

Perceval Sutureless Bioprosthesis for Degenerative Aortic Valve Stenosis: Initial Experience With 67 Patients

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ABSTRACT

Objective: The objective of this prospective study was to evaluate the characteristics (positive and negative) of Perceval S valve in patients undergoing aortic valve replacement with a biological prosthesis. The study included 67 patients operated on at our institution and a mean follow-up period of 18 months.

Methods: From June 2016 to November 2019, 209 patients underwent aortic valve replacement with a biological prosthesis. Of these, 67 patients were included in the study based on the exclusion and inclusion criteria set before the study began. Their data were recorded during their hospital stay (preoperative, intraoperative, and early and late postoperative time).

Results: Fifty-four patients underwent isolated aortic valve replacement (group I) with a Perceval S prosthesis, and 13 patients had combined aortic valve replacement procedures and CABG procedures (group II). Patients were implanted with the following prosthesis sizes: S ($N = 12$), M ($N = 18$), L ($N = 28$), or XL ($N = 9$). The Perceval S valve successfully was implanted in 67 (91.8%) patients (in 6 patients, the preoperative transthoracic echocardiographic data did not coincide with intraoperative TEE and surgical measurement of the size of the annulus in the suture). Surgical approaches in patients were medial sternotomy ($N = 48$), mini sternotomy ($N = 15$), and thoracotomy through the second intercostal space to the right ($N = 4$). The mean clamping time of the aorta and CPB length for isolated cases was 54 and 82 minutes, respectively, and 96 and 120 minutes for combined procedures. Four (5.9%) patients died within 30 days.

Conclusion: Early postoperative results showed that the Perceval S valve was safe. Further follow up is required to evaluate the long-term duration of patients with this bioprosthesis.

INTRODUCTION

The rising age of the population increases the prevalence of degenerative aortic valve (AoV) stenosis, requiring aortic valve replacement (AVR) surgery [Sian 2017]. However, the age and cumulative effect of different comorbidities render almost 25% of patients into a high-risk group for the AVR, with prostheses requiring the conventional suturing technique. This is particularly true for those with heavily calcified, small AoV, impaired left ventricular (LV) function, and combined surgery [Santarpino 2012].

To overcome the problems arising from technically difficult and lengthy procedures, different sutureless AoV bioprostheses have been developed to facilitate AVR and thus to reduce morbidity and mortality. The Perceval S (LivaNova, London, UK) is a collapsible, stent-mounted, sutureless AoV bioprosthesis that has been implanted in more than 22,000 patients worldwide, during the last decade [Phan 2014]. In carefully selected cases, it is intended to replace native AoV with advanced stenosis or steno-insufficiency, or malfunctioning aortic prosthesis via either standard or a less/minimally invasive approach. The Perceval S prosthesis is a bioprosthetic heart valve made from treated bovine pericardium fixed with glutaraldehyde with homocysteic acid to remove free radicals and prevent the calcification process. It is fixed in a metal cage made up of nickel and titanium alloys, known as nitinol. There currently are four sizes of Perceval S aortic valve prosthesis: small - S (19-21 mm); medium - M (22-23 mm), large - L (24-25 mm), and extra large XL (27 mm). Therefore, Perceval S can be used for annulus sizes from 19 to 27 mm [Di Eusanio 2011].

This study we present aims to evaluate the safety and efficiency of Perceval S bioprosthesis in AVR surgery and to compare our initial clinical experience with others.

PATIENTS AND METHODS

Patients: We conducted a prospective study of patients ($N = 67$) who underwent AVR with Perceval S prosthesis between June 2016 and November 2019. During that time, 209 patients underwent surgery in our institution, where a conventional biological aortic valve was implanted.

Isolated AVR replacement was performed in 54 patients (group I) and combined aortic valve replacement with CABG

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procedure in 13 patients (group II). Inclusion criteria were severe aortic valvular stenosis with indication for valve replacement, patients who agreed to participate in the clinical study, those who wished to have a biological valve based on interviews with the selected surgeon, that there were no contraindications for Perceval S prosthesis for these patients, and their signed informed consent to the said procedure.

