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ORIGINAL RESEARCH

Contrast-Induced Nephropathy in Patients Undergoing Staged Versus Concomitant Transcatheter Aortic Valve Implantation and Coronary Procedures

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BACKGROUND: The impact of staged versus concomitant coronary procedures on renal function in patients with aortic stenosis undergoing transcatheter aortic valve implantation (TAVI) remains unclear.

METHODS AND RESULTS: Three-hundred thirty-nine patients undergoing coronary procedures and TAVI as a staged strategy (160, 47.2%) or concomitant strategy (179, 52.8%) were retrospectively analyzed. Contrast-induced acute kidney injury (CI-AKI) occurred in 49 patients in the staged strategy group (30.6%) and in 18 patients (10.1%) in the concomitant strategy group (P<0.001). Among the staged strategy group, 25 (15.6%) patients developed CI-AKI after coronary angiography or percutaneous coronary intervention, 17 (10.6%) after TAVI, and 7 (4.3%) after both the procedures. Staged strategy was associated with a higher risk of CI-AKI (odds ratio, 3.948; P<0.001) after adjustment for multiple confounders and regardless of the baseline renal function (P for interaction=0.4) when compared with the concomitant strategy. At a median follow-up of 24.0 months (3.0–35.3), CI-AKI was not associated with sustained renal injury (P=0.794), irrespective of the adopted strategy. The concomitant strategy did not impact the overall early safety at 30 days follow-up after TAVI compared to the staged strategy (P=0.609).

CONCLUSIONS: Performing coronary procedures with a staged strategy before TAVI was associated with a higher risk of CI-AKI compared with a concomitant strategy. Moreover, a concomitant strategy did not increase the risk of procedure-related complications.

Key Words: contrast-induced nephropathy ■ coronary artery disease ■ transcatheter aortic valve implantation

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Obstructive coronary artery disease is present in more than 60% of patients with severe aortic stenosis (AS) undergoing transcatheter aortic valve implantation (TAVI),[1–3] and coronary angiogram (CA) remains a crucial step of the TAVI work-up. Moreover, percutaneous coronary intervention (PCI) is recommended in the case of obstructive coronary artery disease in proximal vessels in patients undergoing TAVI.[4,5] There is no consensus, however, about the best timing to perform coronary procedures in patients undergoing TAVI.

Available data suggest that performing PCI does not impact early survival, neither in a staged nor in a concomitant fashion related to the TAVI procedure.[6–11]

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CLINICAL PERSPECTIVE

What Is New?

- Performing concomitant coronary angiography/interventions and transcatheter aortic valve implantation was associated with a lower risk of contrast-induced acute kidney injury compared with a staged strategy.

What Are the Clinical Implications?

- The awareness of a limited nephrotoxicity of contrast media for a concomitant strategy compared to a staged strategy could help clinicians when planning the best work-up for patients with severe aortic stenosis undergoing coronary angiography/interventions and transcatheter aortic valve implantation.

Nonstandard Abbreviations and Acronyms

AS	aortic stenosis
CA	coronary angiography
CI-AKI	contrast-induced acute kidney injury
CS	concomitant strategy
Hb	Hemoglobin
SCr	serum creatinine
SS	staged strategy
TAVI	transcatheter aortic valve implantation

However, the relationship between the timing of the coronary procedures and the incidence of contrast-induced acute kidney injury (CI-AKI) in patients undergoing TAVI has not been previously investigated.

A concomitant strategy (CS) could theoretically increase the risk of developing CI-AKI due to the larger amount of contrast medium used to perform associated procedures. Conversely, patients undergoing TAVI and coronary procedures in a staged strategy (SS) are exposed to multiple contrast medium administrations.

Most of the available reports did not consider the cumulative risk of CI-AKI in patients undergoing coronary and TAVI procedures in a staged fashion, limiting their analyses to CI-AKI incidence in patients undergoing concomitant procedures versus standalone TAVI, irrespective of previous angiographic procedures.

Therefore, the present study aims to compare the cumulative risk of CI-AKI in patients with AS undergoing coronary procedures and TAVI in a SS versus a CS.

METHODS

Study Population and Exclusion Criteria

The data that support the findings of this study are available from the corresponding author upon reasonable request.

This is a retrospective single-center study comprising of a consecutive series of patients presenting with severe symptomatic AS at the University of Verona Health Centre from April 2012 to October 2020. All patients underwent coronary procedures as a part of the TAVI work-up in a period comprised between 1 week and 4 months before TAVI (SS) or during the same TAVI procedure (CS).

Only patients undergoing both coronary and TAVI procedures at the University of Verona Health Centers were considered.

Moreover, the following populations were excluded from the analysis: (1) patients in dialysis; (2) patients discharged or transferred before 48–72 hours and, therefore, with an incomplete renal functional assessment; (3) patients undergoing coronary intervention or TAVI in an emergency fashion.

The prospectively collected Verona Valvular Heart Disease Registry was interrogated to retrieve laboratory data, baseline clinical, procedural information, and 30 days of follow up data post-TAVI. The final database used for the analysis comprised clinical data collected from medical records and procedural data regarding pre-TAVI coronary procedures. A list of variables included in the database used for the present analysis is presented as Data S1.

