient developed episodes of sustained VT which resulted in an electrical storm (*Figure 1*). He underwent VT and premature ventricular contraction ablation in three areas of the right ventricular outflow tract (RVOT; free wall, posterolateral, and His area). During the mapping procedure, the patient presented multiple episodes of VT with at least five different morphologies necessitating repeated defibrillations. After substrate-based ablation, there were no inducible VT and a stable sinus rhythm was achieved.

During the following weeks, the patient was medically treated with antiarrhythmic medication like amiodarone and additionally received an implantable cardioverter defibrillator. Fifty days post MI the patient was eligible to be listed as highly urgent for heart transplantation.

However, after 3 days on high urgency waiting list the patient suffered an in-hospital cardiac arrest (IHCA) due to ventricular fibrillation and a cardiopulmonary resuscitation (CPR) time of 75 min with subsequent implantation of an extracorporeal life support system (ECLS).

The cannulation of the ECLS was performed via the right peripheral femoral artery and vein and an additional distal perfusion cannula. Initially, the aortic valve opened after ECLS implantation and the patient

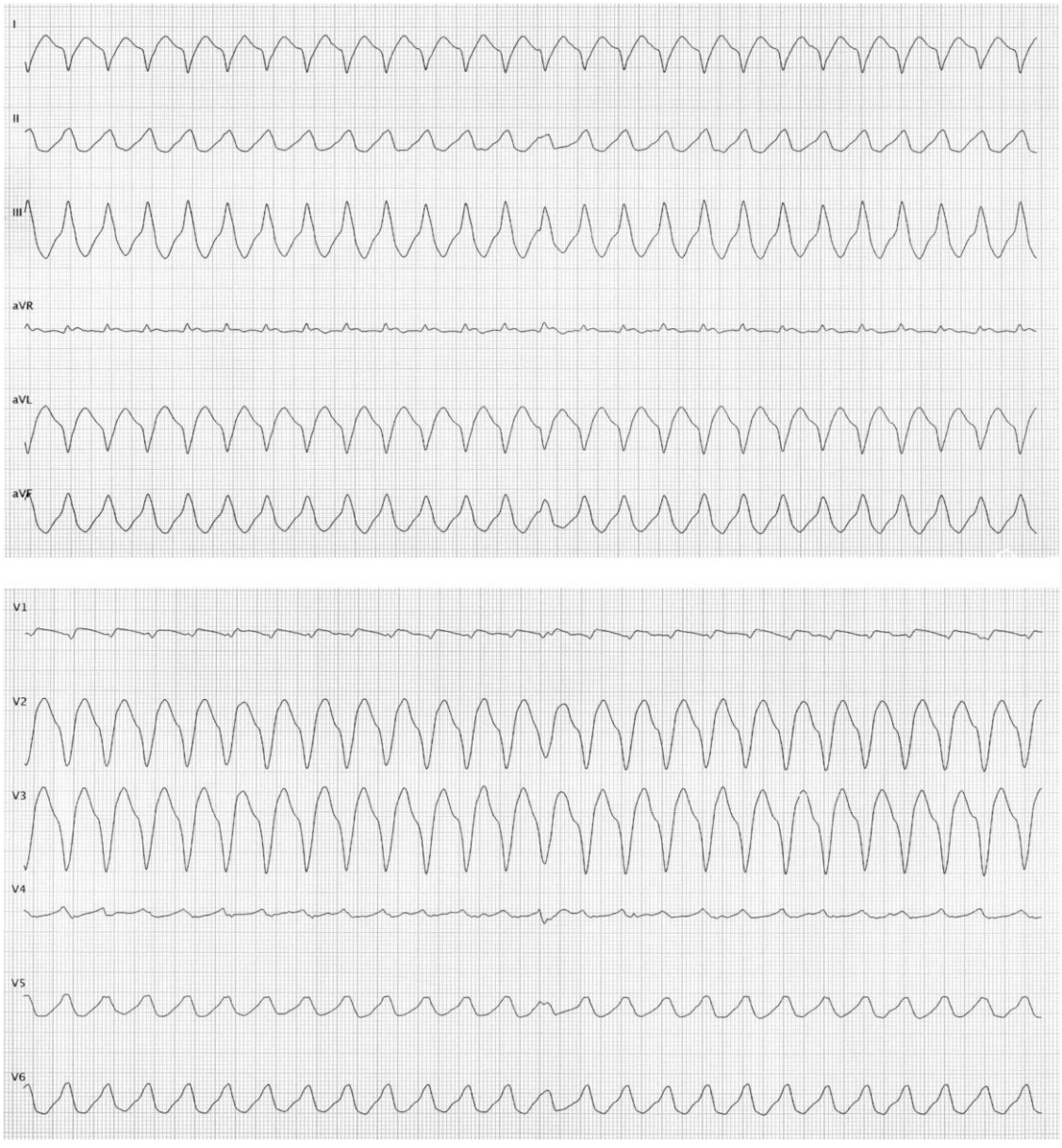


Figure 1 Twelve-lead electrocardiogram showing wide QRS complex ventricular tachycardia (cycle length 392 ms, 153/min).

was transferred to intensive care unit (ICU) without any additional device for unloading. Within the first day, the patient developed increasing left ventricular distension and pulmonary congestion necessitating an additional left ventricular unloading device and an Impella 5.5 (Abiomed, Danvers, MA, USA) was successfully inserted through a 10 mm vascular graft in the right axillary artery. After interdisciplinary discussions, we did not apply therapeutic hypothermia to allow immediate neurologic evaluation.

Following the surgical implantation of Impella 5.5, the chest radiography showed an immediate reduction of pulmonary congestion (*Figure 2*). The ECLS was successfully weaned within 8 days after CPR. After weaning from the ventilator, the patient showed good neurological outcome and underwent physiotherapy with full mobilization and ambulation on ward.

