Original paper

Sex-related differences in clinical outcomes and quality of life after transcatheter aortic valve implantation for severe aortic stenosis

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Abstract

Introduction: There are inconsistent data on the sex-related differences in clinical outcomes and quality of life (QoL) after transcatheter aortic valve implantation (TAVI).

Aim: We sought to investigate sex-related differences in procedural, clinical and QoL outcomes of TAVI.

Material and methods: A total of 101 consecutive patients undergoing TAVI were enrolled. Patients were stratified by gender. Baseline characteristics, procedural and long-term clinical outcomes as well as frailty and QoL indices (EQ-5D-3L questionnaire) were compared between women and men.

Results: Women represented 60.4% of the study population. Periprocedural risk measured with the Logistic EuroSCORE and STS scale was similar for women and men. There were no differences in 30-day or 12-month all-cause mortality between groups (women vs. men: 9.8% vs. 12.5%; age-adjusted odds ratio (OR) (95% CI): 1.38 (0.39–4.94); 13.1% vs. 25.0%; age-adjusted OR (95% CI): 2.51 (0.87–7.25)). Men were at higher risk of new onset atrial fibrillation at follow-up (1.6% vs. 17.5%; age-adjusted OR (95% CI): 14.61 (1.68–127.37)). In multivariable Cox regression analysis, a history of stroke/transient ischemic attack (TIA) (hazard ratio (HR)) (95% CI): 3.93 (1.39–11.07) and blood transfusion (HR (95% CI): 2.84 (1.06–7.63)) were identified as independent factors affecting 12-month mortality. No differences in QoL parameters were noted.

Conclusions: The TAVI can be considered as an effective and safe treatment in high-risk patients with severe aortic stenosis, regardless of gender.

Key words: outcomes, gender, aortic stenosis, transcatheter aortic valve implantation.

Introduction

Transcatheter aortic valve implantation (TAVI) is an effective alternative to conventional surgical treatment of severe aortic stenosis (AS) in high-risk patients, providing good clinical outcomes [1–4] and improvement in quality of life (QoL) in long-term follow-up [5–7]. Previous reports were inconsistent in terms of the gender-related differences in clinical outcomes after TAVI [8–16]. Importantly, female gender is considered as a risk factor for cardiac operations in both the Society of Thoracic Surgeons (STS) Predicted Risk of Mortality Score and in the Logistic EuroSCORE [8]. Most of the recent studies and meta-analyses have reported the protective effect of female gender in patients undergoing TAVI [8, 9, 12, 14, 16]. In contrast, women appear to experience more often postprocedural complications with major vascular complications, major and life-threatening bleeding and blood transfusions [8, 9, 12, 14, 16]. Despite the growing body of evidence in favor of female gender and widespread use of TAVI, there are still limited and inconsistent data on the influence of gender on procedural results as well as clinical and QoL outcomes.

Aim

We sought to investigate sex-related differences in procedural, clinical and QoL outcomes of TAVI.

Material and methods

A total of 101 consecutive patients who underwent TAVI at our center were included. All patients were diagnosed with symptomatic severe AS and had high surgi-

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cal risk or contraindications for aortic valve replacement (AVR). Patients were clinically evaluated to assess operative risk, comorbidities, frailty, and procedural feasibility. Baseline characteristics and procedural data were prospectively collected. The frailty index was assessed before TAVI with the Katz index of Independence of Activities in Daily Living (KI), elderly mobility scale score (EMS), Canadian Study of Health and Aging (CSHA) scale, 5-meter walking test (5MWT), dominant hand grip strength, and Identification of Seniors at Risk (ISAR) scale [17]. To assess hand grip strength patients were asked to squeeze the dominant hand as tightly as possible (repeated twice). The results were distinguished as follows: weak, mild, and strong. Patient screening and selection were performed by a multidisciplinary Heart Team supported by clinical and imaging resources. The TAVI procedures were performed using Edwards Sapien, Edwards Sapien XT, Edwards Sapien 3 (Edwards Lifesciences), Medtronic CoreValve (Medtronic, Inc), and JenaValve (JenaValve Technology). Access routes were transfemoral, transapical and direct aortic. Procedures were performed under general anesthesia or local anesthesia with sedation. Clinical endpoints of the study included all-cause mortality at 30 days and 12 months. The QoL was assessed with the validated Polish version of the EQ-5D-3L questionnaire at baseline and at 12 months after TAVI. The visual analog scale (VAS) score, which is a part of the EQ-5D-3L, was also assessed. All endpoints were assessed according to the recommendations of the Valve Academic Research Consortium (VARC-2) [18]. For the purpose of this analysis, patients were divided into two groups according to gender. The study was approved by the institutional ethical board.

