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Perceval prosthesis implantation into challenging degenerated aortic valves: a literature review and case series

Pouya Nezafati[1], Chimezi Uchime[2] and Sumit Yadav[2,3*]

Abstract

Background The Perceval Sutureless prosthesis can increase the effective orifice area (EOA) and reduce the chance of prosthesis–patient mismatch (PPM). This report presents three patients with challenging degenerated bioprosthetic valves undergoing redo aortic valve replacement (rAVR) using the Perceval (LivaNova, London, UK) prosthesis from a cohort of more than 300 performed cases and a review of the literature on the management of challenging degenerated valves.

Methods Case 1: Degenerated 23 mm Trifecta with the valve cage densely adherent to the annulus. Cage with sewing ring were excised and annulus sized to a large Perceval valve. Case 2: Degenerated 29 mm Epic from a Bentall's procedure. Calcified and rigid prosthetic leaflets as well as stent posts were excised and XL Perceval implanted. Case 3: Degenerated 27 mm Epic with signs of endocarditis from a history of Bentall's procedure. Three calcified leaflets of the Epic valve were completely excised. The orifice accepted a medium Perceval.

Results The total Cardiopulmonary Bypass (CPB) and aortic cross clamp (ACC) times (in minutes) were 99.76, 117.68 and 143.99 in Cases 1, 2 and 3, respectively. Moreover, post-implantation transesophageal echocardiogram (TOE) demonstrated a well-seated valve, no paravalvular leak in all cases and a peak gradient of 12.7 mmHg, 14.8 mmHg and 17.7 mmHg in Cases 1, 2 and 3, respectively.

Conclusion The Perceval prosthesis is an excellent choice for rAVR, as it can safely simplify challenging cases at risk of PPM and is an excellent valve-in-valve alternative to degenerated or infected Bentall valves with patent graft. The Perceval prosthesis can be well seated on the different structures of a degenerated bioprosthetic valve.

Keywords Perceval, Degenerated aortic valve, Aortic valve replacement

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Background

Surgical aortic valve replacement (sAVR) using bioprosthetic valves is often favoured over mechanical valves due to the avoidance of anticoagulation and hence the lower risk of bleeding and thrombotic events [1]. However, due to their lower durability, their use results in more patients presenting with prosthetic valve degeneration needing valve re-replacement [2]. Surgical and non-surgical sutureless AVR are minimally invasive options with fewer complications associated with redo AVR (rAVR) operations for the treatment of degenerated bioprosthetic valves [3].

Although non-surgical sutureless valve-in-valve (ViV) transcatheter AVR (TAVR) is increasingly used, it has significant limitations [4, 5], including the application of TAVR on an externally mounted valve with a higher chance of obstructing coronary ostia, inadequate annulus size (< 18 mm, > 29 mm), plaques with mobile thrombi in the ascending aorta, inadequate vascular access for the transfemoral or subclavian approach, haemodynamic instability and severe Left Ventricular (LV) dysfunction.

Moreover, ViV TAVR generally entails higher readmission rates than redo sAVR [6] and long-term ViV TAVR outcomes (more than five years) are still awaited. Guidelines still recommend the use of sAVR and the consideration of Transcatheter Aortic Valve Implantation (TAVI) for very high-risk older patients [4, 7].

Surgical sutureless AVR using the Perceval prosthesis, which comprises bovine pericardium leaflets built upon a collapsible nithiol stent frame, was first implanted in 2007 [8]. The Perceval prosthesis has attracted considerable attention due to its numerous benefits, including a decrease in cardiopulmonary bypass (CPB) and aortic cross clamp (ACC) time, compared to other surgical aortic valves [9, 10]. Moreover, by eliminating the sewing ring at the valve base with no annular sutures required, sutureless valves can increase effective orifice area (EOA) and significantly improve gradients after reoperation of a degenerated aortic valve [11].