All patients included in the analysis provided their informed consent to the anonymous elaboration of their data. This study is approved by the local Institutional Review Board (CESC n=1918).

Creatinine and Glomerular Filtration Rate Determination

Serum creatinine (SCr) determinations were centralized in the same laboratory and quantified with the kinetic Jaffe method (Dimension, Dade Behring; reference intervals: male, 0.8–1.3 mg/dL; female, 0.6–1.0 mg/dL). The estimated glomerular filtration rate (eGFR) was calculated for each patient using the Cockcroft–Gault formula.[12–14]

Procedures

Staged pre-TAVI coronary procedures, either coronary angiography (CA) alone or CA together with ad-hoc PCI, were performed by standard femoral or radial percutaneous approach. CA/PCI concomitant with TAVI were always performed through the TAVI non-operative femoral or radial vascular access. All TAVI procedures were performed in an elective

fashion by either the percutaneous transfemoral or surgical transapical access. The following transcatheter heart valves were used to perform TAVI: (1) the balloon-expandable Edwards SAPIEN-XT, S3, ULTRA (Edwards Lifesciences, Irvine, CA, USA); (2) the self-expandable Medtronic CoreValve, Evolut-R or Evolut-Pro (Medtronic Inc., Minneapolis, MN, USA); (3) the self-expandable Lotus or Accurate Neo (Boston Scientific, Massachusetts, USA). The appropriate prosthesis was chosen according to the anatomic characteristics of the valve morphology, as determined by the computed tomography-scan analysis.

Contrast Medium and Preventive Measures

In all cases, patients were administered intra-arterial iso-osmolar contrast medium (Iodixanol) or low-osmolar contrast medium (Iohexol, Iopromide). Standard measures to prevent CI-AKI were adopted based on the risk profile of each patient, according to the most recent available guidelines at the moment of the procedure.[15–18] For patients with eGFR<60 mL/min, hydration was started 12 hours before the procedure and was given for at least 24 hours after the procedure and was further continued if any increment of SCr compared with baseline was detected. Therefore, patients treated in emergency conditions or on outpatient or back-transfer modality were not included in the present analysis. The infusion rate was standardized at 1 mL/kg per hour of 0.9% saline, except in cases of severe left ventricular dysfunction (LV ejection fraction [LVEF]<35%) when the infusion rate was reduced to 0.5 mL/kg per hour. For patients with diabetes mellitus with chronic kidney disease, metformin was suspended from the time of contrast medium administration and restarted 48 hours after the procedure, except in the development of CI-AKI.

Definitions

According to the coronary procedure strategy, 2 groups of patients were identified: Staged strategy (SS) patients and Concomitant Strategy (CS) patients.

The main reason behind performing SS or CS was a change in the diagnostic work-up over time, which has favored CS over the past 2 years.

CI-AKI was defined as an increase of at least 0.3 mg/dL[19–21] at 72 hours after the index procedure compared with baseline. Baseline serum creatinine were the most recent value available before the procedure, measured during the hospital stay.

Chronic kidney disease was defined as eGFR <60 mL/min per 1.73 m^2. Severe aortic stenosis was defined accordingly with the current European Guidelines criteria.[4]

Sustained kidney injury was defined as a decrease in eGFR, derived from the last available SCr measurement, lower than 25% compared to baseline.[21–23]

Early safety events were defined as clinical events at 30 days after TAVI according to Valve Academic Research Consortium-2 criteria,[20] including death, major bleeding, vascular complications, stroke, repeated procedure, acute kidney injury, coronary obstruction, and valve dysfunction.

End Points

The primary end point was to compare the incidence of CI-AKI in patients undergoing coronary procedures and TAVI in SS versus CS.

The secondary end points were:

a the comparison of incidence of sustained kidney injury at long-term follow-up in patients developing CI-AKI in SS versus CS;
b the incidence of early safety events following TAVI in the SS versus CS.

Statistical Analysis

Continuous variables are presented as mean and standard deviation if normally distributed or as median and interquartile range compared with unpaired *t*-test or Mann–Whitney test, when appropriate. Categorical data are reported as a percentage and compared with the chi-square test or Fisher exact test. Univariate logistic regression analysis was performed to identify predictors of CI-AKI. Multivariate models were then constructed using variables associated with CI-AKI at univariate analysis with a *P*-value <0.1. The validity of the model was tested using the Hosmer-Lemeshow goodness-of-fit test. Different logistic regression model has been compared using Akaike's information criterion and Bayesian information criterion. Logistic regression analysis was also performed to compare TAVI early safety of the SS versus CS. An interaction analysis was performed to assess the effect modification of baseline eGFR and of the procedural strategy (SS versus CS) on the risk of CI-AKI. A probability value of $P<0.05$ was considered statistically significant. All statistical analyses were performed using SPSS 24.0 (IBM Inc., New York, USA).