Statistical analysis

Results are presented as number of patients (percentages) or median (interquartile range (IQR)) where applicable. Differences between groups were tested using the χ^2 test and Fisher's exact test for dichotomous variables and the Mann-Whitney *U*-test for continuous variables. Changes in the proportions of patients who reported either "no problems" or "some problems"/"extreme problems" on the EQ-5D-3L between baseline and follow-up visits were analyzed using McNemar's test. Differences in the VAS score between baseline and follow-up assessments were analyzed with the Wilcoxon signed-rank test. All paired comparisons between baseline and 12-month measurements were performed excluding unpaired results. The difference in mortality between men and women during follow-up was assessed by the Kaplan-Meier method. In addition, differences in outcomes were presented as age-adjusted odds ratios (OR) with 95% confidence intervals (CI). In addition, multivariable Cox regression analysis was performed to find significant predictors of 12-month mortality. All baseline characteristics and procedural data were tested. Forward selection with a probability value for covariates to enter the model was set at the 0.05 level. Results were presented as hazard ratios (HR) with 95% CI. All tests were two-tailed, and a p-value of < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS 15.0 (SPSS, Inc).

Results

Of the 101 consecutive patients undergoing TAVI women represented 60.4% of the study population. Baseline clinical and demographic characteristics are presented in Table I. Women were more often over 80 years old, with a lower rate of previous myocardial infarction (age-adjusted OR = 6.34, 95% CI: 2.44–16.46; $p = 0.001$), previous coronary artery bypass grafting (age-adjusted OR = 3.32, 95% CI: 1.11–9.96; $p = 0.03$) and incomplete revascularization (age-adjusted OR = 3.30, 95% CI: 1.07–10.19; $p = 0.04$) than men (Table I). In addition, a higher prevalence of atrial fibrillation (AF) among women than men was noted. However, this difference was not significant after adjustment for age (age-adjusted OR = 0.44, 95% CI: 0.17–1.09; $p = 0.08$). Importantly, no differences in periprocedural risk measured with Logistic EuroSCORE and STS were noted. Procedural details are shown in Table II. Similar length of hospital stay was observed for women and men (10.0 (7.0–12.0) vs. 13.0 (6.5–19.5) days; $p = 0.45$). Also, no differences in frailty features were observed (Table III). QoL parameters assessed with the EQ-5D-3L questionnaire are presented in Figure 1. Lower rates of problems with usual activities in men than women at 12 months were noted. However, these results were not maintained after adjustment for gender (age-adjusted OR = 0.28, 95% CI: 0.07–1.08; $p = 0.07$). The median visual analog scale (VAS) at baseline (women vs. men: 40.0 (35.0–50.0) vs. 40.0 (35.0–50.0); $p = 0.92$) and 12 months after TAVI (70.0 (60.0–75.0) vs. 70.0 (62.5–80.0); $p = 0.15$) were comparable between groups. There were no differences in VAS change during follow-up in both female and male patients (25.0 (15.0–30.0) vs. 21.0 (15.0–40.0); $p = 0.83$, respectively). There were no differences in 30-day and 12-month all-cause mortality between groups (women vs. men: 9.8% vs. 12.5%; $p = 0.75$ and 13.1% vs. 25.0%; $p = 0.13$) – Figure 2. Also, no influence of gender on the risk of mortality was confirmed after adjustment for age (for 30-day age-adjusted OR = 1.38, 95% CI: 0.39–4.94; for 12-month age-adjusted OR = 2.51, 95% CI: 0.87–7.25). Rates of in-hospital acute kidney injury (2.7% vs. 10.5%; $p = 0.18$; age-adjusted OR = 1.25, 95% CI: 0.19–8.13), bleeding complications (27.9% vs. 35.0%; $p = 0.45$; age-adjusted OR = 1.49, 95% CI: 0.62–3.56) and blood transfusions (26.2% vs. 30.0%; $p = 0.68$; age-adjusted OR = 1.30, 95% CI: 0.53–3.20) were comparable between groups. Similarly, no differences in stroke/TIA (3.3% vs. 15.0%; $p = 0.06$; age-adjusted

