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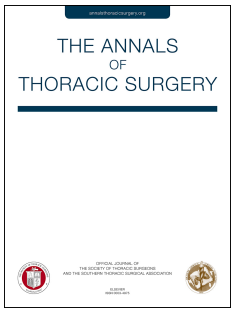

Transcatheter and Surgical Aortic Valve Replacement in Patients with Recent Acute Heart Failure

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Transcatheter and Surgical Aortic Valve Replacement in Patients with Recent Acute Heart Failure

Running head: TAVR and SAVR in acute heart failure

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Abstract

Background: Patients with severe aortic stenosis (AS) and heart failure have poor prognosis, and their outcomes may be suboptimal even after transcatheter (TAVR) and surgical aortic valve replacement (SAVR).

Methods: This is an analysis of the nationwide FinnValve registry which included patients who underwent primary TAVR or SAVR with a bioprothesis for AS. We evaluated the outcome of patients with acute heart failure (AHF) within 60 days prior to TAVR or SAVR.

Results: The prevalence of recent AHF was 11.4% (484/4241 patients) in the SAVR cohort and 11.3% (210/1855 patients) in the TAVR cohort. In the SAVR cohort, AHF was associated with lower 30-day survival (91.3% vs. 97.0%; adjusted OR 1.801, 95%CI 1.125-2.882) and 5-year survival (64.0% vs. 81.2%; adjusted HR 1.482, 95%CI 1.207-1.821). SAVR patients with AHF had higher risk of major bleeding, need of mechanical circulatory support, acute kidney injury, prolonged hospital stay and composite end-point (30-day mortality, stroke and/or acute kidney injury). Patients with AHF had a trend toward lower 30-day survival (crudes rates, 95.2% vs. 97.9%; adjusted OR 2.028 95%CI 0.908-4.529) as well as significantly lower 5-year survival (crude rates, 45.3% vs. 58.5%; adjusted HR 1.530, 95%CI 1.185-1.976) also after TAVR. AHF increased the risk of acute kidney injury, prolonged hospital stay and composite end-point after TAVR.

Conclusions: Recent AHF is associated with increased risk of mortality and morbidity after SAVR and TAVR. These findings suggest that AS patients should be referred for invasive treatment before the development of clinically evident heart failure.

Clinical trial registration: ClinicalTrials.gov Identifier: NCT03385915

Key-words: Transcatheter aortic valve replacement; TAVR; TAVI; Surgical aortic valve replacement; AVR; Aortic valve stenosis; Acute heart failure.

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Acute heart failure (AHF) may complicate the course of aortic stenosis (AS) (3,4) and it is the main cause of death in these patients (5-7). Historical data showed that when symptoms of heart failure develop, patient's prognosis is dismal (7). A recent multicenter study by Nagao et al. (8) confirmed the negative prognostic impact of AHF secondary to AS and that the increased risk of all-cause death persisted after aortic valve replacement. In this study we evaluated the early and late outcomes of patients with recent AHF after transcatheter (TAVR) and surgical aortic valve replacement (SAVR) from a nationwide registry.

Patients and Methods

Study data

The FinnValve registry is a nationwide registry (ClinicalTrials.gov Identifier: NCT03385915), which retrospectively collected data from consecutive patients who underwent TAVR or SAVR with a bioprosthesis for severe AS with or without coronary revascularization at all five Finnish university hospitals (Helsinki, Kuopio, Oulu, Tampere and Turku) from January 2008 to October 2017. This study was approved by the Institutional Review Board of the participating centers. The inclusion criteria for entering this registry were: 1) AS with or without aortic valve regurgitation; 2) patients aged >18 years; and 3) primary TAVR or SAVR with a bioprosthesis with or without concomitant coronary revascularization. The exclusion criteria of this study were: 1) any prior TAVR or surgical intervention on the aortic valve; 2) concomitant major cardiac procedure on the ascending aorta and/or other heart valves or structures; 3) transcatheter or surgical procedure for isolated aortic valve regurgitation; and/or 4) acute endocarditis. For the purpose of the present analysis, only patients with data on the timing of hospitalization for treatment of AHF were included in this study. Patients with an episode of AHF >60 days before index procedure were excluded from the study, because such a delay to invasive treatment might suggest less severe episodes of heart failure or chronic heart failure with less severe prognosis (8). Patients who underwent transapical TAVR were excluded from this analysis because its invasiveness and suboptimal results favored the current use of less invasive peripheral vascular approaches.

