Brief Report

A Word of Caution: Aorto-Right Ventricular Fistula, an Uncommon Pitfall of Perceval Sutureless Valve

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A Word of Caution: Aorto-Right Ventricular Fistula, an Uncommon Pitfall of Perceval Sutureless Valve

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Abstract

Background: Aorto-right ventricular fistula (ARVF) secondary to membranous septum rupture is an exceptionally rare complication after surgical aortic valve replacement (SAVR). While sutureless prostheses such as the Perceval valve have gained wide acceptance due to reduced cross-clamp times and procedural simplification, reported adverse events predominantly include conduction disturbances and paravalvular leaks. Structural septal disruption remains sparsely described. We report a case of early ARVF after Perceval implantation and review the pathophysiological and procedural mechanisms implicated in septal injury following sutureless and transcatheter aortic valve interventions. Case Description: A 66-year-old woman with severe bicuspid aortic valve stenosis underwent SAVR via median sternotomy using a Perceval XL prosthesis after meticulous annular decalcification and sizing. Immediate intraoperative transesophageal echocardiography (TEE) confirmed optimal seating without paravalvular regurgitation. Within 24 hours, the patient developed complete atrioventricular block followed by cardiogenic shock. Repeat TEE revealed a large ARVF with significant left-to-right shunt. Emergent re-exploration identified a membranous septum tear. The Perceval prosthesis was explanted, the defect closed with reinforced patch repair, and a 27 mm Inspiris Resilia bioprosthesis was implanted. Peripheral veno-arterial ECMO support was required temporarily. The patient recovered and remained free of prosthetic dysfunction at two-year follow-up. Discussion: Membranous septum rupture after AVR has an estimated incidence of 0.4-1.5 % in TAVR cohorts but is virtually unreported with Perceval valves. Mechanisms include chronic radial stress from oversized or malpositioned prostheses. Case reports with TAVR devices emphasize oversizing as a risk factor. Predictive factors for septal injury in sutureless AVR mirror those for conduction disturbances: valve oversizing, shallow infra-annular septal length, heavy calcification, and prior valve surgery. Preventive measures: strict sizing protocols, avoidance of balloon dilation, and optimized implantation depth, have reduced conduction complications and may mitigate septal trauma. Treatment choice percutaneous versus surgical closure, depends on hemodynamic stability, defect size and anatomy, and operative risk. Conclusion: Early ARVF after Perceval implantation is exceedingly rare but potentially catastrophic. Strict adherence to sizing principles, awareness of septal anatomy, and prompt management, percutaneous in selected stable cases or surgical in acute large defects, are essential to optimize outcomes in sutureless AVR.

Keywords: aorto-right ventricular fistula; septal tear; perceval; SAVR; sutureless valve; pitfalls

1. Introduction

Aorto-right ventricular fistula (ARVF) secondary to membranous septum rupture represents one of the most dramatic and least anticipated complications following aortic valve replacement

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(AVR). While sutureless prostheses such as the Perceval valve (Corcym, Milano, Italia) have become popular for their reduced cross-clamp times and simplified implantation technique, their expanding use has been accompanied by a spectrum of device-related sequelae: especially conduction disturbances and paravalvular leaks [1,2]. In contrast, mechanical disruption of the membranous septum with consequent septal defect and fistulization into the right ventricle remains exceptionally rare and sparsely described in the literature, particularly in the context of Perceval implantation. We present the case of a patient who developed a large ARVF within 24 hours of Perceval valve implantation, requiring emergent explantation, septum repair, and valve re-replacement. Through a concise review of the literature on septal injury across both TAVR and sutureless AVR platforms, we explore the anatomical and procedural risk factors that predispose to this devastating event and discuss tailored strategies for prevention and repair.