Patients with ascending aortic aneurysm or aortic dissection (acute or chronic), acute endocarditis, emergency cardiac surgery, congenital bicuspid aortic valve (Seivers type 0), or aortic annulus greater than 27 mm or less than 19 mm are excluded on the ostium criterion. The relationship between the sinotubular junction and the aortic annulus should not exceed 1.3. Patients with known hypersensitivity to nickel also were avoided. The operative risk of these patients was evaluated, according to the European Cardiac Operative Risk System. (EuroSCORE) [Kocher 2013]. Inclusion and exclusion criteria for the study as well as follow-up parameters during the hospital stay (preoperative, intraoperative, and early and late postoperative period) previously were defined.

Procedure: The surgical approach was through a full sternotomy (48 cases), partial upper sternotomy (15 cases), and right anterior minithoracotomy (4 cases). Perioperative transoesophageal echocardiography was used in all patients. After central aortic and atrial cannulation, a cardiopulmonary bypass was initiated and cold blood cardioplegic arrest was achieved. A transverse aortotomy (2.5–3 cm above the annulus) was performed, and the native valve was completely resected. The annulus carefully was debrided. This bioprosthesis can be collapsed through a dedicated device and positioned by means of a specific delivery system. The delivery system loaded with the collapsed stent-mounted

valve is guided to its correct position by sliding it over the three guiding sutures (4-0 polypropylene), positioned at the nadir level of each resected cusp. (Figure 1) Once the delivery system is in position, the prosthesis is deployed, guiding sutures are removed, and the valve is finally in place. At this point, postdilation modeling is performed with a dedicated balloon (30 seconds at a pressure of 4 atm), and the valve is flushed with warm saline at 37C to optimize final sealing. (Figure 2) After closure of the aortotomy, transoesophageal echocardiography was performed to assess the correct implantation of the prosthesis and the presence of any valve leak [Nguyen 2015].

Patients were evaluated preoperatively, at hospital discharge, and once postoperatively at a follow-up visit. Control evaluations were performed between 3 months and 18 months after the operation, and the mean follow-up period was 12 months. Six of the patients were unreachable, and 61 patients were contacted. During follow up, transthoracic echocardiography was performed, and the mean peak transvalvular gradient and paravalvular leakage recorded. The collected data were entered into the database and processed in SPSS Statistics 22.0 using the descriptive statistics method.

RESULTS

The mean age of the patients was 71.5 years (range 64–85 years); 13.4% of patients were over 80 years of age. (Table 1) The success rate of the completed procedure with the implantation of Perceval S prosthesis was 91.8%. Six (8.2%) patients were withdrawn from the study during the intraoperative period because the preoperative transthoracic echocardiographic data did not coincide with intraoperative

