Perceval S, sutureless aortic valve: cost-consequence analysis

Ioannis Panagiotopoulos1, Nikolaos Kotsopoulos2, Georgios-Ioannis Verras3, Francesk Mulita3, Anastasia Katinioti4, Efstratios Koletsis1, Konstantinos Triantafyllou5, John Yfantopoulos6

1Department of Cardiothoracic Surgery, General University, Hospital of Patras, Patras, Greece
2Division of Health Economics, Global Market Access Solutions, St-Prex, Switzerland
3Department of Surgery, General University, Hospital of Patras, Patras, Greece
4Cardiology Unit, Hippokration Hospital, Athens University Medical School, Athens, Greece
5Gastroenterology Unit, 2nd Department of Internal Medicine-Propaedeutic, National and Kapodistrian University of Athens, Athens, Greece
6MBA – Health Department of Economics, National and Kapodistrian University of Athens, Athens, Greece

Kardiochirurgia i Torakochirurgia Polska 2022; 19 (1): 22-27

Abstract

Introduction: Sutureless aortic valve prostheses have the potential of shortening ischemic time.

Aim: We conducted the present study to assess the clinical and economic impact of the biological, sutureless, self-expanding Perceval S valve since the effect of shortened operative times on hospital costs remains unclear.

Material and methods: This is a retrospective analysis. From January 2018 to January 2019, 29 patients underwent isolated aortic valve replacement with the Crown PRT bioprosthetic Aortic Valve, whereas 35 patients underwent aortic valve replacement with Perceval S (auto-expanded, sutureless, bioprosthesis). Preoperative data, hospital outcome, and health care resource consumption were compared, using χ² and t-test.

Results: Aortic cross-clamp, cardiopulmonary bypass, and operation times were significantly shorter in the Perceval S group (p < 0.001). Patients in the sutureless group required blood transfusion less frequently (p = 0.03) and had a shorter intensive care unit (ICU) stay (p = 0.01). Hospital stay (p = 0.57) and pacemaker implantation were similar between groups. The reduction of aortic cross-clamp, extracorporeal circulation times, and ICU stay resulted in reduced resource consumption in the sutureless group.

Conclusions: The use of the Perceval S valve is clinically safe and effective. A shorter procedural time in the sutureless group is associated with better clinical outcomes and reduced hospital costs.

Key words: Perceval S, sutureless aortic valve, cost effectiveness, aortic valve replacement.

Introduction

The prevalence of heart valve disease within European countries is estimated at about 13.3 million patients [1]. Despite the fact that rheumatic fever prevalence (once a prominent cause of heart valve disease) is being reduced, in certain countries – mostly the developing ones – valvular heart disease is still a major issue [2]. The magnitude of the problem is not to be ignored either; today, it is estimated that 10–20% of all cardiac surgery is performed to treat some form of valvular disease [3]. On the other hand, and as the life expectancy of the population increases [4], the recommendations on the management of cardiac surgery patients are modified accordingly. As a result, today’s cases are harder to manage, and include many high-risk patients. Therefore, the cardiac surgeon must be ever ready to adapt and include surgical techniques that are better tolerated by the at-risk population. One such important advance in cardiac surgery is the application of self-expandable bioprosthetic valves, utilized in surgical aortic valve replacement, indicated for severe aortic stenosis or insufficiency. Literature on self-expanding valve use is expanding rapidly, and the indications for their utilization are broadened accordingly.

Aim

Our retrospective study aims to depict our experience with the Perceval S (LivaNova PLC, UK) self-expanding bioprosthetic aortic valve, in a single cardiac surgery center as well as to evaluate its safety profile, effectiveness and economic efficiency.