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Data was collected retrospectively into an electronic case report form with pre-specified baseline- and operative covariates and outcomes by cardiologists, cardiac surgeons and research nurses. Data underwent robust checking of its completeness and quality by the local investigators. Further data checking was performed by repeating selected data collection into a control Excel datasheet. Longitudinal data included only all-cause mortality occurred during the follow-up period. Data on mortality was retrieved from the national Population Register Center (Väestörekisteri) by linkage of patients' social security numbers. The last date of follow-up was December 31st, 2018. This registry is a highly reliable registry collecting data from the death certificates issued by physicians and these should be promptly delivered for further checking and collection of the information in to this national registry. Follow-up was considered complete for all patients, but for two patients (0.003%) not residing in Finland at the time of the index procedure and whose follow-up was truncated at hospital discharge.

Definition Criteria of Baseline Risk Factors

Baseline variables were defined according to the EuroSCORE II criteria (9). The operative risk of these patients was stratified according to the EuroSCORE II (9) and STS (10) risk scores. Severe frailty was defined according to the Geriatric Status Scale (GSS) and herein is defined as GSS grades 2-3 (11). Coronary artery disease was defined as any stenosis ≥50% of the main coronary branches. Recent AHF was defined as any new-onset or worsening of symptoms and signs of heart failure requiring hospital admission and rapid escalation of therapy within 60 days from TAVR or SAVR. Critical preoperative state was defined as ventricular tachycardia or fibrillation or aborted sudden death, preoperative cardiac massage, preoperative ventilation before anesthetic room, preoperative inotropes or intra-aortic balloon pump insertion (IABP) and/or preoperative acute renal failure (9). Critical preoperative state at admission for TAVR or SAVR procedure was considered as a condition comparable to AHF.

Outcome Measures

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The primary outcomes were 30-day and 5-year survival. The secondary outcomes were stroke, use of IABP and/or extracorporeal membrane oxygenation (ECMO), blood transfusion, transfusion of >4 units of red blood cells (RBC) and/or resternotomy for bleeding (12) and/or transfusion of >4 units of RBC and/or resternotomy or any reoperation for peripheral bleeding, major and life threatening VARC-2 bleeding (13), moderate to severe paravalvular regurgitation, implantation of permanent pace-maker, acute kidney injury and postoperative length of stay in the hospital where the procedure was performed and a composite end-point including 30-day death, stroke and/or KDIGO acute kidney injury stage 3. The length of stay in the intensive care unit was not considered in this analysis because of inter-institutional differences in the organizational program of postoperative care of patients undergoing TAVR. Stroke was defined as any focal or global neurological deficit lasting 24 hours or longer with a new brain infarct or hemorrhage detected at neuroimaging, or a neurological deficit resulting in death. Valve Academic Research Consortium-2 (VARC-2) consensus document major bleeding was defined as bleeding either associated with a drop in the hemoglobin level of at least 3.0 g/dL or requiring transfusion of two or three units of RBC, or causing hospitalization or permanent injury, or requiring surgery (13). VARC-2 life threatening bleeding was defined as any bleeding causing hypovolemic shock or severe hypotension requiring vasopressors or surgery or overt source of bleeding with drop in hemoglobin ≥5.0 g/dL or transfusion of more than three units of RBC or causing death (13). Acute kidney injury was defined according to the KDIGO classification criteria (14), i.e. an increase in serum creatinine ≥1.5 times the baseline level or serum creatinine increase ≥26.5 µmol/l and/or de novo renal replacement therapy during the hospital stay. Stage 3 acute kidney injury was defined as any increase in serum creatinine ≥3.0 times the baseline level or serum creatinine increase ≥353.65 µmol/l during the hospital stay and/or de novo renal replacement therapy during the hospital stay.

