Journal of Surgery
Lodo V, et al. J Surg 8: 1769
www.doi.org/10.29011/2575-9760.001769
www.gavinpublishers.com
Research Article

Impact of Post-Procedural Acute Kidney Injury in Patients Undergoing Surgical Aortic Valve Replacement Versus Transcatheter Aortic Valve Implantation

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Citation: Lodo V, Audisio K, Zingarelli E, Italiano EG, Beccaria S, et al. (2023) Impact of Post-Procedural Acute Kidney Injury in Patients Undergoing Surgical Aortic Valve Replacement Versus Transcatheter Aortic Valve Implantation. J Surg 8: 1769 DOI: 10.29011/2575-9760.001769

Received Date: 24 March, 2023; **Accepted Date:** 27 March, 2023; **Published Date:** 29 March, 2023

Abstract

Aims: The aim was to compare Acute Kidney Injury (AKI) incidence and outcomes among Surgical Aortic Valve Replacement (SAVR) vs Transcatheter Aortic Valve Implantation (TAVI) patients.

Methods: Patients undergoing SAVR or TAVI for severe aortic valve stenosis from 09/2017 to 12/2019 were enrolled. The primary endpoint was post-procedural AKI. Main secondary endpoints were AKI at discharge, 30-day and 1-year mortality.

Results: 457 patients (SAVR: 201 [44.0%]; TAVI: 256 [56.0%]) were enrolled. The incidence of AKI was higher in the SAVR group (n=58/201 [28.9%] vs 15/256 [5.9%], p<0.001). At discharge, the percentage of AKI patients was higher in the TAVI group (n=8/15 [53.3%] vs 9/58 [15.5%], p<0.001). A significantly higher 30-day and 1-year mortality were recorded among AKI vs no-AKI patients in both groups (30-day mortality: n=5/58 [8.6%] vs 1/143 [0.7%], p=0.01 for SAVR; n=3/15 [20.0%] vs 1/241 [0.4%], p<0.001 for TAVI. 1-year mortality: n=8/58 [13.8%] vs 5/143 [3.5%], p=0.01 for SAVR; n=5/15 [33.3%] vs 21/241 [8.7%], p=0.02 for TAVI). In the SAVR group, the Kaplan-Meier 1-year survival estimate was 96.5% for no-AKI patients and 67.0% for AKI III patients (log-rank p<0.001). In the TAVI group, it was 91.5% for no- AKI patients and 16.5% for AKI III patients (log-rank p<0.001).

Conclusions: AKI is a risk factor for 30-day and 1-year mortality in both SAVR and TAVI patients. Despite the higher AKI incidence in SAVR patients, it lasted longer in TAVI patients. TAVI patients with severe AKI had a lower estimate 1-year survival compared to SAVR patients in the same category.

Introduction

Acute Kidney Injury (AKI) is one of the most significant complications in patients undergoing Surgical Aortic Valve Replacement (SAVR) or Transcatheter Aortic Valve Implantation (TAVI) for severe aortic valve stenosis [1]. Its incidence varies between 4% and 49% depending on AKI definition and study population characteristics [2,3]. AKI has been shown to be associated with increased short- and long-term morbidity and mortality after cardiothoracic surgery [4,5]. The pathophysiological mechanisms underlying the onset of AKI in SAVR versus TAVI patients are different. In patients undergoing SAVR, such a complication may be related to the duration of the procedure and the use of Cardiopulmonary Bypass (CPB) [2,6], on the other hand, in TAVI patients, it may be triggered by the administration of intravenous contrast, the presence of a short period of severe hypotension (e.g during rapid pacing and valve deployment), and the increased risk of embolization due to aortic catheterization [1]. To date, only few studies compared incidence and evolution of AKI in SAVR versus TAVI patients [7,8]. The aim of the present analysis is to understand if the onset of AKI has a different impact on short- and mid-term outcomes in these two groups of patients.

Patients and Methods

The study was conducted in accordance with the declaration of Helsinki and the study design was approved by the local Ethics Committee at the Mauriziano Hospital, Turin - Italy (protocol number 260-2022). Informed consent was obtained from all patients.

