Association Between Blood Transfusions and 12-Month Mortality After Transcatheter Aortic Valve Implantation

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**Summary**

Blood transfusions are considered as an important predictor of adverse outcome in patients with severe aortic (AS) undergoing transcatheter aortic valve implantation (TAVI). We sought to investigate the association between blood transfusions and mortality after TAVI. We enrolled 101 consecutive patients with severe AS undergoing TAVI. Patients who required transfusion were defined as patients in whom at least one unit of packed red blood cells (PRBCs) was transfused in the perioperative period. Twelve-month outcomes were assessed based on Valve Academic Research Consortium definitions. A total of 28 (27.7%) patients required blood transfusion after TAVI. Baseline characteristics of the patients with and without a transfusion were similar. Median amount of PRBCs was 2 (interquartile range, 2-4). Twelve-month all-cause mortality was higher in patients with than without a blood transfusion (39.3% versus 9.6%; \(P = 0.001\)). Importantly, the need for a blood transfusion after TAVI was an independent predictor of higher mortality rates after 12 months (hazard ratio (HR) 2.84, 95%CI (1.06-7.63); \(P = 0.039\); (HR for incomplete coronary revascularization 10.86, 95%CI 3.72-31.73; \(P < 0.001\); HR for a history of stroke/TIA 3.93, 95%CI 1.39-11.07; \(P < 0.001\)). The duration of inhospital stay was longer in patients requiring transfusion (16.0 (14.0-22.0) versus 7.0 (7.0-11.5) days; \(P = 0.014\)). In conclusion, blood transfusions after TAVI were associated with higher mortality rates after 12 months, longer in-hospital stay, and were identified as an independent predictor of impaired clinical outcome. (Int Heart J 2017; 58: 50-55)

**Key words:** Aortic stenosis, Elderly, Outcomes, Bleedings

Surgical aortic valve replacement (AVR) is the standard treatment for patients with symptomatic, severe aortic stenosis (AS). Transcatheter aortic valve implantation (TAVI) is a less invasive option for elderly, high-risk patients with symptomatic severe AS. More importantly, TAVI improves survival and quality of life as compared to medical treatment in inoperable patients. TAVI is also non-inferior to AVR regarding survival in high risk patients. A successful TAVI procedure requires a complex selection process for patients, including detailed imaging information of the aortic valve anatomy and the peripheral arteries, and also critical clinical assessment by an interdisciplinary heart team. The occurrence of bleeding and access site complications after TAVI, as defined by the Valve Academic Research Consortium (VARC), ranges from 26.8 to 77.0% and 9.5 to 51.6%, respectively. The negative impact of these adverse events on outcomes has been clearly defined. Moreover, bleeding complications frequently require transfusion of packed red blood cells (PRBCs). However, the impact of blood transfusion related to bleeding events after TAVI is less established, as most of the previous studies have focused on preprocedural blood transfusions related to baseline anemia. Thus, we aimed to investigate the association of blood transfusions with long-term mortality after TAVI.

**Methods**

A total of 101 consecutive high-risk elderly patients with severe symptomatic AS undergoing TAVI were enrolled. Patient screening and selection were performed by a multidisciplinary heart team supported by clinical and imaging resources. TAVI procedures were performed using the following equipment: Edwards Sapien, Edwards Sapien XT, Edwards Sapien 3 (Edwards Lifesciences, Irvine, USA), Medtronic CoreValve (Medtronic Inc., Minneapolis, USA) and JenaValve (JenaValve Technology, Munich, Germany). Access routes were transfemoral, transapical, and direct aortic. Procedures were performed under general anesthesia or analgosedation. Baseline characteristics and procedural data were collected.
Blood counts were collected before TAVI, one day after TAVI, and at discharge or at any time at the physician’s discretion. Preoperative anemia was defined according to the World Health Organization criteria as hemoglobin < 12 g/dL in female patients and < 13 g/dL in male patients. Patients who received PRBCs transfusions (at least one unit) were compared to those who did not. Indication for transfusion was left to the discretion of the attending physician, however, institutional guidelines recommended transfusion at a hemoglobin level < 7 mg/dL and/or in the case of hemodynamic instability related to bleeding. The study was approved by the appropriate ethics committee and has been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from the patients.