Statistical Analysis

Statistical analysis was performed using SAS statistical package, version 9.2 (SAS Institute Inc, Cary, NC), SPSS v. 25.0 statistical software (IBM Corporation, New York, USA) and Stata v. 15.0 (SAS Institute Inc., Cary,

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NC, USA). The normal distribution of continuous variables was assessed with the Shapiro-Wilk test which showed that none of the continuous variables was normally distributed. The Mann-Whitney *U*-test, Fisher's exact test, Chi-square test and linear-by-linear association tests were used for univariate analysis in the overall population. Logistic and Cox regression analyses without stepwise selection were employed for risk adjusted analysis of binary outcomes. Ordinal and linear regression methods were employed to adjust the risk for rank-ordered and continuous outcomes. Regression models were adjusted for the following covariates: following covariates: age, gender, anemia (<1.2 g/dL in women, <1.3 g/dL in men), estimated glomerular filtration rate, diabetes, stroke, pulmonary disease, extracardiac arteriopathy, left ventricular ejection fraction 50% or less, porcelain aorta, atrial fibrillation, frailty GSS grades 2-3, active malignancy, recent myocardial infarction, coronary artery disease, prior percutaneous coronary intervention and prior cardiac surgery. The Kaplan-Meier method was used to estimate late survival in the study cohorts. Propensity score matching analysis was used to compare the outcomes after TAVR and SAVR in patients with AHF and the employed methods are described in the Supplementary material. All tests were two-sided and $p<0.05$ was set for statistical significance.

Results

Characteristics and Outcomes of the Overall Registry

The FinnValve registry includes data from 6463 patients who underwent primary TAVR and SAVR with a bioprothesis for severe AS. The Institutional volumes of TAVR and SAVR ranged from 263 to 254 patients and from 532 to 1403 patients, respectively. Thirty-day mortality in patients without prior AHF was 2.7%, whereas it was 8.2% in patients with AHF within 30 days before the procedure, 5.2% in patients with AHF 31-60 days before the procedure, 2.1% in patients with AHF 61-90 days before procedure and 2.8% (36 patients) in patients with AHF episode more than 90 days before the procedure ($p<0.0001$). Since patients with AHF episode within 60 days from the procedure had a markedly increased risk of early death, the outcomes of these patients were compared with those of patients without history of AHF. After excluding

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patients who underwent transapical TAVR and those without data on the timing of hospitalization for AHF, 6 096 patients were available for the present analysis (Fig. 1).

Characteristics and Outcomes of the Study Cohorts

The prevalence of recent AHF was 11.4% (484/4241 patients) in the SAVR cohort and 11.3% (210/1855 patients) in the TAVR cohort (Fig. 1). The proportion of patients with recent AHF undergoing SAVR decreased significantly along the study period (Linear-by-linear association test, p=0.002), whereas no significant changes were observed among patients undergoing TAVR (Linear-by-linear association p=0.258) (Suppl. Fig. 1). The baseline characteristics of patients in the TAVR and SAVR cohorts are summarized in Table 1. Patients with recent AHF had markedly increased operative risk compared to patients with no AHF both in the TAVR (STS score 8.1±6.8 vs. 4.0±2.2%, p<0.0001) and the SAVR cohort (STS score 7.0±5.8 vs. 2.6±3.2%, p<0.0001) (Tab. 1). The mean follow-up of this series was 4.3±2.7 years (median, 3.9 years; range, 0-11.7 years) and its completeness was 99.9%.

In the overall series, recent AHF was associated with significantly lower 30-day survival (crude rates, 92.5% vs. 97.3%; adjusted for treatment method and multiple covariates OR 1.579, 95%CI 1.212-2.708) and 5-year survival (crude rates, 64.0% vs. 81.2%; adjusted for treatment method and multiple covariates HR 1.523, 95%CI 1.300-1.786).