Patient Population And Study Design

Consecutive patients undergoing SAVR or TAVI for severe aortic valve stenosis from September 2017 to December 2019 at the Mauriziano Hospital were included in the analysis. The diagnosis of severe aortic valve stenosis was based on the best practice of the European Society of Cardiology/European Association for Cardiothoracic Surgery guidelines [9]. Exclusion criteria were reoperations or valve-in-valve procedure and the need for concomitant procedures (i.e. coronary artery bypass grafting, mitral valve replacement, percutaneous coronary intervention). Each patient was allocated to the most appropriate approach after an accurate Heart Team evaluation involving cardiothoracic surgeons, cardiologists, anesthesiologists, and radiologists assessing clinical history, blood tests, electrocardiogram, trans-thoracic echocardiography, computed tomography, and cardiac catheterization of the patients. The Euroscore II was also calculated for each patient and used as a further reference of evaluation [10]. Baseline characteristics such as age, sex, Body Mass Index (BMI), hypertension, dyslipidemia, diabetes mellitus, smoking, peripheral vascular disease, New York Heart Association (NYHA) class, and serum creatinine (SCr) level were recorded in both groups. The pre-procedural estimated glomerular filtration rate (eGFR) was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula [11]. Based on the eGFR, patients were divided into five groups following the Kidney Disease Outcomes Quality Initiative (KDOQI) classification for Chronic Kidney Disease (CKD) [12]:

- Stage I: eGFR > 90 ml/min/1,73

- Stage II: 89 ≤ eGFR ≥ 60 ml/min/1,73

- Stage III: 59 ≤ eGFR ≥ 30 ml/min/1,73

- Stage IV: 29 ≤ eGFR ≥ 15 ml/min/1,73

- Stage V: eGFR ≤ 14 15 ml/min/1,73.

All TAVI patients with pre-procedural CKD stage III-V (eGFR ≤ 60 ml/min) received a prophylactic treatment with 0,9% saline solution, N-acetylcysteine, and sodium bicarbonate. The urgency for the intervention was also investigated in all patients. In the SAVR group, CPB and aortic cross-clamp times were listed, as well as the amount of intravenous contrast used during TAVI.

Surgical Techniques

The operative techniques have been previously described [13,14]. Briefly, SAVR were performed using sternotomy or mid-sternotomy, central aortic cannulation, hypothermic CPB, aortic cross-clamping, and myocardial protection with antegrade blood or crystalloid cardioplegia. TAVI were performed mainly by a transfemoral approach while alternative accesses, such as trans-carotid, trans-subclavian, transapical, and transcaval, were used only in few patients when the former approach was not feasible. Both self-expandable and balloon-expandable prosthesis were implanted. If necessary, a valvuloplasty was performed before or after prosthesis implantation.

Outcomes

The primary endpoint was the onset and the stage of post-procedural AKI based on SCr level following the Kidney Disease: Improving Global Outcomes (KDIGO) criteria [15]:

- Stage I: SCr 1,5-1,9 times baseline or ≥ 0,3 mg/dL increase

- Stage II: SCr 2,0-2,9 times baseline

- Stage III: SCr 3 times baseline or ≥ 4.0 mg/dL increase or initiation of Renal Replacement Therapy (RRT).

The secondary endpoints were need and duration of RRT, Intensive Care Unit (ICU) and in-hospital length of stay, KDIGO stage at discharge, eGFR at 1 year of follow-up, and 30-day and 1-year mortality.

All the patients received a follow-up visit at 3 months after surgery, a blood test at 1 year, and a follow-up phone call at 1 year. The follow up was completed on December 13, 2020.

Statistical Analysis

Data were collected into a dedicated database and retrospectively analyzed. For continuous variables data were expressed with mean and Standard Deviation (SD); for categorical variables data were represented with frequency and percentage. Differences between groups were assessed using the Student's test for continuous variables and chi-square test or Fisher's exact test for categorical variables. One-year mortality was assessed and reported using the Kaplan-Meier method. The long-rank test was used to compare the survival distribution among different AKI stages in the two groups. All p-values were two-sided and a p-value <0.05 was considered statistically significant. All analyses were performed with SPSS 26.0 (IBM, Chicago, USA).