**Statistical analysis:** Results are presented as the numbers of patients (percentages) or median (interquartile range [IQR]) where applicable. Differences between groups were tested using the chi-square test and Fisher’s exact test for dichotomous variables and the Mann-Whitney U-test for continuous variables. The difference in death rates between groups during the follow-up period was assessed by the Kaplan-Meier method. Also, a landmark analysis starting at 30 days was conducted. In addition, multivariate Cox regression analysis was performed to identify significant factors affecting all-cause mortality at 30 days, 12 months, and between 30 days and 12 months after TAVI.

| Table I. Baseline Clinical Data | All Patients | Transfusion (-) | Transfusion (+) | p |
|--------------------------------|-------------|-----------------|-----------------|---|
| Age, median (IQR) [years]     | 81.0 (76.0-84.0) | 81.0 (76.0-84.0) | 82.5 (77.5-84.0) | 0.48 |
| Age ≥ 80 years, n (%)         | 59 (58.4)   | 41 (56.2)       | 18 (64.3)       | 0.51 |
| Men, n (%)                    | 40 (39.2)   | 28 (38.4)       | 12 (42.9)       | 0.68 |
| Body mass index, median (IQR) [kg/m²] | 28.0 (25.2-31.1) | 28.0 (26.0-31.8) | 27.0 (25.0-29.0) | 0.17 |
| eGFR, median (IQR) [mL/minute/1.73 m²] | 61.0 (39.0-81.0) | 65.0 (43.0-82.0) | 50.0 (34.0-74.0) | 0.09 |
| NYHA I, n (%)                 | 0 (0.0)     | 0 (0.0)         | 0 (0.0)         | 0.30 |
| NYHA II, n (%)                | 17 (16.8)   | 15 (20.5)       | 2 (7.1)         | 0.28 |
| NYHA III+IV, n (%)            | 84 (83.2)   | 58 (79.5)       | 26 (92.9)       | 0.24 |
| Arterial hypertension, n (%)  | 94 (93.1)   | 67 (91.8)       | 27 (96.4)       | 0.37 |
| Diabetes mellitus, n (%)      | 35 (34.7)   | 25 (34.2)       | 10 (35.7)       | 0.89 |
| Atrial fibrillation, n (%)    | 35 (34.7)   | 24 (32.9)       | 11 (39.3)       | 0.55 |
| Previous myocardial infarction, n (%) | 31 (30.7)   | 26 (35.6)       | 5 (17.9)        | 0.08 |
| Previous PCI, n (%)           | 29 (28.7)   | 19 (26.0)       | 10 (35.7)       | 0.34 |
| Previous CTO, n (%)           | 17 (16.8)   | 12 (16.4)       | 5 (17.9)        | 0.87 |
| Previous BAV, n (%)           | 4 (4.0)     | 1 (1.4)         | 3 (10.7)        | 0.06 |
| CTO, n (%)                    | 9 (8.8)     | 6 (8.2)         | 3 (10.7)        | 0.71 |
| COPD, n (%)                   | 12 (11.9)   | 9 (12.3)        | 3 (10.7)        | 0.99 |
| Previous stroke/TIA, n (%)    | 10 (9.9)    | 5 (6.8)         | 5 (17.9)        | 0.14 |
| Pacemaker, n (%)              | 11 (10.9)   | 6 (8.3)         | 5 (18.5)        | 0.17 |
| Logistic Euroscore I, median (IQR) [%] | 14.0 (10.0-22.5) | 14.0 (10.0-22.0) | 14.5 (10.0-26.5) | 0.43 |
| STS, median (IQR) [%]         | 12.0 (5.0-24.0) | 9.0 (5.0-24.0)  | 16.0 (8.0-22.5) | 0.31 |
| TG max, median (IQR) [mmHg]   | 87.0 (71.5-109.0) | 89.0 (73.0-109.0) | 85.5 (59.5-101.5) | 0.20 |
| TG mean, median (IQR) [mmHg]  | 51.0 (42.5-66.5) | 52.0 (44.0-67.0) | 50.0 (34.8-63.5) | 0.28 |
| AVA, median (IQR) [cm²]       | 0.6 (0.4-0.8) | 0.6 (0.4-0.8)   | 0.7 (0.6-0.9)   | 0.038 |
| LVEF, median (IQR) [%]        | 60.0 (47.5-65.0) | 60.0 (47.5-65.0) | 60.0 (50.0-65.0) | 0.93 |