RESULTS

Study Population

A total of 890 patients with AS underwent TAVI procedures at the University Hospital of Verona between April 2012 and October 2020. Among this population, 547 (66.8%) patients underwent either staged or

concomitant CA/PCI in our center as previously defined and were therefore considered for this analysis. A total of 339 patients were included in the present analysis after checking for exclusion criteria. The study flow chart is shown in Figure 1.

SS was adopted in 160 (47.2%) patients, while CS in 179 (52.8%) patients.

Data at 30-day follow-up were available for all patients. Long-term data on renal function were available for 279 (82.3%) patients.

Clinical and Procedural Characteristics

The mean age was 82.69±5.53, and 44.5% were male. The majority of patients (70.8%) had baseline chronic kidney disease (mean eGFR 52.35±21.17), 12% presented with chronic kidney disease grade ≥4 (eGFR<30 mL/min per 1.73 m^2). Complete clinical characteristics of the population are reported in Table 1.

PCI was performed in 28 (17.5%) patients in the SS group versus 46 (25.7%) patients in the CS group (*P*=0.087). In all the remaining cases a diagnostic only procedure was performed.

In the SS group TAVI was performed at a median of 22 days (1–3 IQ: 9.0–49.5 days) after coronary procedures.

Incidence of CI-AKI

Among the overall population, CI-AKI occurred in 67 patients (19.8%). The incidence of CI-AKI was significantly higher in patients who underwent SS compared with those who underwent CS [49 (30.6%) versus 18 (10.1%); *P*<0.001] (Figure 2).

This difference was mainly driven by CI-AKI occurring after the pre-TAVI coronary procedures. Indeed, among the staged group, 25 patients (15.6%) developed CI-AKI after the pre-TAVI coronary procedures, 17 (10.6%) after TAVI and, of note, 7 patients (4.3%) developed CI-AKI twice, after both procedures. Of note, the occurrence of CI-AKI after the TAVI procedure alone was almost identical in the 2 groups (Figure 2).

At regression analysis, SS was associated with a significantly higher risk of CI-AKI compared with CS (odds ratio [OR], 3.948; 95% CI 1.836; 8.635; *P*<0.001), also after adjusting for multiple confounders as shown in Table 2.

SS was associated with a higher risk of CI-AKI regardless the baseline renal function (*P* for interaction=0.4), as shown in Figure 3.

The severity of CI-AKI, indicated by the delta in SCr (ΔSCr; peak value of SCr minus the baseline SCr value), was not significantly different between patients presenting CI-AKI in the 2 groups (0.71±0.58 mg/dL in the staged group versus 0.89±1.02 in the concomitant group; *P*=0.432).

Furthermore, no significant differences in CI-AKI severity according to Kidney Disease Improving Global Outcomes [19] classification were observed among the 2 groups (*P*=0.580) (Figure 4).

Sustained Kidney Injury

Long-term follow-up creatinine values were available for 279 (82.3%) patients. At a median follow-up of 24 months (IQ_{1-3}: 3.0–35.3), sustained kidney injury was present in 31 patients (11.1%) among the total

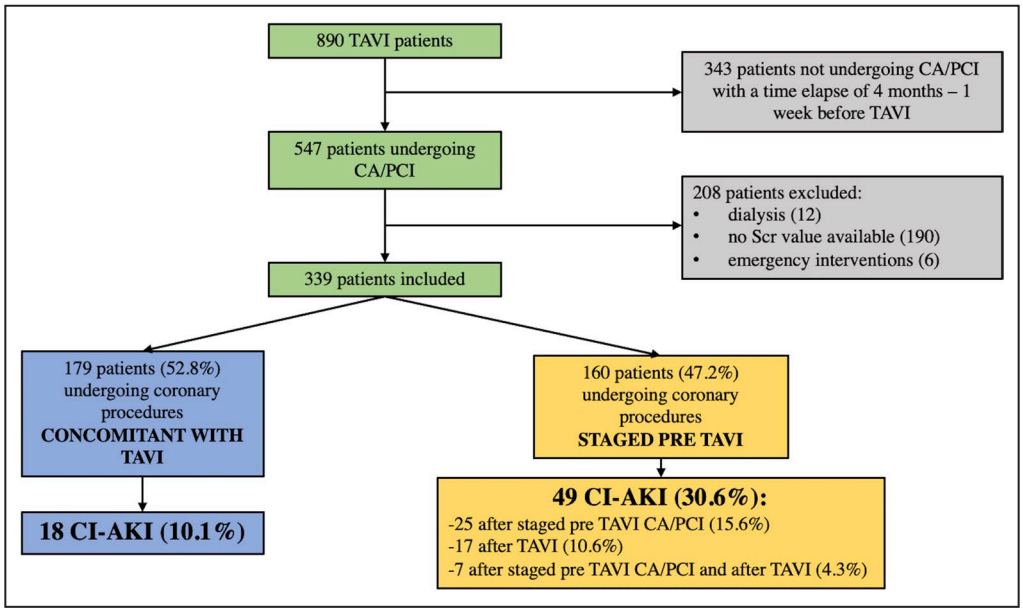

Figure 1. Study flow-chart.
CI-AKI indicates contrast-induced acute kidney injury; CA, coronary angiography; PCI, percutaneous coronary intervention; SCr, serum creatinine; and TAVI, transcatheter aortic valve implantation.