Results

From September 2017 to December 2019, 457 consecutive patients with diagnosis of severe aortic valve stenosis underwent SAVR (n=201, 44.0%) or TAVI (n=256, 56.0%) at the Mauriziano Hospital in Italy and were enrolled in the present analysis. Baseline characteristics of the two groups are described in Table 1. Patients in the TAVI group were older (82.7 ± 4.9 vs 71.6 ± 9.8, p<0.001), with higher incidence of NYHA class III-IV (54.3% vs 38.8%, p=0.001), and higher Euroscore II (5.7 ± 5.9 vs 2.4 ± 3.1, p<0.001), when compared to the SAVR group. Patients in the SAVR group had higher incidence of smoking (42.3% vs 23.4%, p<0.001) and hypertension (97.5% vs 92.9%, p=0.03) compared to the TAVI group. Regarding renal function, TAVI patients had higher SCr level (1.28 ± 0.92 vs 0.92 ± 0.53, p<0.001) and lower eGFR (55.9 ± 21.8 vs 77.5 ± 18.8, p<0.001) at baseline, with higher rate of CKD II-V (52.3% vs 17.4%, p<0.001).

Variables	SAVR (n=201)	TAVI (n=256)	p value
Age, mean (SD)	71.6 ± 9.8	82.7 ± 4.9	**<0.001**
Male sex, n (%)	89 (44.3)	113 (44.1)	1.00
BMI, mean (SD)	26.4 ± 3.8	25.7 ± 4.8	0.13
Hypertension, n (%)	195 (97.5)	237 (92.9)	**0.03**
Diabetes, n (%)	37 (18.4)	43 (16.9)	0.20
Dyslipidemia, n (%)	97 (48.5)	115 (45.1)	0.47
Smoking, n (%)	85 (42.3)	60 (23.4)	**<0.001**
Peripheral vascular disease, n (%)	42 (20.9)	70 (27.3)	0.11
NYHA class 0-II, n (%)[a]	109 (54.2)	116 (45.3)	0.06
NYHA class III-IV, n (%)	78 (38.8)	139 (54.3)	**0.001**
Euroscore II, mean (SD)	2.4 ± 3.1	5.7 ± 5.9	**<0.001**
Creatinine (mg/dL), mean (SD)	0.92 ± 0.53	1.28 ± 0.92	**<0.001**
eGFR (ml/min), mean (SD)	77.5 ± 18.8	55.9 ± 21.8	**<0.001**
CKD II-V, n (%)	35 (17.4)	134 (52.3)	**<0.001**

BMI: body mass index, CKD: chronic kidney disease, eGFR: estimated glomerular filtration rate, NYHA: New York Heart Association, SAVR: surgical aortic valve replacement, TAVI: trans-catheter valve implantation.

aNYHA class was not available for 14 patients in the SAVR group and 1 patient in the TAVI group.

Table 1: Baseline characteristics of the two groups.

The incidence of post-procedural AKI was significantly higher in the SAVR group when compared to the TAVI group (n=58/201 [28.9%] vs 15/256 [5.9%], p<0.001). The KDIGO stages of AKI in both groups are reported in Table 2. The RRT was used in 10/58 (17.2%) patients in the SAVR group and 6/15 (40.0%) patients in the TAVI group; the duration of RRT was significantly higher in the TAVI group (6.2 ± 8.0 vs 3.2 ± 1.7 days, p<0.001) (Table 2).

	SAVR (n=201)	TAVI (n=256)	p value
Post-procedural AKI, n (%)	58 (28.9)	15 (5.9)	**<0.001**
• **AKI I**, n (%)	28 (13.9)	6 (2.3)	-
• **AKI II**, n (%)	17 (8.5)	3 (1.2)	-
• **AKI III**, n (%)	13 (6.5)	6 (2.3)	-
RRT, n (%)[a]	10 (17.2)	6 (40.0)	0.06
RRT duration, mean (SD)	3.2 ± 1.7	6.2 ± 8.0	**<0.001**
AKI at discharge, n (%)[a]	9 (15.5)	8 (53.3)	**<0.001**
• **AKI I**, n (%)	2 (3.4)	5 (33.3)	-
• **AKI II**, n (%)	3 (5.2)	0 (0.0)	-
• **AKI III**, n (%)	4 (6.9)	3 (20.0)	-
30-day mortality, n (%)	6 (3.0)	4 (1.7)	0.35
1-year mortality, n (%)	13 (6.5)	26 (10.2)	0.16

AKI: acute kidney injury, RRT: renal replacement therapy, SAVR: surgical aortic valve replacement, TAVI: trans-catheter valve implantation. [a]For RRT and AKI at discharge percentages, the denominator was the number of patients who developed post-procedural AKI in each group.

Table 2: Main outcomes of the analysis.

