CASE REPORTS
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Case report
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RIGHT ANTERIOR MINITHORACOTOMY AND SUTURELESS AORTIC VALVE – A PERFECT MATCH

DESNA PREDNJA MINITORAKOTOMIJA I BEŠAVNA AORTNA VALVULA − SAVRŠEN SPOJ

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Summary

Introduction. Traditionally, surgical aortic valve replacement has been considered the gold standard for treating symptomatic patients with severe aortic stenosis. However, the development of transcatheter technology has introduced the concept of sutureless aortic valve replacement. As a result, minimal invasive aortic valve surgery is becoming increasingly popular and effective option in experienced centers, offering enhanced patient satisfaction and fewer complications. The utilization of sutureless valves has the potential to simplify and optimize aortic valve surgery by reducing the duration of the operation and facilitating prosthesis implantation. Nonetheless, there remain uncertainties regarding the optimal therapeutic choice, durability, and long-term outcomes. **Case Reports.** The case series involving 10 patients who underwent Perceval valve implantation demonstrated that the procedure was well-tolerated and yielded favorable outcomes. The surgery resulted in reduced implantation time and a decrease in complications. The patients experienced a postoperative course free from complications or cardiac rhythm disturbances, and they were discharged from the hospital on the fifth day of hospitalization. **Conclusion.** In essence, sutureless valves such as Perceval offer a promising solution for patients with aortic stenosis, particularly in the context of minimal invasive surgery. They can provide excellent hemodynamic performance, shorter the duration of the operation, and reduce hospital stay morbidity and mortality. However, long-term results and further research are necessary to definitively confirm their benefits.

Key words: Aortic Valve; Aortic Valve Stenosis; Thoracotomy; Heart Valve Prosthesis Implantation; Minimally Invasive Surgical Procedures; Treatment Outcome; Transcatheter Aortic Valve Replacement; Sutureless Surgical Procedures

Sažetak

Uvod. Hirurška zamena aortnog zaliska bila je zlatni standard za lečenje simptomatičnih pacijenata sa ozbiljnom aortnom stenozom. Međutim, razvoj transkateterske tehnologije uveo je koncept zamene aortnog zaliska bez šavova. Minimalno invazivna hirurgija aortnog zaliska postaje sve popularnija kao efikasna opcija u iskusnim centrima, pružajući veće zadovoljstvo pacijenata i manje komplikacija. Upotreba bešavnih zalistaka ima potencijal da pojednostavi i unapredi hirurgiju aortnog zaliska tako što smanjuje trajanje operacije i olakšava implantaciju proteze. Međutim, postoje nesigurnosti u vezi sa najboljim terapijskim izborom, trajnošću i dugoročnim rezultatima. **Prikaz slučajeva.** Serija slučajeva od 10 pacijenata koji su podvrgnuti implantaciji *Perceval* valvule pokazala je da je procedura dobro podnošljiva. Hirurgija je dala povoljne rezultate u smislu vremena implantacije i smanjenja komplikacija. Pacijenti su imali postoperativni tok bez komplikacija ili poremećaja srčanog ritma. Pušteni su kući petog dana hospitalizacije. **Zaključak.** U suštini, bešavne valvule, poput Percevala, nude obećavajuće rešenje za pacijente sa aortnom stenozom, posebno u minimalno invazivnoj hirurgiji. Mogu obezbediti odlično hemodinamičko ponašanje, kraće trajanje operacije i smanjenje morbiditeta i mortaliteta tokom boravka u bolnici. Međutim, dugoročni rezultati i dalja istraživanja su potrebni kako bi se definitivno potvrdile njihove prednosti.

Ključne reči: aortni zalistak; stenoza aortnog zaliska; torakotomija; implantacija proteze srčanog zaliska; minimalno invazivne hirurške procedure; ishod lečenja; transkateterska zamena aortnog zaliska; bešavne hirurške procedure

Introduction

The past decade has witnessed a notable interest in research focused on degenerative aortic stenosis, a condition whose incidence and prevalence continue to rise in Western countries [1]. With the aging population, aortic stenosis has become the most prevalent valvular heart disease in adults [2]. Surgical aortic valve replacement (AVR) remains the established standard for treating symptomatic patients with severe aortic stenosis, effectively restoring their life expectancy [3]. However, the presence

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Abbreviations

AVR	– aortic valve replacement
MI-AVR	– minimal invasive aortic valve replacement
MI	– mini-sternotomy
ART	– right anterior thoracotomy
ACC	– aortic cross-clamp
ICU	– Intensive Care Unit
AS	– aortic stenosis
ECC	– extracorporeal circulation
CPB	– cardiopulmonary bypass

of multiple comorbidities in older patients undergoing aortic valve surgery has led to the development of new valve implantation techniques aimed at reducing surgical risk [4].