Table 1. Clinical Baseline and Procedural Characteristics: SS Versus CS

Baseline/Procedural Characteristics	Total Population (339)	SS (160)	CS (179)	*P* Value
Sex (% male)	44.5%	44.4%	44.7%	1.000
Hypertension	86.4%	86.3%	86.5%	1.000
Diabetes mellitus	28.1%	29.4%	27.0%	0.630
Dyslipidemia	55.5%	61.3%	50.3%	0.048
Atrial fibrillation	38.3%	32.5%	43.5%	0.044
Previuos stroke	8.6%	8.8%	8.4%	1.000
Previous CABG	6.2%	8.6%	4.0%	0.108
Previous AMI	13.1%	15.7%	10.8%	0.198
Anemia	50.4%	51.3%	49.7%	0.828
Coronary artery disease	47.9%	51.7%	44.8%	0.226
eGFR<60, mL/min	70.8%	70.6%	70.9%	1.000
Pulmonary hypertension	48.1%	50.6%	45.8%	0.384
Age, y	82.69±5.53	82.28±5.58	83.06±5.47	0.198
BMI	25.65±4.72	25.60±4.49	25.70±4.91	0.861
Hb (g/L)	12.11±1.86	11.98±1.55	12.22±2.07	0.227
ACEI Therapy	50.7%	51.7%	50.0%	0.890
LVEF%	53.20±13.00	51.86±14.04	54.63±11.68	0.068
Mean trans-aortic gradient	43.76±15.23	44.10±17.10	43.45±13.36	0.740
Basal creatinine (mg/dL)	1.12±0.50	1.12±0.47	1.12±0.53	0.937
Basal eGFR (mL/min)	52.35±21.17	52.43±21.49	52.27±20.95	0.947
TAVI-TA, n%	8.6%	11.9%	5.6%	0.051
Edwards Sapien, n%	71.7%	72.5%%	70.9%	0.809
Medtronic CoreValve, n%	26.5%	26.9%	26.3%	0.903
Boston accurate, n%	1.2%	0.0%	2.2%	0.125
Lotus, n%	0.6%	0.6%	0.6%	1.000
PreDilation	54.6%	67.5%	43.3%	<0.001
PostDilation	7.8%	6.8%	8.8%	0.531
PCI	21.8%	17.5%	25.7%	0.087
Cumulative contrast	192.25±103.24	249.34±102.58	154.31±84.80	<0.001

ACEI indicates angiotensin-converting enzyme inhibitor; AMI, acute myocardial infarction; BMI, body mass index; CABG, coronary artery bypass graft; eGFR, estimated glomerular filtration rate; Hb, Hemoglobin; LVEF, left ventricular ejection fraction; PCI, percutaneous coronary intervention; and TAVI-TA, transcatheter aortic valve implantation performed by trans-apical approach.

population: 13 SS group patients (9.6%) and 18 CS group patients (12.5%) (*P* for comparison 0.568). At the univariate analysis, CI-AKI was not associated with sustained kidney injury (hazard ratio [HR], 1.127, 95% CI 0.460; 2.761, *P*=0.794). The same result was found when analyzing separately SS patients (HR, 1.381, 95% CI 0.424; 4.502, *P*=0.794) and CS patients (HR, 1.087, 95% CI 0.224; 5.265, *P*=0.918). Finally, at last available follow-up, none of the patients who underwent CI-AKI required renal replacement therapy.

Length of Stay

The medium length of hospitalization of patients included in the present study was 12.0 days (IQ_{1-3}: 7.0–21.0). Patients which followed a SS had a significant higher total length of stay when compared with CS [20.0 (IQ_{1-3}: 13.3–29.0) versus 8 days (IQ_{1-3}: 6.0–13.0); *P*<0.01], when summing the length of stay of both the hospitalizations. Also, the length of hospitalization of patients subject to CI-AKI, was significantly longer than the other patients [22.5 (IQ_{1-3}: 12.0–30.8) versus 10.0 days (IQ_{1-3}: 6.0–19.0); *P*<0.01].

At univariate linear regression analysis, CI-AKI and SS were both associated with length of hospitalization (R 0.278; 95% CI 5.501; 12.690; *P*<0.001 and R 0.492; 95% CI –14.662; –9.717; *P*<0.001, respectively). This result was confirmed at multivariate analysis for both the variables (R 0.522; 95% CI 2.547; 9.106; *P*=0.001 for CI-AKI; R 0.522; 95% CI –13.700; –8.723; *P*<0.001 for SS versus CS).