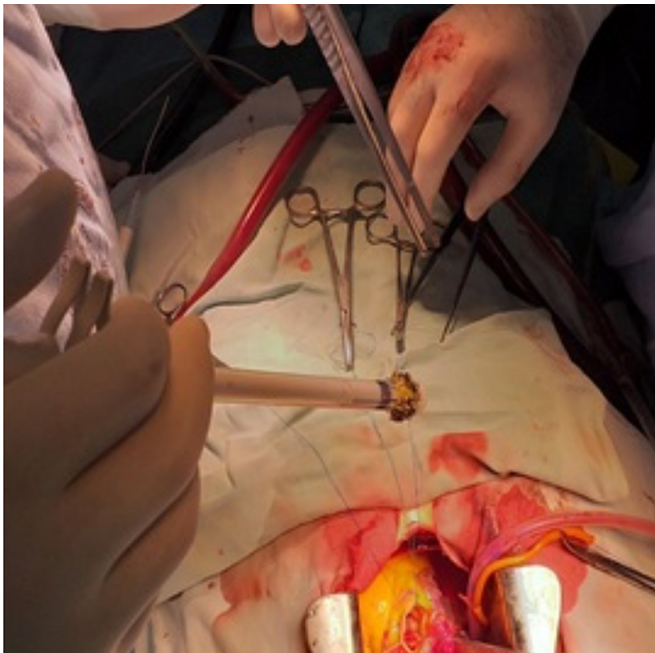


Figure 1. Prosthesis correctly mounted on the holder

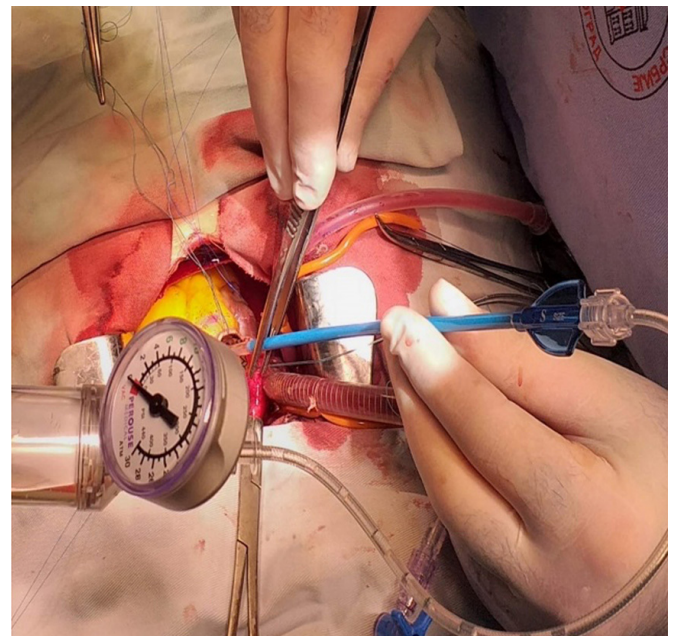


Figure 2. Final expansion of inflow ring using a balloon catheter

transesophageal echocardiogram (TEE) and surgical measurement of the size of the annulus in the suture. In each of these cases, another conventional biological valve eventually was implanted.

In the group of patients undergoing combined cardiac surgery with AVR, surgical revascularisation with the help of one bypass was recorded in 5 patients, with two bypass in 2 patients, and with three bypass in 6 patients. The mean aortic clamp and CPB intersection times were 54 and 82 minutes for isolated AVR cases, respectively, and 96 and 120 minutes for combined procedures. Size S (annulus range 19-21 mm) was fitted in 12 (18%) patients, size M (annulus range 21-23 mm) in 18 (27%), size L (annulus range 23-25 mm) in 28 (42%), and size XL (annulus range 25-27 mm) in 9 (13%) eligible patients. The mean length of stay in the intensive care unit was 2.4 days (range 1-26 days). The hospital stay averaged 7.7 days (range 4-31). There were no cases of unexpected adverse effects of the device, valve thrombosis, secondary valve migration, endocarditis, or the occurrence of hemolytic anemia during the intrahospital period.

Nine patients (13.4%) developed transient postoperative thrombocytopenia (<80x10⁹). The condition in 3 patients (4.5%) with significant early postoperative bleeding led to reoperation in the early postoperative course. The incidence rate of permanent pacemaker implantation was 4.5%. The mean gradient across the Perceval prosthesis was found to be higher for smaller valves (S and M) and smaller for larger valves (L and XL). It ranged from 4-24 mmHg, with a mean of 11.2 mmHg. The range of maximal gradients after surgery was 9-43 mmHg, with a mean value of 22.7 mmHg. Hospital mortality was 5.9% (N = 4).

DISCUSSION

High-risk patients, especially those who would have surgery for a long time, would have the benefit of implanting a Perceval S prosthesis as well as resurgery where the

implantation time would be shortened by avoiding suture placement to ensure bioprosthesis within the aortic annulus. Shrestha et al. also confirmed the safety and efficacy

Table 1. Preoperative characteristics

	N = 67	(%)
Male/Female	35/32	(52/48)
Isolated aortic valve replacement	54	(81)
AVR + CABG	13	(19)
History of hypertension	60	(89)
History of pulmonary disease	13	(19)
History of neurological disease	19	(28)
History of CKD	13	(19)
History of PVD	11	(16)
Smoking history	50	(75)
History of DM type 2	30	(44)
History of HLP	44	(65)
	Mean	(+St. Deviation)
Age of patients	71.5	(7.49)
Weight (kg)	77.9	(8.4)
Height (cm)	167.5	(14.4)
EuroScore	2.01	(0.92)
Ejection fraction	N	(%)
EF>50%	53	(79)
EF 30-50%	13	(19)
EF<30%	1	(2)

AVR, aortic valve replacement; CABG, coronary artery bypass grafting; CKD, chronic kidney disease; PVD, peripheral vascular disease; HLP, hyperlipoproteinemia; EF, ejection fraction

