

A case series: alternative access for refractory shock during cardiac arrest

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Background

In patients with iliofemoral arterial disease, transcaval and percutaneous axillary artery access are safe alternatives for delivery of transcatheter aortic valve replacement for severe aortic stenosis. In the setting of cardiac arrest, arterial access is crucial for delivery of mechanical circulatory support devices such as an Impella CP[®] or cannulation for extracorporeal cardiopulmonary resuscitation (ECMO). We report the use of transcaval and axillary artery access in three cases of cardiac arrest in which the emergent placement of an Impella CP[®] (Abiomed, Danvers, MA, USA) or cannulation for ECMO was instrumental in resuscitation from refractory cardiac arrest.

Case summary

The first patient is a 59-year-old woman who developed ventricular fibrillation arrest after percutaneous intervention with emergent placement of a transcaval Impella CP[®]. In the second case, a 67-year-old man with coronary vasospasm developed cardiac arrest with an axillary artery Impella CP[®] placed. The third case highlights a 67-year-old man who developed cardiac arrest 1 day after unsuccessful chronic total occlusion repair requiring ECMO cannulation to his axillary artery. All three patients achieved spontaneous circulation after placement of assist devices.

Discussion

To our knowledge, a case report of transcaval or percutaneous axillary artery access for Impella CP[®] during cardiac arrest has not been published. While the long-term prognosis following cardiac arrest is poor, younger patients deserve every chance for survival with rapid cardiopulmonary support by alternative access if necessary. Advanced large bore alternative access techniques should be learned by all interventional operators.

Keywords

Alternative access • Cardiac arrest • Percutaneous left ventricular assist device • ECMO • Transcaval • Axillary artery access • Case series

Learning points

- Transcaval and percutaneous axillary artery access are safe alternatives studied in the setting of routine transcatheter aortic valve replacement for severe aortic stenosis.
- In the setting of cardiac arrest, interventional cardiologists should consider alternative access given the increased incidence of peripheral artery disease and other comorbidities that may preclude traditional femoral artery access.

Introduction

In the setting of cardiac arrest, arterial access is crucial for delivery of mechanical circulatory support devices such as an Impella CP[®] (Abiomed, Danvers, MA, USA) or cannulation for extracorporeal cardiopulmonary resuscitation (ECMO).^{1,2} When the femoral artery is inaccessible due to iliofemoral atherosclerosis, tortuosity, calcifications, abdominal aneurysm, or previous surgery, other approaches should be considered.³ Transcaval/caval-aortic and percutaneous axillary artery access have both been proven safe alternative access in

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patients undergoing transcatheter aortic valve replacement (TAVR) for severe aortic stenosis.^{3–5}

During transcaval access, the infrarenal aorta is accessed through the inferior vena cava typically at the L3–L4 disc space using an electrosurgical strategy with an 0.014" wire and serial escalation to deliver a large bore sheath. In patients with cardiogenic shock and preclusions to typical vascular access, transcaval access has been used successfully for delivery of mechanical circulatory support devices.⁶ Similarly, percutaneous axillary artery access is a feasible alternative for patients that require transcatheter intervention.⁵

The assist device—Impella CP[®] is an axial rotary pump capable of delivering up to 4.0 L/min at peak flow via a 14-Fr sheath.¹ Indications for Impella CP[®] placement include cardiogenic shock and as an adjunct for high risk percutaneous coronary intervention (PCI). The use of the Impella CP[®] has been published even in cases of refractory cardiac arrest.¹ Extracorporeal cardiopulmonary resuscitation provides heart lung bypass support which is crucial in the setting of cardiac arrest.² In this report, we describe three cases of cardiac arrest in which the emergent placement of an Impella CP[®] (Abiomed, Danvers, MA, USA) or cannulation for ECMO via transcaval approach and axillary approaches are instrumental in resuscitating patients from refractory cardiac arrest.

Timeline

Patient 1

A 59-year-old woman presents with anterior ST-elevation myocardial infarction
Emergent revascularization with left anterior descending artery (LAD) stent
Ventricular fibrillation with Advanced Cardiac Life Support (ACLS) protocol initiated

Transcaval access with delivery of Impella CP device

Return of spontaneous circulation

Acute in-stent thrombosis of LAD stent with second stent placed in the LAD

Transferred to intensive care unit (ICU) with transcaval closure 48 h after

Patient 2

A 67-year-old man with history of coronary vasospasm presents with chest pain

Complete heart block with inferior ST elevations seen on electrocardiogram

Ventricular fibrillation in the catheterization lab with ACLS protocol initiated

Left axillary artery access with Impella CP placement

Return of spontaneous circulation

Patent vessels with right coronary artery (RCA) vasospasm seen on coronary angiogram