The emergence of transcatheter technology in 2002 has introduced the concept of sutureless valve replacement, offering a novel approach to aortic valve replacement [5], which has been in clinical practice since 2008 [6]. In our region, the Perceval valve is the sole available sutureless valve for implantation, and it has demonstrated excellent short-term and mid-term outcomes with reduced implantation time [2].

Minimal invasive aortic valve replacement (MI-AVR) has gained traction as an effective choice for surgical treatment in well-established centers, providing higher patient satisfaction and fewer complications [4]. This is particularly relevant for older patients with multiple comorbidities, for whom minimizing overall risk and enhancing surgical outcome is paramount [7, 8]. A multidisciplinary patient-centered approach is essential for this group of patients as there are no standardized guidelines determining when to employ a minimally invasive approach [4]. The most common approaches for MI-AVR currently include the upper mini-sternotomy and right anterior thoracotomy (ART) techniques [9]. While both approaches offer various clinical benefits compared to the traditional sternotomy, the adoption of MI-AVR has been limited within the surgical community [10]. This may be attributed to the perceived increased surgical complexity associated with MI-AVR, which can result in longer operative times compared to conventional AVR [9]. However, the use of sutureless valves and their rapid deployment may help streamline and promote MI-AVR by simplifying and expediting the implantation process [11]. Sutureless valves can reduce the duration of the operation and facilitate easier prosthesis implantation through a limited approach, thereby mitigating some of the primary limitations of MI-AVR procedures, and they can be considered a primary choice in minimally invasive surgery [9]. However, uncertainties still exist regarding the optimal therapeutic selection, durability, and long-term outcomes [1].

Case Reports

The Perceval sutureless aortic valve was successfully implanted in 10 patients at the Institute of Cardiovascular Diseases of Vojvodina. These patients all presented with isolated valvular pathology in the form of severe aortic stenosis and were aged over 65. They comprised a mix of genders and exhibited varying Body Mass Index (BMI) values. Additionally, they presented with various comorbidities, including atrial fibrillation, diabetes, left bundle branch block, chronic obstructive pulmonary disease, and chronic kidney insufficiency. Preoperative echocardiographic examinations confirmed that all patients had a trileaflet aortic valve with severe aortic stenosis, accompanied with varying degrees of aortic regurgitation. Importantly, these examinations ruled out any contraindications for the implantation of the Perceval valve. None of the patients exhibited a dilated aortic root, and the relationship between the sinotubular junction and the diameter of the aortic annulus was less than 1.3 mm, eliminating the possibility of a dilated ascending aorta or aortic dissection.

In preparation for the minimally invasive approach, all patients underwent preoperative computed tomography aortography focused on understanding the relationships between the aortic valve, the sternum, and the intercostal spaces. In general, the relative dextroposition of the ascending aorta (at least 50% of the aortic width positioned to the right of the sternal edge at the level of the pulmonary bifurcation) and an appropriate depth of the aortic root, not exceeding 10 cm from the skin to the aortic annulus, provided an ideal surgical exposure for the right minithoracotomy.

Exclusion criteria for Perceval implantation through the ART approach included acute endocarditis, irregular aortic annulus or aortic anatomy, isolated aortic regurgitation, bicuspid aortic valve, severe chest deformities, adhesions of the right pleural cavity, or technical difficulties with peripheral percutaneous cannulation.

Prior to the intervention, informed consent was obtained from each patient. Premedication included administration of 3.75 mg of Midazolam orally and 1 mg of Atropine intramuscularly, half an hour before the intervention. Additionally, a 16 G intravenous cannula was placed for preoperative preparation, an arterial catheter was inserted into the left radial artery, and a central venous catheter was positioned in the right internal jugular vein. Following induction with Midazolam, Propofol, Sufentanyl, and Rocuronium, the patients were intubated using a double-lumen tube. A transesophageal echocardiography probe was also introduced.