This report presents three patients with challenging degenerated bioprosthetic valves undergoing rAVR using the Perceval (LivaNova, London, UK) prosthesis by a single surgeon from a cohort of more than 300 performed cases. The post-operative prosthesis haemodynamic performance was excellent in all cases.

Methods and results

Informed consent for the publication of this study was obtained from the patients.

Case series

Case 1

A 70-year-old man with a body surface area (BSA) of 1.88 m^2, eight years following an AVR with a 23 mm Trifecta valve for severe symptomatic aortic stenosis (AS) in 2015, presented with heart failure symptoms secondary to a degenerated bioprosthetic valve. His echocardiogram revealed severe aortic regurgitation and moderate AS, with peak and mean gradients of 81 mmHg and 47 mmHg, respectively (left ventricular ejection fraction (LVEF): 65%).

Right femoral arterial and right atrial appendage cannulations were performed. After the application of the cross clamp, the heart was arrested in diastole with cardioplegia delivered via a root vent.

Following aortotomy, a highly calcified and degenerated trifecta with signs of pannus on the valve ring involving the anterior aortic leaflet was removed. The valve cage was densely adherent to the annulus and was mobilised in the endarterectomy plane and taken out in the cage first (Fig. 1a) and the stitches as well as the swing ring in the second step. The annulus was debrided of calcification and pledgers. The annulus was sized using a large Perceval sizer.

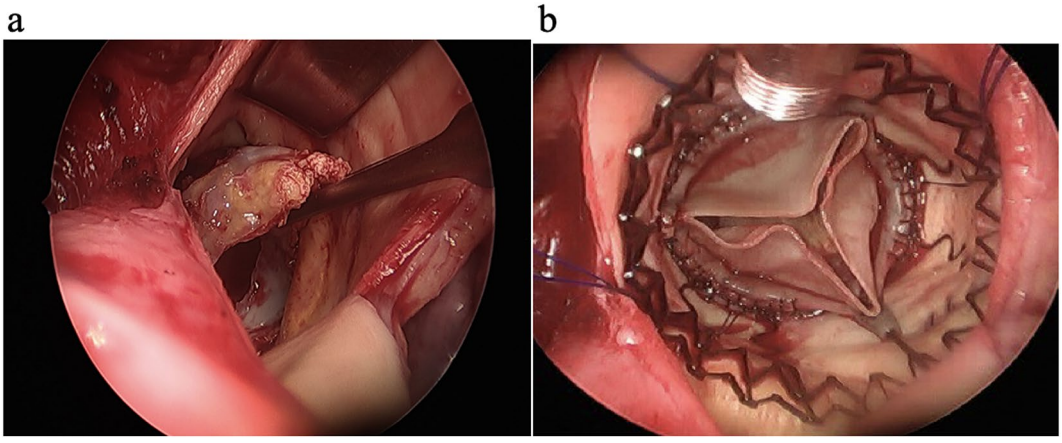

Fig. 1 (**a**) Stepwise complete excision of Trifecta valve (**b**) Large Perceval Implanted onto the annulus

Using the unfolded valve leaflets and expanded valve frame, the Perceval prosthesis was implanted (Fig. 1b). The aortotomy was closed in two layers. We implanted the prosthesis in 99 min (cardiopulmonary bypass (CPB) time) and 76 min (ACC time).

A post-operative transesophageal echocardiogram (TOE) demonstrated a well-seated valve and no paravalvular leak with a peak gradient (PG) of 12 mmHg and a mean gradient (MG) of 7 mmHg.

Case 2

A 65-year-old man with a BSA of 2.11 m^2 (weight: 156 kg, height: 184 cm) on a background of Bentall's procedure with a 29 mm Epic valve and a 32 mm Valsalva graft in 2013 for a severely regurgitant bicuspid aortic valve and a 57 mm dilated aortic root. Ten years after his operation, he presented with acute on chronic New York Heart Association (NYHA) IV heart failure symptoms a few months prior to his redo surgery. Initially, a TAVI had been planned; however, due to acute decompensation of heart failure, a decision was made to proceed with sAVR. TOE findings suggested mixed severe AS and moderate regurgitation, with a PG of 66 mmHg, an MG of 39 mmHg, an LVEF of 50%, an aortic valve area (AVA) of 1.6 cm^2 and a normal-looking aortic root and ascending aortic prosthetic.

