Specific clinical vignettes in high-risk protected percutaneous coronary intervention

Vasileios Panoulas1,2*, Sian-Tsung Tan1, Jonathan Hill1, and Giuseppe Tarantini3

1Department of Cardiology, Royal Brompton and Harefield Hospitals, Guy’s and St Thomas’ NHS Foundation Trust, Harefield Hospital, London, Harefield, UB9 6BJ, UK; 2Cardiovascular Sciences, National Heart and Lung Institute, Imperial College London, UK; and 3Department of Cardiac, Thoracic, Vascular Sciences and Public Health, University of Padua Medical School, Italy

KEYWORDS
pVAD; Complete revascularization; Imaging; Debulking

There are several cardiac- and patient-related factors that come into play when considering patients for protected percutaneous coronary intervention (PCI). Cardiac factors include complexity/location of coronary lesions, the degree of left or right ventricular impairment, and ventricular arrhythmias. Patient related factors include comorbidities that would render the patient at a higher risk of death should cardiogenic shock ensue during the procedure. Comorbidities include chronic lung disease (chronic obstructive airways disease, asthma, pulmonary fibrosis), renal or liver impairment, other cardiovascular diseases (such as previous cerebrovascular accident or transient ischemic attack, peripheral arterial disease, carotid stenosis), diabetes, frailty and advanced age. Here, we present three very different cases where left ventricular support was deemed appropriate to reduce peri-procedural risk and optimize outcomes.

Introduction

The Impella (Abiomed, Danvers, USA) percutaneous microaxial left ventricular assist device (pVAD) has been established as a clinical tool with the potential to reduce major adverse clinical events in high-risk patients requiring percutaneous coronary intervention (PCI).1 Several cardiac and patient related factors come into play when considering patients for protected PCI. Cardiac factors include complexity/location of coronary lesions, the degree of left or right ventricular impairment, and the presence of valvular lesions and/or ventricular arrhythmias. Patient-related factors include comorbidities that would render the patient at a higher risk of death should cardiogenic shock ensue during the procedure. Such complex patients should always be discussed by an experienced heart team to decide upon the best revascularization strategy and whether there is a need for left ventricular (LV) support.2 Herein, we present three very different cases where LV support was deemed appropriate to reduce peri-procedural risk and led to optimal outcomes.

Case 1

An 88-year-old male who was independent in all daily activities, walking without aid and living alone, presented to his local hospital with non-ST elevation myocardial infarction and decompensated heart failure. His electrocardiogram showed ST depression globally, and his echocardiogram showed significant LV impairment with ejection fraction (EF) at 30% alongside low-flow, low-gradient severe aortic stenosis with dimensionless index of 0.2, area 0.8 cm2, and flow rate of 141 mLS/sec (Figure 1). There was moderate mitral regurgitation (MR) present.
Figure 1 Case of severe aortic stenosis, with significant LV systolic impairment, critical calcified left main stenosis (last remaining conduit) and tortuous thoracic aorta.

Figure 2 Intravascular lithotripsy to the calcific left main lesion, performed with left ventricular support with the use of Impella CP, leading to robust angiographic and intravascular ultrasound results.
His CT revealed a perimeter of 86 mm with an area of 564 mm², the ostia of the coronaries were at a satisfactory distance from the aortic annulus, and there were good calibre iliofemorals albeit with some mild tortuosity. The descending aorta had a significant kink (Figure 1); however, there was no calcification at that point.

Coronary angiogram revealed critical calcific left main stem stenosis, diffuse calcific atheroma in the remaining vessels with moderate mid circumflex and proximal obtuse marginal disease, and a chronic total occlusion of the right coronary artery (RCA, Figure 1).

His case was discussed in the multidisciplinary heart team (MDT), and we agreed that the best way forward for this male would be protected PCI followed by transcatheter aortic valve implantation (TAVI) using single access.

The case was carried out under local sedation. Initially, we performed balloon valvuloplasty with a 20 mm VACS II valvuloplasty balloon catheter (OSYPKA, Germany) at 200 bpm, and subsequently we positioned the Impella CP in the left ventricle (LV). The left main stem (LMS) lesion was initially tackled with 2.5 semi-compliant and 3.5 non-compliant balloons followed by intravascular lithotripsy (IVL) using a shockwave 3.5×13 mm balloon (ShockWave Medical, CA, USA) (Figure 2). A 4.0×12 mm Promus Elite (Boston Scientific, MA, USA) stent was implanted at 16 atm and post-dilated with a 4.0 NC to 10 atm. Intravascular ultrasound (IVUS) showed well-apposed and expanded stent covering the LMS ostium (Figure 2). Given the absence of any haemodynamic instability, the Impella CP was then removed through the Peel away sheath, and the Edwards E-sheath (Edwards Lifesciences, CA, USA) was positioned in its place. The aortic valve was then crossed again with an AL1 catheter and a straight wire, and the latter was exchanged for a Confida Brecker stiff guidewire (Medtronic, Dublin, Ireland). An Edwards SAPIEN 3 29 mm valve (Edwards Lifesciences, CA, USA) was implanted at optimal height with no immediate complications (Figure 3).