2. Case Description

In October 2022, a 66-year-old woman with a bicuspid aortic valve presented with symptomatic severe aortic stenosis associated with moderate aortic regurgitation (Figure 1). Preoperative transthoracic echocardiography demonstrated preserved left ventricular ejection fraction and concentric hypertrophy without additional structural abnormalities. Her body weight was 107 kg, and surgical risk was considered low to intermediate. The patient underwent elective surgical aortic valve replacement via median sternotomy. After careful and complete annular decalcification, intraoperative sizing was performed strictly according to manufacturer recommendations. Based on annular assessment and obturator testing, a Perceval sutureless bioprosthesis (size XL) was selected. Deployment was technically straightforward without post-implantation ballooning, with symmetrical expansion and stable anchoring.

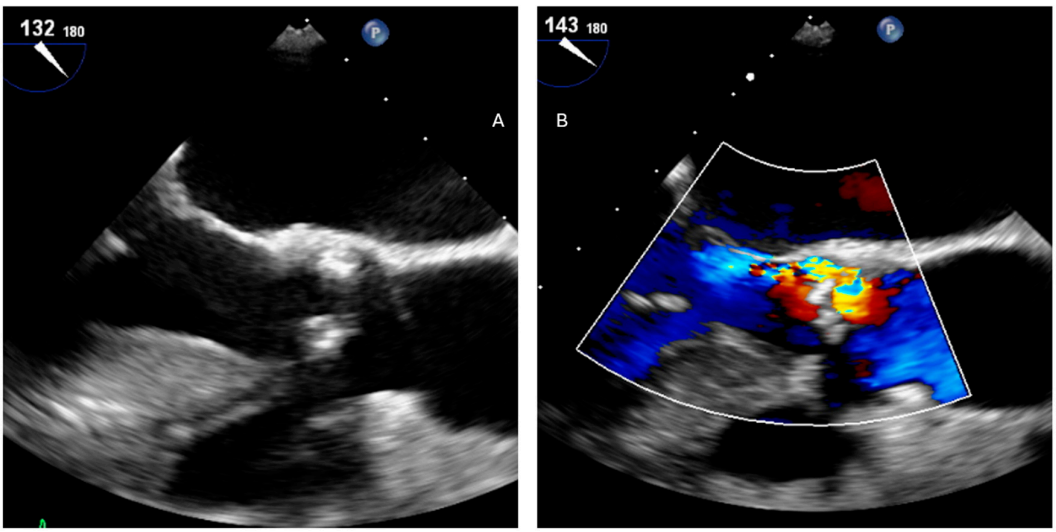

Figure 1. (A) Pre-operative TEE showing bicuspid valve with stenosis and moderate regurgitation.

Immediate intraoperative transesophageal echocardiography (TEE) demonstrated optimal prosthesis positioning, no paravalvular regurgitation, low transvalvular gradients (max 9 mmHg and mean 5 mmHg), and preserved biventricular function (Figure 2). There was no evidence of septal disruption or perivalvular hematoma. The patient was extubated in the operating room and transferred to the intensive care unit in stable hemodynamic condition.

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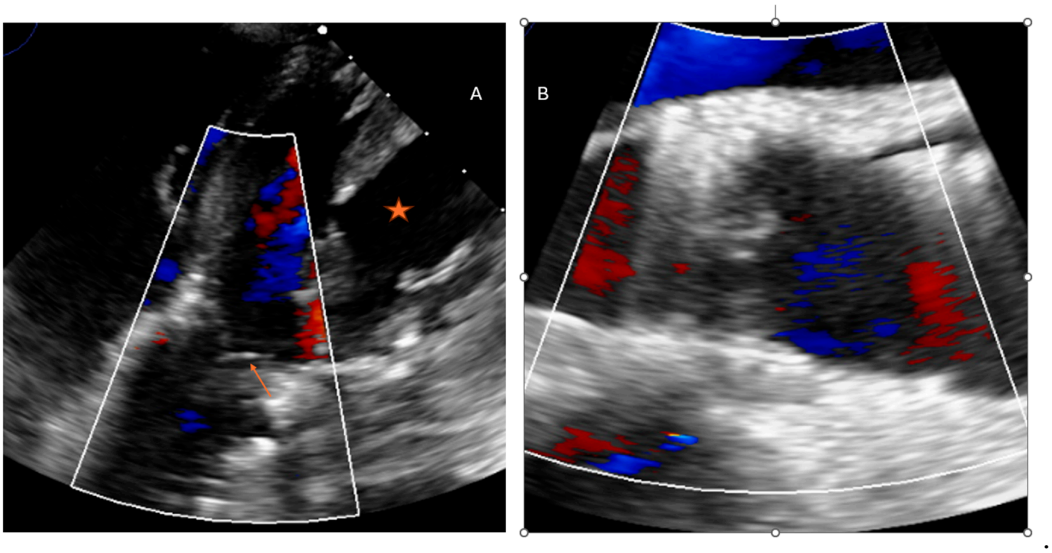

