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CASE REPORT
Heart failure

A successful bridge to recovery with Impella 5.0 and subsequent hybrid cardiac resynchronization therapy in systemic right ventricle failure: a case report

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Background Impella 5.0 is currently used as a temporary mechanical circulatory support device in cardiogenic shock (CS). However, Impella 5.0 implantation for the systemic right ventricle (sRV) has not been well documented.

Case summary A 50-year-old man with atrial switch for dextro-transposition of the great arteries was transferred to our hospital for the treatment of embolic acute myocardial infarction of the left main trunk lesion with CS. To stabilize haemodynamics, we implanted Impella 5.0 via the left subclavian artery in the sRV. After optimal medical therapy initiation and gradual weaning of Impella 5.0, Impella 5.0 was successfully explanted. An electrocardiogram was obtained, which showed complete right branch block with a QRS duration of 172 ms. Acute invasive haemodynamic evaluation of cardiac resynchronization therapy (CRT) pacing showed that dP/dt increased from 497 to 605 mmHg/s (21.7% improvement), and hybrid cardiac resynchronization therapy defibrillator (CRTD) with a sRV epicardial lead was subsequently implanted. The patient was discharged without inotropic support.

Discussion Coronary artery embolism is a rare but serious complication of dextro-transposition of the great arteries after atrial switch operations. Impella 5.0 implantation is a feasible bridge strategy for refractory CS due to sRV failure. Although CRT implantation in patients with sRV is controversial, an acute invasive haemodynamic evaluation can help assess its potential benefits.

Keywords Transposition of great arteries • Impella • Mechanical circulatory support • Cardiac resynchronization therapy • Case report

ESC Curriculum 7.1 Haemodynamic instability • 9.7 Adult congenital heart disease

Learning points

- Arterial embolism is a rare but serious complication of dextro-transposition of the great arteries with an arterial switch operation.
- The Impella 5.0 device is a reasonable bridging strategy for cardiogenic shock even among patients with systemic right ventricle (sRV).
- Cardiac resynchronization therapy is recommended for patients with sRV if the sRV ejection fraction is lower than 35% with complete right branch block. dP/dt in pacing studies may aid in decision-making.

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Introduction

Cardiogenic shock (CS), a life-threatening state, is characterized by low cardiac output with accompanying end-organ hypoperfusion and multisystem organ dysfunction.[1] Impella 5.0, a currently available short-term percutaneous mechanical circulatory support, offers haemodynamic improvement and is used as a bridge to decision-making devices for cardiogenic shock.[2] Patients with dextro-transposition of the great arteries (d-TGA) and atrial switch operation (Mustard or Senning operation) are known to develop arrhythmias, systemic right ventricle (sRV) failure, and heart failure in long-term follow-up,[3–4] and coronary artery embolism was reported in some cases.[5]

The effect of cardiac resynchronization therapy (CRT) is controversial in sRV patients.[6] Preoperative determination of CRT effectiveness is difficult, particularly for invasive procedures that require implantation of epicardial leads. Recently, invasive haemodynamic evaluation has been reported to be effective for assessing the potential benefits of CRT.[7–8]

We described d-TGA after a Mustard atrial switch operation in a patient who developed cardiogenic shock due to coronary artery embolism and was successfully bridged to recovery with Impella 5.0. Subsequently, the patient underwent hybrid CRT using defibrillator (CRTD) implantation with an sRV epicardial lead.

Timeline

Time	Events
2 years of age	Mustard atrial switch operation for d-TGA.
~ 50 years of age	Lost to follow-up.
Day 1	Left main trunk acute myocardial infarction with cardiogenic shock. VA-ECMO + IABP started. PCI performed.
Day 3	Explant VA-ECMO, resulting cardiogenic shock and ventricular tachycardia.
Day 4	Transferred to our hospital.
Day 7	Impella 5.0 support via left subclavian artery was started.
Day 32	Impella 5.0 explantation, CRT study, and IABP insertion.
Day 37	Hybrid CRTD implantation.
Day 43	Explant IABP.
Day 57	Transferred to the local hospital.