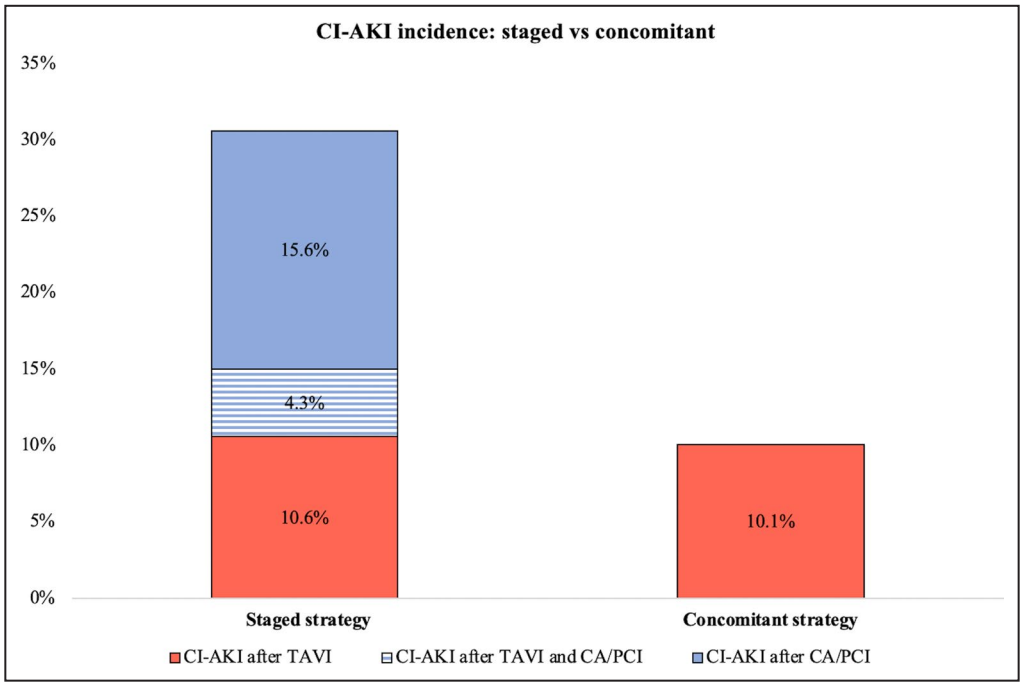

Figure 2. Incidence of CI-AKI (%) among patients undergoing staged strategy (SS) vs concomitant strategy (CS).
For patients undergoing SS contrast induced acute kidney injury (CI-AKI) could occur after coronary angiography/percutaneous coronary intervention (CA/PCI) (blue column), after transcatheter aortic valve implantation (TAVI) (left red column), or after both the procedures (blue stripes column). In contrast, for CS patients, CI-AKI could occur only after TAVI+CA/PCI (right red column).

Early Safety of TAVI: SS Versus CS

Early safety events defined according to Valve Academic Research Consortium-2 criteria at 30 days following TAVI occurred in 45 (13.3%) patients: 23 (14.3%) in the SS group and 22 (12.2%) in the CS group (P=0.632). At the regression analysis, no significant differences in the risk of early safety events were detected between TAVI in SS versus CS (OR, 1.198; 95% CI 0.639–2.245; P=0.573). Details of 30-day clinical events are reported in Table S1.

DISCUSSION

To the best of our knowledge, this is the first study investigating the impact of coronary procedures on CI-AKI and sustained kidney injury when performed in a SS versus CS with the TAVI procedure.

The main findings of the present study are the following:

1. Patients with AS undergoing TAVI and coronary procedures in a SS had a significantly higher rate of CI-AKI compared with those who underwent CS. This difference was mainly driven by the incidence of CI-AKI following the pre-TAVI coronary procedures;
2. CI-AKI in patients undergoing TAVI was not associated with sustained kidney injury at a mean follow-up of 2 years, irrespective of the adopted strategy, in contrast with available data considering patients undergoing coronary procedures.[21] However, this observation needs to be confirmed by larger studies;
3. Performing TAVI and coronary procedures during the same interventional session did not jeopardize early safety when compared with the stand-alone TAVI after previous myocardial diagnosis and/or revascularization.

Patients affected by severe AS candidates to TAVI are usually at high-risk of kidney injury following angiographic procedures, mainly because of the advanced age, baseline impaired renal function, cardiac damage and the concomitant presence of anemia and peripheral vascular disease.[24–26] However, the impact of staged pre-TAVI versus concomitant coronary procedures, using iodinated contrast medium, has not been extensively investigated.

Performing coronary procedures during the same TAVI interventional session could raise concerns among clinicians related to the larger amount of contrast media required, but in our experience the concomitant strategy actually reduced by 3 times the risk of acute renal damage, supporting an indirect observation derived