Material and methods

Our team retrospectively studied all patients in the two-year period of 2018–2019 who underwent aortic valve replacement with the use of a bioprosthetic valve in our cen-
ter. Inclusion criteria of the study were eligibility for aortic valve replacement surgery in accordance with international guidelines and ability to provide informed consent. Patients excluded from the study included those whose valve replacement was part of a reoperation, patients undergoing combinatory surgery and patients who underwent replacement of the aortic valve with any bioprosthetic valve other than the two types included in the study. After analysis of the enrolled patients, 3 patients were further excluded from the study (2 from the control group and 1 from the study group), due to extraordinary and rare complications that would alter the study’s results (intraoperative arrest and intensive care unit (ICU) hospitalization with open chest, intraoperative aortic dissection and multiple intraoperative efforts of valve installment). The two final patient populations were: the control population of 29 patients, in which the classic bioprosthetic Crown Pr T (LivaNova PLC, UK) valve was used, and the test population of 35 patients, in which the self-expanding bioprosthetic Perceval S (LivaNova PLC, UK) was used.

In order to evaluate the economic impact of sutureless valve implementation, we utilized literature data to measure the cost of several aspects of cardiothoracic surgery. In that aspect, the average cost of a packed red blood cell (pRBC) unit was set at €500 [5, 6], use of the operating room at €20/minute of operation [5–7], and admission to the ICU at €700 for the first 3 days and €500/day afterwards.

**Statistical analysis**

Our results included usage of the t-test and the χ² test to compare measures of means and proportions. Results were viewed as significant for p levels < 0.05.

**Results**

The preoperative, intraoperative and postoperative data of the patients are presented in Tables I–III respectively. The patients within the two groups differed in several preoperative factors, mainly in their disease severity, measured by the EuroSCORE II scale. This finding is in line with another characteristic of the study group, which was the older age, a major factor in valvular disease severity and heart failure. Despite the observed differences, the study group can be seen to have comparable outcomes with the control group in most of the expected complications of the operation (Table I).

Another difference between the two groups is that the study group began the operation with significantly lower Hb levels than the control group (11.2 ±1.1 versus 12.3 ±1.3, p < 0.001); however, postoperative hemoglobin (Hb) levels did not differ significantly between the two groups. The average number of pRBC units also differed significantly between the two groups, with the Perceval S population requiring 0.9 ±0.9 pRBC units on average, as opposed to 1.5 ±1.3 units of the Crown group (p = 0.03). As a result, average transfusion costs were also significantly reduced, measuring at 485.7 ±461.5 euros per patient for the Per-

| Table I. Preoperative characteristics of our patients |
|-----------------------------------------------------|
| Parameter                              | Crown (%) | Perceval S (%) | P-value |
| Men                                    | 20 (69)   | 11 (31.4)      | < 0.01  |
| Women                                  | 9 (31)    | 24 (68.6)      | < 0.01  |
| BSA                                    | 1.89 ±0.24| 1.76 ±0.19     | 0.015   |
| Age                                    | 70.3 ±6.07| 80.34 ±4.22    | < 0.001 |
| PVD                                    | 3 (10.3)  | 5 (14.2)       | NS      |
| Presence of diabetes mellitus          | 7 (24.1)  | 15 (42.85)     | < 0.001 |
| Presence of COPD                       | 4 (13.8)  | 7 (20)         | 0.05    |
| Presence of chronic renal disease      | 2 (6.9)   | 7 (20)         | 0.05    |
| Presence of arterial hypertension      | 19 (65.5) | 25 (71.4)      | NS      |
| Presence of dyslipidemia               | 16 (55.1) | 20 (57.1)      | NS      |
| Presence of pulmonary hypertension     | 2 (6.9)   | 6 (17.1)       | 0.001   |
| Ejection fraction:                     |           |               | < 0.05  |
| Good                                   | 15 (51.7) | 10 (28.5)      |         |
| Moderate                               | 10 (34.5) | 18 (51.5)      |         |
| Bad                                    | 4 (13.8)  | 7 (20)         |         |
| EuroSCORE                              | 2.90 ±0.91| 4.37 ±0.51     | < 0.001 |