Figure 2. Post implantation Perceval valve XL, no paravalvular leakage in diastole (arrow: cusps of Perceval closed), star: left ventricle; B: good sitting position of Perceval valve.

Within the first 18 postoperative hours, she developed complete atrioventricular block requiring temporary pacing. Shortly thereafter, she experienced acute hemodynamic deterioration characterized by hypotension, rising lactate levels, and escalating inotropic requirements, consistent with evolving cardiogenic shock. Urgent repeat TEE revealed a large communication between the aortic root and the right ventricle at the level of the membranous septum, producing a significant left-to-right shunt with right ventricular volume overload (Figure 3). No prosthesis migration was observed, but septal integrity was clearly compromised.

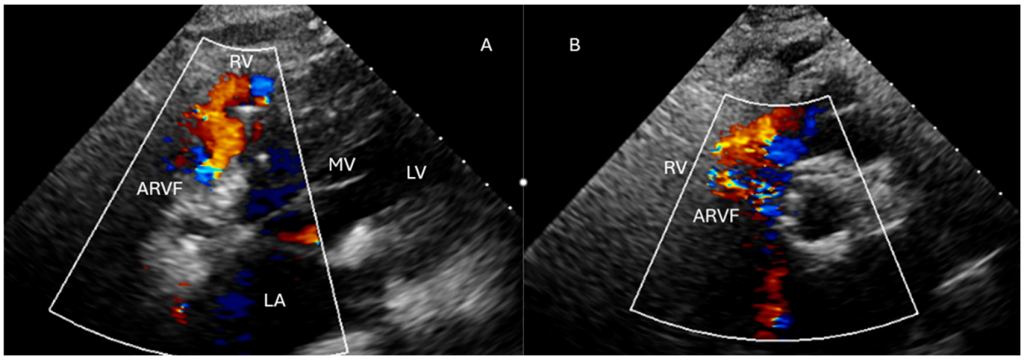

Figure 3. LA: left atrium, MV: mitral valve, LV: left ventricle, RV: right ventricle, ARVF: aorto-right ventricular fistula. (A) diastolic ARV shunts from the membranous septum tear to the right ventricle. The mitral valve is opened and the jet is in the opposite direction to the left chambers. (B) Another view showing the ARVF jet to the RV, from the side of the aorta.

Given the rapid clinical decline, emergent surgical re-exploration was undertaken. Intraoperative findings confirmed the tear of the membranous interventricular septum with direct aorto-right ventricular fistulization. The Perceval prosthesis was carefully explanted to allow full visualization of the rupture. The septal defect was closed using interrupted pledgeted sutures reinforced with a patch at the aorto-ventricular junction to restore structural continuity. A 27 mm Inspiris Resilia valve (Edwards Lifesciences, Irvine, California, USA) was then implanted using a conventional sutured technique to ensure controlled seating and minimize further septal stress. Due to persistent high-degree atrioventricular block, a permanent epicardial pacemaker system was

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implanted during the same procedure. Post-repair hemodynamics remained unstable, necessitating initiation of peripheral veno-arterial extracorporeal membrane oxygenation (VA-ECMO) via femoral cannulation for temporary circulatory support. Myocardial recovery allowed successful ECMO weaning after three days. The postoperative course was complicated by critical illness neuropathy and intensive care unit–acquired weakness, but no recurrent shunt or prosthetic dysfunction was detected on serial echocardiography. The patient was discharged from the ICU on postoperative day 15 and transferred to a rehabilitation facility after a total hospital stay of five weeks. At one- and two-year follow-up, she remains clinically stable and asymptomatic, with normal prosthetic valve function, no residual intracardiac shunt, and satisfactory ventricular performance.