Among 4241 patients who underwent SAVR, recent AHF was associated with significantly lower 30-day survival (crude rates, 91.3% vs. 97.0%; adjusted for multiple covariates OR 1.801, 95%CI 1.125-2.882) and 5-year survival (crude rates, 64.0% vs. 81.2%; adjusted for multiple covariates HR 1.482, 95%CI 1.207-1.821). In the SAVR cohort, when adjusted for multiple covariates, patients with recent AHF had higher risk of major bleeding, need of mechanical circulatory support, acute kidney injury, prolonged hospital stay as well as of composite end-point compared to patients without AHF (Tab. 2).

Among 1855 patients who underwent TAVR, recent AHF showed a trend toward lower 30-day survival (crudes rates, 95.2% vs. 97.9%; adjusted for multiple covariates OR 2.028 95%CI 0.908-4.529) as well as

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lower 5-year survival (crude rates, 45.3% vs. 58.5%; adjusted for multiple covariates HR 1.530, 95%CI 1.185-1.976). In the TAVR cohort, when adjusted for multiple covariates, patients with recent AHF had higher risk of postoperative acute kidney injury, prolonged hospital stay as well as of composite end-point compared to patients without AHF (Tab. 2).

Propensity score matching resulted in 130 pairs with similar baseline characteristics (Suppl. tab. 1). Among these matched pairs, 30-day survival (94.6% vs. 96.1%, p=0.527, Suppl. tab. 2) were similar in the study cohorts. After a mean follow-up of 2.9±2.5 years, 1-, 3-, and 5-year survival in the TAVR cohort were 86.8%, 71.4% and 49.5% and in the SAVR cohort were 82.1%, 70.0% and 63.0%, respectively (restricted mean survival time ratio, 1.001, 95%CI 0.886-1.132, p=0.947, Suppl. fig. 2).

Comment

This study provides evidence of the poor early and late prognosis of AS patients with recent AHF undergoing aortic valve replacement. The present findings suggest that release of high afterload by TAVR or SAVR should be performed before the development of irreversible pathological changes and clinically evident heart failure. Recent studies documented a benefit of early operative treatment in patients with peak aortic jet velocity of 5.0 m/s or greater and with reduced left ventricular ejection fraction (7,8).

Recent AHF was an independent predictor of poor early and intermediate survival after SAVR. A trend toward poorer 30-day survival was observed also after TAVR and adjusted analysis confirmed the negative prognostic impact of AHF on 5-year survival after TAVR. It is worth noting that the observed 30-day mortality after TAVR was markedly lower than predicted by the EuroSCORE II and STS risk scores, while the observed 30-day mortality was similar to the expected rates in the SAVR cohort. Similarly, recent AHF was associated with increased risk of several early adverse events after SAVR, but not after TAVR.

In the present study, a significant number of patients with recent AHF and increased STS score were treated surgically. This may be related to several factors such as the delay between referral and TAVR treatment

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during the early study period, which was significantly shortened during the last few years. Furthermore, most of these patients were at intermediate risk and only recently the evidence on the safety and efficacy of TAVR in these patients has driven a shift toward it. This resulted in a decrease of the proportion of patients with recent AHF undergoing SAVR in this series (Likelihood ratio test, p=0.016; Suppl. Fig. 1).

A recent study showed in patients with asymptomatic AS that 2 years after recommendation for SAVR (93.2% underwent surgery) survival was 92.5% whilst it was 83.9% when watchful waiting was recommended (47.2% underwent surgery) (p=0.044) (15). In 2016 Généreux et al. (16) pooled the available evidence on this topic and showed that patients with severe asymptomatic AS have 3.5-fold higher rate of all-cause death with a watchful waiting strategy compared with aortic valve replacement. The present study further documented the magnitude of the adverse events in patients who develop clinically evident heart failure and highlight the importance of early referral to invasive treatment for severe AS.