In the SAVR group, AKI patients were significantly older (76.1 ± 5.4 vs 69.7 ± 10.7, p<0.001), with higher BMI (27,4 ± 3,9 vs 26,0 ± 3,8, p=0.02), higher Euroscore II (3.1 ± 3.7 vs 2.1 ± 2.8, p=0.03), higher incidence of emergency operations (n=11/58 [19.0%] vs 12/143 [8.4%], p=0.04), lower eGFR (69.2 ± 18.1 vs 82.9 ± 18.1, p<0.001), and higher incidence of CKD II-V (n=21/58 [36.2%] vs 15/143 [10.5%], p<0.001). In the TAVI group, AKI patients were more likely men (n=11/15 [73.3%] vs 103/241 [42.7%], p=0.03), with higher incidence of smoking (n=7/15 [46.7%] vs 53/241 [22.0%], p=0.03) and peripheral vascular desease (n=8/15 [53.3%] vs 62/241 [25.7%], p=0.02), lower eGFR (41.7 ± 17.6 vs 56.8 ± 21.8, p=0.003), and higher incidence of CKD II-V (n=12/15 [80.0%] vs 123/241 [51.0%], p=0.03) (Table 3). In the SAVR group, CPB time (90.3 ± 30.9 vs 89.9 ± 25.2, p=0.92) and cross-clamp time (63.4 ± 18.6 vs 64.4 ± 18.8, p=0.73) were similar in AKI vs no-AKI patients. In the TAVI group, the amount of intravenous contrast used during the procedure was higher in AKI patients (99.7 ± 54.0 vs 71.9 ± 29.7, p=0.001) (Table 3). In both groups, AKI patients had longer ICU length of stay (5.0 ± 6.6 vs 2.0 ± 6.6, p=0.004 for SAVR; 7.0 ± 8.0 vs 2.0 ± 7.0, p=0.01 for TAVI) and in-hospital length of stay (13.0 ± 10.3 vs 9.8 ± 10.3, p=0.05 for SAVR; 16.7 ± 12.9 vs 8.4 ± 12.3, p=0.01 for TAVI) when compared to no-AKI patients (Table 4).

	SAVR			TAVI		
Variables	**AKI (n=58)**	**No-AKI (n=143)**	**p value**	**AKI (n=15)**	**No-AKI (n=241)**	**p value**
Age, mean (SD)	76.1 ± 5.4	69.7 ± 10.7	**<0.001**	83.4 ± 6.2	82.7 ± 4.9	0.57
Male sex, n (%)	30 (51.7)	82 (57.3)	0.47	11 (73.3)	103 (42.7)	**0.03**
Smoking, n (%)	20 (34.5)	65 (45.5)	0.15	7 (46.7)	53 (22.0)	**0.03**
Peripheral vascular disease, n (%)	14 (24.1)	28 (19.6)	0.52	8 (53.3)	62 (25.7)	**0.02**
BMI, mean (SD)	27.4 ± 3.9	26.0 ± 3.8	**0.02**	27.1 ± 4.7	25.7 ± 4.8	0.27
Hypertension, n (%)	56 (96.6)	139 (97.2)	1.00	13 (86.7)	224 (92.9)	0.31

Dyslipidemia, n (%)	30 (52.6)	67 (46.9)	0.46	5 (33.3)	110 (45.8)	0.43
Diabetes, n (%)	8 (13.8)	29 (20.3)	0.3	2 (13.3)	41 (17.1)	0.87
Euroscore II, mean (SD)	3.1 ± 3.7	2.1 ± 2.8	**0.03**	6.64 ± 5.52	5.36 ± 5.62	0.4
Emergency procedure, n (%)	11 (19.0)	12 (8.4)	**0.04**			
Creatinine (mg/dL), mean (SD)	0.97 ± 0.31	0.89 ± 0.59	0.33	1.69 ± 0.88	1.25 ± 0.91	0.07
eGFR (ml/min), mean (SD)	69.2 ± 18.1	82.9 ± 18.1	**<0.001**	41.7 ± 17.6	56.8 ± 21.8	**0.003**
CKD II-V, n (%)	21 (36.2)	15 (10.5)	**<0.001**	12 (80.0)	123 (51.0)	**0.03**
CPB time (min), mean (SD)	90.3 ± 30.9	89.9 ± 25.2	0.92	-	-	-
Cross-clamp time (min), mean (SD)	63.4 ± 18.6	64.4 ± 18.8	0.73	-	-	-
IV contrast (ml), mean (SD)	-	-	-	99.7 ± 54.0	71.9 ± 29.7	**0.01**

AKI: acute kidney injury, BMI: body mass index, CKD: chronic kidney disease, CPB: cardiopulmonary bypass, eGFR: estimated glomerular filtration rate, IV: intravenous contrast, NYHA: New York Heart Association, SAVR: surgical aortic valve replacement, TAVI: trans-catheter valve implantation.