Routine sternotomy, cannulation, cross clamp and cardioplegia were performed as in Case 1.

Aortotomy was performed, and degenerated calcified, rigid prosthetic leaflets were excised and the valve was sized as medium. To overcome a highly probable prosthesis–patient mismatch (PPM), the decision was made to excise the valve stent posts and size the annulus again (Fig. 2a), and this time an XL Perceval was indicated, which was implantable with three 3 – 0 Prolene sutures (Fig. 2b). Coronary ostia was confirmed to be far from the Perceval valve leaflet for future TAVI. The aortotomy was closed in two layers. The AVR lasted 117 min (CPB) and 68 min (ACC). A post-operative TOE demonstrated a well-seated valve, no paravalvular leak, a PG of 14 mmHg and an MG of 8 mmHg.

Case 3

A 73-year-old man with a BSA of 2.11 m^2 underwent a Bentall's procedure with 27 mm Epic and 32 mm Valsalva graft and left atrial appendage (LAA) ligation in 2014 for a native bicuspid aortic valve, aortic aneurysm of 64 mm and permanent atrial fibrillation (AF). Four years later, he presented with NYHA II symptoms and echo findings suggestive of a heavily calcified bioprosthetic valve with a severe trans-valvular aortic valve eccentric regurgitation mostly directed anteriorly, representing chronic healed endocarditis with a PG of 71 mmHg, an MG of 41 mmHg, an AVA of 1.1 cm^2, an LVEF of 60% and an aortic root and ascending aortic prosthetic that looked normal.

The severe aortic regurgitation due to degeneration of the prosthetic valve was attributed to infective endocarditis (IE) with *Streptococcus salivarius* for which the patient received six weeks of antibiotics with serial negative blood cultures and underwent surgery.

Routine sternotomy, cannulation, cross clamp and cardioplegia were performed as in Case 1.

A transverse aortotomy was performed to access the aortic valve. An examination of the aortic bioprosthesis showed that the three calcified leaflets of the Epic valve were completely calcified, with no clear endocarditis morphological signs. Valve leaflets were excised. The orifice accepted a medium Perceval sizer. Three 3 – 0 Prolene sutures were placed midway between each of the Epic prosthetic struts (Fig. 3a). The introduction of the prosthesis into the annular area was performed using a valve-in-ring method, and the self-expandable Perceval M prosthesis was cautiously released (Fig. 3b). The aortotomy was closed in two layers. The prosthesis was implanted in 143 min (CPB) and 99 min (ACC).

Post-operative TOE demonstrated a well-seated valve, no paravalvular leak, PG of 17 mmHg and a MG of 7 mmHg.

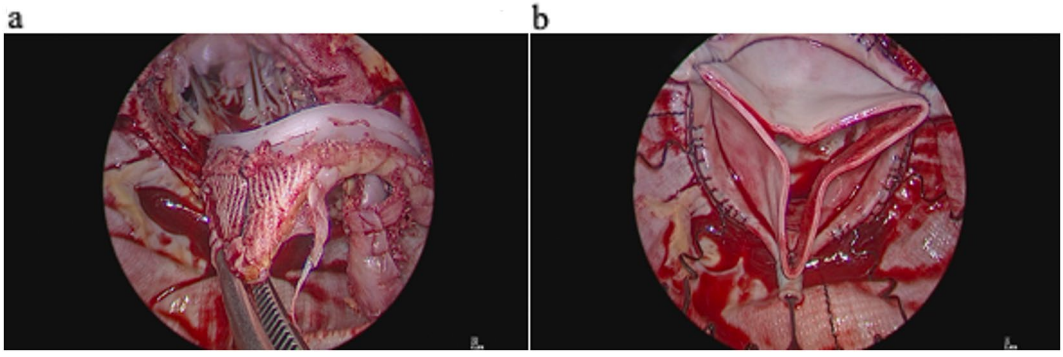

Fig. 2 (**a**) Excision of Epic stent posts from a Valsalva graft (**b**) X-Large Perceval implanted onto the Valsalva graft