3. Discussion

Focusing specifically on membranous septum rupture, this complication of ARVF remains exceedingly rare after aortic valve interventions and is far less documented than conduction disturbances. In transfemoral TAVR cohorts, its incidence has been estimated at 0.37 % in a single-center series from 2012–2020 [3] and 1.5 % in a 2015 multicenter registry of 400 Sapien (Edwards Lifesciences, Irvine, California, USA) and CoreValve (Medtronic Inc, Minnesota, USA) implants [4]. Although the precise mechanism is not fully elucidated, it likely involves chronic pressure exerted by an oversized or malpositioned prosthesis on the adjacent membranous septum, compounded by potential septal penetration from stiff guidewires.

Case reports in the TAVR literature underscore this pathophysiology. An 87-year-old man developed a septal defect two years after Sapien implantation, attributed retrospectively to oversizing [5]; similarly, a 70-year-old experienced both septal rupture and aortic root perforation after Sapien 3 deployment with post-TAVR oversizing again implicated [6]. Another CoreValve case in a 76-year-old highlighted a postoperative septal tear managed conservatively [7]. Such complications are virtually unreported following Perceval valve implantation, underscoring their exceptional rarity within the sutureless AVR domain.

Beyond TAVR, two reports describe iatrogenic subaortic septal defects following repeat conventional AVR: one in a patient undergoing sequential Mitroflow (Sorin Group USA Inc, Arvada, Colo) then Epic valve (abbott, Chicago, USA) replacements, and another after combined mitral and aortic root surgery with Epic valves and a Dacron graft [8]. To our knowledge, only a single prior Perceval-related instance, a peri-membranous defect presenting two months postoperatively, has been documented [9]. Likewise, a lone report of an aorto-right ventricular fistula after surgical Perceval implantation exists, in which annular rupture necessitated percutaneous plug closure [10]. Against this backdrop, our case represents one of fewer than five published reports of septal rupture or fistula complicating Perceval use, highlighting the need to scrutinize its unique risk factors.

Several predictive factors for conduction disturbances, and by extension septal trauma, have emerged with the Perceval prosthesis: valve oversizing, shallow infra-annular septal length relative to implantation depth, heavy annular calcification, and prior valve surgery [12–16]. Retrospective analyses demonstrate that avoiding oversizing not only improves hemodynamics and reduces central regurgitation but also halves new pacemaker rates (from 11 % to 6.1 %) [17–20]. Moreover, a short membranous septum significantly increases the risk of high-degree AV block, suggesting that excessive septal compression may predispose both to conduction injury and mechanical rupture.

Preventive strategies have therefore focused on meticulous sizing, using only the white obturator to confirm annular fit with slight friction, eschewing balloon dilation and optimizing prosthesis depth to spare the membranous septum [21,22]. In one series, deliberate leftward displacement of the septum after Perceval deployment in 11 patients yielded only mild conduction delays and no septal defects [23]. These tailored techniques underscore the delicate balance between secure anchoring and septal preservation.

The radial force exerted by self-expanding Perceval valves plays a central role in achieving prosthesis stability and sealing within the aortic root. However, this same force may, under certain conditions, contribute to adverse structural outcomes. In vitro and computational studies led by

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Cabrera et al. [24] and Finotello et al. [25], have demonstrated that radial force increases proportionally with oversizing, with forces exceeding 16 N associated with transmural arterial stress and potential vessel wall damage. Although Perceval valves generate lower radial force compared to balloon-expandable devices [21,26], oversizing beyond 22.6% has been linked to increased rates of degeneration [21], and in rare cases, complications such as right aorto-ventricular fistulas: this risk is particularly pronounced in patients with bicuspid aortic valves, whose aortic roots are known to exhibit congenital structural vulnerabilities [27]. (Figure 4)

