Adding Pre-procedural Glycemia to the Mehran Score Enhances Its Ability to Predict Contrast-induced Acute Kidney Injury in Patients With and Without Diabetes Undergoing Percutaneous Coronary Intervention

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Abstract

Background: The Mehran score is the most widely accepted tool for predicting contrast-induced acute kidney injury (CI-AKI), a major complication of percutaneous coronary intervention (PCI). Similarly, abnormal fasting pre-procedural glycemia (FPG) represents a modifiable risk factor for CI-AKI, but it is not included in current risk models for CI-AKI prediction. We sought to analyze whether adding FPG to the Mehran score improves its ability to predict CI-AKI following PCI.

Methods: We analyzed 671 consecutive patients undergoing PCI (age 69 [63,75] years, 23% females), regardless of their diabetic status, to derive a revised Mehran score obtained by including FPG in the original Mehran score (Derivation Cohort). The new risk model (GlyMehr) was externally validated in 673 consecutive patients (Validation Cohort) (age 69 [62,76] years, 21% females).

Results: In the Derivation Cohort, both FPG and the original Mehran score predicted CI-AKI (AUC 0.703 and 0.673, respectively). The GlyMehr score showed a better predictive ability when compared with the Mehran score both in the Derivation Cohort (AUC 0.749, 95%CI 0.662-0.836; $p=0.0016$) and the Validation Cohort (AUC 0.848, 95%CI, 0.792–0.903; $p=0.0008$). In the overall population ($n=1344$), the GlyMehr score confirmed its independent and incremental predictive ability regardless of diabetic status ($p\leq 0.0034$) or unstable/stable coronary syndromes ($p\leq 0.0272$).

Conclusions: Adding FPG to the Mehran score significantly enhances our ability to predict CI-AKI. The GlyMehr score may contribute to improve the clinical management of patients undergoing PCI by identifying those at high risk of CI-AKI and potentially detecting modifiable risk factors.

Introduction

The rate of contrast-induced acute kidney injury (CI-AKI) has declined over the last decade (1-2), but it still represents a leading cause of in-hospital acquired renal insufficiency (3). In the specific setting of percutaneous coronary intervention (PCI), CI-AKI increases in-hospital and long-term mortality, exerting a deleterious impact on patients' outcome (4-6). The negative role of CI-AKI on post PCI outcome should not be a surprise, since a significant percentage of patients developing this complication do not completely recover their renal function, sometimes experiencing persistent renal insufficiency with potential need of dialysis (7).

The identification of patients at higher risk of CI-AKI prior to PCI is challenging, but necessary. In stable coronary artery disease, the potential advantages of PCI need to be weighed against the risk of renal insufficiency (8). In the setting of acute coronary syndromes, the risk of CI-AKI may provide indications when planning the extent of the revascularization to be achieved (9). After the procedure, the application of CI-AKI predictive scores could improve clinical management through tailored post-procedural monitoring and volume administration.

The Mehran score is the most widely used tool for predicting CI-AKI following PCI (10-11). Pre-procedural hyperglycemia, regardless of the presence of diabetes, has also been associated with an increased risk of CI-AKI (12-14), but it is not included in current risk scores.

The aim of the present study was to assess the potential incremental predictive value of adding fasting pre-procedural glycemia (FPG) to the Mehran score in identifying patients at higher risk of CI-AKI after PCI. The processes we used to derive and validate the score comply with the Tripod Statement (15).

Methods

Study design and inclusion/exclusion criteria

The study population was identified by searching the prospectively assembled institutional database of the catheterization laboratory of our Institution, enrolling patients undergoing PCI at the University Campus Bio-Medico of Rome from August 2016 through September 2019. Exclusion criteria were: ST-segment elevation acute coronary syndromes, severe chronic kidney disease (defined as glomerular filtration rate, GFR <15 ml/min/m³), and peritoneal or hemodialytic treatment at the time of the procedure. The Derivation cohort consisted of the first 671 consecutive eligible patients undergoing PCI (from August 2016 through February 2018). The Validation cohort included the next 673 patients, sampled by the same investigators from a later time period (from March 2018 to September 2019) as contemplated by the Tripod statement (external validation) (15). The study was conducted in accordance with institutional guidelines, national and local legal requirements, and the Declaration of Helsinki.