Case presentation

A 50-year-old man was transferred to the emergency department of a local hospital because of acute chest pain and shock.

The patient had been diagnosed with d-TGA at birth and underwent a Mustard atrial switch operation at 2 years of age. He had not been admitted to any medical facilities during the decades he had resided at his current address. His blood pressure and heart rate on admission were 86/48 mmHg and 70 per min, and lactate level was elevated up to 2.9 mmol/L. His extremities were cold, and capillary refill time was more than 2 s. Emergency coronary angiography revealed complete occlusion of the left main trunk (LMT) with a thrombus, which was diagnosed as acute myocardial infarction (AMI) due to coronary artery embolism (*Figure 1*). After veno-arterial extracorporeal membrane oxygenation (VA-ECMO) and intra-aortic balloon pumping (IABP) were initiated for ventricular tachyarrhythmia and cardiogenic shock, thrombus aspiration and percutaneous balloon angiography were performed. The peak creatinine kinase (CK) and CK–myoglobin binding (CK–MB) levels were 5931 and 524 IU/L (normal: 41–153 and 0–12 IU/L), respectively. After haemodynamic stabilization, VA-ECMO was removed on Day 3. After VA-ECMO removal, he received several inotropic and vasoactive therapy, including dobutamine, milrinone, noradrenaline, and vasopressin (maximum doses: 5.74 mcg/kg/min, 0.13 mcg/kg/min, 0.31 mcg/kg/min, and 1.0 U/h, respectively). However, soon after VA-ECMO removal, ventricular and atrial tachycardia developed, leading to difficulty in managing cardiogenic shock. On Day 4, the patient was transferred to our hospital.

On examination, his temperature was 36.8°C, pulse was 128 b.p.m. with atrial tachycardia, and blood pressure was 87/49 mmHg. Pitting oedema of the legs with cold extremities was noted. Transthoracic echocardiography showed severely reduced sRV contraction, and the right ventricular ejection fraction was 15% (*Videos 1* and *Video 2*). The right ventricle fractional area contraction was 10% (systolic and diastolic areas were 32.4 and 36.0 cm^2, respectively). Pulmonary left ventricular motion was also reduced. As renal and hepatic dysfunctions deteriorated despite IABP support, Impella 5.0 (Abiomed, Danvers, MA) was inserted through the left subclavian artery (LSCA) on Day 7 to maintain adequate cardiac output and unloading the sRV (*Video 3*). The patient was ineligible for heart transplantation or a durable ventricular assist device due to socioeconomic reasons. Soon after Impella 5.0 implantation, cardiogenic shock was improved. Subsequently, guideline-directed medical therapy was initiated and titrated to maximal tolerable doses (bisoprolol 0.625 mg, sacubitril/valsartan 100 mg, spironolactone 50 mg, and empagliflozin 10 mg), with the expectation of some extent of reverse remodelling. Under several inotropic and vasoactive therapy, including dobutamine (5.91 mcg/kg/min) and milrinone (0.13 mcg/kg/min), Impella 5.0 was successfully weaned to level P2 (31 000 rotations per min, 2.0 L/min) without haemodynamic deterioration (heart rate: 95 b.p.m., blood pressure 83/58 mmHg, $ScvO_2$ 57.9%) on Day 28 and was switched to IABP on Day 32. An electrocardiogram showed complete right branch block with a QRS duration of 172 ms. Acute invasive haemodynamic evaluation of CRT [transvenous left atrium (LA), transvenous left ventricle (LV), and transaortic right ventricle (RV)] was performed after Impella explantation, showing improvements with CRT pacing in dP/dt (from 497 to 605 mmHg/s, 21.7% improvement), systemic blood pressure (from 105/79 to 116/81 mmHg), and QRS duration (from 172 to 122 ms) as compared with intrinsic conduction (*Figures 2* and *3A*). A hybrid CRTD (transvenous LA, transvenous LV, and epicardial RV) was implanted at Day 37 (*Figure 3B*), and IABP was successfully explanted on Day 43. Subsequently, inotropic support was gradually weaned. The patient was transferred to the local hospital on Day 57, inotropic support was stopped on Day 125, and the patient was finally discharged on Day 157. He was hospitalized for heart failure at Day 200 and died at Day 302.