His post-procedural day-2 echocardiogram revealed well-seated TAVI with trivial paravalvular leak and a peak gradient of 19 mmHg and MG 7 mmHg with an LVEF that improved to 40% with a reduction in MR to only mild.

He was discharged day-3 post procedure and is doing well 1-year post with no significant cardiovascular symptoms.

Case 2

A 75-year-old male with a background of hypertension, hypercholesterolaemia and benign prostate hyperplasia presented to his local hospital with a non-ST elevation myocardial infarction. A coronary angiogram showed severe distal left main, proximal left anterior descending (LAD), and left circumflex (LCx) disease. The RCA was small and non-dominant. His echocardiogram at the time was showing a preserved LV with mild aortic and MR. He was subsequently transferred to our institution for surgical assessment and treatment. The heart team agreed that surgery would be in his best interests.

He underwent off-pump surgery with left internal mammary artery (LIMA) to LAD and vein graft to a small calibre obtuse marginal (OM) and was extubated and stepped down to a high dependency unit on the same day. However on day 3 post-op, he developed pulmonary oedema and cardiogenic shock with dynamic global ST depression and severe LV failure (EF 15%). His lactate was rising to 4.5 mmol/L, and his inotropic requirements were increasing. He was therefore urgently transferred to the catheter laboratory for an emergency angiogram. This showed an occluded vein graft to OM and a LIMA graft that appeared constricted at the side of the anastomosis with the LAD (Figure 4). His natives revealed tight
calcific distal LMS, ostial LAD, and ostial LCx disease, whereas there was significant diffuse disease throughout his LAD (Figure 4).

The decision was made to proceed to PCI to LMS bifurcation using Impella CP support and T and protrusion (TAP) two-stent strategy. The Impella CP was implanted...
via the right transfemoral route with some difficulty due to extensive tandem stenosis and calcification at the level of the right common iliac. We used two BMW wires (Abbott, IL, USA) and predilated lesions in proximal-mid LAD, LMS, and LCx with a 2.5 and 3.0 mm semi-compliant balloons. The proximal-mid LAD was first stented with a 3.0 × 28 mm Xience Sierra stent (Abbott, IL, USA) (Figure 5). The LMS into LCx was stented with a 3.5 × 28 mm Xience Sierra drug eluting stent, and LMS was dilated with a 4.0 mm non-compliant balloon to 20 atm. The LAD was re-crossed and kissing balloon inflation performed with 3.5 mm semi-compliant balloons in both LAD and LCx (Figure 5). The ostial LAD lesion was covered with a 3.5 × 28 mm stent using the TAP technique. Final kissing balloon with 3.5 semi compliant balloons and POT with 4.5 NC to LMS was performed (Figure 5). IVUS showed well-apposed and expanded stents with MSA of 14.2 mm.²

He made a good recovery, and the Impella CP was explanted at the bedside 3 days later using two Prostyles (Abbott, IL, USA). His LV recovered to 40% pre-discharge 9 days following the percutaneous procedure.

Case 3

An 83-year-old female with a history of hypertension, dyslipidaemia, strong familial hypercholesterolemia (FH) of ischemic heart disease (IHD), and a previous TIA was admitted to her local hospital with significant dyspnoea due to congestive cardiac failure (CCF). She was treated for an NSTEMI and CCF. Her troponin was elevated at 12 700 ng/L.

An echo showed moderate LV dilatation with severe LV impairment (EF 30%), moderate right ventricular systolic dysfunction with severe MR and moderate TR. Stress cardiovascular magnetic resonance (CMR) confirmed these findings and identified global inducible ischaemia. Coronary angiography showed chronic total occlusion (CTO) of the mid RCA, tight calcific proximal and distal left main, tight proximal LAD which is followed by an aneurysmal segment, and proximal to mid calcific LCx disease.

Initial attempts to cross the lesion with a 1.0 Sapphire II PRO (Orbus Neich, Hong Kong, China) balloon failed; hence Rotablation (1.5 burr) (Boston Scientific, CA, USA) and Shockwave IVL (3 × 12 balloon) were needed to carry out successful calcium modification of the significant LMS/LAD disease and facilitate IVUS guided deployment of drug eluting stents (overlapping 3.5 × 38 and 2.5 × 18 Xience Sierra) (Figure 6).

Given the long procedure time, decision was made to review patient symptomatically and repeat stress CMR and echocardiogram to assess the need for further intervention in RCA CTO and non-dominant LCx and reassess the severity of mitral valve disease.

The Impella CP was removed at the end of the case, and haemostasis was achieved using two Prostyles and an 8F Angio-Seal (Terumo, Tokyo, Japan). She went home 5 days later in a good functional status.