**Table II. Procedural and Follow-Up Data**

| All Patients | Transfusion (-) | Transfusion (+) | p |
|--------------|-----------------|-----------------|---|
| (n = 101)    | (n = 73)        | (n = 28)        |   |
| Transfemoral access, n (%) | 78 (77.2) | 58 (79.5) | 20 (71.4) | 0.33 |
| Transapical access, n (%) | 21 (20.7) | 13 (7.8) | 8 (28.6) |   |
| Transaortic access, n (%) | 2 (1.9) | 2 (2.7) | 0 (0.0) |   |
| Medtronic Corevalve, n (%) | 20 (19.8) | 16 (21.9) | 4 (14.3) | 0.08 |
| Edwards Sapien, n (%) | 77 (76.2) | 56 (76.7) | 21 (75.0) |   |
| Jena, n (%) | 4 (3.9) | 1 (1.4) | 3 (10.7) |   |
| Valve size, median (IQR) [mm] | 26.0 (26.0-29.0) | 26.0 (26.0-29.0) | 26.0 (25.5-26.0) | 0.49 |
| TG max 12 months after TAVI, median (IQR) [mmHg] | 14.5 (11.0-19.0) | 14.0 (10.1-19.1) | 15.0 (12.5-17.5) | 0.75 |
| TG mean 12 months after TAVI, median (IQR) [mmHg] | 8.0 (6.0-10.0) | 7.8 (6.0-10.0) | 8.0 (6.0-9.0) | 0.94 |
| AR grade ≥ 2, n (%) | 6 (7.9) | 5 (9.3) | 1 (4.5) | 0.95 |
| LVEF 12 months after TAVI, median (IQR) [%] | 49.0 (43.0-60.0) | 47.0 (43.0-55.0) | 50.0 (45.0-60.0) | 0.53 |

AR indicates aortic regurgitation; LVEF, left ventricle ejection fraction; TAVI, transcatheter aortic valve implantation; and TG, transaortic gradient.
months. Forward selection with a probability value for covariates to enter the model was set at the 0.05 level. All baseline clinical and procedural characteristics were tested. Results are presented as hazard ratios (HR) with 95% confidence intervals (CI). All tests were two-tailed, and a \( P \) value < 0.05 was considered statistically significant. All statistical analysis was performed using SPSS 15.0 (SPSS, Inc., Chicago, IL, USA).