Discussion

To our best knowledge, this is the first case report to describe Impella 5.0 implantation in an sRV. In our case, Impella 5.0 was maintained for 32 days without complications and successfully bridged to recovery.

Coronary artery embolism is a rare but important non-atherosclerotic cause of AMI.[9] Although atrial tachyarrhythmia is the most common cause of coronary artery embolism, systemic atrial and ventricular anatomical anomalies, including previous surgical interventions, can cause arterial embolism. As this case fulfilled one major criterion (angiographic evidence of embolism without atherosclerotic disease) and two minor criteria (previous history of cardiac surgery

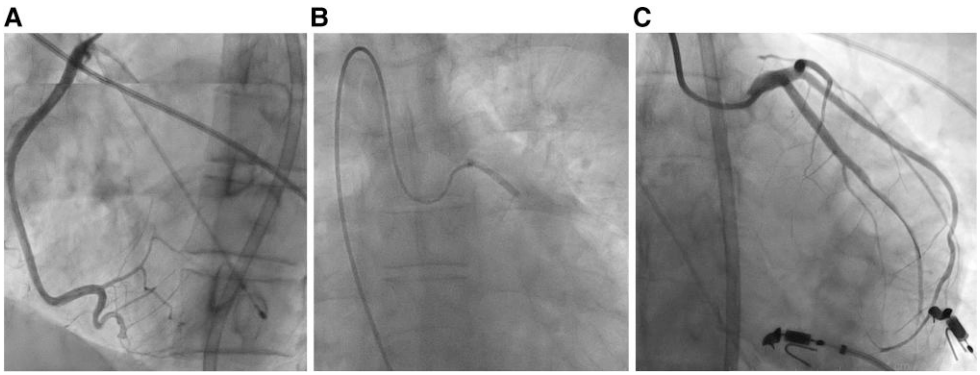
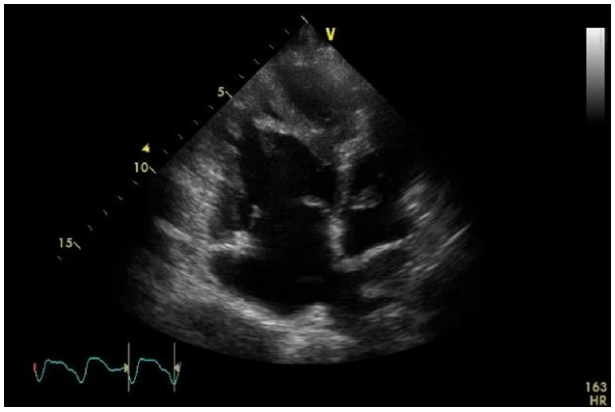
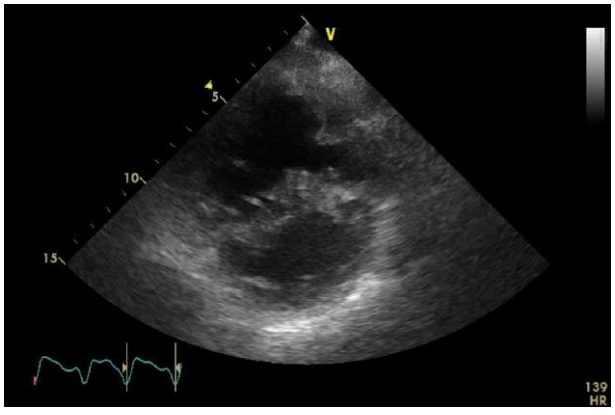