| Table II. Intraoperative data |
|-------------------------------|
| Parameter                   | Crown | Perceval S | P-value |
| Hb prior to surgery          | 12.3 ±1.3 | 11.2 ±1.1 | < 0.001 |
| Hb after surgery             | 7.6 ±1.03 | 7.9 ±5.8  | 0.79    |
| No of pRBC transfusions      | 1.5 ±1.3  | 0.9 ±0.9   | 0.03    |
| Transfusion cost             | 793.1 ±661.6| 485.7 ±461.5| 0.03  |
| ECC time                    | 89.7 ±30.2 | 54.1 ±9.8  | < 0.001 |
| ACC time                    | 68.2 ±17.8 | 37.6 ±7.2  | < 0.001 |
| Length of surgery           | 181.8 ±45.2| 132.1 ±18.1| < 0.001 |
| Prosthetic valve size       | 21.8 ±1.5  | 22.5 ±2.0   | 0.1     |
| Total surgery cost          | 3640 ±919.8| 2664.2 ±350.2| < 0.001|

| Table III. Postoperative data |
|-------------------------------|
| Parameter                   | Crown | Perceval S | P-value |
| Length of ICU stay [days]   | 1.8 ±0.9 | 1.2 ±0.6 | 0.01    |
| Total length of hospital stay [days] | 5.7 ±1.0 | 5.8 ±0.9 | 0.57    |
| ICU cost                    | 1417.2 ±679.1| 998.5 ±495.9| 0.007  |
| Atrial fibrillation         | 3 (10.3%) | 3 (8.1%) | NS      |
| Pleural effusion            | 5 (17.2%) | 7 (20%)  | NS      |
| Permanent pacemaker placement | 1 (3.4%) | 1 (2.8%) | NS      |
| Reoperation                 | 2 (6.9%)  | 2 (5.7%)  | NS      |
| Wound infection             | 0       | 0         | NS      |
| Respiratory infection       | 2 (6.9%)  | 2 (5.7%)  | NS      |
As a consequence, aortic valve replacement, due to the age of 75 years of age, it increases to 8.1% at 85 years of age. The prevalence of aortic valve disease is estimated at 2.5% throughout the lifespan. In fact, it has been documented that while in high and very high surgical risk patients report enhanced postoperative morbidity, with a 1.4% increase in postoperative morbidity risk for every minute of ACC time [15, 21, 22]. Our results demonstrated added value for sutureless valve replacement, in the form of both ACC and ECC times being driven down when compared to the Crown valve replacement. These findings are in line with those of previous studies evaluating the use of Perceval bioprosthetic valves [16, 17, 23–27]. Most prominently, results from the SURD-IR registry, with an analysis of more than 4,500 patients, also demonstrated reduced cross-clamp times and ECC times, that were in fact associated with improved hemodynamic status of the patients, when compared to traditional bioprosthetic valve options [28].

In addition, sutureless valve utilization will allow for minimally invasive surgical procedures, a practice that until now has been excessively demanding, when conventional bioprosthetic valves were used. These procedures also result in minimal trauma and reduced recovery times and therefore can also be employed to make valve replacement surgery accessible to patients with a heavy comorbidity burden [17, 20]. The additional costs of implementing newer bioprosthetic materials seem to be counterbalanced by the clinical benefits, and the hastened patient discharge that as our study suggests can be effective in lowering the overall cost of the patient admitted for cardiac surgery. In fact, data suggest that elderly patients have higher overall costs for a heart valve implantation than younger patients [14, 29]. Therefore, novel bioprosthetic valves such as the one we studied are not only able to be implemented in elderly and comorbidity-ridden patients, but by doing so they might reduce the admission costs of the costliest age group of patients.