Table I. Baseline clinical and echocardiographic characteristics

Parameter	All patients (*n* = 101)	Women (*n* = 61)	Men (*n* = 40)	*P*-value
Age, median (IQR) [years]	81.0 (76.0–84.0)	82.0 (78.0–84.0)	79.0 (73.0–83.0)	0.10
Age ≥ 80 years, *n* (%)	59 (58.4)	41 (67.2)	18 (45.0)	0.027
Body mass index, median (IQR) [kg/m^2]	28.0 (25.2–31.1)	28.7 (25.4–32.0)	27.3 (25.4–28.7)	0.15
eGFR, median (IQR) [ml/min/1.73 m^2]	61.0 (39.0–81.0)	60.5 (39.5–77.0)	65.0 (43.0–73.0)	0.80
NYHA class, *n* (%):				0.36
I	0 (0.0)	0 (0.0)	0 (0.0)	
II	17 (16.8)	9 (14.8)	8 (20.0)	
III	74 (73.3)	44 (72.1)	30 (75.0)	
IV	10 (9.9)	8 (13.1)	2 (5.0)	
Arterial hypertension, *n* (%)	94 (93.1)	56 (91.8)	38 (95.0)	0.70
Diabetes mellitus, *n* (%)	35 (34.7)	22 (36.1)	13 (32.5)	0.71
Atrial fibrillation, *n* (%)	35 (34.7)	26 (42.6)	9 (22.5)	0.038
History of myocardial infarction, *n* (%)	31 (30.7)	10 (16.4)	21 (52.5)	< 0.001
PCI, *n* (%)	29 (28.7)	16 (26.2)	13 (32.5)	0.50
CABG, *n* (%)	17 (16.8)	6 (9.8)	11 (27.5)	0.020
CTO, *n* (%)	9 (8.9)	3 (4.9)	6 (15.0)	0.15
Incomplete revascularization, *n* (%)	16 (15.8)	6 (9.8)	10 (25.0)	0.041
COPD, *n* (%)	9 (8.9)	3 (4.9)	6 (15.0)	0.21
Stroke/TIA, *n* (%)	10 (9.9)	6 (9.8)	4 (10.0)	0.99
Pacemaker, *n* (%)	11 (11.1)	6 (9.8)	5 (13.2)	0.75
Logistic EuroSCORE I, median (IQR) [%]	14.0 (10.0–22.5)	12.5 (8.5–22.0)	15.0 (12.0–27.0)	0.08
STS, median (IQR) [%]	12.0 (5.0–24.0)	11.0 (5.0–25.0)	14.0 (6.0–22.0)	0.65
TG max, median (IQR) [mm Hg]	87.0 (71.5–108.0)	90.0 (73.0–114.0)	82.0 (71.0–97.0)	0.13
TG mean, median (IQR) [mm Hg]	51.0 (42.5–66.5)	53.0 (43.0–69.5)	50.0 (41.0–55.0)	0.19
AVA, median (IQR) [cm^2]	0.6 (0.4–0.8)	0.6 (0.5–0.8)	0.7 (0.6–0.9)	0.013
LVEF, median (IQR) [%]	60.0 (47.5–65.0)	65.0 (55.0–65.0)	50.0 (40.0–60.0)	< 0.001

AVA – aortic valve area, CABG – coronary artery bypass graft, COPD – chronic obstructive pulmonary disease, CTO – chronic total occlusion, eGFR – estimated glomerular filtration rate, LVEF – left ventricle ejection fraction, NYHA – New York Heart Association, PCI – percutaneous coronary intervention, STS – Society of Thoracic Surgeons, TG – transvalvular gradient, TIA – transient ischemic attack.