Transferred to ICU

Patient 3

A 55-year-old man presents with chest pain

Two stents placed to obtuse marginal (OM) with chronic total occlusion (CTO) of RCA seen

Unsuccessful intervention to CTO of the RCA complicated by 5 min cardiac arrest

Next morning, pulseless electrical activity (PEA) arrest with placement of automated chest compression device

Left axillary artery access with initiation of extracorporeal cardiopulmonary resuscitation

Return of spontaneous circulation with bilateral pulmonary embolism (PE) seen on pulmonary angiogram

Transferred to the ICU

Case presentation

Patient #1

A 59-year-old woman with a previous history of coronary artery disease with posterior ST-elevation myocardial infarction (STEMI) in 2015 requiring percutaneous intervention to the right coronary artery (RCA) and proximal circumflex via right femoral arterial access presents with chest pain. Her other comorbidities include hypertension, non-insulin dependent diabetes, and active smoking. She presented to the emergency room 7 h after the onset of acute chest pain and shortness of breath. An initial electrocardiogram in the emergency department demonstrated ST elevations in leads V1–V4, consistent with an anterior STEMI. Emergent coronary angiography through right femoral artery access demonstrated a thrombotic occlusion of the mid left anterior descending artery (LAD). She was also noted to have a 90% stenosis in the mid RCA. A Resolute Onyx (Medtronic, Minneapolis, MN, USA) 2.5 × 15 mm drug-eluting stent was placed successfully in the LAD with restoration of thrombolysis in myocardial infarction 3 flow.

Shortly following intervention to the LAD, the patient developed rapid progressive hypotension and subsequent ventricular fibrillation arrest. Despite ongoing advanced life support protocol, the patient was unable to re-gain a perfusing rhythm. In consideration of Impella placement, right femoral angiography was performed and revealed diffuse vasospasm with lack of flow distal to the 6-Fr sheath in the right common femoral artery. Right subclavian artery access was attempted, but unsuccessful. Given ongoing cardiac arrest and lack of peripheral access options, the decision was made to proceed with emergent transcaval access for Impella CP[®] placement.

In addition to the 6-Fr sheath in the right common femoral artery, a 7-Fr sheath was placed in the right femoral vein. Abdominal aortic angiogram showed normal caliber aorta with minimal disease. Through the 7-Fr venous sheath, a 6-Fr renal length IMA guide catheter was advanced in the inferior vena cava at the L3 vertebral level. A 6-Fr JR4 guide catheter was then advanced into the descending aorta, and a 20 mm Gooseneck snare was advanced into the descending aorta at the L3 vertebral level. The IMA guide catheter was then directed towards the Gooseneck snare, with positioning confirmed on both AP and lateral views (Figure 1A). A mother–daughter system was utilized with an Astato XS 20 wire inside a piggyback wire inside a Navicross catheter. The mother–daughter system was then delivered to the tip of the IMA catheter. The back end of the Astato XS 20 wire was then activated with 50 W via an electrosurgical pencil on cut mode, with successful penetration across the IVC into the descending aorta. The Astato wire was then captured with the Gooseneck snare and advanced up the descending aorta. The piggyback wire and Navicross easily followed and the wires removed and Lunderquist wire delivered to the ascending aorta via the Navicross. The Navicross, IMA catheter and 7-Fr sheath were then removed from the right femoral vein, and a 16-Fr Cook sheath was then advanced through the R femoral vein and across the IVC into the descending aorta. A 5-Fr pigtail catheter was then delivered via the transcaval access and used to cross the aortic valve and deliver an 0.18" wire into the left ventricle. The Impella CP[®] was then advanced over the wire to proper positioning within the left ventricle.