The major areas of focus for the economic cost of a patient undergoing cardiac surgery are thought to be the operating room, days spent either on ICU admission or normal ward admission, and the cost of complications. In our study cohort, there were no significant complications recorded, so the focus of the analysis was on the length of the operation and hospital stay. Especially concerning the length of cICU admission, it is widely known that this can be the costliest aspect of admitting a patient for cardiac surgery [29]. In our study, length of both ICU and non-ICU stay was significantly decreased within the study group, and led to significant per-patient cost reduction. This is in line with previous findings of research on sutureless valves, and is additionally associated with lower complication rates among patients, apart from the reduced cost of the operation [24, 30, 31].

By making the assumption that all other variables within the operating room remained approximately the same (personnel use, methods of disinfection, anesthesia methods, etc.), we attributed the observed difference in surgical outcomes and favorable safety profiles with comparable mortality rates to those of traditional bioprosthetic valves [18–20]. Factors that influence mortality rates include both the ACC and ECC times studied here. ACC time in cardiac surgery is an independent risk factor for serious postoperative morbidity, with a 1.4% increase in postoperative morbidity risk for every minute of ACC time [15, 21, 22].
times, and in turn costs, to the different methods utilized. Our results showed that on average there were cost savings of approximately 1000 euros per surgical patient when the Perceval S was utilized.

Results on transfusion outcomes also differed between the two groups. Despite the fact that our study population presented with significantly lower Hb levels preoperatively, it also required significantly fewer packed red blood cell (pRBC) transfusions than the control population. Transfusions during aortic valve replacement have also been studied by several teams, demonstrating less reliance on intraoperative blood transfusion in all studies, which was also related to better outcomes and less time spent in the ICU [18, 23, 32, 33]. Therefore, another positive outcome of sutureless valve implementation was the requirement of fewer transfusion procedures, which further reduces surgical costs for the patient.

When evaluating a novel surgical method, one must not forget to look into the reported shortcomings of the technique. In the literature it is reported that utilization of sutureless aortic valve replacement may be associated with high incidence of postoperative rhythm disturbances, most frequently heart blocks, that can affect up to 7.9% of the patients, as opposed to 3.1% when conventional stented bioprostheses were used [34–37]. However, follow-up of the patients still revealed better hemodynamic status of the patients who underwent sutureless aortic valve replacement, despite the conduction abnormalities [37]. Predictors of permanent pacemaker implantation including age, the presence of preoperative right bundle branch block (RBBB) as well as left bundle branch block (LBBB) and pre-existing first-degree block are all factors that predict postoperative pacemaker placement [32]. There are also concerns raised by several authors regarding the postoperative occurrence of thrombocytopenia with sutureless valve usage, but none of the authors described further complications stemming from thrombocytopenia [38–40]. Thrombocytopenia after sutureless valve implantation has been a cause for debate among cardiac surgeons for a while. Current literature seems to indicate that there is no real need for concern stemming from the transient decrease in platelet counts in patients with sutureless valve replacement, compared to other valve replacement methods. In one recently published randomized controlled trial (RCT), the researchers found that while platelet reduction on the third postoperative day was indeed higher in the Perceval group of patients, platelet counts quickly normalized without further intervention, and there were no differences in the occurrence of bleeding or stroke events, or transfusion needs [41]. Centers have also reported that postoperative platelet counts were more favorable in sutureless valve patients, compared to standard stented valve patients [42]. At any rate, the observed tendency towards thrombocytopenia has not been associated with worse patient outcomes or major bleeding events in several studies [42–45]. Thrombocytopenia was not assessed within our patient cohort, largely due to previous experience that showed only a minimal to moderate decrease in platelet counts, which recovered to normal values without requiring platelet transfusions. A 2016 international consensus of cardiac surgery experts, however, stated that complications including prolonged ventilation, atrial fibrillation, pleural effusion, paravalvular leakage and aortic regurgitation are reduced with the use of sutureless valves [46]. In our study, there were not sufficient numbers of the aforementioned complications in order to compare them.