OR = 5.12, 95% CI: 0.97–27.06), myocardial infarction (1.6% vs. 7.5%; $p = 0.30$; age-adjusted OR = 4.48, 95% CI: 0.44–45.27) or need for permanent pacemaker stimulation (16.4% vs. 15.0%; $p = 0.85$; age-adjusted OR = 0.86, 95% CI: 0.28–2.62) were reported during 12-month follow-up. Interestingly, new-onset AF was observed more often after TAVI in male patients (1.6% vs. 17.5%; $p = 0.006$). However, this difference was no longer significant after adjustment for age (age-adjusted OR = 14.61, 95% CI: 1.68–127.37), which may suggest that the difference in new-onset AF was driven mainly by the difference in age between groups rather than gender per se. Gender was not identified as an independent predictor of mortality in multivariable Cox regression analysis. A history of stroke/TIA (HR = 3.93, 95% CI: 1.39–11.07; $p = 0.001$) and blood transfusion (HR = 2.84, 95% CI: 1.06–7.63; $p = 0.04$) were identified as independent factors affecting 12-month mortality.

Discussion

Our study revealed no differences in crude and age-adjusted 30-day and 12-month all-cause mortality rate between women and men with severe AS undergoing TAVI. Also, the only independent predictors of 12-month mortality in our cohort were previous stroke/TIA and blood transfusion. In the study we outlined the frailty and QoL

Table II. Procedural and follow-up data

Parameter	All patients (*n* = 101)	Women (*n* = 61)	Men (*n* = 40)	*P*-value
Transfemoral access, *n* (%)	78 (77.2)	49 (80.3)	29 (72.5)	0.30
Transapical access, *n* (%)	21 (20.8)	10 (16.4)	11 (27.5)	
Transaortic access, *n* (%)	2 (2.0)	2 (3.3)	0 (0.0)	
Medtronic CoreValve, *n* (%)	20 (19.8)	10 (16.4)	10 (25.0)	0.48
Edwards Sapien, *n* (%)	77 (76.2)	49 (80.3)	28 (70.0)	
Jena, *n* (%)	4 (4.0)	2 (3.3)	2 (5.0)	
Prosthesis size:				< 0.001
23	16 (15.8)	13 (21.3)	3 (7.5)	
25	2 (2.0)	0 (0.0)	2 (5.0)	
26	48 (47.5)	38 (62.3)	10 (25.0)	
27	1 (1.0)	0 (0.0)	1 (2.5)	
29	29 (28.7)	10 (16.4)	19 (47.5)	
31	5 (5.0)	0 (0.0)	5 (12.5)	
Prosthesis size [mm]	26.0 (26.0–29.0)	26.0 (26.0–26.0)	29.0 (26.0–29.0)	< 0.001
AR before:				0.75
0	35 (34.7)	22 (36.1)	13 (32.5)	
1	51 (50.5)	31 (50.8)	20 (50.0)	
2	14 (13.9)	8 (13.1)	6 (15.0)	
3	1 (1.0)	0 (0.0)	1 (2.5)	
AR after:				0.043
0	59 (58.4)	32 (52.5)	27 (67.5)	
1	36 (35.6)	25 (41.0)	11 (27.5)	
2	4 (4.0)	4 (6.6)	0 (0.0)	
3	2 (2.0)	0 (0.0)	2 (5.0)	
Radiation dose [mGy]	733.0 (634.0–831.5)	729.0 (654.0–823.0)	769.0 (634.0–836.5)	0.78
Contrast media load [ml]	100.0 (75.0–150.0)	100.0 (75.0–150.0)	100.0 (75.0–150.0)	0.63
Fluoroscopy time [min]	14.0 (13.0–15.5)	14.0 (13.0–16.0)	14.0 (12.5–15.0)	0.44

AR – aortic regurgitation.