The medical management approach of this complex patient consisted of daily multi-disciplinary discussion within the heart failure team including the department of cardiology and electrophysiology, cardiac surgery and intensive care medicine, psychology consultation, physiotherapy, and nursing staff.

Within the following weeks, the patient presented another episode of VT which degenerated into a ventricular storm. Given the persistence of medically non-responsive VT, the patient underwent another high-risk and extensive substrate-based VT ablation of the RVOT and the free and septal wall of the RV as well as concomitant stellate ganglion blockade under Impella 5.5 support. After extensive ablation, there were no inducible VT and a postprocedural stable sinus rhythm was achieved (*Figure 3*).

Despite stable Impella 5.5 support without inotropic therapy, the severely reduced RV function and recurrent ventricular arrhythmias persisted, leading to a high risk of RV-failure post LVAD implantation. No pulmonary artery catheter was performed due to the risk of inducing further arrhythmias. After interdisciplinary discussion of the optimal treatment strategy and goal, prognosis after heart transplantation was considered to be better compared to the durable left- and biventricular assist devices support as destination therapy.

The patient was further stabilized under Impella 5.5 support in a bridge-to-transplant strategy despite anticipated longer waiting times in Germany.

After 34 days of tMCS with an axillary transaortic microaxial LVAD a suitable donor organ was accepted and the patient underwent successful and uneventful orthotopic heart transplantation with explantation of the Impella 5.5 and shortening of the axillary graft closed to the anastomosis. During the entire course of treatment with the Impella 5.5 device, there were no pump-related complications. Pathological findings in the explanted heart showed signs of dilated cardiomyopathy as well as advanced atherosclerotic plaques of the coronary arteries. The aortic valve did not show any pathologies. Overall these findings were consistent with a massive cardiac involvement in terms of granulomatosis/sarcoidosis. Postoperative course was uneventful with the absence of transplant dysfunction. Thirteen days after OHT he was discharged to a rehabilitation facility, after which he was discharged home after three weeks.

Discussion

We here report the treatment with an axillary transaortic microaxial LVAD for multiple different indications in one patient in an interdisciplinary and interprofessional fashion.