There are a few limitations of our study design. Due to a lack of specific data on our country’s operating room cost, the estimate employed here was based on observations from other countries within the EU. However, in any case, the observed percentile difference remains the same. Also, a more accurate estimate of the economic effects of the Perceval S implementation would require a detailed micro-costing model to be employed, but this was not the focus of our study. Finally, it would be appropriate to include data on the long-term follow-up of our patients in order to truly evaluate the impact of different material used, and it is within our future goals to evaluate this mid- to long-term impact, once sufficient data are available from our patient cohort.

Conclusions

It seems that the studied method of sutureless aortic valve implantation is effective in the treatment of high-risk patients with aortic valve disease, while at the same time it provides satisfactory clinical results; patients achieved a lower average length of stay, including length of stay in the cICU, and no major postoperative complications were recorded. Additionally, patients required fewer blood transfusions on average, and a reduction in surgical times that specifically impact mortality was noted. These results can be attributed to the unique technical characteristics of the utilized material that allows for high-risk surgical interventions to be achieved in a less burdensome manner towards the patient. Adding to the observed advantages, the Perceval S valve use was also associated with a reduction in resources employed and total expenses, mainly through improvement of the overall hospital stay of the patients.

Disclosure

The authors report no conflict of interest.

References

1. Timmis A, Townsend N, Gale C, Grobbee R, Maniadakis N, Flather M, Williams E, Wright L, Vos R, Bax J, Blum M, Pinto F, Vardas P, ESC Scientific Document Group. European Society of Cardiology: Cardiovascular Disease Statistics 2017. Eur Heart J 2018; 39: 508-77.
2. Watkins DA, Johnson CO, Colquhoun SM, Karthikeyan G, Beaton A, Bukhman G, Forouzanfar MH, Longenecker CT, Mayosi BM, Mensah GA, Nascimento BR, P Ribeiro A, Sable CA, Steer AC, Naghavi M, Mokdad AH, Murray CJL, Vos T, Carapeti JS, Roth GA. Global, regional, and national burden of rheumatic heart disease, 1990–2015. N Engl J Med 2017; 377: 713-22.
3. Zipes DP, Libby P, Bonow RO, Mann DL, Tomasselli GF, Braunwald E. Braunwald’s Heart Disease: a Textbook of Cardiovascular Medicine. Elsevier 2018.
4. Aburto JM, Villavicencio F, Basellini U, Kjærgaard S, Vaupel JW. Dynamics of life expectancy and life span equality. Proc Natl Acad Sci USA 2020; 117: 5250-9.
Perceval, sutureless aortic valve: cost-consequence analysis

5. Harmonised index of consumer prices (HICP) (prc_hicp). Accessed October 11, 2021. https://ec.europa.eu/eurostat/cache/metadata/ en/prc_hicp_esms.htm

6. Al-Ruzzeh S, Epstein D, George S, Bustami M, Wray J, Isley C, Sculpher M, Ansari M. Economic evaluation of coronary artery bypass grafting surgery with and without coronary bypass surgery: cost-effectiveness and quality-adjusted life years in a randomized controlled trial. Artif Organs 2008; 32: 891-7.

7. Murtuza B, Pepper JR, Stanbridge RD, Jones C, Rao C, Darzi A, Athanasiou T. Minimal access aortic valve replacement: is it worth it? Ann Thorac Surg 2008; 85: 1211-31.

8. Durston TE, Carvalho D, Ryan WH, Herbert MA, Prince SL, Mack MJ. Reliability of risk algorithms in predicting early and late operative outcomes in high-risk patients undergoing aortic valve replacement. J Thorac Cardiovasc Surg 2008; 135: 180-7.

9. Bonov RO, Caraballo BA, Karu C, de Leon JR AC, Faxon DP, Freed MD, Gaasch WY, Blyth NW, Nishimura RA, O’Gara PT, O’Rourke RA, Otto CM, Shah PM, Shanevis JS, Smith JR SC, Jacobs AK, Adams CD, Anderson JL, Antman EM, Faxon DP, Fuster V, Halperin JL, Hiratzka LF, Hunt SA, Lytle BW, Nishimura R, Page RL, Riegel B. ACC/AHA 2006 Guidelines for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (writing committee to revise the 1998 Guidelines for the Management of Patients With Valvular Heart Disease): developed in collaboration with the Society for Cardiovascular Anesthesiologists: endorsed by the Society for Cardiovascular Angiography and Interventions and the Society of Thoracic Surgeons. Circulation 2006; 114: e84-231.