outcomes after TAVI related to gender. No differences in frailty or QoL assessment were observed between women and men. These findings with no sex-related benefit in terms of survival are opposite to most recent studies and meta-analyses reporting the protective effect of female gender in TAVI patients. For example, results from the PARTNER trial suggested lower mortality at 24 months in women than in men [19]. A survival advantage for females after TAVI has been proved in the STS/ACC TVT Registry, as in this registry male sex was identified as an independent predictor of 1-year mortality [20, 21]. Furthermore, the previous meta-analyses revealed that female sex was associated with lower short- and long-term mortality [8, 11, 12]. However, data are not uniform, as some of the studies suggested no advantage in survival favoring women. Recent studies reported similar survival for female and male patients [10, 11, 16]. Finally, the largest pooled meta-analysis to date, including a total of 11,310 patients, reported no differences in mortality rates at 30 days between men and women, despite the differences in baseline risk profiles [15]. However, female sex was independently associated with improved survival at median follow-up of 387 days from the index procedure. These results were obtained despite a higher rate of major vascular complications, major bleeding events, and stroke [15]. Another meta-analysis found greater risk of

Table III. Frailty indices in women and men

Parameter	Categories	All patients (*n* = 101)	Women (*n* = 61)	Men (*n* = 40)	*P*-value
5MWT [s]	≥ 6, frail	18 (17.8)	9 (14.8)	9 (22.5)	0.71
EMS [points]	< 10, frail	8 (7.9)	4 (6.6)	4 (10.0)	0.85
	10–13	66 (65.3)	40 (65.6)	26 (65.0)	
	> 13	27 (26.7)	17 (27.9)	10 (25.0)	
CSHA scale [points]	1–3	56 (55.4)	37 (60.7)	19 (47.5)	0.45
	4	28 (27.7)	16 (26.2)	12 (30.0)	
	5, frail	3 (3.0)	1 (1.6)	2 (5.0)	
	6–7, frail	14 (13.9)	7 (11.5)	7 (17.5)	
Katz index [points]	< 6, frail	18 (17.8)	9 (14.8)	9 (22.5)	0.43
Grip strength [grade]	1 weak, frail	7 (6.9)	3 (4.9)	4 (10.0)	0.56
	2 mild	14 (13.9)	8 (13.1)	6 (15.0)	
	3 strong	80 (79.2)	50 (82.0)	30 (75.0)	
ISAR scale [points]	≥ 2, functional decline, frail	53 (52.5)	30 (49.2)	23 (57.5)	0.41

5-meter walking test (5MWT): ≥ 6 s – frail, < 5 s not frail; elderly mobility scale (EMS): < 10 – high level of help with mobility and activities in daily living, 10–14 – borderline in terms of safe mobility and independence in activities of daily living (ADL), i.e. home with help, > 14 – independent mobility, home and no help needed; Canadian Study of Health and Aging (CSHA) scale: 1 – very fit for one's age, 2 – well but less fit than people in category 1, 3 – well, with treated comorbid disease, 4 – apparently vulnerable although not frankly dependent, 5 – mildly frail with limited dependence, 6 – moderately frail, help is needed, 7 – severely frail, completely dependent from others, 8 – terminally ill; Katz index: 6 – not frail, < 6 – frail; Identification of Seniors at Risk (ISAR) scale: ≥ 2 indicates person at high risk of functional decline, 0 or 1 indicates person at low risk.

major vascular complications and major and life-threatening bleeding in women [11]. Permanent pacemaker implantation and stroke rate were not significantly different between the groups in previously published data [9, 12, 22]. Nevertheless, some studies have also reported that women undergoing TAVI experience higher stroke rate in comparison with men [11, 15]. In our study no differences in bleeding complications, blood transfusions, permanent pacemaker implantation or stoke/TIA rates were observed between male and female patients. Importantly, these results were maintained after adjustment for age. However, the numerically higher rate of stroke/TIA in males with a *p*-value 0.06 suggested that this result could reach statistical significance with a higher number of included patients. Furthermore, this result seems to be more important when we keep in mind that stroke/TIA was identified as an independent factor affecting long-term survival in our study. New-onset AF was more often reported after TAVI in male patients. This finding is in line with previous-