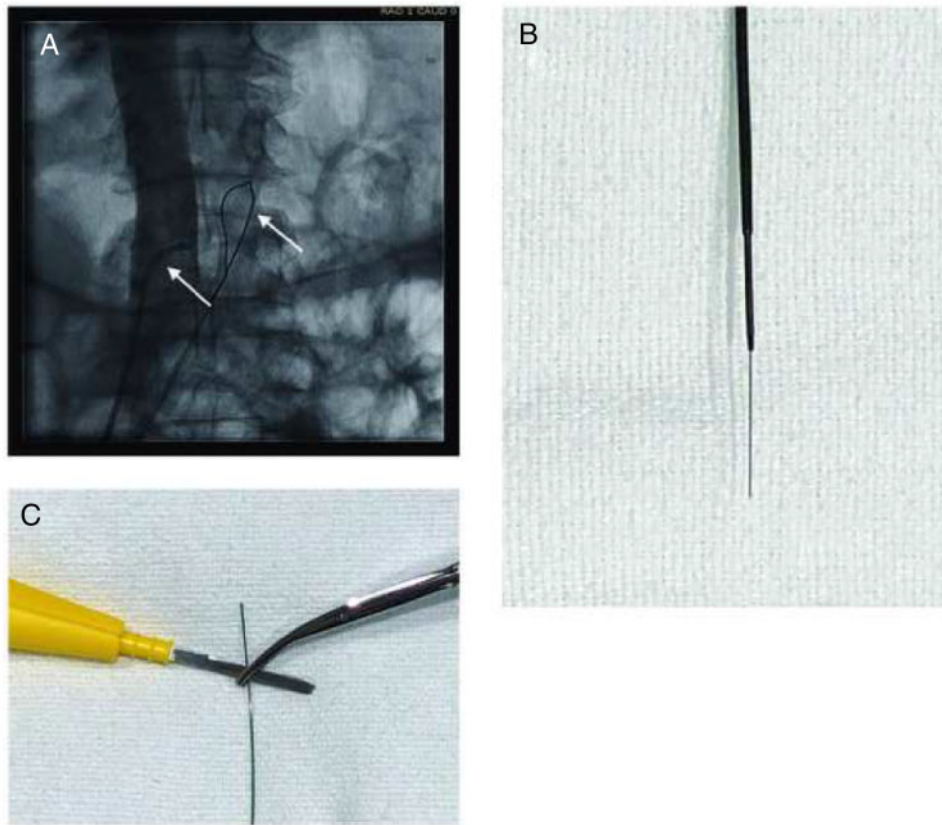


Figure 1 (A) A 20 mm goose neck snare visualized in the abdominal aorta and IMA catheter in the inferior vena cava. (B) Ex vivo of the mother/daughter system for transcaval access. The Astato XS 20 0.014 inch (Asahi, Aichi, Japan) wire advanced through an 0.035 inch PiggyBack Converter wire (Vascular Solutions, Minneapolis, MN, USA). This system is then advanced inside a NaviCross Support Catheter (Terumo, Somerset, NJ, USA). (C) Externalized wire clamped to the electro-surgical pencil.

Shortly after placement and activation of the Impella CP[®], the patient's haemodynamics improved and return of spontaneous circulation was achieved. Repeat coronary angiography showed acute in-stent thrombosis of the mid LAD stent. Following aspiration thrombectomy, a second Resolute Onyx 2.5 × 12 mm drug-eluting stent was successfully placed in the mid LAD with return of flow achieved. Upon transfer from the cath lab to the cardiac intensive care unit (ICU), the patient remained haemodynamically stable and demonstrated purposeful movements following prolonged cardiopulmonary resuscitation. She underwent successful transcaval closure with Amplatz 10/8 ADO (Abbott, Santa Clara, CA, USA) 48 h after Impella CP[®] insertion (Figure 2). Unfortunately, she developed unexpected recurrent cardiogenic shock and died days later.

Patient #2

A 67-year-old man with history of hypertension, hyperlipidaemia, active smoking, with known coronary artery, and peripheral arterial disease presents with acute chest pain. He has a history of plain old balloon angioplasty to left circumflex artery and RPLB with four Xience drug-eluting stents to his RCA in 2017 via right radial artery access. On his last heart catheterization, RCA vasospasm was seen in the setting of a non-ST elevation myocardial infarction with access

again through his right radial artery. Initial EKG in the field demonstrated ST elevation in leads V1, V2, and V3 which resolved on admission to the emergency room.

An hour later, patient's chest pain returned with intermittent complete heart block and new inferior ST elevation seen on electrocardiogram. He was taken to the catheterization lab where he developed cardiac arrest. CPR was initiated and patient was defibrillated for ventricular fibrillation. While anaesthesia was intubating the patient, right femoral artery access was attempted. Given the difficulty in advancing the wire, angiogram was done which showed complete occlusion of the right iliac artery (Figure 3A). The left iliac artery was similarly occluded (Figure 3B) and right radial and brachial access was unsuccessful with no pulsation seen on ultrasound.

After 45 min of CPR with persistent ventricular fibrillation and tachycardia arrest, left axillary artery access was attempted. An 18 gauge needle was inserted under ultrasound with guidewire with angiogram demonstrating patency of the axillary and subclavian arteries (Figure 4). Subsequent Impella CP[®] sheath placement was successful (Figure 5). Impella CP[®] was delivered to the left ventricle over a 0.018" wire. The mean arterial pressure increased to 80 mmHg with pulse regained minutes afterwards.

After return of spontaneous circulation, the right axillary artery was accessed under ultrasound guidance with insertion of a 6-Fr sheath for a left heart catheterization. Coronary angiogram showed patent right coronary arteries. There was spasm noted in the distal RCA that improved with intracoronary nitroglycerine similar to his last heart catheterization. Patient was transferred successfully to the ICU haemodynamically stable. He survived to discharge with no access site complications.