Table 2. Perioperative outcomes

Data patients (N = 67)	Median sternotomy (N = 48)	Mini sternotomy (N = 15)	Thoracotomy (N = 4)	With Concomitant CABG (N = 13)	Isolated AVR (N = 54)
(Mean+Sd)					
CC time (min)	65.8+27.6	53.6+15.8	64.7+5.9	96.1+29.3	54.5+14.6
CPB time (min)	97.4+44.5	81.3+22.0	93.0+9.4	120.3+38.2	82.7+21.8
Valve size					
S	12				
M	18				
L	28				
XL	9				

CC, cross clamp; CPB, cardiopulmonary bypass; S, small; M, medium; L, large; XL, extra large

of sutureless aortic valve in patients undergoing combined cardiac surgery as a therapeutic option. This is important because the proportion of patients for the combined CABG and AVR procedure has increased from 5% to 25% over the last 20 years. Effectively, the surface of the prosthesis opening is larger for any size Perceval S valve because it does not have a prosthesis anchor ring (conventional prosthesis). This would be particularly useful for patients with small aortic roots, where the risk of prosthetic mismatch is high. The Perceval S valve is also useful in minimally invasive AVR technology because it technically is difficult to fit sutures in these cases because of workspace limitations. Sutureless valves eliminate this technical difficulty. Combined and complex procedures may be associated with prolonged CPB time, which may lead to an increase in morbidity, especially in elderly and at-risk patients (patients with high EuroScore). The use of a Perceval S prosthesis for combination cases may reduce the duration of the surgical procedure. The simultaneous replacement of the mitral and aortic valves initially was considered a contraindication to the use of the Perceval S, due to concerns about its potential interaction with the mitral prosthesis at the level of the aorto-mitral curtain. However, numerous cases have demonstrated the feasibility and safety of suture-free AVR in this setting. In the largest series of combined procedures (i.e., AVR and CABG and/or tricuspid annuloplasty and/or ascending aortic replacement) published so far, Shrestha et al. mean CPB and aortic clamp times were 79 ± 32 and 51 ± 23 minutes, respectively [Shrestha 2009; Sedaghat 2015; D'Onofrio 2012].

The durability of Perceval S valve is also problematic. Englberger presented the longest follow-up study of sutureless bioprostheses (5-year follow up) and suggested that these prostheses should not be implanted in all patients with indications for biological AVR. There is currently little information on the use of the Perceval S prosthesis in patients with bicuspid aortic valvular. Initially, congenital bicuspid valve was considered as a contraindication for the use of sutureless AVR, due to the concern and the fact that the aortic annulus in these patients is round rather than ellipsoidal. However, Nguyen et al. reported results on the implantation of a Perceval S prosthesis in 25 consecutive patients with bicuspid valves [Englberger 2014]. No PVL (paravalvular leak) was observed on transesophageal echocardiography and no migration or embolization was observed after surgery. In our study, only two patients had a bicuspid aortic valve (type 1). We compared our perioperative and early postoperative results with other published works using sutureless valves. Most authors use the Perceval S prosthesis, except two that used Edwards Intuiti and ATS 3f valves. We replaced 2.9% of prosthesis due to heavy PVL. This rate was 1.9%, 2.2%, 1.8%, 1.4%, and 0.9% for Kocher, Martens, Miceli, Shrestha, Laborde, in works in succession [Concistrè 2013; Martens 2011; Miceli 2016; Shrestha 2013; Cerillo 2018; Laborde 2016; Gilmanov 2014; Berretta 2019]. Folliguet et al. talks about 4.6% of prostheses for heavy PVL. A complete heart block requiring a permanent pacemaker is a known complication of AVR [Folliguet 2012]. This incidence was 4.5% in our study, which is quite consistent with Santarpino et al. and

Table 3. Postoperative outcomes

	N = 67	% (+sd)
Reoperation for bleeding	3	4.5
PVL	4	5.9
Postoperative neurological dysfunction	4	5.9
Mortality	4	5.9
Postoperative peak transvalvular gradient [mmHg]	23	(+5)
Postoperative mean transvalvular gradient [mmHg]	11	(+3)
Follow-up peak transvalvular gradient [mmHg]	19	(+2)
Follow-up mean transvalvular gradient [mmHg]	9	(+2)
Implantation PM	3	4.5
Hospital stay in days	7.7	(+3.6)
Postoperative blood loss at 24 hours (ml)	417	(+115)