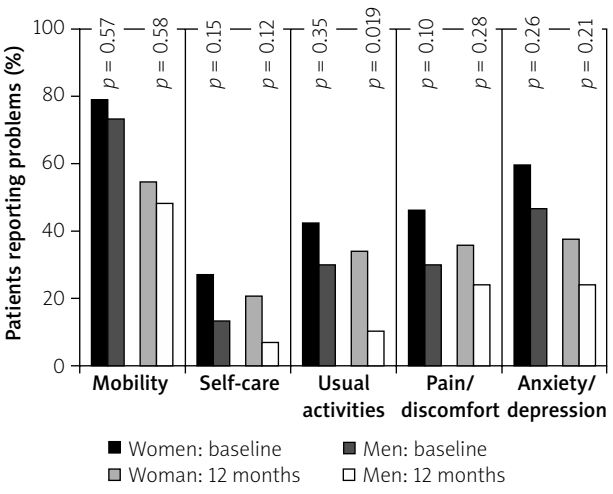

Figure 1. Proportions of patients who report either "some problems"/"extreme problems" for each category of the EQ-5D-3L at baseline and at 12 months

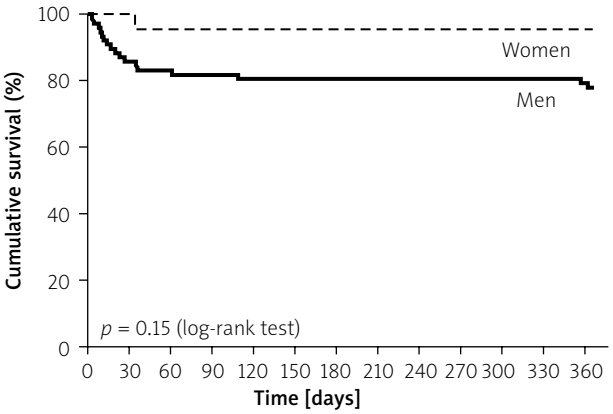

Figure 2. Kaplan-Meier curves for survival after transcatheter valve implantation stratified by gender

ly reported data showing that women had lower adjusted risk for new onset AF compared with men [23]. Previous data postulated a lower rate of moderate to severe aortic regurgitation (AR) in women after TAVI [8, 15, 24]. In our study AR grade 1 and 2 after TAVI was observed more often in female patients, while grade 3 occurred more frequently in men. However, this adverse event was observed only in 2 patients. Females seems to have lower incidence of severe AR probably because of more frequent undersizing in men due to larger annular sizes. Potential bias related to the relatively small sample size could not be excluded. Furthermore, aortic regurgitation after TAVI has been shown to be associated with increased mortality [25]. In our study AR was not found to be an independent predictor of 12-month mortality. Several factors may explain the suggested improved outcomes in women with severe AS undergoing TAVI. Higher periprocedural risk and rate of comorbidities are usually reported in women. Almost all studies found lower left ventricle ejection fraction at baseline in men than women undergoing TAVI, which might be attributed to the above-mentioned unequal prevalence of comorbidities [12, 26]. Importantly, bleeding complications are strongly linked to poorer outcome. However, most of the studies reported higher prevalence of bleeding complications in females. It is believed that this is related to smaller vessel size in women [12]. Reduction of sheath and valve sizes may allow for a consequent decrease in vascular complications. Finally, among patients with AS, women adapt differently than men [15]. Higher levels of interstitial fibrosis in men and a more rapid reversal of myocardial hypertrophy in women after surgical aortic valve replacement were reported [27, 28]. Despite mortality being used to measure the effectiveness of treatments, QoL should be an additional target [5–7]. The QoL improvement is commonly considered as a major expectation for elderly patients' profile after TAVI. The improvement in QoL after TAVI may be higher than observed after AVR, even with the use of less invasive surgical techniques (mini thoracotomy, mini sternotomy) [7]. Data obtained in our study demonstrated a similar rate of problems with usual activities in the male group in comparison to the female group at 12-month follow-up, with no difference in QoL improvement after TAVI. This may suggest an equal response to TAVI in regard to symptoms and everyday activities in men and women [29, 30]. Frailty assessment has also been shown as an important factor of overall health status, which is combined with morbidity and mortality in various clinical settings [17]. In our study we compared baseline frailty scores and their impact on mortality, finding no gender-related differences affecting outcomes. In patients with severe AS undergoing TAVI, frailty assessment has become crucial for decision-making irrespective of gender.