RESULTS

A total of 101 consecutive patients with severe symptomatic AS undergoing TAVI were enrolled. The baseline patient characteristics and procedural details are summarized in Tables I and II, respectively. Before TAVI 24 (23.8%) patients were treated with triple treatment (TAPT; acetylsalicylic acid, clopidogrel and oral anticoagulant), 56 (55.4%) patients with dual antiplatelet therapy (DAPT; acetylsalicylic acid and clopidogrel), 13 (12.9%) with acetylsalicylic acid only, and 8 (7.9%) with a combination of acetylsalicylic acid and oral anticoagulant. All patients received acetylsalicylic acid together with clopidogrel after the procedure. A total of 61.4% of the patients continued DAPT at discharge and 32.7% of the patients were discharged with TAPT. Anticoagulation therapy in all patients with TAPT was bridged with low-molecular-weight heparin. All patients received a weight adjusted dose of unfractionated heparin (UFH) during the procedure. In 83.9% of the patients a blood transfusion was related to a bleeding event which occurred after TAVI. In particular, 28.6% of the blood transfusions were associated with vascular complications, 10.7% with acute cardiac tamponade, and 3.6% with respiratory system bleeding. Blood transfusion rates were numerically the highest in patients treated with TAPT - 41.7% (DAPT - 25.0%; acetylsalicylic acid only - 23.1%; acetylsalicylic acid and oral anticoagulant - 12.5%; \( P = 0.37 \)). A trend towards higher bleeding requiring transfusion was noted for patients treated with TAPT versus others (41.7% versus 23.4%; \( P = 0.12 \)). Blood transfusion rates for patients treated with clopidogrel as compared to patients without clopidogrel were comparable (TAPT or DAPT versus others: 30.0% versus 19.0%; \( P = 0.42 \)). Similarly, there was no difference in blood transfusion rates between patients treated with oral anticoagulants as compared to patients without oral anticoagulants (TAPT or acetylsalicylic acid and oral anticoagulant versus others: 34.4% versus 24.6%; \( P = 0.35 \)). There was no difference in bleeding event rates and blood transfusions between patients receiving DAPT versus TAPT at discharge. The rate of blood transfusion in patients undergoing transapical TAVI was 38% as compared to 25% in patients undergoing transfemoral TAVI (\( P = 0.33 \)). The glomerular filtration rate at baseline was lower in patients who received transfusions, albeit with borderline significance (\( P = 0.09 \)). The frequency of the PRBCs infused is presented in Figure 1. The median amount of packed PRBCs was 2 (interquartile range, 2-4). One patient required 8 units of PRBCs and one patient 23 units of PRBCs. In all, there were 18 deaths (17.8%) during 12-months of follow-up. Twelve-month all-cause mortality was higher in patients who received blood transfusion than in patients not requiring PRBCs (39.3% versus 9.6%; \( P = 0.001 \), Figure 2A). Interestingly, in a landmark analysis limited to patients who survived 30 days, all-cause mortality was higher in patients with as compared to patients without blood transfusion (Figure 2B). A
Table III. Multivariable Cox Regression Analysis for All-Cause Mortality

| Variable                              | Hazard ratio | 95% Confidence interval | P    |
|---------------------------------------|--------------|--------------------------|------|
| 30-day mortality                      |              |                          |      |
| Incomplete coronary revascularization | 6.64         | 1.71-25.81               | 0.006|
| Previous stroke/TIA                   | 5.20         | 1.40-19.37               | 0.014|
| 12-month mortality                    |              |                          |      |
| Need for blood transfusion            | 2.84         | 1.06-7.63                | 0.039|
| Incomplete coronary revascularization | 10.86        | 3.72-31.73               | <0.001|
| Previous stroke/TIA                   | 3.93         | 1.39-11.07               | <0.001|
| 30 days to 12 months mortality       |              |                          |      |
| Need for blood transfusion            | 9.36         | 1.04-84.35               | 0.046|
| Incomplete coronary revascularization | 13.93        | 2.52-76.94               | 0.003|

TIA indicates transient ischemic attack.

Figure 3. Twelve-month all-cause mortality stratified by packed red blood cells (PRBCs) infused. * - 8 units in 1 (3.6%) patient, 23 units in 1 (3.6%) patient.

12-month all-cause mortality stratified by the number of infused PRBCs is shown in Figure 3. In Cox regression analysis, blood transfusion after TAVI was not identified as an independent predictor of 30-day all-cause mortality (Table III). In contrary, blood transfusion after TAVI was an independent predictor of higher mortality rates after 12 months (HR 2.84 95%CI (1.06-7.63); P = 0.039; HR for history of stroke / TIA 3.93, 95%CI 1.39-11.07; P < 0.001), as well as between 30 days and 12 months (Table III). More importantly, overall bleeding (in contrary to bleeding requiring transfusion) was not identified as an independent predictor of 12-month mortality in Cox regression analysis. No interaction between antiplatelet/antithrombotic therapy model and short-term and long-term all-cause mortality was confirmed. Duration of in-hospital stay was longer in patients requiring blood transfusions (16.0 (14.0-22.0) versus 7.0 (7.0-11.5) days; P = 0.014).