The chronology of fistula presentation further implies radial force as a progressive, rather than immediate, pathological factor. Multiple case reports, including those by Francisco et al. [10] and Hagiwara et al. [28], have documented fistulae developing between 3 days and one-month post-implantation, suggesting an erosive mechanism rather than an intraoperative injury [29]. Unlike acute defects from ballooning or surgical trauma, these delayed lesions align more closely with chronic pressure necrosis or remodeling of the aortic wall in response to sustained mechanical loading. Simulation data support this interpretation, indicating that even in human arteries with relatively high circumferential stress thresholds (~290 kPa), focal 'von Mises stress' may approach 210 kPa under oversizing conditions [24], which over time may exceed the adaptive capacity of the vessel wall. This is particularly relevant in calcified or fibrotic roots, where compliance is already compromised [21,27].

Procedural adjuncts may further influence the biomechanical environment and exacerbate the effects of radial force. The use of traction sutures at the level of the aortic commissures, especially when not removed after deployment, as in the modified technique described by Oldenburg [30,31], has been associated with annular deformation and altered stress distribution. Although this technique is not recommended by the manufacturer [32], it continues to be used at the surgeon's discretion [31,33]. Vasanthan et al. emphasized the potential for unretrieved guiding sutures to cause deformation at the annular level, with possible consequences for valve seating and force dynamics [34]. These alterations may amplify localized stress and contribute to delayed structural compromise. Considering these findings, further biomechanical research, ideally cadaveric or ovine models focused on the Perceval valve in the aortic position, is warranted to better define the threshold forces and anatomical conditions that precipitate fistula formation.

In terms of management, percutaneous closure of an aorto-right ventricular fistula has emerged as a viable, less invasive alternative in carefully selected cases, particularly when patients are hemodynamically stable, the defect is focal and small (<5–8 mm), and there is no need for concomitant valve intervention. Multiple case reports have demonstrated successful deployment of Amplatzer vascular plugs or occluder devices under fluoroscopic and echocardiographic guidance, with relatively short procedural times, minimal blood loss, and same-day mobilization. Such an approach is especially appealing for elderly or high-operative-risk patients, as it avoids sternotomy, cardiopulmonary bypass, and the inflammatory sequelae of major surgery. However, in scenarios of acute presentation, with rapid cardiogenic shock, large-bore fistulas, or associated prosthesis malposition, surgical repair remains the gold standard. Open exploration permits direct inspection of the rupture site, complete removal of any damaged or malpositioned prosthesis, and precise patch reconstruction of the membranous septum using bovine pericardium or synthetic materials. It also allows for immediate re-implantation of a properly sized valve and simultaneous management of conduction disturbances through epicardial pacing leads. In our patient, the combination of a sizeable septal tear, perilous shunt volume, and need for device explantation and pacemaker placement necessitated urgent surgical revision.

4. Conclusions

Rupture of the membranous septum with aorto-right ventricular fistula is an exceptionally rare but potentially life-threatening complication following Perceval valve implantation. Its occurrence underscores the critical importance of meticulous valve sizing and precise implantation depth to minimize septal trauma. Management must be individualized: in stable patients with small, delayed

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defects and high surgical risk, percutaneous closure offers a safe and effective alternative, whereas acute, large-bore ruptures require prompt surgical repair. Moving forward, systematic identification of anatomical risk factors and ongoing refinement of sutureless AVR techniques will be essential to prevent both conduction disturbances and structural septal injuries.

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Institutional Review Board Statement: This report describes a single fully anonymized clinical case. According to the Swiss Human Research Act and guidance from the Cantonal Ethics Committee of Vaud (CER-VD), formal ethics approval was not required.

Informed Consent Statement: Written informed consent for publication was obtained from the patient.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

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Conflicts of Interest: The authors declare that they have no competing interests related to this work, which is completely independent.

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