This data does not allow an analysis of the impact of the timing of treatment when AHF develops. However, we speculate that AS patients with AHF may benefit from an early release of the high afterload to the same extent of urgent balloon aortic valvuloplasty in the setting of AS-related cardiogenic shock (17). In view of the similar risk of adverse events after balloon aortic valvuloplasty and TAVR (18), patients with AHF secondary to severe AS may be considered for primary TAVR. Although, this may require changes of the diagnostic and treatment pathway, current evidence suggests that urgent/emergency TAVR may pay off with excellent early and intermediate survival (19). However, the present study was not able to document the validity of TAVR over SAVR in this setting because of the limited number of patients included in this analysis. In propensity score matched pairs of patients, SAVR was associated with increased risk of major bleeding, acute kidney injury and prolonged hospital stay compared to TAVR and after a mean follow-up of 2.9 years, 3-year survival was similar in the study cohorts. Lower survival was observed after TAVR at 5 years, but the limited number of patients at risk prevented conclusive results on the efficacy of these treatment methods on the long run.

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In this study, hospital stay was shorter in patients with no recent AHF than in patients with recent AHF (SAVR, mean 8.0 vs. 10.7 days, p<0.0001; TAVR, mean 5.0 vs. 6.5 days, p<0.0001). Furthermore, among propensity score matched pairs, TAVR was associated with significantly shorter hospital stay, which is likely related to benefits of using this minimally invasive treatment method (Suppl. tab. 2). Hospital stay in patients with recent AHF significantly declined from 2009 to 2017 after TAVR (mean, 16.7 to 4.4 days, ordinal regression p<0.0001), but not after SAVR (mean, 12.6 to 10.8 days, ordinal regression p=0.214) (data not shown).

Limitations

The retrospective nature is the main limitation of this study. Second, the definition of AHF is based on history of recent hospitalization for its treatment, but neither the severity of AHF nor information on its treatment were captured in this registry. Third, the limited number of patients does not allow a comparative analysis of patients without coronary artery disease undergoing SAVR or TAVR. Finally, the relatively small sample size of this study as well as the rather short follow-up (mean, 2.9 years) are potential biases of this study and limited the validity of comparative analysis of TAVR versus SAVR. On the other hand, this dataset represents a 10-year nationwide experience with these treatment methods, and the unselected nature of this series and reliability of data on survival are the strengths of this analysis.

Conclusions

Recent AHF is associated with increased morbidity and mortality after SAVR and TAVR. These findings suggest that TAVR and SAVR should be performed before the early and late outcome is jeopardized by the development of irreversible pathological changes and clinically evident heart failure. Larger studies are needed to assess the potential benefits of TAVR over SAVR in these high risk patients.

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Figure Legends

Figure 1. Study flowchart.

Figure 2. Survival in patients with and without recent acute heart failure after transcatheter (TAVR) and surgical aortic valve replacement (SAVR).

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Table 1. Characteristics of patients with and without recent acute heart failure undergoing transcatheter and surgical aortic valve replacement.