**Discussion**

The study population consisted of typical elderly high-risk patients scheduled for TAVI. Our results showed that the need for blood transfusions after TAVI was associated with higher 12-month all-cause mortality. More interestingly, blood transfusions were identified as an independent predictor of higher mortality rates after 12 months after TAVI in our single center analysis. Our findings correspond with other published data.14-15 Bleeding events and access site complications are known factors of impaired clinical outcomes.16-18 However, in our study a majority of bleedings resulting in blood transfusion were associated with gastrointestinal bleeding and in only one third of patients with vascular complications. In addition, the rate of blood transfusions in patients undergoing transapical TAVI was only numerically higher than in patients undergoing transfemoral TAVI. Importantly, this difference was statistical significant in other larger studies in favor of a transfemoral approach.19,20 Thus, transapical access seems to be associated with periprocedural bleeding events with an impact on long-term mortality rate. In the PARTNER trial, patients with major bleeding had a two-fold increase in the risk of death.21 Similarly, the CoreValve Italian Registry showed an association between life-threatening bleeding and higher mortality at 3-year follow-up.22 Some may assume that most deaths after TAVI are related to life-threatening complications which may require blood transfusion, but not blood transfusions per se. Our landmark analysis as well as Cox regression models have confirmed that the need for a blood transfusion might impact the outcomes of patients who survived the first 30 days after TAVI. On the contrary, overall bleedings were not associated with short-term and long-term mortality. Thus, the need for a blood transfusion in patients with bleeding complications after TAVI might help to identify the patients at risk of death at follow-up. According to our data, there was no significant difference in the blood transfusion rate between patients receiving DAPT and TAPT. However, the blood transfusions rates were numerically the highest in patients with TAPT at baseline. On the other hand, bleeding rates related to TAPT may be influenced by bridging therapy with heparins before TAVI. Pre-procedural DAPT is frequent and does not increase short-term bleeding complications or the need for transfusion following TAVI.23 There is a lack of evidence and recommendations in terms of antiplatelet regimen after TAVI and this may vary between hospitals.24,25 Most of the data regarding the risk of combined therapy with DAPT comes from studies on patients with acute coronary syndrome. It is known that bleeding complications are observed in 2–8% of patients with coronary artery disease and are more frequent in women, the elderly, and patients with renal dysfunction and those with a history of bleeding.26,27 Several risk scores were proposed to predict bleeding in patients...
with acute coronary syndromes and/or undergoing PCI. The possible value of risk score models in the prediction of bleeding after TAVI is not clearly defined. Larger randomized clinical trials are needed to identify adequate antiplatelet or anticoagulant strategies to minimize the thromboembolic event rate while minimizing the risk of bleeding. In our study all patients received UFH during the procedure. In the BRAVO-3 trial on TAVI periprocedural pharmacotherapy, bivalirudin did not reduce the rates of major bleeding at 48 hours or net adverse cardiovascular events within 30 days as compared to UFH. Patients in our cohort who underwent TAVI did not have a preexisting anemia. Subjects who were diagnosed with anemia were temporally disqualified from TAVI and the procedure was postponed after finding the reason for the anemia or achieving an optimal hemoglobin level. It has been reported that baseline anemia was the strongest predictor of the need for a blood transfusion and is associated with impaired survival after TAVI. Previous data showed that there were no significant differences between TAVI patients and patients undergoing AVR via minithoracotomy, ministernotomy, and surgical AVR in terms of blood transfusions during hospitalization, however, access site complications were frequent.