10. Pereira JJ, Laufer MS, Bashuir M, Afridi I, Blackstone EH, Stewart WJ, McCarthy PM, McCarthy PM, Tanaka K, Akiyama T, Imai J, Nakamura H, Tsuchida K, Tsuchida K, Tsuchida K. Aortic valve replacement in patients with severe aortic stenosis with low transvalvular gradients and severe left ventricular dysfunction. J Am Coll Cardiol 2002; 39: 1356-63.

11. Connolly HM, Oh JK, Schaff HV, Roger VL, Osborn SL, HodGE DO, Tajik AJ. Severe aortic stenosis with low transvalvular gradient and severe left ventricular dysfunction: result of aortic valve replacement in 52 patients. Circulation 2000; 101: 1940-6.

12. Pai RG, Varadarajan P, Razouk A. Survival benefit of aortic valve replacement in patients with severe aortic stenosis with low ejection fraction and low normal ejection fraction. Ann Thorac Surg 2008; 86: 1871-9.

13. Casserly IP, Kapadia SR. Advances in percutaneous valvular intervention. Expert Rev Cardiovasc Ther 2005; 3: 143-58.

14. Iung B, Baron G, Butchart EG, Delahaye F, Gohlke-Bärwolf C, Levang OW, Torre-Amione G, Torre-Amione G, Torre-Amione G. EAPCM/ESC/EACTS Guidelines for the management of valvular heart disease: a report of the European Association for Cardiovascular Pathology and the European Society of Cardiology Working Group on Valvular Heart Disease. Eur Heart J 2006; 27: 375-407.

15. Al-Ruzzeh S, Epstein D, Sculpher M, Ansari M, Ansari M, Ansari M, Ansari M. The cost-effectiveness of transapical aortic valve replacement. Eur J Cardiothorac Surg 2010; 37: e158-63.

16. Folliguet TA, Shrestha ML, Roselli EE, Mclothin A, Kappert U, Pfeiffer S, Corbi P, Losurdo R, Perceval Sutureless Implant Versus Standard-Aortic Valve Replacement Investigators. Sutureless versus conventional bioprostheses for aortic valve replacement in severe symptomatic aortic valve stenosis. J Thorac Cardiovasc Surg 2021; 161: 920-31.

17. Hurley CT, O’Sullivan KC, Segurode R, Hurley JA. A meta-analysis examining differences in short-term outcomes between sutureless and conventional aortic valve prostheses. Innov Tech Cardiothorac Surg 2015; 10: 375-82.

18. Di Eusanio M, Beretta P. The sutureless and rapid-deployment aortic valve replacement international registry: lessons learned from more than 4,500 patients. Ann Cardiothorac Surg 2020; 9: 289-97.

19. Huygens SG, Goossens LMA, Ekelens JA van, Takkenberg JM, Molken MPMHR. Original research article: how much does a heart valve implantation cost and what are the health care costs afterwards? Open Heart 2018; 5: e000672.

20. de Varennes B, Lachapelle K, Cecere R, Szczepikowski I, Buitstith J, North American single-center experience with a sutureless aortic bioprosthesis. J Thorac Cardiovasc Surg 2021; 165: 734-42.

21. Takagi H, Uemoto T, ALICE (All-Literature Investigation of Cardiovascular Evidence) Group. Sutureless aortic valve replacement may improve early mortality compared with transcatheter aortic valve implantation: a meta-analysis of comparative studies. J Cardiol 2016; 67: 504-12.