PVL, paravalvular leak; PM, pacemaker

Flameng et al. but slightly higher than Gilmanov et al. (2.3%) [Santarpino 2012; Flameng 2011; Gilmanov 2014]. Early 30-day mortality was 5.9% in our study, which is slightly higher than other studies cited. In the study by Flameng et al., 9.4% of patients died after 6-12 months of surgery. Permanent pacemaker implantation was a bit of a concern with the use of Perceval S [Flemeng 2011]. Most world literature cites implantation rates for permanent pacemakers between 3% and 8%. Glauber et al. publish encouraging data after a prospective study of 3.3% [Glauber 2019]. In our study, a permanent pacemaker was implanted in 3 (4.5%) patients. Meta and associates based on meta-analysis have a gradual rate of 7.9%. However, some studies report much higher rates than as high as 23%. This is worrying, given the significant morbidity associated with permanent pacemakers. The papers revealed that age, presence of preoperative rhythm disturbances, thickness of membrane septum, presence of bicuspid aortic valve and combined procedures on mitral or tricuspid valve are predictors of postoperative implantation of permanent pacemaker [Fischlein 2021; Lorusso 2020; Meco 2018].

Limitations: The main limitation of this study is that it is based on data from one institution and a limited number of cases. What's more, it lacks a control group and randomization within them. This study showed only early outcomes, and there remains a need to obtain data documenting the long-term performance of the Perceval S valve that we will monitor over the next 5 years.

CONCLUSION

The Perceval S prosthesis is a safe and feasible procedure. Sutureless AVR may become the first choice of procedure in the elderly high risk population. Further follow up is needed to evaluate the long-term outcome of this bioprosthesis.