Table 3: Baseline and intraoperative characteristics in the two groups based on the onset of AKI.

	SAVR			**TAVI**		
Variables	**AKI (n=58)**	**No-AKI (n=143)**	**p value**	**AKI (n=15)**	**No-AKI (n=241)**	**p value**
ICU length of stay, mean (SD)	5.0 ± 6.6	2.0 ± 6.6	**0.004**	7.0 ± 8.0	2.0 ± 7.0	**0.01**
In-hospital length of stay, mean (SD)	13.0 ± 10.3	9.8 ± 10.3	**0.05**	16.7 ± 12.9	8.4 ± 12.3	**0.01**
30-day mortality, n (%)	5 (8.6)	1 (0.7)	**0.01**	3 (20)	1 (0.4)	**<0.001**
1-year eGFR (ml/min), mean (SD)	61.7 ± 16.9	80.6 ± 18.2	**<0.001**	50.8 ± 20.6	54.8 ± 20.0	0.45
1-year mortality, n (%)	8 (13.8)	5 (3.5)	**0.01**	5 (33.3)	21 (8.7)	**0.02**

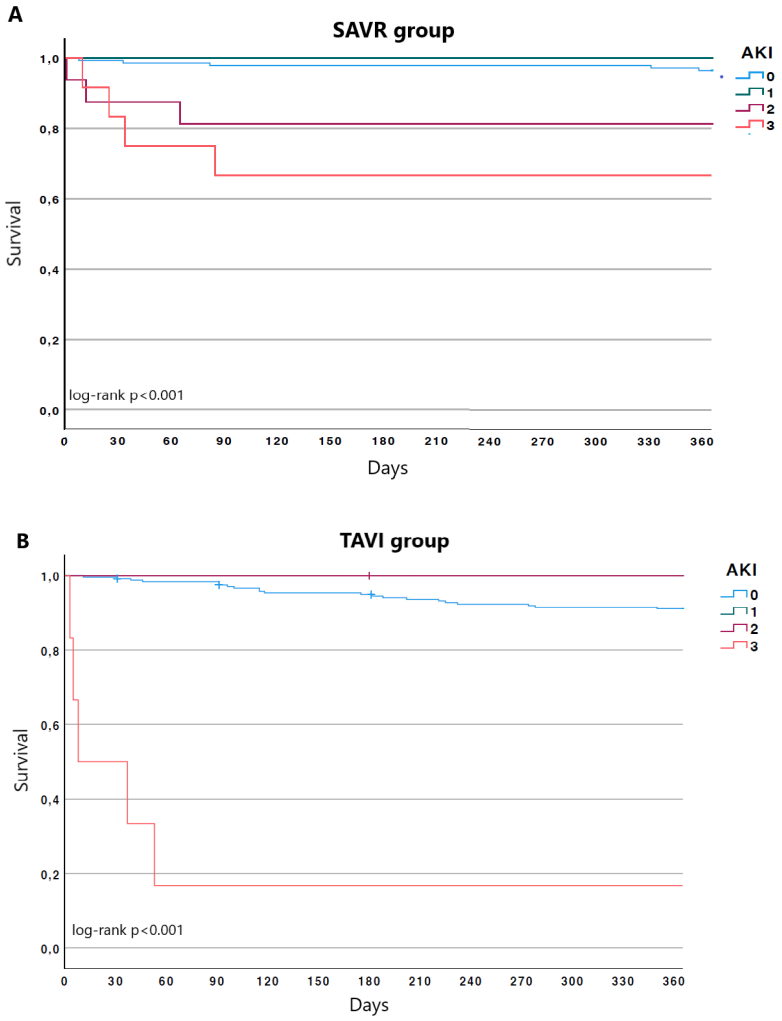
AKI: acute kidney injury, eGFR: estimated glomerular filtration rate, ICU: intensive care unit, SAVR: surgical aortic valve replacement, TAVI: trans-catheter valve implantation.

Table 4: Main outcomes in the two groups based on the onset of AKI.