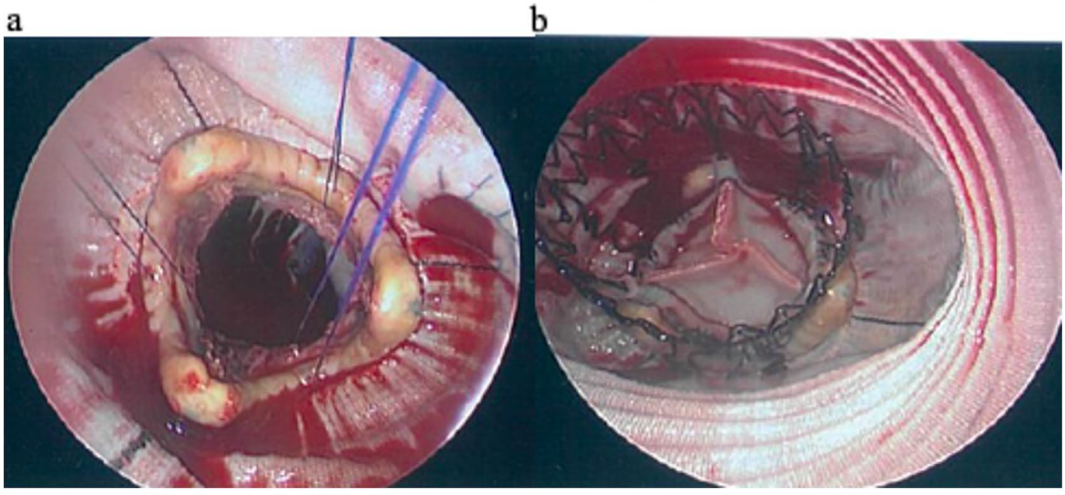

Fig. 3 (**a**) Excision of Epic Leaflets and placement of stay sutures (**b**) Implantation of Medium Perceval onto Stent posts

Discussion

Perceval prosthesis in degenerated trifecta valve with a high risk of PPM

The Trifecta valve, a biological prosthesis with external mounted leaflets, is famous for its excellent post-operative haemodynamic performance [12]. It was reported to be a great valve for smaller sized annuli, which creates a large EOA. PPM is defined when the EOA is too small relative to the body size, and the use of the Trifecta valve has been highly encouraged for this purpose. Nonetheless, the durability of the Trifecta valve has recently become a concern, with studies reporting significantly higher rates of short-term structural valve degeneration (SVD) in Trifecta valves compared to other bioprosthetic valves [13]. Subsequently, more symptomatic degenerated Trifecta valves with small native annuli have been presented, which require challenging rAVR.

The Perceval prosthesis is rapidly deployed and the elimination of sutures, as well as the absence of a sewing cuff, can provide an excellent EOA and better haemodynamic performance, which makes this valve an ideal replacement for smaller annuli valves [11] as in Case 1, where the indication for the use of the Trifecta valve in the initial operation was to overcome PPM due to small annuli. The same discussion applies to the use of the Perceval prosthesis in morbidly obese patients with a high BSA and therefore a high chance of PPM, which requires the most optimal EOA post rAVR as in Case 2. Furthermore, promising findings of up to 10 years have been reported for all sizes of Perceval prostheses, with an MG of 13 mmHg [14].

Moreover, due to the rigid sewing cuff and an externally mounted valve, ViV TAVI is challenging and requires a smaller size valve compared to that of the Trifecta valve, which can result in reduced haemodynamic performance and PPM [15], especially in smaller annuli (< 21 mm) [16]. In addition, since the Trifecta valve has a tall, wide externally mounted stand, expansion with ViV TAVI could cause obstruction on the coronary ostia [17].