	SAVR			TAVR		
Characteristics	No AHF 3757 pts	AHF 484 pts	p-value	No AHF 1645 pts	AHF 210 pts	p-value
Age, years	75.0±6.4	75.2±7.1	0.375	81.6±6.5	80.7±6.6	0.039
Female	1785 (47.5)	203 (41.9)	0.021	945 (57.4)	111 (52.9)	0.206
Anemia	903 (24.0)	255 (52.7)	<0.0001	711 (43.2)	137 (65.2)	<0.0001
eGFR, ml/min/1.73m^2	77±21	70±24	<0.0001	66±22	60±25	<0.0001
Diabetes	960 (25.6)	165 (34.1)	<0.0001	440 (26.7)	67 (31.9)	0.114
Stroke	241 (6.4)	48 (9.9)	0.004	184 (11.2)	22 (10.5)	0.758
Pulmonary disease	525 (14.0)	103 (21.3)	<0.0001	351 (21.3)	39 (18.6)	0.354
Extracardiac arteriopathy	446 (11.9)	78 (16.1)	0.008	267 (16.2)	41 (19.5)	0.227
LVEF ≤50%	559 (14.9)	301 (62.3)	<0.0001	350 (21.3)	119 (56.9)	<0.0001
Porcelain aorta	12 (0.3)	2 (0.4)	0.486	79 (4.8)	9 (4.3)	0.740
Atrial fibrillation	766 (20.4)	163 (33.7)	0.000	680 (41.3)	116 (55.2)	<0.0001
Frailty	95 (2.5)	11 (2.3)	0.734	218 (13.3)	43 (20.5)	0.005
Active malignancy	46 (1.2)	12 (2.5)	0.025	69 (4.2)	6 (2.9)	0.354
SPAP			<0.0001			<0.0001
31-55 mmHg	1269 (33.8)	222 (45.9)		651 (39.6)	111 (52.9)	
>55 mmHg	175 (4.7)	112 (23.1)		189 (11.5)	39 (18.6)	
Missing data	93 (2.5)	11 (2.3)		276 (16.8)	15 (7.1)	
Coronary artery disease	1647 (43.8)	272 (56.2)	<0.0001	446 (27.1)	74 (35.2)	0.014
Prior cardiac surgery	85 (2.3)	10 (2.1)	0.784	293 (17.8)	30 (14.3)	0.205
Recent myocardial infarction	133 (3.5)	161 (33.3)	<0.0001	24 (1.5)	15 (7.1)	<0.0001
Urgency of the procedure			<0.0001			<0.0001
Urgent	194 (5.2)	317 (65.5)		26 (1.6)	101 (48.1)	
Emergency	11 (0.3)	47 (9.6)		0 (0)	5 (2.4)	
Recent balloon valvuloplasty	5 (0.1)	6 (1.2)	0.001	32 (1.9)	16 (7.6)	<0.0001
Planned concomitant revascularization	1534 (40.8)	252 (52.1)	<0.0001	9 (0.5)	1 (0.5)	0.895
Critical preoperative state	0	96 (19.8)	<0.0001	0	28 (13.3)	<0.0001
EuroSCORE II, %	3.1±2.7	12.1± 1.1	<0.0001	5.9±5.2	13.5±13.6	<0.0001
STS Score, %	2.6±3.2	7.0± 5.8	<0.0001	4.0±2.2	8.1±6.8	<0.0001

AHF, acute heat failure; SAVR, surgical aortic valve replacement; TAVR, transcatheter aortic valve replacement; eGFR, glomerular filtration estimated according to the MDRD equation; LVEF, left ventricular ejection fraction; Frailty, GSS grades 2-3; SPAP, systolic pulmonary artery pressure; PCI, percutaneous coronary intervention.

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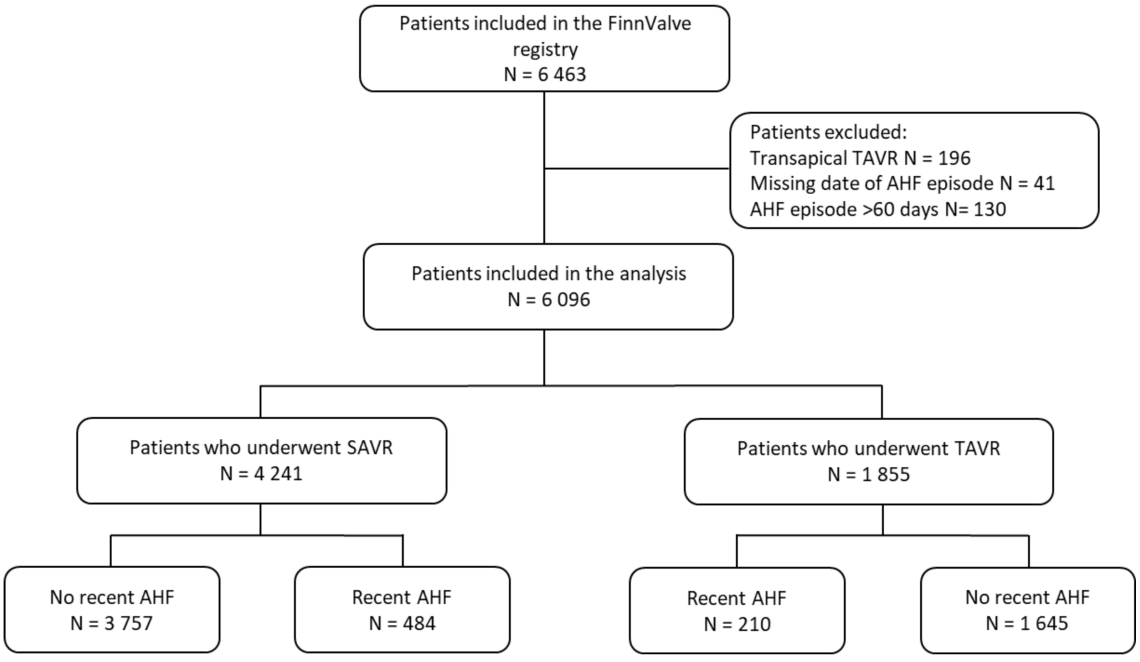
Table 2. Outcomes after transcatheter and surgical aortic valve replacement in patients with and without recent acute heart failure.