**Limitations:** Our findings are presented with several limitations including a small sample size and recruitment from only one center. The overall number of deaths at 12 months was low (18 events) and thus the results from multivariate Cox regression analysis should be considered to be rather exploratory and hypothesis-generating. No interaction between the antiplatelet/antithrombotic therapy model and the frequency of blood transfusion/mortality was confirmed. However, such a relationship cannot be excluded as our study was probably underpowered for such subgroup analyses.

**Conclusions:** Blood transfusions after TAVI were associated with higher mortality rates after 12 months, longer in-hospital stay, and were identified as an independent predictor of impaired clinical outcome. Careful selection of patients scheduled for TAVI in terms of bleeding risk resulting in blood transfusion should be mandatory.

**DISCLOSURE**

Conflict of interest: No conflict of interest.

**REFERENCES**

1. Joint Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology (ESC); European Association for Cardio-Thoracic Surgery (EACTS); Vahanian A, Alfieri O, Andreotti F, et al. Guidelines on the management of valvular heart disease (version 2012). Eur Heart J 2012; 33: 2451-96.

2. Leon MB, Smith CR, Mack M, et al; PARTNER Trial Investigators. Transcatheter aortic-valve implantation for aortic stenosis in patients who cannot undergo surgery. N Engl J Med 2010; 363: 1597-607.

3. Bagienski M, Kleczyński P, Dzwierz A, et al. Early- and midterm outcomes after transcatheter aortic valve implantation. Data from a single-center registry. Postepy Kardiol Interwencyjnej 2016; 12: 122-7.

4. Kleczyński P, Bagienski M, Sorysz D, et al. Short- and intermediate-term improvement of patient quality of life after transcatheter aortic valve implantation: a single-center study. Kardiol Pol 2014; 72: 612-6.

5. Smith CR, Leon MB, Mack MJ, et al; PARTNER Trial Investigators. Transcatheter versus surgical aortic-valve replacement in high-risk patients. N Engl J Med 2011; 364: 2187-98.

6. Vahanian A, Alfieri O. Guidelines on valvular heart disease in clinical practice. EuroIntervention 2013; 9: S11-3.

7. Kappetein AP, Head SJ, Généreux P, et al; Valve Academic Research Consortium-2. Updated standardized endpoint definitions for transcatheter aortic valve implantation: the Valve Academic Research Consortium-2 consensus document. EuroIntervention 2012; 8: 782-95.

8. Généreux P, Head SJ, Van Mieghem NM, et al. Clinical outcomes after transcatheter aortic valve replacement using valve academic research consortium definitions: a weighted meta-analysis of 3,519 patients from 16 studies. J Am Coll Cardiol 2012; 59: 2317-26.

9. Halliday BP, Dworakowski R, Brickham B, Wendler O, MacCarthy P. Usefulness of periprocedural bleeding to predict outcome after transcatheter aortic valve implantation. Am J Cardiol 2012; 109: 724-8.

10. Seifert M, Schnabel R, Conradi L, et al. Predictors and outcomes after transcatheter aortic valve implantation using different approaches according to the valve academic research consortium definitions. Catheter Cardiovasc Interv 2013; 82: 640-52.

11. Tamburino C, Capodanno D, Ramondo A, et al. Incidence and predictors of early and late mortality after transcatheter aortic valve implantation in 663 patients with severe aortic stenosis. Circulation 2011; 123: 299-308.

12. Van Mieghem NM, Nuis RJ, Tzikas A, et al. Prevalence and prognostic implications of baseline anaemia in patients undergoing transcatheter aortic valve implantation. EuroIntervention 2011; 7: 184-91.

13. Nuis RJ, Sinning JM, Rodés-Cabau J, et al. Prevalence, factors associated with, and prognostic effects of preoperative anemia on short- and long-term mortality in patients undergoing transcatheter aortic valve implantation. Circ Cardiovasc Interv 2013; 6: 625-34.

14. Tchetche D, Van der Boom RM, Dumonteil N, et al. Adverse impact of bleeding and transfusion on the outcome post-transcatheter aortic valve implantation: Insights from the Pooled-Rotterdam-Am-Milano-Toulouse In Collaboration Plus (PRAGMATIC Plus) initiative. Am Heart J 2012; 164: 402-9.