At discharge, the percentage of patients still in AKI was significantly higher in the TAVI group when compared to the SAVR group (n=8/15 [53.3%] vs 9/58 [15.5%], p<0.001). Particularly, in the SAVR group, 2 patients with diagnosis of AKI II were discharged in AKI I, 2 patients with diagnosis of AKI II and 1 patient with diagnosis of AKI III were discharged in AKI II, and 4 patients with diagnosis of AKI III were discharged in the same category. In the TAVI group, 3 patients with diagnosis of AKI I, 1 patient with diagnosis of AKI II, and 1 patient with diagnosis of AKI III were discharged in AKI I while 3 patients in AKI III were discharged in the same category.

Thirty-day mortality was 3.0% (n=6/201) in the SAVR group and 1.7% (n=4/256) in the TAVI group (Table 4). In the SAVR group, 3 patients died with diagnosis of AKI III and 2 patients with diagnosis of AKI II. In the TAVI group, 3 patients died with diagnosis of AKI III. Two patients, one in each group, died within 30 days without developing AKI. In the SAVR group, a significantly higher 30-day mortality was recorded among AKI patients (n=5/58 [8.6%] vs 1/143 [0.7%], p=0.01) as well as in the TAVI group (n=3/15 [20.0%] vs 1/241 [0.4%], p<0.001) (Table 4). In the SAVR group, one-year eGFR was significantly lower in AKI patients (61.7 ± 16.9 vs 80.6 ± 18.2, p<0.001) when compared to no-AKI patients while this difference was not observed in the TAVI group (50.8 ± 20.6 vs 54.8 ± 20.0, p=0.45) (Table 4). One-year mortality was 6.5% (n=13/201) in the SAVR group and 10.2% (n=26/256) in the TAVI group (Table 2). In the SAVR group, a

significantly higher 1-year mortality was recorded among AKI patients (n=8/58 [13.8%] vs 5/143 [3.5%], p=0.01) as well as in the TAVI group (n=5/15 [33.3%] vs 21/241 [8.7%], p=0.02) (Table 4). In the SAVR group, the Kaplan-Meier 1-year survival estimate was 96.5% for patients without AKI, 81.5% for patients with AKI II, and 67.0% for patients with AKI III (log-rank p<0.001) (Figure 1A). In the TAVI group, the Kaplan-Meier 1-year survival estimate was 91.5% for patients without AKI and 16.5% for patients with AKI III (log-rank p<0.001) (Figure 1B).



AKI: acute kidney injury, SAVR: surgical aortic valve replacement, TAVI: trans-catheter valve implantation.

Figure 1: Kaplan-Meier survival curves for AKI stages in (A) SAVR group and (B) TAVI group.

Discussion

In this single-center retrospective analysis evaluating short- and mid-term outcomes associated with post-procedural AKI in patients undergoing SAVR vs TAVI for severe aortic valve stenosis, we found that despite a higher incidence of AKI in SAVR patients, it lasted longer in TAVI patients. Post-procedural AKI was associated with higher 30-day and 1-year mortality in both groups. TAVI patients with severe AKI had a lower estimate 1-year survival compared to SAVR patients in the same category. In developed countries, calcific aortic valve stenosis represents the most common valvulopathy with a prevalence of 3% among people over the age of 75 [16]. A strong association between aortic valve stenosis and renal dysfunction is reported: leaflet calcification is accelerated in patients with chronic renal dysfunction due to an altered phosphor and calcium metabolism, and a long-standing aortic valve stenosis leads to decreased

kidney perfusion due to reduced cardiac output [17]. SAVR remains the gold standard for the treatment of aortic valve stenosis but in recent years the transcatheter approach has emerged as an attractive alternative [18-21]. Recent guidelines from the European Society of Cardiology/European Association for Cardiothoracic Surgery and the American College of Cardiology/American Heart Association have highlighted that the choice between the two abovementioned approaches needs to be based on an accurate Heart Team evaluation of patient's characteristics, comorbidities, and risk of developing post-procedural complications [9,22]. Among these, post-procedural AKI is a frequent complication of both surgical and transcatheter procedures. In our analysis, the incidence of AKI was 28.9% among SAVR patients and 5.9% among TAVI patients in accordance with literature findings, even if post-procedural AKI in TAVI patients tends to be slightly higher [2-4].