	SAVR				TAVR			
Outcomes	No AHF 3757 pts	AHF 484 pts	Univariate analysis P-value	Multivariate analysis Risk estimates, 95%CI	No AHF 1645 pts	AHF 210 pts	Univariate analysis P-value	Multivariate analysis Risk estimates, 95%CI
Mortality, %			<0.0001				<0.0001	
30-day	3.0	8.7		**1.801, 1.125-2.882**	2.1	4.8		2.028, 0.908-4.529
1-year	5.9	16.8			7.7	16.7		
3-year	10.8	28.4			22.8	37.9		
5-year	18.8	36.0			41.5	54.7		
Stroke	139 (3.7)	22 (4.5)	0.359	0.840, 0.484-1.456	36 (2.2)	8 (3.8)	0.146	1.849, 0.781-4.377
ECMO or IABP	49 (1.3)	27 (5.6)	<0.0001	**2.213, 1.199-4.084**	1 (0.1)	0 (0.0)	0.887	-
RBC transfused, units	2.7±3.6	5.0±5.1	<0.0001	**1.223, 0.826-1.620**	0.5±1.4	0.7±1.6	0.020	0.169, -0.050-0.387
Transfusion of >4 RBC units and/or resternotomy for bleeding	773 (20.9)	225 (46.9)	<0.0001	**2.152, 1.685-2.749**	46 (2.8)	10 (4.8)	0.122	1.865, 0.852-4.086
Transfusion of >4 RBC units and/or any operation for bleeding	775 (20.9)	225 (46.9)	<0.0001	**2.148, 1.682-2.743**	69 (4.3)	15 (7.2)	0.056	1.801, 0.950-3.416
VARC-2 bleeding grades			<0.0001	**0.453, 0.213-0.694**			0.617	**0.382, 0.056-0.709**
Major bleeding	1402 (37.4)	133 (27.7)			402 (24.5)	56 (26.8)		
Life-threatening bleeding	2204 (58.7)	333 (69.2)			101 (6.2)	15 (7.2)		
Resternotomy for bleeding	289 (7.7)	50 (10.3)	0.044	1.217, 0.828-1.787	8 (0.5)	3 (1.4)	0.119	4.191, 0.932-18.838
KDIGO acute kidney injury stages			<0.0001	**0.866, 0.360-1.372**			<0.0001	**0.597, 0.346-0.848**
1	459 (12.3)	99 (21.0)			63 (3.9)	18 (9.1)		
2	98 (2.6)	29 (6.1)			18 (1.1)	3 (1.5)		
3	90 (2.4)	30 (6.4)			7 (0.4)	5 (2.5)		
Permanent pacemaker	147 (3.9)	16 (3.3)	0.513	0.856, 0.469-1.562	157 (9.5)	16 (7.6)	0.366	0.808, 0.458-1.423
Moderate or severe paravalvular regurgitation	22 (0.6)	5 (1.0)	0.244	2.555, 0.763-8.548	60 (3.6)	7 (3.3)	0.818	1.073, 0.460-2.507
Hospital stay, days	8.0±5.8	10.7±9.3	<0.0001	**2.085, 1.391-2.779**	5.0±4.2	6.5±6.0	<0.0001	**1.447, 0.769-2.126**
Composite end-point[a]	283 (7.5)	81 (16.7)	<0.0001	**1.617, 1.157-2.261**	69 (4.2)	20 (9.5)	0.001	**2.266, 1.272-4.037**