Coronary procedure

Patients underwent PCI according to the standard techniques with radial or femoral approach. At the time of the procedure, all patients were receiving dual antiplatelet therapy with aspirin and clopidogrel or other novel antiplatelet agents maintained for a variable interval (1-12 months) according to the implanted stent type (bare metal stent versus drug-eluting stent) and/or clinical presentation. Routine hydration with normal saline at 1 ml/hour/kg was performed in all patients with serum creatinine (SCr) >1.3 mg/dl for at least 12 hours before and 24 hours after intervention; a reduced rate of 0.5 ml/hour/kg was administered in those with reduced left ventricle ejection fraction (<40%). PCI was performed using iodinated, low-osmolarity radiographic contrast agent (Iohexol, Omnipaque™, GE Healthcare AS).

Model predictors and outcome

Using standard methods, FPG was measured in all patients in the 2 hours prior to intervention. Two investigators blinded to glycemia data calculated the Mehran score as previously described (hypotension: 5 points; intra-aortic balloon pump – IABP- insertion: 5 points; congestive heart failure: 5 points; age >75 years: 4 points; anemia: 3 points; diabetes mellitus: 3 points; chronic renal failure: 4 points; contrast medium volume: 1 point for each 100 ml) (10). Patients were classified as having diabetes if their medical records reported a previous history of diabetes mellitus or any use of anti-diabetic agents.

Anemia was defined as a hematocrit value <39% for men and <36% for women. Chronic renal disease was considered if baseline SCr >1.5 mg/dl. Congestive heart failure was defined as the presence of congestive symptoms/signs (New York Heart Association Class III-IV) and left ventricle ejection fraction $\leq 40\%$. Hypotension was considered as the occurrence of systolic pressure <80 mmHg for at least one hour requiring inotropic agents or IABP insertion within 24 of the PCI.

The outcome of interest was the occurrence of CI-AKI. Thus, SCr values were collected before the procedure, at 24 hours after PCI, and thereafter if available. GFR was calculated using the Modification of Diet in Renal Disease (MDRD) Study equation. CI-AKI was defined as an absolute increase in SCr ≥ 0.3 mg/dl within 24-48 hours after contrast exposure (16). The diagnosis of CI-AKI was decided blinded to clinical information and the same definition was applied to the validation cohort.

Sample size and missing data

We did not calculate formal sample size because all available data were used to maximize the power of the results; however, there is no generally accepted approach to estimate sample size for derivation and validation studies of risk prediction models (15). No missing data related to either predictors or outcomes were observed in either the derivation cohort or the validation cohort.

Statistical methods

Data are expressed as frequencies and percentages for categorical variables and mean $\pm$ standard deviation or median [Q1,Q3] for continuous variables. Normal distribution was evaluated by using the Shapiro-Wilk test. Differences between parametric and non-parametric continuous variables were tested with the Student *t* test and Mann–Whitney *U* test, respectively. Fisher exact test or Pearson χ^2 test were used to compare categorical variables. Receiver operating characteristic (ROC) curve analysis was applied to estimate the ability of the Mehran score and FPG to discriminate between patients with and without CI-AKI; their predictive validity was quantified as the area under the curve (AUC). In addition, the incremental value of combining the Mehran score and FPG together was assessed in predicting the primary end point. Therefore, AUC was calculated for the logistic regression model including both Mehran and FPG and differences between AUCs were assessed using the jackknife method, as described by DeLong et al (17). Furthermore, net reclassification improvement (NRI) (based on 3 pre-specified risk categories: <2%, 2-5%, and >5%) was calculated to assess the predictive value of adding FPG to the Mehran score. Hence, a new risk score (GlyMehr) was developed in the Derivation cohort; it was built by adding baseline hyperglycemia, defined as a $FPG \geq 124$ mg/dl (corresponding to the glycemic value with the highest sensitivity and specificity in predicting CI-AKI according to the ROC curve analysis), to the clinical and procedural variables included in the Mehran score. Both Mehran and $FPG \geq 124$ mg/dl were entered in another multivariable logistic regression model to identify independent predictors of CI-AKI and, based on the z-score (model coefficient divided by SE), a weighted integer of 4 was assigned to $FPG \geq 124$ mg/dl. GlyMehr was calculated as the sum of the integers of each variable included in the original Mehran score plus that of $FPG \geq 124$ mg/dl. The discrimination ability of the GlyMehr score was assessed

by ROC curve and associated AUC and by the index of separation (difference between the predicted probability of events in the group with the worst prognosis and the predicted probability of events in the group with the best prognosis). The calibration was evaluated using the Hosmer-Lemeshow goodness-of-fit test (the lower the χ^2 value and the higher the p value, the more calibrated the score) and by calculating the average absolute difference between the observed and the expected event rate across GlyMehrs score tertiles (Mean Δ ; the lower the value, the better the calibration). The accuracy of the GlyMehrs score was then tested on the Validation set. Furthermore, a pre-specified subgroup analysis on the overall population (Derivation and Validation cohorts) was performed to compare the discriminatory performance of the GlyMehrs model with the original Mehran score according to the diabetic status and stable/unstable clinical presentation. Statistical analysis was performed using Stata/IC version 10.0 (STATA Corp, College Station, TX). A 2-tailed P value <0.05 was considered significant.