Discussion

Despite the ongoing debate on the appropriate patient selection for pVAD support, it is has become evident
that pVAD support in certain high-risk groups can aid more complete revascularization, which subsequently leads to improved outcomes.3

In the above clinical vignettes, we presented a series of cases, each one with their own unique challenges. Significant valvular disease is often present in patients with poor LV and complex coronary artery disease. The feasibility of pVAD implantation in patients with severe aortic stenosis, poor LV function, and critical complex coronary artery disease has been demonstrated in a recent case series.4 Patients post-coronary artery bypass surgery with acute graft occlusion can be very challenging to treat, as cardiogenic and distributory shock can often be present concomitantly. In the case presented herein, we deployed pVAD support prior to any coronary intervention5 in order to stabilize the patient haemodynamically as he was already in Society for Cardiovascular Angiography and Intervention (SCAI) D shock.6 The third case shows the importance of pVAD support in cases where extensive decalcification with rotation and IVL7 in a last or major remaining conduit is required. Such cases have been labelled in recent case reports as ‘Rota-Shock-Pella’ cases.8

In conclusion, there are several occasions where LV support with pVAD use can facilitate complex PCI in various subgroups of high-risk patients. Protected PCI leads to more complete revascularization including optimal bifurcation strategies, thorough decalcification and stent optimization with the use of intracoronary imaging.

Acknowledgements
This manuscript is one of eight manuscripts published as a Supplement to address best practices for Impella protected PCI. JetPub Scientific Communications, LLC, supported by funding from Abiomed Europe GmbH, provided editorial assistance to the authors during preparation of this manuscript.

Funding
This work has been supported by the Abiomed Europe GmbH to cover publication costs as well as professional language editing of each manuscript. No individual fees were paid to the authors in the generation of this publication. This paper was published as part of a supplement financially supported by Abiomed GmbH.

Conflict of interest: G.T.: Grant funding from Abiomed; Consulting fees from Abiomed, GADA, Edwards Lifesciences, Abbott Vascular, Medtronic, Boston Scientific; Honoraria from GADA, Edwards, Abbott, Boston Scientific, Teleflex, Terumo, Chiesi, Daichii, Sankyo, Etikon. J.H.: Grant funding from Abbott Vascular, Abiomed, Boston Scientific; Consulting fees from Shockwave, Abbott Vascular, Boston Scientific, Abiomed; Honoraria from Shockwave, Abbott Vascular, Boston Scientific, Abiomed; Advisory Board at Shockwave, Abbott Vascular, Boston Scientific, Abiomed; Travel support from Shockwave. V.P.: Consulting fees from Abiomed; Honoraria from Abiomed. N.V.M.: has received research grants from Abbott Vascular, Boston Scientific, Biotronic, Edwards Lifesciences, Medtronic, Pulse Cath BV, and Abiomed.

Data availability
The data underlying this article will be shared on reasonable request to the corresponding author.

References
1. Dangas GD, Kini AS, Sharma SK, Henriques JP, Claessen BE, Dixon SR, et al. Impact of hemodynamic support with Impella 2.5 versus intra-aortic balloon pump on prognostically important clinical outcomes in patients undergoing high-risk percutaneous coronary intervention (from the PROTECT II randomized trial). Am J Cardiol 2014; 113:222-228.
2. Chieffo A, Dudek D, Hassager C, Combes A, Gramegna M, Halvorsen S, et al. Joint EAPCI/ACVC expert consensus document on percutaneous ventricular assist devices. Eur Heart J Acute Cardiovasc Care 2021; 10:570-583.
3. Burzotta F, Russo G, Ribichini F, Piccoli A, D’Amario D, Paraggio L, et al. Long-term outcomes of extent of revascularization in complex high risk and indicated patients undergoing Impella-protected percutaneous coronary intervention: report from the RomaVerona registry. J Interv Cardiol 2019;2019:5243913.
4. Panoulas V, Greenough N, Sulemane S, Monteagudo-Vela M, Lees N. The role of mechanical circulatory support in patients with severe left ventricular impairment treated with transcatheter aortic valve implantation and percutaneous coronary intervention. Cardiovasc Revasc Med 2021; 285:169-175.
5. Iannaccone M, Franchin L, Hanson ID, Bocuzzo G, Basir MB, Truesdell BV, and Abiomed. Timing of Impella placement in PCI for acute myocardial infarction complicated by cardiogenic shock: an updated meta-analysis. Int J Cardiol 2022; 362:47-54.
6. Baran DA, Grines CL, Bailey S, Burkhoff D, Hall SA, Henry TD, et al. SCAI Clinical expert consensus statement on the classification of cardiogenic shock: this document was endorsed by the American College of Cardiology (ACC), the American Heart Association (AHA), the Society of Critical Care Medicine (SCCM), and the Society of Thoracic Surgeons (STS) in April 2019. Catheter Cardiovasc Interv 2019;94:29-37.
7. Hill JM, Kereakes DJ, Shlomfritz RA, Klein AJ, Riley RF, Price MJ, et al. Intravascular lithotripsy for treatment of severely calcified coronary artery disease. J Am Coll Cardiol 2020;76:2635-2646.
8. Chan KCA, Luk NHV, Lee KYM, Chan KT. A case of rota-shock-pella. JACC Case Rep 2019;1:765-770.