Table 2. CI-AKI Predictors at Univariate and Multivariate Regression Analysis

	Univariate Analysis			Multivariate Analysis		
	OR	CI 95%	*P* Value	OR	CI 95%	*P* Value
SS vs CS	3.948	2.185; 7.136	<0.001	3.316	1.443; 7.621	0.005
Male sex	1.732	0.591; 1.732	0.966			
Hypertension	0.854	0.400; 1.824	0.684			
Diabetes mellitus	1.249	0.697; 2.236	0.455			
Dislipidemia	1.298	0.750; 2.246	0.352			
Atrial fibrillation	1.147	0.663; 1.986	0.624			
Previous stroke	0.637	0.214; 1.899	0.419			
Previous CABG	1.948	0.717; 5.295	0.191			
Previous AMI	0.893	0.394; 2.023	0.786			
Anemia	1.094	0.641; 1.868	0.743			
Coronary artery disease	0.947	0.552; 1.623	0.842			
Pulmonary hypertension	0.890	0.514; 1.541	0.678			
Age	0.992	0.946; 1.041	0.775			
BMI	1.023	0.966; 1.084	0.434			
HB (g/L)	0.898	0.775; 1.041	0.153			
ACEI therapy	1.478	0.742; 2.943	0.266			
LVEF%	0.993	0.971; 1.014	0.502			
Mean trans-aortic gradient	0.996	0.975; 1.018	0.717			
Basal creatinine (mg/dL)	1.609	1.001; 2.587	0.050	1.416	0.775; 2.587	0.258
Basal gfr (mL/min) <60	1.726	0.907; 3.286	0.096			
TAVI-TA	1.621	0.684; 3.893	0.272			
Valve type	0.688	0.405; 1.170	0.168			
PreDilation	1.723	0.984; 3.016	0.057	1.098	0.531; 2.268	0.802
PostDilation	1.351	0.513; 3.561	0.543			
PCI	0.494	0.232; 1.052	0.067	0.493	0.151; 1.615	0.243
Cumulative contrast	1.004	1.001: 1.007	0.010	1.002	0.998; 1.006	0.340

(Hosmer-Lemeshow: chi^2=6.8, *P*=0.56; AIC=223.9, BIC=245.1).

ACEI indicates angiotensin-converting enzyme inhibitor; AMI, acute myocardial infarction; BMI, body mass index; CABG, coronary artery bypass graft; CS, concomitant strategy; eGFR, estimated glomerular filtration rate; Hb, Hemoglobin; LVEF, left ventricular ejection fraction; PCI, percutaneous coronary intervention; SS, staged strategy; and TAVI-TA, transcatheter aortic valve implantation performed by trans-apical approach.

from a meta-analysis that showed that CI-AKI is not related to contrast medium after TAVI.[24]

As a matter of fact, patients undergoing TAVI and coronary procedures as a SS receive more contrast and are exposed to an unfavorable hemodynamic condition. Indeed, performing an angiographic procedure before aortic valve replacement could bare a higher risk of renal toxicity because of a compromised prerenal perfusion secondary to the impaired cardiac output and the systemic venous congestion associated with aortic valve stenosis that may lead to a type-2 cardiorenal syndrome.[24,25]

Available literature usually neglects this aspect and does not consider the odds of CI-AKI related to coronary procedures performed electively before TAVI.[11] Our study shows, for the first time, that performing staged coronary procedures and TAVI is associated with higher odds of CI-AKI than CS.

The higher rate of CI-AKI in the SS group was almost exclusively driven by pre-TAVI coronary procedures, likely because of the previously mentioned unfavorable hemodynamic milieu.

Cardiac output acutely increases after aortic valve implantation, and this hemodynamic improvement has been related to kidney recovery post-TAVI,[13,27] likely due to a concomitant increase in renal perfusion.[28] Therefore, we hypothesize that performing a diagnostic coronary procedure concomitant to TAVI may be safer than in a staged pre-TAVI fashion, when the valve dysfunction prevents favorable hemodynamic changes. Similarly, elective coronary interventions, not motivated by acute coronary syndromes, may be better tolerated by the kidneys if performed after the valve replacement.

Perhaps because of the same hemodynamic mechanism, CI-AKI was not a predictor of sustained