The most important limitation of this prospective observational study is the non-randomized design. Patients were allocated to TAVI after the evaluation of a multidisciplinary local heart team, as suggested by current guidelines, although this policy still might have generated an unavoidable risk for bias regarding treatment selection. Therefore, these results can only be considered to be hypothesis generating rather than causative. The relatively small sample size did not allow us to definitively confirm/exclude the relationship between gender and clinical outcomes of patients with severe AS undergoing TAVI. On the other hand, this study represents a comprehensive analysis of consecutive patients without any exclusion criteria and with complete frailty, QoL and follow-up data available for all patients. We presented the single-centre experience of 101 consecutive patients undergoing TAVI. Despite all these limitations, our data reflect the outcome of a "real-world" population which is different from that selected in randomized controlled trials, and thus the results can be extrapolated to the general population. Furthermore, the patients in this registry had a prevalence of cardiovascular risk factors comparable to multiple other registries and therefore accurately reflect real-world practice and patient selection.

Conclusions

Despite the presence of some sex-related differences in baseline and procedural characteristics, the all-cause mortality rate was similar among women and men with severe AS undergoing TAVI. Improvement in QoL after TAVI was confirmed for both sexes. Thus, TAVI can be considered as an effective and safe treatment strategy in high-risk patients, regardless of gender.

Conflict of interest

The authors declare no conflict of interest.

References

1. Leon MB, Smith CR, Mack M, et al. Transcatheter aortic-valve implantation for aortic stenosis in patients who cannot undergo surgery. PARTNER Trial Investigators. N Engl J Med 2010; 363: 1597-607.
2. Leon MB, Smith CR, Mack MJ, et al. Transcatheter or surgical aortic-valve replacement in intermediate-risk patients. N Engl J Med 2016; 374: 1609-20.
3. Tokarek T, Sobczyński R, Dziewierz A, et al. Clinical outcomes in patients after surgical and transcatheter aortic valve replacement. Pol Arch Med Wewn 2015; 10: 755-64.
4. Bagienski M, Kleczynski P, Dziewierz A, et al. Early and mid-term outcomes after transcatheter aortic valve implantation. Data from a single center registry. Adv Interv Cardiol 2016; 12: 122-7.
5. Kleczyński P, Bagieński 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.
6. Kleczyński P, Bagieński M, Dziewierz A, et al. Twelve-month quality of life improvement and all-cause mortality in elderly patients undergoing transcatheter aortic valve replacement. Int J Artif Organs 2016; 39: 444-9.