Results

Study population

Baseline characteristics of the Derivation and Validation cohorts are reported in Table 1. Patients in the Validation cohort were more likely to have a diagnosis of dyslipidemia, probably related to the stricter cut-offs proposed for lipid management over time. Similarly, a reduced percentage of diabetic patients receiving insulin-therapy was reported in the Validation cohort and an increased use of novel anti-diabetic agents was observed.

Predicting abilities of Mehran score and FPG in the Derivation cohort

CI-AKI occurred in 30 patients (4.5%) of the Derivation cohort. No patient required hemodialysis treatment. No sex-related difference was observed in CI-AKI incidence.

Patients with CI-AKI were more likely to have insulin-treated diabetes, chronic heart failure or anemia. Furthermore, they were more commonly hospitalized with a non-ST elevation acute coronary syndrome (NSTEMI-ACS) and received larger amounts of contrast media (Supplementary Table S1).

In the Derivation cohort, the original Mehran score significantly discriminated between patients with/without CI-AKI at ROC curve analysis (AUC 0.673; 95% CI, 0.580-0.765; $p=0.001$) (Supplementary Figure 1).

Patients with CI-AKI showed higher FPG levels ($p=0.008$). According to ROC curve, FPG meaningfully predicted CI-AKI with an AUC of 0.703 (95% CI, 0.589-0.817; $p<0.001$) (Supplementary Figure 1). A pre-procedural glycemic value ≥ 124 mg/dl was identified as the best cut-off to classify patients with post-contrast acute renal impairment (sensitivity 63.0%, specificity 81%). Patients with a pre-procedural glycemic value above this threshold reported an increased incidence of CI-AKI, regardless of diabetic status ($p=0.013$ and $p<0.0001$) (Figure 1).

By combining FPG with the Mehran score in the same logistic regression model for prediction of CI-AKI, the AUC of the model significantly increased to 0.731 (95% CI, 0.646-0.817; $p=0.022$ versus AUC of the Mehran score) (Supplementary Figure 1). The net reclassification improvement (NRI) [cutoff 2-5%] was estimated at 0.319 ($p<0.001$) (Supplementary Table S2).

Performance of the new GlyMehar score in the Derivation cohort

The revised risk score (GlyMehar) was built by adding $\text{FPG} \geq 124$ mg/dl, with a weighted integer of 4, to the variables entering in the determination of the original Mehran score. The GlyMehar score ranged from 0 to 24 in the Derivation cohort, with a median value of 5 (lower quartile <2, upper quartile >8).

The GlyMehar score demonstrated a greater discrimination between patients with/without CI-AKI compared with the original Mehran score (AUC 0.749; 95% CI, 0.662-0.836, $p=0.0016$ compared with Mehran AUC) (Figure 2). The index of separation was estimated to be 7.85% (9.26%-1.41%). An increase in predicted CI-AKI probability was also observed as the score increased (Supplemental Figure 2).

The GlyMehar score showed good calibration (Hosmer–Lemeshow, $p=0.183$) (mean Δ , 0.30%). The distribution of patients with CI-AKI according to the Mehran and GlyMehar scores tertiles are reported in Figure 3.

Performance of the GlyMehar score in the Validation cohort and Subgroup analysis

The incidence of CI-AKI in the Validation cohort was 2.7% (18 patients). Both the original Mehran and the GlyMehar scores were able to significantly classify patients with/without CI-AKI (AUC 0.763; 95% CI, 0.696–0.829 for Mehran score; AUC, 0.848; 95% CI, 0.792–0.903 for GlyMehar score). Of note, the GlyMehar model showed a greater discriminatory performance compared with the original Mehran score in this cohort too ($p=0.0008$ for AUC comparison).

Since the incidence of CI-AKI was similar in the two cohort populations (Derivation and Validation), for descriptive purposes, we performed a subgroup analysis on the overall population consisting of 1344 patients.