Furthermore, different studies have reported a worse prognosis in patients who developed AKI after cardiothoracic surgery. In patients undergoing SAVR, the onset of AKI is associated with higher in-hospital mortality with an incidence of 15.0% in patients with severe renal dysfunction versus 2.9% in patients without kidney injury [3]. In TAVI patients, AKI is related with an increased 30-day mortality which ranges from 10% to 30% and a 3-fold increase in 1-year mortality [7]. In the present analysis, a significantly higher 30-day mortality was recorded among AKI patients in both SAVR (8.6% vs 0.7%) and TAVI group (20.0% vs 0.4%) and this finding persisted for 1-year mortality (13.8% vs 3.5% for SAVR and 33.3% vs 8.7% for TAVI). We also found that patients who developed AKI in both groups presented worse baseline characteristics compared to patients who did not such as lower eGFR and higher incidence of CKD II-V, as previously described [8-23]. The higher mortality rates in TAVI patients is not surprising, they are usually older, frailer, and with more comorbidities than surgical patients, as a consequence, AKI has a higher impact on their outcomes. In our analysis, TAVI patients were older, with higher Euroscore II, lower eGFR, and higher rate of CKD II-V. Despite the incidence of AKI was higher in SAVR patients, kidney injury lasted longer in the TAVI group. At discharge, 84.5% of SAVR patients had a complete kidney function recovery versus 46.7% in the TAVI group. Several studies have focused on AKI duration as an important risk factor for worse clinical outcomes. Patients developing a long-standing AKI have a worse prognosis when compared to patients with transient AKI or no AKI, including progressive kidney disease and increased in-hospital and long-term mortality. Thongprayoon and collogues reported that, at discharge, the 13% of TAVI patients who remained in AKI had a significantly higher 1-year mortality [24]. This finding is comparable to our results, TAVI patients had a higher incidence of persisting AKI at discharge and an increased 1-year mortality. Furthermore, TAVI patients with severe AKI had a lower estimate 1-year survival compared to SAVR patients in the same category.

A higher incidence of post-procedural AKI in the SAVR group has been reported in literature which is unremarkable considering different pathophysiological mechanisms underlying this post-procedural complication. In the surgical group, AKI is related to hypoperfusion, ischemia-reperfusion injury, inflammation, and oxidative stress during CPB [2], while in the TAVI group, kidney injury is mainly due to intravenous contrast administration. Previous studies have showed that prolonged CPB time increases the incidence of post-procedural AKI [25,26]. Fisher and collogues evaluated the effect of CBP time on kidney function and found that CBP duration was significantly longer in patients with post-procedural AKI (166 ± 77 min versus 107 ± 40 min, $p<0,001$). In our analysis, however, we did not find a significant association between CPB time and post-procedural AKI. The association between amount of intravenous contrast and onset of AKI after TAVI is controversial. Podolecka and colleagues evaluated pre-procedural and post-procedural eGFR and SCr level in 39 TAVI patients with a mean intravenous contrast volume of 187 ± 91 ml. They found that the intravenous contrast amount was not correlated with a decreased renal function [27]. Similar findings were reported by Nguyen and colleagues who showed that intravenous contrast load was not associated with a higher incidence of renal failure [28]. On the other hand, Yamamoto and colleagues reported a higher incidence of AKI in patients in which a higher volume of intravenous contrast was used [29]. In the present analysis, we showed that the onset of post-procedural AKI is significantly related to the amount of intravenous contrast used during the procedure. A larger patient population and a longer follow up are mandatory to confirm these findings.

This study must be interpreted in the setting of its limitations. First, this is a retrospective analysis and thus susceptible to the usual biases associated with these series [30]. Second, the results herein presented are specific to a single-center and may not be easily applied across all hospital and geographic settings. Finally, comparisons among groups may be underpowered to detect significant differences in clinical outcomes due to the limited number of patients.

Conclusion

To conclude, post-procedural AKI is a risk factor for 30-day and 1-year mortality in both SAVR and TAVI patients. Despite the higher AKI incidence in SAVR patients, AKI lasted longer in TAVI patients. TAVI patients who develop a severe AKI, according to KIDGO criteria, had a lower estimate 1-year survival compared to SAVR patients in the same category. An accurate Heart Team evaluation including a nephrological examination for the patients with higher risk of post-procedural AKI is mandatory in order

to allocate each patient to the most appropriate approach. In our opinion, SAVR remains the safest approach for patients eligible for both procedures and with high risk of devolving post procedural AKI.

Acknowledgement: Fondazione Scientifica Mauriziana Onlus

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