SAVR, surgical aortic valve replacement; TAVR, transcatheter aortic valve replacement; AHF, acute heat failure; KDIGO, Kidney Disease: Improving Global Outcomes; ECMO, extracorporeal membranous oxygenation; IABP, intra-aortic balloon pump; RBC, red blood cell units; VARC, Valve Academic Research Consortium; [a], 30-day death, stroke and/or KDIGO acute kidney injury stage 3. Risk estimates are odds ratios and coefficients with their 95% confidence interval (CI).


Patients included in the FinnValve registry
N = 6 463
Patients excluded:
Transapical TAVR N = 196
Missing date of AHF episode N = 41
AHF episode >60 days N= 130
Patients included in the analysis
N = 6 096
Patients who underwent SAVR
N = 4 241
Patients who underwent TAVR
N = 1 855
No recent AHF
N = 3 757
Recent AHF
N = 484
Recent AHF
N = 210
No recent AHF
N = 1 645

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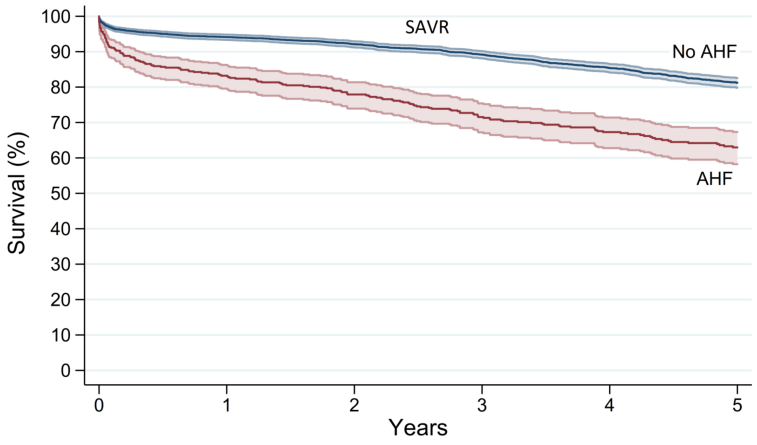
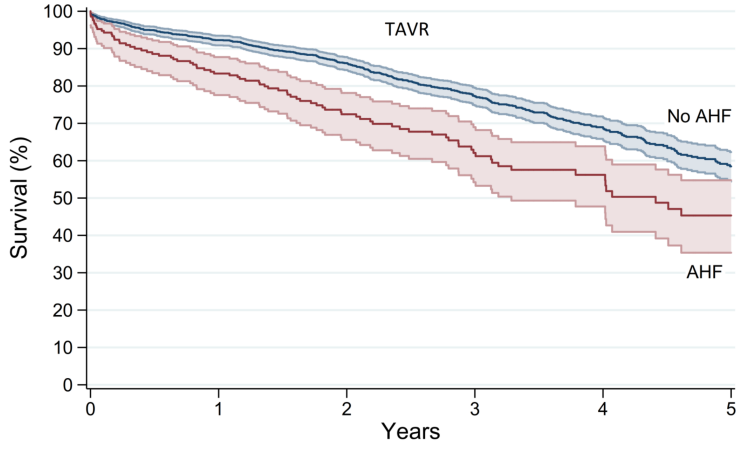


No AHF	3757	3536	3244	2814	2328	1862
AHF	484	401	356	305	251	205



No AHF	1645	1518	1056	604	331	171
AHF	210	175	117	71	39	20