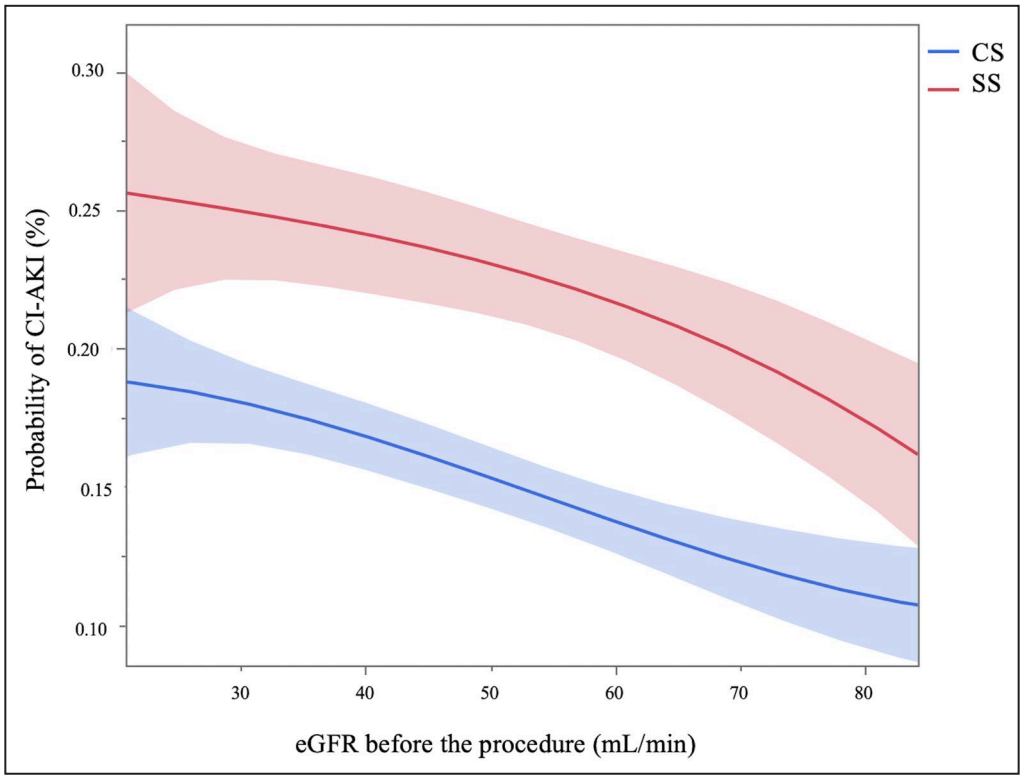

Figure 3. Relationship between the strategy of the coronary procedure (SS vs CS) and CI-AKI incidence at different baseline eGFR values (*P* for interaction 0.4).
CI-AKI indicates contrast-induced acute kidney injury; CS, concomitant strategy; eGFR, estimated glomerular filtration rate; and SS, staged strategy. Light blue and red curves represent the confidence of interval for spline curves of CS and SS, respectively.

kidney injury at long-term in our series, irrespective of the adopted strategy and, furthermore, none of the patients subject to CI-AKI required dialysis at long term follow-up. This finding is in contrast with studies that have focused on patients with coronary artery disease, for whom CI-AKI has always been associated with long-term kidney function impairment.[21] Such a discrepancy might be explained by the immediate beneficial hemodynamic effects of the aortic valve replacement that override the contrast-related renal damage.

In addition, the majority of patients suffered from grade 1 CI-AKI according to Kidney Disease Improving Global Outcomes classification (Figure 4), likely leading to a low rate of long-term renal dysfunction. However, a significant delay of the hospital stay was observed among patients subject to CI-AKI. The subsequent increase in hospitalization cost and risk for in-hospital complication such as infections, along with the well-known association between CI-AKI and adverse clinical outcome,[24,29] should prime clinicians to adopt all the possible strategies to minimize the risk of CI-AKI.

Interestingly, there was a clear trend for a higher number of transapical access in the staged strategy group (11.9% versus 5.6 %, *P*=0.051), respecting the request of the surgeons of knowing the coronary anatomy before the aortic valve intervention. However, the type of access did not impact CI-AKI incidence among our study cohort (OR 1.621; 95% CI 0.684; 3.893; *P*=0.272), and the higher rate of CI-AKI in the SS group was driven by pre-TAVI coronary procedures as mentioned above and not by type of TAVI procedure.

Finally, consistently with previous reports,[6–11] the present study showed that performing coronary procedures concomitant with TAVI (CS) did not compromise the early safety of the valvular procedure compared to a strategy of preventive coronary diagnosis and/or intervention (SS). Moreover, performing coronary interventions and TAVI in a single procedure may yield potential benefits simplifying the TAVI workflow, limiting vascular access (and complications), shortening hospital stay by limiting the occurrence of CI-AKI, and reducing hospital admissions for diagnostic purposes.[9,11]

Limitations

This is a single-center, retrospective observational study; therefore, results need further validation. Computerized