While on ECLS the patient presented progressive pulmonary congestion and echocardiography showed distension of the left ventricle. The surgical implantation of an Impella 5.5 device resulted in immediate cardiac unloading and safe weaning from extracorporeal life support.[3] The risk of bleeding complications and haemolysis is increased in patients under ECLS support. Implantation of an axillary Impella and early explantation of the ECLS device results in a reduction of transfusion-related adverse events and infection rates.[4] Additionally, the device serves as a bridge-to-decision tool to evaluate neurologic function.[5]

There is limited evidence regarding the potential benefit of hypothermia after IHCA. The concept of inducing hypothermia is based on the decrease of cerebral metabolism and the possible neuroprotective effect after a period of global cerebral hypoxia in patients with out-of-hospital cardiac arrest. Although the appropriate therapeutic window and optimal duration of temperature control as well as its clinical effectiveness remain unknown.[6,7] After interdisciplinary discussion we decided not to apply hypothermia to our patient to allow immediate neurological evaluation and promote early weaning of the sedation medication and mechanical ventilation. Additionally, while on Impella 5.5 support the patient could be fully mobilized during the course of treatment in a bridge-to-heart transplantation strategy.[8,9]

In patients with severe heart failure especially with structural heart disease VT frequently occurs and can result in an increased mortality.[10]

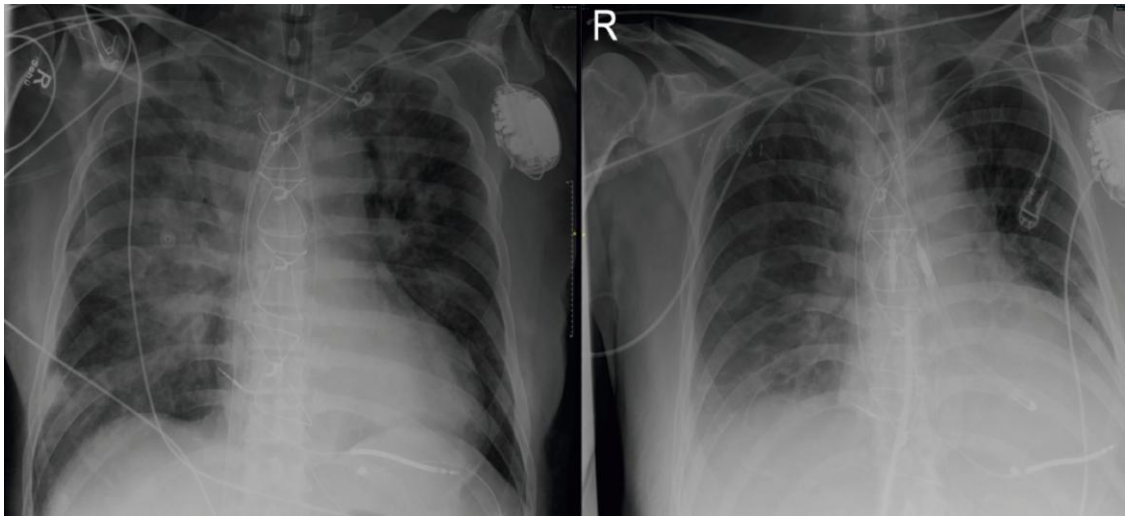


Figure 2 Chest radiograph in anterior–posterior projection before (left) and after (right) implantation of an Impella 5.5 device.