The minimally invasive procedure was conducted through a right anterior thoracotomy via the second intercostal space. Following the longitudinal opening and pre-ventilation of both lung fields, the right lung was collapsed, and ventilation continued with "one-lung ventilation". The pericardium was suspended, and distal cannulation of the ascending aorta was performed, along with venous cannulation of the right atrium. An external aortic clamp was then directly applied to the aorta, and crystalloid cardioplegia was indirectly administered through an angiocatheter.

The procedure involved a transverse aortotomy, followed by the excision and decalcification of the

native valve leaflets. The Perceval valve, prepared for implantation, was initially placed on a holder and inserted into a collapsor of the corresponding size. By rotating the handle of the collapsor, the proximal and distal rings of the valve were collapsed while maintaining the integrity of the leaflets. The prepared valve was then immersed in warm physiological saline and stored until implantation. This method facilitated size reduction and enabled placement through a small incision without manipulation at the annulus level.

Prior to valve implantation, three guiding sutures were placed to ensure the proper positioning of the bioprosthesis. The holder containing the bioprosthesis was lowered into the aortic annulus until it reached the location where the guiding sutures were positioned. The next step involved releasing the holder and confirming the correct valve size, precise positioning, and full expansion. Following this confirmation, balloon dilation was performed to enhance valve adaptation and optimal sealing on the native aortic annulus. The balloon was inflated to 4 atmospheres for 30 seconds, while a stream of warm physiological saline was continuously directed into the aortic root to further secure the sealing of the aortic valve and fixation, considering the thermosensitive nature of the nitinol stent material.

Different valve sizes were implanted in our patients, with 4 patients receiving size S, 2 patients size M, 3 patients size L, and 1 patient size XL. Following the implantation of the bioprosthesis, the aortotomy was closed, and deaeration was conducted after tying the final suture. The heart was subsequently filled with blood, both lung fields were re-expanded, and the aortic clamp was released. The average duration of aortic cross-clamping (ACC) was 36 minutes, and extracorporeal circulation (ECC) lasted 43 minutes.

Transesophageal examination confirmed the accurate implantation of the prosthetic valve following the discontinuation of extracorporeal circulation. The patients were then reintubated with a single-lumen tube, and were hemodynamically and rhythmically stable as they were transferred to the Intensive Care Unit (ICU). On average, the patients were extubated 2 hours and 27 minutes after the completion of the operation. They spent one day in the ICU. The postoperative course progressed without any complications in all patients. As there were no instances of paravalvular leaks, rhythm disturbances, drainage, or revisions, the patients were discharged in good general condition on the 5th day of hospitalization.

Discussion

Aortic stenosis (AS) is the most prevalent valvular condition, leading to reduced life expectancy in symptomatic patients [12]. Aortic valve replacement (AVR) remains the primary therapeutic approach for managing these cases [13, 14]. Data from The Society of Thoracic Surgeons reveal a substantial improvement in AVR's operative risk over the past decade, reducing mortality rates from 4.3% to 2.6% [15]. However, despite these advancements, elderly patients and those with significant comorbidities referred for AVR continue to face unacceptably high perioperative risks and suboptimal outcomes, suggesting that innovative approaches such as sutureless valves could help mitigate mortality and morbidity [12].

The concept of sutureless aortic valve prostheses was originally introduced by Magovern and Cromie in the early 1960s [16]. Their objectives were to simplify aortic valve replacement, reduce surgical duration, and circumvent complications linked to prolonged cardiopulmonary bypass (CPB) and ACC times [15]. However, this groundbreaking idea was abandoned due to complications associated with the valve, including frequent perivalvular leaks, dehiscence in patients with enlarged aortic roots, and thromboembolic complications [17]. Advances in bioprosthetic technology have since resolved these initial challenges, with published data confirming promising results in terms of mortality, morbidity, and hemodynamic performance following the implantation of these sutureless valves [15].

The Perceval valve is a biological prosthesis comprised of bovine pericardium stabilized in a buffered glutaraldehyde solution and mounted on a nitinol stent [12]. It is available in various sizes: small, medium, large, and extra-large (S (19–21 mm), M (22–23 mm), L (24–25 mm), and XL (26-27 mm)) [8]. All our patients had the Perceval valve implanted. In cases of incorrect positioning during implantation, the Perceval valve can be safely removed, even after balloon dilation. If no malformations are observed in the prosthesis after the procedure, it can be reimplanted in the correct intra-annular position [15]. Three out of our ten patients required repositioning due to inadequate initial valve placement. Since no valve malformations were detected, successful reimplantation was performed without complications.