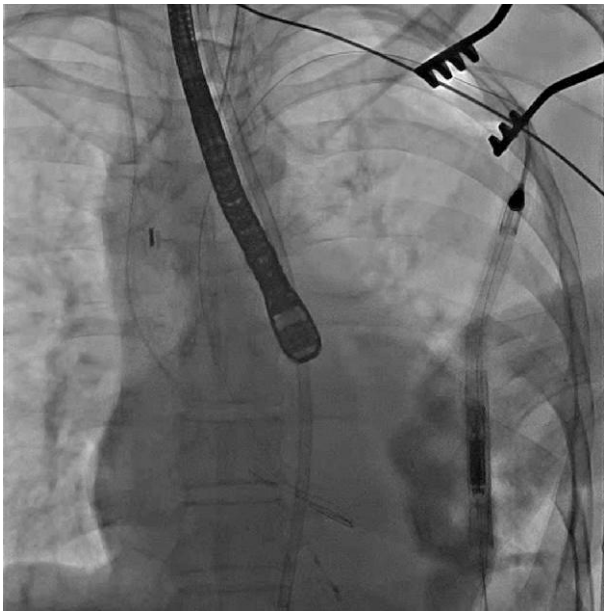
Figure 1 Coronary angiography of the right (*A*) and left (*B*) coronary artery before coronary revascularisation and the left coronary artery after revascularisation (*C*).



Video 1 Apical four-chamber view of transthoracic echocardiography on admission.



Video 2 Short-axis view of transthoracic echocardiography on admission.



Video 3 Impella 5.0 implantation via the LSCA.

and coronary angiography with <25% stenosis apart from the suspected embolic lesion) of the National Cerebral and Cardiovascular Centre criteria for clinical diagnosis of coronary artery embolism,[9] the diagnosis of coronary artery embolism was made. Even though atrial tachyarrhythmia, ventricular anatomical anomalies, and previous surgical interventions may be a cause of coronary embolism in this case, the precise source of the thrombus was inconclusive.

Variations in coronary arteries are present in one-fifth of patients with d-TGA. In our case, as a large proportion of the sRV was supplied by the left coronary artery and a relatively small portion was supplied by the right coronary artery, LMT-AMI resulted in cardiogenic shock due to sRV failure.

The efficacy of CRT in sRV may vary across defects and may depend on the individual anatomy and cause of dyssynchrony.[6] The current expert consensus statement defines CRT as a class IIa recommendation for