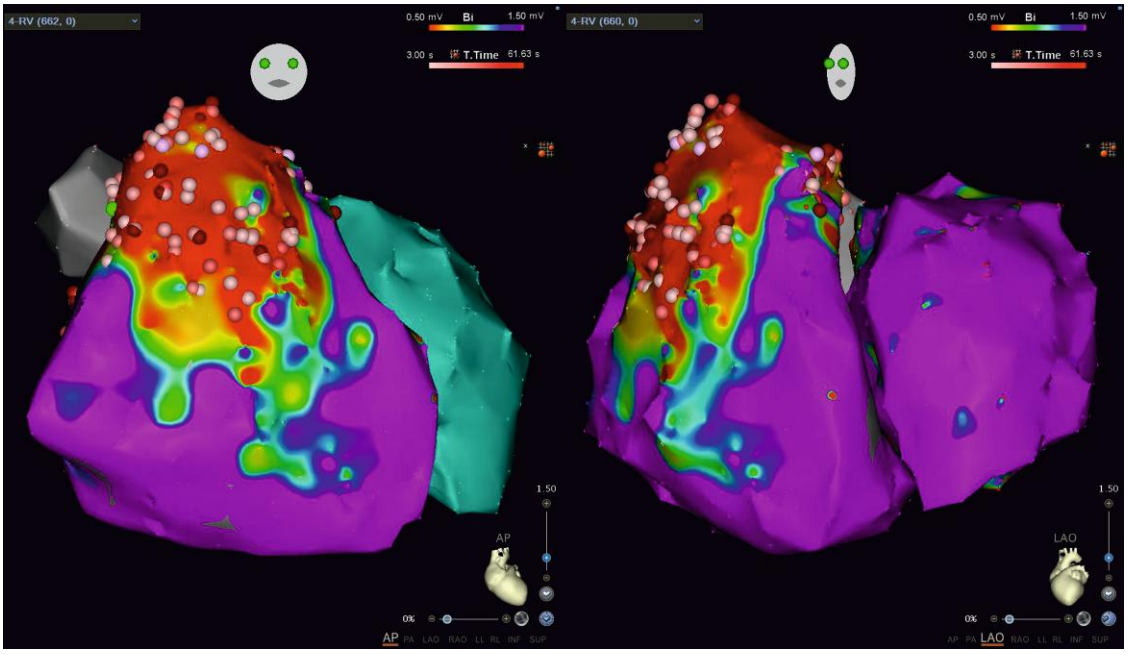


Figure 3 High-density electroanatomical carto map of the right ventricle in (left) anterior—posterior and (right) left anterior oblique projections. The different coloured areas represent tissue types (scar tissue—red < 0.50 mV), borderline tissue (orange to blue, 0.5–1.5 mV), and healthy tissue (purple, >1.5 mV). Ablation lesions are displayed as red and pink dots.

To re-establish rhythm stabilization the catheter ablation of VT is a widely used and a guideline-recommended treatment strategy in patients with ischaemic heart disease and sustained VT.[11] Due to complex cardiac substrates in patients with structural heart disease the procedure often requires repetitive inductions of VT and extensive mapping which results in a prolonged duration of the procedural time which can negatively affect the haemodynamic stability of the patient. In this case, the Impella 5.5 support ensured haemodynamic stability and sufficient systemic end-organ perfusion by providing complete left ventricular support with up to 5.8 L/min of flow during lengthy and extensive high-risk procedures like VT ablations and neuromodulation.[12]

Treatment options to be considered in this patient included the implantation of durable assist devices. The treatment with a temporary assist device before the implantation of a durable LVAD can ensure mobilization of the patient and optimization of the RV function.[13] In this case the severely reduced RV function and ventricular arrhythmias persisted, leading to a high risk of RV-failure post LVAD implantation. According to the second EUROMACS report the survival rates of LVAD patients were 69% at 1 year and 44% at 3 years whereas the survival rates for biventricular assist device (BIVAD) patients were 32% at 1 year and 21% at 3 years after implantation.[14] Therefore, the implantation of a LVAD or BIVAD was deemed not a suitable therapeutic strategy due to the expected inferior outcome compared to heart transplantation. After an interdisciplinary discussion of the optimal treatment strategy and goal, the prognosis after heart transplantation was considered to be better compared to the durable left- and biventricular assist devices as destination therapy.

During the past decade organ donation in Germany dropped from 1024 donors in 2012 to 899 donors in 2021 leading to a severe organ shortage crisis with 10.8 donors per million inhabitants in 2021. Out of 324 performed heart transplantations in 2021 within Germany, 236 patients have been listed in high urgency status.[15,16] According to the German Organ Procurement Organization (DSO) the average mortality rate on the waiting list was 17% in 2021.[17] Although the utilization of a heart from a marginal donor may result in an increased risk of primary graft dysfunction (PGD), the current graft scarcity and long waiting times in Germany may promote the usage of marginal donor hearts in carefully selected cases.[18] The overall incidence of PGD is observed to be between 3.5 and 7.7% with 1-year mortality rates up to 41%. Risk factors include female sex and size-mismatch as well as recipient factors like renal insufficiency, temporary or durable mechanical support as well as prolonged ischaemic time.[19] Taking these aspects into account, the acceptance of a marginal organ compared to accepting a longer waiting and short-term device support time associated with potential adverse event risks should be carefully and individually balanced.