22. Powell R, Pelletier MP, Chu MWA, Bouchard D, Melvin KN, Adams C. The Perceval sutureless aortic valve review of outcomes, complications, and future direction. Innov Tech Cardiothorac Surg 2017; 12: 155-73.

23. Casha AR, Manche A, Camilleri L. Sutureless Perceval aortic valve implantation compared with conventional Metilflow valve replacement. Indian J Thorac Cardiovasc Surg 2018; 34: 109-15.

24. Micieli A, Beretta P, Fiore A, Andreas M, Solinas M, Santarpino G, Kappert U, Misfeld M, Savini C, Albertini A, Villa E, Phan K, Fischlein T, Meuris B, Martinelli G, Teoh K, Mignosa C, Shrestha ML, Carnicelli E, Clauser M, Glauer M, Di Eusanio M. Sutureless and rapid deployment implantation in bicuspid aortic valve: bypass in adult cardiac surgery. Perfusion 2009; 24: 297-305.

25. Folliguet TA, Laborde F, Zannis K, Ghorabey G, Haverich A, Shrestha M. Sutureless Perceval aortic valve replacement: results of two European centers. Ann Thorac Surg 2012; 93: 1483-8.

26. Nikleski W, Filipak K, Przybylowski R, Zembla M, Kukulski T, Zembla M. Aortic valve replacement with a new prostheses and outcome in aortic valve re-
pili M, Repossini A, Folliguet T. A comparison of conventional surgery, transcatheter aortic valve replacement, and sutureless valves in “real-world” patients with aortic stenosis and intermediate- to high-risk profile. Read at the 95th Annual Meeting of the American Association for Thoracic Surgery, Seattle, Washington, April 25-29, 2015. J Thorac Cardiovasc Surg 2015; 150: 1570-9.

41. Lorusso R, Jiritano F, Roselli E, Shrestha M, Folliguet T, Meuris B, Pollar F, Fischlein T, PERSIST-AVR Investigators. Perioperative platelet reduction after sutureless or stented valve implantation: results from the PERSIST-AVR controlled randomized trial. Eur J Cardiothorac Surg 2021; 60: 1359-65.

42. Santarpino G, Vogt F. Letter to the Editor: thrombocytopenia after sutureless aortic valve implantation: does it really matter? J Hear Valve Dis 2017; 26: 492.

43. Stanger O, Grabherr M, Gahl B, Longrus S, Mehnitzer A, Fiedler M, Tevaearai H, Carrel T. Thrombocytopenia after aortic valve replacement with stented, stentless and sutureless bioprostheses. Eur J Cardiothorac Surg 2017; 51: 340-6.

44. Mujtaba SS, Ledingham S, Shah AR, Schueler S, Clark S, Pillay T. Thrombocytopenia after aortic valve replacement: comparison between sutureless perceval s valve and perimount magna ease bioprosthesis. Brazilian J Cardiovasc Surg 2018; 33: 169-75.

45. Thitivaraporn P, Chiramongkol S, Muntham D, Pompabyanarak N, Kittayarak C, Namchaisri J, Singhatanadgit S, Ongcharit P, Benjacholamas V. Thrombocytopenia in moderate- to high-risk sutureless aortic valve replacement. Korean J Thorac Cardiovasc Surg 2018; 51: 172-9.

46. Glauber M, Moten SC, Quaini E, Solinas M, Folliguet TA, Meuris B, Miceli A, Oberwalder PI, Rambaldini M, Teoh KHT, Bhatnagar G, Borger MA, Bouchar D, Bouchot G, Clark SC, Daupunt OE, Ferrari M, Fischlein TJM, Laufer G, Miglona C, Milliner R, Noirihomme P, Pfeiffer S, Ruyra-Balard X, Shrestha ML, Sirri RM, Troise G, Gersak B. International Expert Consensus on sutureless and rapid deployment valves in aortic valve replacement using minimally invasive approaches. Innov Tech Cardiothorac Vasc Surg 2016; 11: 165-73.