Patient #3

A 55-year-old man with diabetes, hyperlipidaemia, and no prior cardiac history presented with shortness of breath, syncope, and

exertional chest pressure. He underwent urgent heart catheterization for unstable angina. Angiography demonstrated chronic total occlusion (CTO) of his mid RCA. His culprit lesion was suspected to be an 85% stenosis of the obtuse marginal branch of his left circumflex artery. Patient underwent successful PCI with two overlapping Promus (2.5×20 mm and 2.5×16 mm) drug-eluting stents.

The next day, intervention was attempted on the CTO of the RCA. The Asahi Fielder XT 190 cm guidewire was advanced across the lesion. However, there was failure to cross the CTO with a micro catheter and balloon. Patient developed cardiac arrest during the procedure requiring 5 min of CPR with initial ventricular rhythm. Post arrest, he returned to his baseline and did not require intubation.



Figure 2 Final aortic angiography performed 48 h after Impella® insertion after removal of aorta and transcaval closure with Amplatz 10/8 ADO demonstrating no contrast extravasation.



Figure 4 Angiogram of left axillary artery into the subclavian.



Figure 3 (A) Right iliac artery occlusion seen on angiogram. (B) Left iliac artery occlusion.

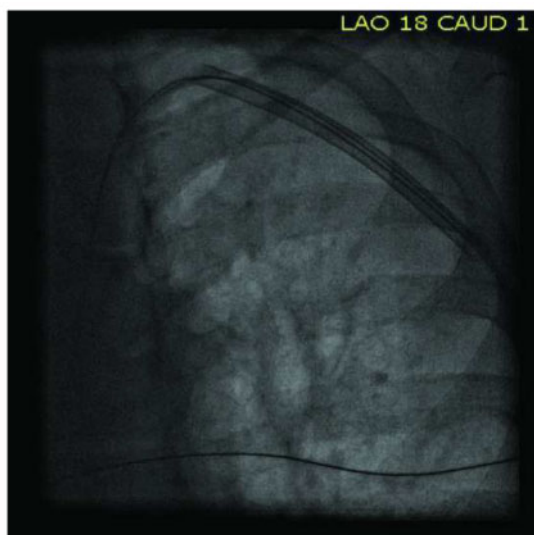


Figure 5 Impella sheath placement in the left axillary artery.

The following morning, patient became unresponsive when he walked to the restroom. Cardiac arrest protocol was initiated when nursing staff could not palpate a pulse. Initial code was PEA arrest for 5 min until return of circulation. Patient was transferred to the ICU where he developed refractory PEA arrest. An automated chest compression device was placed with decision by cardiothoracic surgery and cardiology to proceed with emergency ECMO.

Given challenges from morbid obesity and haematoma from recent catheterizations, femoral arterial access was unsuccessful. Left axillary artery became an option given the severity of disease and lack of other viable access sites. Under ultrasound, arterial access was gained with a guidewire placed down the left axillary artery. The vessel was dilated and a 15-Fr Bio-Medicus cannula was placed with venous cannulation from the femoral vein. Flow increased to 4 L/min and pressures increased to a mean arterial pressure of 53 mmHg allowing discontinuation of the CPR machine.

Subsequent pulmonary angiography demonstrated massive bilateral pulmonary embolism as the cause of his cardiac arrest. Patient underwent catheter directed lytic therapy while on ECMO by interventional radiology. While haemodynamic stability was achieved, he never recovered neurological function leading to palliative withdrawal of care.

Discussion

Transcaval and axillary artery access are both well described in the setting of routine TAVR for severe aortic stenosis.³⁻⁵ However, the use of transcaval access and percutaneous axillary artery access in the setting of active cardiopulmonary resuscitation has not previously

been described. As the incidence of peripheral arterial disease and comorbidities within the population increases, the necessity of novel approaches to vascular access for a variety of endovascular procedures is becoming more common. This series highlights three cases where the patient's short-term survival was dependent on alternative access. While alternative access approaches are becoming more common in the structural interventional community, these techniques should also be considered by all interventional cardiologists for delivery of large bore ventricular assist devices used in high risk PCI and shock.

Lead author biography



Charles Q. Cui is a graduate of the University of Louisville School of Medicine. He completed his internal medicine training at Virginia Commonwealth University and is currently a cardiology fellow at Carilion Virginia Tech School of Medicine in Roanoke, Virginia with an interest in interventional and structural cardiology.

Supplementary material

[Supplementary material](#) is available at *European Heart Journal - Case Reports* online.

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

Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: J.R.F. is a proctor for Medtronic and Edwards. C.Q.C. and B.S.C. have declared no conflict of interest.

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