To provide a holistic treatment approach, a multi-disciplinary management of patients with end-stage heart failure is essential for ensuring a patient-centered treatment plan. The concept of multi-disciplinary treatment is ranked with a class 1A recommendation in current ESC heart failure guidelines.[1] In our case we discussed the patient's clinical course in daily grand rounds involving experts of cardiology, cardiac surgery, and intensive care medicine ensuring a comprehensive treatment strategy involving the patient's opinion in the decision-making process. Besides other specialties like physiotherapy, heart failure nursing, and pharmacology, cardiac psychotherapists seemed to have a crucial impact during the treatment process on improving the patient's well-being before and after transplantation.

Overall, an important aspect of ensuring the best possible management and treatment concept for the patient involved a careful evaluation of therapeutic strategies within a multi-disciplinary team approach. The use of tMCS as bridge-to-transplantation strategy is rare in Europe, especially in Germany. The Impella 5.5 is CE (Conformité Européenne) approved in Europe for up to 30 days of support.[20] However, the implantation and longer-term support of an Impella 5.5 device as a bridging strategy is feasible and safe even in countries with a shortage of donor organs and anticipated longer waiting times.

Conclusion

In this interdisciplinary and interprofessional case, the implantation of an Impella 5.5 was used for multiple indications and treatments in one patient. First, the full-flow Impella 5.5 allowed immediate cardiac unloading and safe weaning from ECLS. Second, in a patient with end-stage heart failure and recurrent electrical storm, the Impella 5.5 allowed haemodynamic stabilization during high-risk interventions such as VT-ablation and neuromodulation. Third, the implantation and longer-term support of an Impella 5.5 as a bridge-to-transplant strategy is feasible and safe even in countries with anticipated longer waiting times.

Patient's perspective

I have been a healthy and retired physician until I got admitted to the emergency department with acute MI. The initial bypass surgery went without complications but my clinical condition gradually worsened and I experienced dyspnoea at rest as well as extreme fatigue. Eventually, I got transferred to the University Heart and Vascular Center to explore further treatment options.

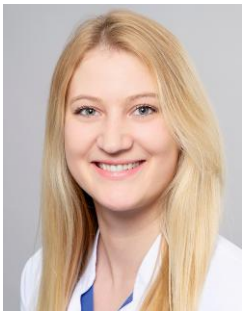
I have undergone multiple test and interventions until I was resuscitated due to ventricular fibrillation. Retrospectively, most of those days have become a vague memory. In some way, I have distanced myself from that experience. Eventually, I have been evaluated and listed for a heart transplantation.

Personally, the prolonged Impella 5.5 support was extremely important for me as it provided the opportunity to mobilize myself during the weeks on the waiting list. Throughout this time, my medical knowledge helped me to follow the daily discussion of the heart failure team about my clinical course. I knew that my heart was failing and that a heart transplantation was my only option.

I have been a physician most of my life and now becoming the patient was exceptionally hard on me. Due to the COVID-pandemic, my family could not visit, which made it unbearable at times. I experienced episodes of depression and I was immensely thankful for the support from specialized transplantation psychotherapists.

When I was finally told that a donor heart had been accepted, I was confident that the surgery would be successful as I had absolute trust in the whole team treating me. Today, living with a transplanted heart beating inside my chest has become a very natural feeling and I have made a full recovery.

Lead author biography



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Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports*.

Slide set: A fully edited slide set detailing this case is available online as Supplementary data.

Consent: The authors confirm that written consent for the submission and publication of this case report, including images and associated text has been obtained from the patient in line with COPE guidance.

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Data availability

All data are incorporated into the article and its online supplementary material.

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