REFERENCES

- Berretta P, Andreas M, Carrel TP, Solinas M, Teoh K, Fischlein T, et al. 2019. Minimally invasive aortic valve replacement with sutureless and rapid deployment valves: a report from an international registry (sutureless and rapid deployment international registry). *Eur J Cardiothorac Surg*. 56: 793-799.
- Cerillo AG, Amoretti F, Mariani M, et al. 2018. Increased Gradients After Aortic Valve Replacement With the Perceval Valve: The Role of Oversizing. *Ann Thorac Surg*. 106:121-8.
- Concistrè G1, Santarpino G, Pfeiffer S, et al. 2013. Two alternative sutureless strategies for aortic valve replacement: a two-center experience. *Innovations (Phila)*. 8: 253-7.
- D'Onofrio A, Messina A, Lorusso R, et al. 2012. Sutureless aortic valve replacement as an alternative treatment for patients belonging to the gray zone between transcatheter aortic valve implantation and conventional surgery: a propensity-matched, multicenter analysis. *J Thorac Cardiovasc Surg*. 144: 1010-6.
- Di Eusanio M, Fortuna D, De Palma R. 2011. Aortic valve replacement: results and predictors of mortality from a contemporary series of 2256 patients. *J Thorac Cardiovasc Surg*. 141:940-7.
- Englberger L, Carrel TP, Doss M, Sadowski J, Bartus K, Eckstein FF, et al. 2014. Clinical performance of a sutureless aortic bioprosthesis: five-year results of the 3f Enable long-term follow-up study. *J Thorac Cardiovasc Surg*. 148(4):1681-7.
- Fischlein T, Folliguet T, Meuris B, Shrestha M, Roselli E, McGlothlin A, et al. 2021. Sutureless versus conventional bioprostheses for aortic valve replacement in severe symptomatic aortic valve stenosis. *J Thorac Cardiovasc Surg*. Mar;161(3):920-932.
- Flameng W, Herregods MC, Hermans H, Van der Mieren G, Vercalsteren M, Poortmans G, et al. 2011. Effect of sutureless implantation of the Perceval S aortic valve bioprosthesis on intraoperative and early postoperative outcomes. *J Thorac Cardiovasc Surg*. 142(6):1453-7.
- Folliguet TA, Laborde F, Zannis K, Ghorayeb G, Haverich A, Shrestha M. 2012. Sutureless Perceval aortic valve replacement: results of two European centers. *Ann Thorac Surg*. 93(5):1483-8.
- Gilmanov D, Miceli A, Ferrarini M, Farneti P, Murzi M, Solinas M, et al. 2014. Aortic valve replacement through right anterior minithoracotomy: can sutureless technology improve clinical outcomes? *Ann Thorac Surg*. 98(5):1585-92.
- Glauber M, Di Bacco L, Cuenca J, Di Bartolomeo R, Baghai M, Zakova D, et al. 2019. Minimally Invasive Aortic Valve Replacement with Sutureless Valves: Results From an International Prospective Registry Innovations (Phila). Dec 26:1556984519892585.
- Kocher AA, Laufer G, Haverich A, et al. 2013. One-year outcomes of the Surgical Treatment of Aortic Stenosis With a Next Generation Surgical Aortic Valve (TRITON) trial: a prospective multicenter study of rapid-deployment aortic valve replacement with the EDWARDS INTUITY Valve System. *J Thorac Cardiovasc Surg*. 145: 1105.
- Laborde F, Fischlein T, Hakim-Meibodi K, Misfeld M, Carrel T, Zem-bala M, et al. 2016. Clinical and haemodynamic outcomes in 658 patients receiving the Perceval sutureless aortic valve: early results from a prospective European multicentre study (the Cavalier Trial) Cavalier Trial Investigators. *Eur J Cardiothorac Surg*. Mar;49(3):978-86.
- Lorusso R, Folliguet T, Shrestha M, Meuris B, Kappetein A, Roselli E, et al. 2020. Sutureless versus Stented Bioprostheses for Aortic Valve Replacement: The Randomized PERSIST-AVR Study Design *Thorac Cardiovasc Surg*. Mar;68(2):114-123.
- Martens S, Sadowski J, Eckstein FS, Bartus K, Kapelak B, Sievers HH, et al. 2011. Clinical experience with the ATS 3f Enable® Sutureless Bioprosthesis. *Eur J Cardiothorac Surg*. 40(3):749-55.
- Meco M, Montisci A, Miceli A, Panisi P, Donatelli F, Cirri S, et al. 2018. Sutureless Perceval Aortic Valve Versus Conventional Stented Bioprostheses: Meta-Analysis of Postoperative and Midterm Results in Isolated Aortic Valve Replacement. *J Am Heart Assoc*. Feb 16;7(4).
- Miceli A, Gilmanov D, Murzi M, Marchi F, Ferrarini M, Cerillo AG, et al. 2016. Minimally invasive aortic valve replacement with a sutureless valve through a right anterior mini-thoracotomy versus transcatheter aortic valve implantation in high-risk patients. *Eur J Cardiothorac Surg*. Mar;49(3):960-5.
- Nguyen A, Fortin W, Mazine A, Bouchard D, Carrier M, El Hamamsy I, et al. 2015. Sutureless aortic valve replacement in patients who have bicuspid aortic valve. *J Thorac Cardiovasc Surg*. Oct;150(4):851-7.
- Phan K, Tsai Y-C, Niranjana N, Yan TD, Di Eusanio M. 2014. Sutureless aortic valve replacement: a systematic review and meta-analysis. *Ann Cardiothorac Surg*.
- Santarpino G, Pfeiffer S, Concistrè G, Fischlein T. 2012. A supra-annular malposition of the Perceval S sutureless aortic valve: the ‘-movement’ removal technique and subsequent reimplantation. *Interact Cardiovasc Thorac Surg*. (15):280-1.
- Santarpino G, Pfeiffer S, Fischlein T. 2012. Sutureless aortic valve replacement to prevent patient-prosthesis mismatch in the era of valve in valve implantation. *J Thorac Cardiovasc Surg*. 144(1): 279-80.
- Sedaghat A, Al-Rashid F, Sinning JM, Wendt D, Thielmann M, Grube E, et al. 2015. Outcome in TAVI patients with symptomatic aortic stenosis not fulfilling PARTNER study inclusion criteria. *Catheter Cardiovasc Interv*. Nov 15;86(6):1097-104.
- Shrestha M, Folliguet T, Meuris B, Dibie A, Bara C, Herregods MC, et al. 2009. Sutureless Perceval S aortic valve replacement: a multicenter, prospective pilot trial. *J Heart Valve Dis*. 18:698-702.
- Shrestha M, Maeding I, Höffler K, Koigeldiyev N, Marsch G, Siemieni T, et al. 2013. Aortic valve replacement in geriatric patients with small aortic roots: are sutureless valves the future? *Interact Cardiovasc Thorac Surg*. 17(5):778-82.
- Sian K, Li S, Selvakumar D, Mejia R. 2017. Early results of the Sorin(R) Perceval S sutureless valve: systematic review and meta-analysis. *J Thorac Dis*. 9(3):711-724.