The advantages of sutureless bioprostheses include quicker implantation as there is no need for sewing the valve, along with reduced durations of CPB and ACC [12]. It is important to note that extended ACC and CPB times are associated with increased perioperative morbidity and mortality [18]. A meta-analysis by Sian et al. demonstrated that the Perceval valve significantly reduces ACC and CPB times compared to conventional AVR. The average ACC and CPB times for isolated AVR were 39.7 and 64.2 minutes, respectively, which were shorter than the established conventional AVR times of 76 and 106 minutes [2]. In our cases, the average aortic cross-clamp duration was 36 minutes, and the average CPB duration was 43 minutes. A study by Concistre et al. reported slightly longer CPB and ACC times, likely due to the surgical approach [14]. Solinas and colleagues reported an average CPB time of 81.6±30.8 minutes and an ACC time of 50.3±24.5 minutes [18].

The effective orifice area of sutureless valve prostheses is larger for any Perceval valve size than for conventional prostheses due to the absence of an an-

choring ring. This feature is particularly beneficial for patients with small aortic roots, which was the case for most of our patients [19]. Additionally, reduced surgical manipulation during sutureless aortic valve implantation and decreased presence of foreign material around the aortic annulus may offer advantages [1].

Adverse events related to sutureless valve implantation are minimal. Overall rates of reoperation (1.43%) and early infections (<1%) are low, further supporting favorable early outcomes with sutureless valves [2]. None of our patients required reoperation or experienced early infections. According to the meta-analysis by Sian et al. an acceptable early mortality rate of 2.1% and an incidence of strokes of 1.4% were reported after Perceval valve implantation, with no statistically significant difference compared to conventional aortic valves [2]. However, after Perceval valve implantation, there was an increased need for pacemaker implantation, 6.7% compared to 3.6% with conventional valves [2], a finding also confirmed by Solinas et al. who reported a need for pacemaker implantation in 5.2% of operated patients [18]. Nevertheless, a study by Gilmanov et al. showed that the intrahospital morbidity and mortality, incidence of postoperative strokes, as well as the need for pacemaker implantation were the same for sutured and sutureless valves [1]. Fortunately, our patients did not experience rhythm disturbances, undesired cerebrovascular events, or require pacemaker implantation after surgery. According to Solinas et al. the length of hospitalization for patients with implanted Perceval valves was 6.4±3.8 days [18]. All our patients were discharged on the 5th day of hospitalization.

In recent years, the focus on treating aortic valve pathology has shifted towards the development and promotion of minimally invasive procedures [20]. Sutureless valves offer a distinct advantage in this context, as they are well-suited for MI-AVR due to their ease of insertion with minimally invasive approaches [21]. The collapsible delivery system of these prostheses allows for optimal intraoperative exposure of the aortic root, even in patients with suboptimal anatomical conditions [8]. Typically, this procedure is performed through a right anterior mini-thoracotomy, which was the chosen approach for our patients [18]. Previously, this challenging approach was reserved for experienced surgeons due to the limited working space, restricted visibility, and deviations from the normal course, which deterred many surgeons from adopting it [1].

In comparison to standard median sternotomy, MI-AVR has been shown to yield superior clinical outcomes, including reduced postoperative complications, decreased blood loss and transfusion requirements, lower risk of reoperation due to bleeding, reduced postoperative pain, shorter ventilation times, shorter stays in the ICU, and overall hospital stays, faster return to functional activities, improved cosmetic appearance [9, 21], as well as enhanced patient satisfaction [2]. Despite these promising findings, the utilization of MI-AVR surgery remains disappointingly low, with most AVR interventions being still performed via full sternotomy [22].

However, despite the established benefits, there remains a lack of evidence regarding the long-term outcomes of sutureless aortic valve prostheses, highlighting the need for larger studies in this area [18].

Conclusion

Minimally invasive surgical approaches coupled with the implantation of sutureless valves synergistically present a less invasive treatment concept that may offer distinct advantages over traditional approach, particularly for older patients with elevated surgical risk and frailty indices. In addition to delivering excellent hemodynamic outcomes, these techniques contribute to shorter durations of cardiopulmonary bypass, decreased intrahospital morbidity and mortality rates, and heightened patient satisfaction, collectively providing promising results.

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