15. Nuis RJ, Rodés-Cabau J, Sinning JM, et al. Blood transfusion and the risk of acute kidney injury after transcatheter aortic valve implantation. Circ Cardiovasc Interv 2012; 5: 680-8.

16. Seifert M, Conradi L, Terstesce AC, et al. Blood transfusion is associated with impaired outcome after transcatheter aortic valve implantation. Catheter Cardiovasc Interv 2015; 85: 460-7.

17. Binder RK, Barbanti M, Ye J, et al. Blood loss and transfusion rates associated with transcatheter aortic valve replacement: recommendations for patients who refuse blood transfusion. Catheter Cardiovasc Interv 2014; 83: E221-6.

18. Kochman J, Rymuza B, Huzeck Z, et al. Incidence, predictors and impact of severe periprocedural bleeding according to VARC-2 criteria on 1-year clinical outcomes in patients after transcatheter. Int Heart J 2016; 57: 35–40.

19. Czerwińska-Jelonkiewicz K, Michalowska I, Wiktowski K, et al. Vascular complications after transcatheter aortic valve implantation (TAVI): risk and long-term results. J Thromb Thrombolysis 2014; 37: 490-8.

20. Biancari F, Rosato S, D’Errigo P, et al; OBSERVANT Research Group. Immediate and intermediate outcome after transapical versus transfemoral transcatheter aortic valve replacement. Am J Cardiol 2016; 117: 245-51.

21. Ghatak A, Bavishi C, Cardoso RN, et al. Complications and mortality in patients undergoing transcatheter aortic valve replacement with Edwards SAPIEN & SAPIEN XT valves: a meta-analysis of world-wide studies and registries comparing the transapical and transfemoral accesses. J Interv Cardiol 2015; 28: 266-78. (Review)

22. Makkar RR, Fontana GP, Jilaihawi H, et al; PARTNER Trial Investigators. Transcatheter aortic valve replacement for inoperable severe aortic stenosis. N Engl J Med 2012; 366: 1696-704.
23. Ussia GP, Barbanti M, Petronio AS, et al; CoreValve Italian Registry Investigators. Transcatheter aortic valve implantation: 3-year outcomes of self-expanding CoreValve prosthesis. Eur Heart J 2012; 33: 969-76.

24. Huczek Z, Kochman J, Grygier M, et al. Pre-procedural dual antiplatelet therapy and bleeding events following transcatheter aortic valve implantation (TAVI). Thromb Res 2015; 136: 112-7.

25. Watanabe Y, Kozuma K, Ishikawa S, Hosogoe N, Isshiki T. Hyper-response to clopidogrel in Japanese patients undergoing transcatheter aortic valve implantation. Int Heart J 2016; 57: 190-7.

26. Vavuranakis M, Kalogeras K, Vrachatis D, et al. Antithrombotic therapy in patients undergoing TAVI with concurrent atrial fibrillation. One center experience. J Thromb Thrombolysis 2015; 40: 193-7.

27. Mosucci M, Fox KA, Cannon CP, et al. Predictors of major bleeding in acute coronary syndromes: The Global Registry of Acute Coronary Events (GRACE). Eur Heart J 2003; 24: 1815-23.

28. Andró G, Costa F. Bleeding risk stratification in acute coronary syndromes. Is it still valid in the era of the radial approach? Postepy Kardiol Interwencyjnej 2015; 11: 170-3.

29. Dangas GD, Lefèvre T, Kupatt C, et al; BRAVO-3 Investigators. Bivalirudin versus heparin anticoagulation in transcatheter aortic valve replacement: the randomized BRAVO-3 trial. J Am Coll Cardiol 2015; 66: 2860-8.

30. Tokarek T, Sobczyński R, Dziewierz A, et al. Clinical outcomes in patients after surgical and transcatheter aortic valve replacement. Pol Arch Med Wewn 2015; 125: 755-64.