7. Tokarek T, Siudak Z, Dziewierz A, et al. Assessment of quality of life in patients after surgical and transcatheter aortic valve replacement. Catheter Cardiovasc Interv 2016; 88: 80-8.
8. Conrotto F, D'Ascenzo F, Presbitero P, et al. Effect of gender after transcatheter aortic valve implantation: a meta-analysis. Ann Thorac Surg 2015; 99: 809-16.
9. Sherif MA, Zahn R, Gerckens U, et al. Effect of gender differences on 1-year mortality after transcatheter aortic valve implantation for severe aortic stenosis: results from a multicenter real-world registry. Clin Res Cardiol 2014; 103: 613-20.
10. D'Ascenzo F, Gonella A, Moretti C, et al Gender differences in patients undergoing TAVI: a multicentre study. EuroIntervention 2013; 9: 367-72.
11. Conrotto F, D'Ascenzo F, Salizzoni S, et al. A gender based analysis of predictors of all cause death after transcatheter aortic valve implantation. Am J Cardiol 2014; 114: 1269-74.
12. Stangl V, Baldenhofer G, Laule M, et al. Influence of sex on outcome following transcatheter aortic valve implantation (TAVI): systematic review and meta-analysis. J Interv Cardiol 2014; 27: 531-9.
13. Onorati F, D'Errigo P, Barbanti M, et al. OBSERVANT Research Group. Different impact of sex on baseline characteristics and major periprocedural outcomes of transcatheter and surgical aortic valve interventions: results of the multicenter Italian OBSERVANT Registry. J Thorac Cardiovasc Surg 2014; 147: 1529-39.
14. Humphries KH, Toggweiler S, Rodés-Cabau J, et al. Sex differences in mortality after transcatheter aortic valve replacement for severe aortic stenosis. J Am Coll Cardiol 2012; 60: 882-6.
15. O'Connor SA, Morice MC, Gilard M, et al. Revisiting sex equality with transcatheter aortic valve replacement outcomes: a collaborative, patient-level meta-analysis of 11,310 patients. J Am Coll Cardiol 2015; 66: 221-8.
16. Zhao ZG, Liao YB, Peng Y, et al. Sex-related differences in outcomes after transcatheter aortic valve implantation: a systematic review and meta-analysis. Circ Cardiovasc Interv 2013; 6: 543-51.
17. Kleczyński P, Dziewierz A, Bagienski M, et al. Impact of frailty on mortality after transcatheter aortic valve implantation. Am Heart J 2017; 185: 52-8.
18. 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.
19. Williams M, Kodali SK, Hahn RT, et al. Sex-related differences in outcomes after transcatheter or surgical aortic Valle replacement in patients with severe aortic stenosis: insights from the PARTNER trial (placement of aortic transcatheter valve). J Am Coll Cardiol 2014; 63: 1522-8.
20. Holmes DR Jr, Nishimura RA, Grover FL, et al. Annual outcomes with transcatheter valve therapy: from the STS/ACC TVT Registry. J Am Coll Cardiol 2015; 66: 2813-23.
21. Finkelstein A, Havakuk O, Steinvil A, et al. Gender differences and clinical outcome in patients undergoing trans-femoral aortic valve implantation. Int J Cardiol 2013; 168: 4854-5.
22. Wilczek K, Reguła R, Bujak K, et al. Conduction disturbances after transcatheter aortic valve implantation procedures – predictors and management. Adv Interv Cardiol 2016; 12: 203-11.
23. Tarantini G, Mojoli M, Urena M, et al. Atrial fibrillation in patients undergoing transcatheter aortic valve implantation: epidemiology, timing, predictors, and outcome. Eur Heart J 2017; 38: 1285-93.
24. Athappan G, Patvardhan E, Tuzcu EM, et al. Incidence, predictors, and outcomes of aortic regurgitation after transcatheter aortic valve replacement: meta-analysis and systematic review of literature. J Am Coll Cardiol 2013; 61: 1585-95.
25. Moat NE, Ludman P, de Belder MA, et al. Long-term outcomes after transcatheter aortic valve implantation in high-risk patients with severe aortic stenosis: the U.K. TAVI (United Kingdom Transcatheter Aortic Valve Implantation) Registry. J Am Coll Cardiol 2011; 58: 2130-8.
26. Bochenek T, Kusz B, Mizia M, et al. Echocardiographic evaluation of myocardial strain in patients after transcatheter aortic valve implantation. Postep Kardiol Interw 2015; 11: 95-9.
27. Villari B, Campbell SE, Schneider J, et al. Sex-dependent differences in left ventricular function and structure in chronic pressure overload. Eur Heart J 1995; 16: 1410-9.
28. Petrov G, Regitz-Zagrosek V, Lehmkuhl E, et al. Regression of myocardial hypertrophy after aortic valve replacement: faster in women? Circulation 2010; 122: 23-8.
29. Stańska A, Jagielak D, Brzeziński M, et al. Improvement of quality of life following transcatheter aortic valve implantation in elderly: multi-centre study based on Polish national TAVI registry. Kardiol Pol 2017; 75: 13-20.
30. Salsano A, Regesta T, Viganò G, et al. Expectation and quality of life after aortic valve replacement over 85 years of age match those of the contemporary general population. Int J Artif Organs 2016; 39: 56-62.