Perceval on previous bentall procedure

Management of degenerated valves on previous Bentall procedures can be challenging, as in many circumstances, coronary artery reimplantation and redo of the root are required. In cases of patent graft, however, valves can be replaced with different approaches using a Perceval prosthesis. As reported in this paper, one approach is to excise the valve leaflet only, as the Perceval prosthesis, with its unique cage design and no sewing cuff, can still provide maximum EOA and avoid PPM. Therefore, the remainder of the previous valve can stay in place to avoid unnecessary hazards to the homograft or its structures. Moreover, it has been reported that excision of stent posts can cause significantly longer CPB and ACC time [16, 18, 19]. Stent posts can remain in situ when a ViV Perceval prosthesis is implanted, which provides a great EOA, as in Case 1.

The use of the Perceval prosthesis and homograft has attracted considerable attention, to the point that sutureless biological Bentall has been described as a novel technical modification to the manufactured biological Bentall that not only simplifies the operation itself but also facilitates surgical re-intervention with TAVI in the future [20].

Perceval in prosthetic valve endocarditis (PVE)

Despite advances in early PVE management and diagnosis, rAVR for PVE is challenging and associated with high mortality (20–30%) [21]. Rapid deployment valves are used in the redo setting for IE – as performed in Case 1 using a valve-in-ring technique – as a new perspective,

possibly due to a decent quality of the root, the absence of root abscess and no pre-operative paravalvular leak.

Furthermore, the Perceval prosthesis has the advantage of not including foreign materials, such as pledgets and sutures, reducing the risk of recurrent IE, as recurrence of PVE is a serious and common concern after rAVR [21]. Studies have also reported that cuff fabric can play an important role in the occurrence of PVE [22].

ViV TAVR is ineffective for PVE cases requiring reconstruction and extensive debridement and is thus considered a contraindication [4, 7].

The prosthesis implantation is contraindicated in the following cases: (a) patients with aortic root enlargement, where the ratio of observed to expected diameters (calculated according to age and body surface area) is ≥1.3; (b) patients with a known allergy to nickel alloys; and (c) patients with aneurysmal dilation or dissection of the ascending aortic wall that necessitates surgical intervention. It is to note that implantation of Perceval onto Stenotic Bicuspid Aortic Valves is not a contraindication yet shown to be associated with technical challengesl. A detailed analysis of aortic root geometry, along with certain technical considerations—especially proper decalcification of the aortic annulus and accurate sizing—has identified key prerequisites for this success [23].

Conclusion

The Perceval valve is an excellent choice for rAVR, as it can safely simplify challenging cases with pre-existing small aortic annuli, a previous Bentall procedure or an infected bioprosthetic valve. It can be well seated on different structures of a degenerated bioprosthetic valve; therefore, different structural levels of the degenerated valve can be excised to achieve optimal EOA.

The design of the Perceval prosthesis provides high haemodynamic performance for small annuli valves; therefore, it is a great valve for the treatment of recently concerning degenerated Trifecta valves – where the initial indication for their implantation was on small annuli to overcome PPM – as well as in patients with a high BSA. In addition, in cases of patent Bentall graft, the degenerated valve can be replaced with a Perceval prosthesis in different fashions by implanting it after excising only the leaflets. Furthermore, the absence of foreign materials, such as sutures and pledgets, decreases the risk of recurrent IE on PVE.

Moreover, this sutureless rapid deployment valve can reduce the CPB and ACC time, which are especially prolonged in redo operations. This can further lower systemic inflammatory reactions associated with CPB and minimise organ failure.

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PN: writing manuscript, revising; CH: revising manuscript; SY; data collection, finalizing manuscript.

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Data availability
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Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Written informed consent was obtained from all participants.

Competing interests
The authors declare no competing interests.

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