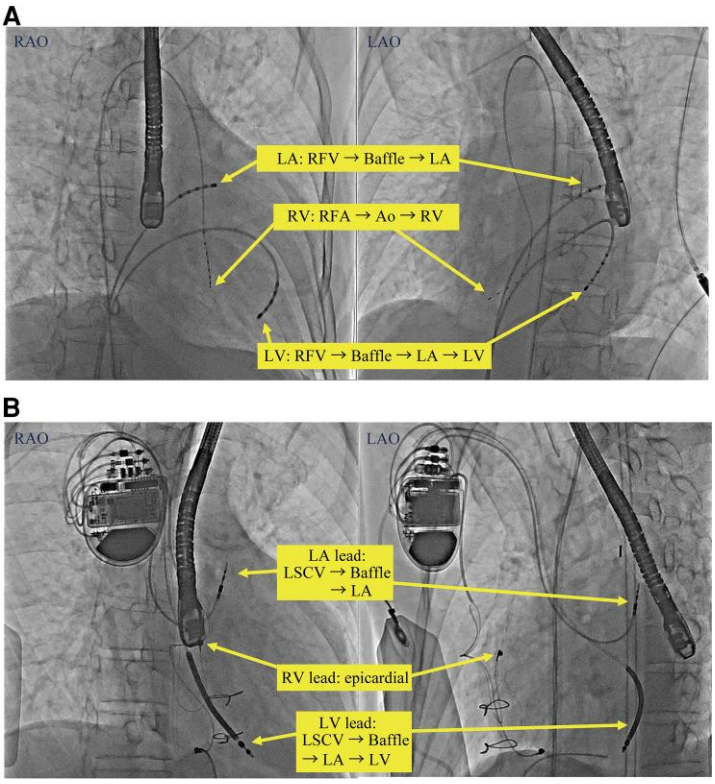


Figure 2 The electrocardiogram with and without cardiac resynchronisation therapy (CRT) pacing (sinus rhythm).

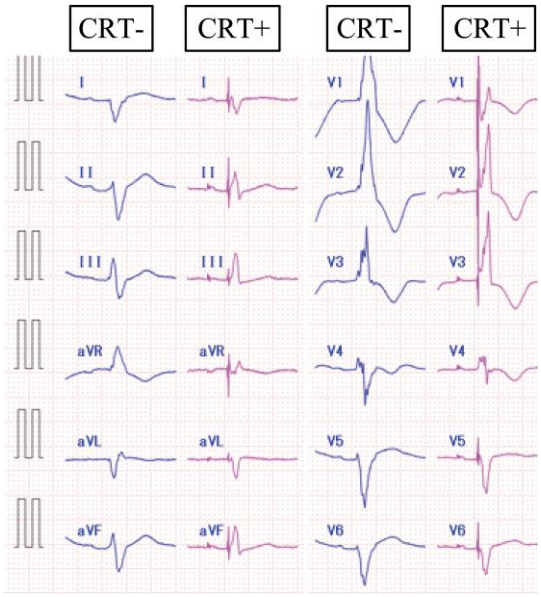


Figure 3 Chest X-ray images of the patient during CRT pacing study (*A*) and CRTD implantation (*B*). The following devices were used: CRTD, Cobalt XT HF CRTD MRI; LA lead, CapsureFix Novus 5076–45; LV lead, Sprint Quattro Secure 6935M-55; and RV epicardial lead, 4968–35. CRTD, cardiac resynchronization therapy defibrillator; LA, left atrium; LSCV, left subclavian vein; LV, left ventricle; RFA, right femoral artery; RFV, right femoral vein; RV, right ventricle.

patients with a systemic right ventricular ejection fraction ≤35%, right ventricular dilation, New York Heart Association (NYHA) class II to IV symptoms, and complete right bundle branch block with a QRS complex ≥150 ms (spontaneous or paced), but only with evidence level C.[10–11] Because invasive epicardial RV lead implantation is often necessary to achieve CRT in sRV patients due to the lack of coronary sinus access, preoperative determination of CRT effectiveness is difficult. As several studies previously revealed that dP/dt changes in invasive haemodynamic evaluation of CRT pacing were useful in predicting CRT responsiveness, including in sRV patients,[7–8] hybrid CRTD with sRV epicardial lead was implanted based on invasive haemodynamic evaluation results.

This case report describes a d-TGA man with cardiogenic shock due to coronary artery embolism, successfully bridged to recovery with Impella 5.0 and subsequently underwent CRTD implantation. Impella 5.0 is a feasible bridge strategy for cardiogenic shock due to systemic right ventricle failure.

Lead author biography

Keiichiro Iwasaki obtained his MD in 2012 and completed cardiology residency at Kurashiki Central Hospital, followed by advanced heart failure and heart transplant training at the National Cerebral and Cardiovascular Center. He is currently working as a cardiologist at the Okayama University Hospital (Japan). He has a special interest in heart failure, mechanical circulatory support, and heart transplantation.

Supplementary material

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

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Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case report, including images and associated text, was obtained from the patient in line with the Committee on Publication Ethics (COPE) guidance.

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Data availability

The data underlying this article are available in the article and in its online supplementary material.

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