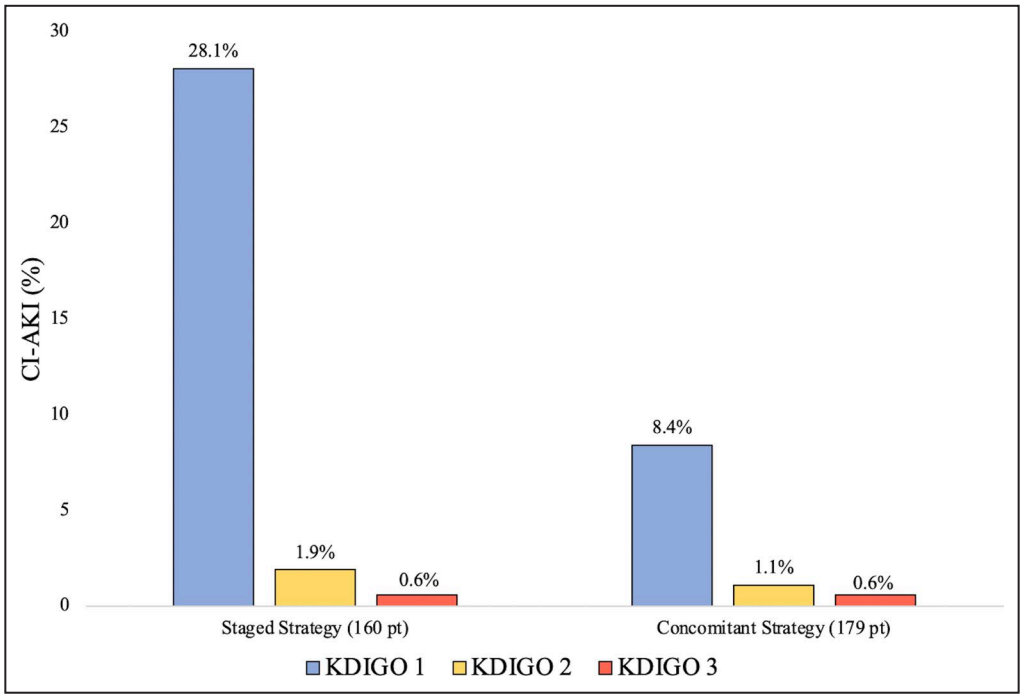

Figure 4. CI-AKI severity according to KDIGO classification: Staged Strategy group vs Concomitant Strategy group.
CI-AKI indicates contrast-induced acute kidney injury; and KDIGO, Kidney Disease Improving Global Outcomes.

tomography performed as part of the work up for TAVI is a contrast-related procedure and may potentially impact the renal function. The time elapse between computerized tomography and angiographic procedures was not available for this analysis. Nevertheless, the fact that computerized tomography was performed uniformly and with the same protocol in all the patients included in this study limits potential selection bias.

CONCLUSIONS

Performing staged coronary and TAVI procedures is associated with a significantly higher risk of developing CI-AKI compared with CA/PCI performed in concomitance with TAVI without adding any risk to the TAVI procedure.

ARTICLE INFORMATION

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None.

Supplementary Material

Data S1
Table S1

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SUPPLEMENTAL MATERIAL

Table S1. Clinical events at 30 days follow up post-TAVI: SS vs. CS.

	TOTAL POPULATION (339)	Staged (160)	Concomitant (179)	OR	CI 95%	p value
Death	5 (1.5%)	4 (2.5%)	1 (0.6%)	/	0.000; /	0.995
Major bleeding	7 (2.1%)	5 (3.1%)	2 (1.1%)	1.892	0.445; 8.048	0.388
Vascular Complications	11 (3.2%)	7 (4.4%)	4 (2.2%)	2.002	0.575; 6.969	0.276
Stroke	4 (1.2%)	1 (0.6%)	3 (1.7%)	0.369	0.038; 3.583	0.390
Repeated Procedure	9 (2.6%)	3 (1.9%)	6 (3.4%)	0.739	0.205; 2.668	0.645
Aki post-TAVI	17 (5.0%)	9 (5.6%)	8 (4.5%)	1.578	0.822; 3.031	0.170
Coronary Obstruction	3 (0.9%)	0 (0%)	3 (1.7%)	0.000	0.000; /	0.996
Early safety events	43 (12.7%)	21 (13.1%)	22 (12.3%)	1.198	0.639; 2.245	0.573

SS: staged strategy; CS: concomitant strategy; CI-AKI: contrast-induced acute kidney injury.

Data S1.

List of variables included in the database used for the present analysis.

Name, Surname, Patient number, EPID, DOB, TAVI date, Sex, Age, Weight (Kg), Height (m), BMI, BSA), Hypertension, Diabetes, Dyslipidemia, Smoke, Previous cardiac surgery, Atrial fibrillation, Previous Stroke, Previous Myocardial infarction, Peripheric vascular disease, baseline Creatinine (mg/dL), Baseline eGFR (ml/min), dialysis, Baseline hemoglobin (g/dl), Baseline echocardiography (left ventricular ejection fraction, Biscupid aortic valve, Mean gradient, Peak gradient, Aortic regurgitation, Mitral regurgitation, Mitral stenosis), Baseline Pacemaker, Coronary artery disease (Yes-1, No-0), Baseline presentation (Symptomatic, Acute Heart Failure, Unstable angina, Angina, Syncope, NYHA Class), Baseline Therapy (ASA, Clopidogrel, B-blocker, ACE inhibitor, Warfarin, New Oral Anticoagulants), PCI concomitant vs staged, Valve in valve, Iliac PTA pre TAVI, Approach (transfermoral vs transapical), Closure (Surgery-1, Device-2), Valve Type, Valve Size, Pre-dilation, Post Dilation, Amount of contrast (ml) for TAVI procedure, Procedural complication, Type of procedural complication, Discharge date, Stay In Hosp (days) after TAVI, ICU Stay (days) after TAVI, Intra-hospital complications, Type of intra hospital complication, Serum creatinine at 24 hours after TAVI, Serum creatinine at 48 hours after TAVI, Serum creatinine at 72 hours after TAVI, Creatinine peak if CI-AKI, Creatinine at discharge, Echocardiography at discharge (left ventricular ejection fraction, Biscupid aortic valve, Mean gradient, Peak gradient, Aortic regurgitation, Mitral regurgitation, Mitral stenosis), Follow up data (death, any myocardial infarction, Stroke, Heart failure, NYHA class, Any in-hospital admission, Last available creatinine, Last available echocardiography at follow-up).