In the overall cohort, the GlyMehar score confirmed a higher predicting ability compared with the Mehran score (AUC 0.787; 95% CI, 0.728–0.845 for GlyMehar score, versus AUC 0.706; 95% CI, 0.642–0.770 for Mehran score; $p<0.0001$ for AUC comparison). These results were confirmed in both diabetic and non-diabetic patients ($p=0.0034$ for AUC comparison among diabetics and $p=0.0012$ for AUC comparison among non-diabetic patients) and regardless of clinical presentation ($p=0.0272$ for AUC comparison in patients with stable coronary artery disease and $p=0.0001$ for AUC comparison in the NSTEMI-ACS group) (Figure 4 A and B).

Discussion

To the best of our knowledge, this is the first study including pre-procedural glycemia in a risk model for CI-AKI prediction in the specific setting of PCI. We found that: 1) pre-procedural hyperglycemia is associated with an increased incidence of CI-AKI; 2) adding FPG to a pre-existing model for CI-AKI prediction such as the Mehran score to form the new GlyMehar score improves the performance in predicting this procedural complication.

Hyperglycemia and CI-AKI

In our analysis, FPG alone significantly discriminated between patients with/without CI-AKI; furthermore, those with pre-procedural hyperglycemia (≥ 124 mg/dl) reported a higher incidence of this complication. Of note, the same glycemic cut-off (≥ 124 mg/dl) was previously found as the best value for CI-AKI prediction in a cohort of 421 patients with diabetes, pre-diabetes and normal fasting glucose undergoing coronary angiography (18).

Of course, these results highlight the importance of optimal glycemic control before and during PCI, regardless of the presence of diabetes. Previous studies have already demonstrated the relationship between hyperglycemia and CI-AKI among patients with acute myocardial infarction undergoing primary PCI (12-14); nevertheless, to date few data were available in those receiving elective procedures.

Pathophysiological mechanisms underlying the association between elevated FPG and acute renal damage are not completely recognized. Therefore, whether hyperglycemia is a marker of increased comorbidity burden or the direct cause of CI-AKI is undetermined. Several investigations reported direct renal effects mediated by acute hyperglycemia. Acute hyperglycemia may reduce endothelial-mediated vasodilation and worsen medullary hypoxia due to a lower availability of nitric oxide (19). Acute hyperglycemia could also stimulate inflammation and reactive oxygen species synthesis, increasing contrast-induced injury on renal tubular cells (20).

Of note, in our population, the causes of hyperglycemia were unknown. While in diabetic patients high FPG could account for a not well-controlled diabetic status, different explanations may be considered in patients without diabetes, such as the lack of a previous diagnosis of the metabolic disorder or an acute response to stress, ischemia, infections or other chronic conditions. However, the focus of our investigation was to demonstrate the predictive value of pre-procedural glycemia on the incidence of CI-AKI, regardless of its specific cause.

CI-AKI prediction models: Mehran and GlyMehar

In our study, the Mehran score was able to effectively identify patients who developed CI-AKI both in the Derivation and Validation cohorts. This was expected since it represents a proven score for CI-AKI prediction (10,11). However, several other predictive models have been validated for this purpose (21-25). Some of these scores integrated an impressive number of variables needing complex algorithms to be calculated and have been proved in cohorts of patients undergoing primary PCI (21,22,24). Thus, we

focused on the Mehran score taking into account its favorable balance between prediction accuracy and feasibility that represents one of the reasons for its widespread application in clinical practice.

However, in our analysis, combining FPG with the Mehran score in the new GlyMehar model revealed an even higher predictive ability for CI-AKI. Higher values of GlyMehar score mean greater predicted probability and observed incidence of CI-AKI. This is especially attractive if we consider that we obtained this result by adding a simple and easy parameter such as FPG.

Of note, like the Mehran score, most of the previously reported scores for CI-AKI prediction do not include FPG. Whether adding FPG to these models may also improve their performance is unknown and could be assessed in further studies. Nowadays, only one model counting FPG along with another twelve biochemical variables has recently been proposed, albeit based on a cohort of Chinese patients undergoing intra-arterial and intra-venous contrast administration for angiography and computer tomography (25).

The performance of the GlyMehar was greater compared with the original Mehran score also in the Validation cohort and in the overall population. Interestingly, according to the results of the subgroup analysis, the higher predictive ability of the new score was maintained both in diabetic and non-diabetic patients, suggesting that glycemic status might have a significant impact on outcomes also in those without an established diagnosis of diabetes. Similarly, previous studies reported a higher incidence of CI-AKI in hyperglycemic patients without known diabetes in the setting of acute myocardial infarction (12,13).

Clinical implications

CI-AKI represents one of the most common and serious non-cardiac complications in patients undergoing PCI, together with bleeding. Despite a noteworthy decline of CI-AKI incidence over time, its negative prognostic impact has remained unchanged (4). This is even more important in view of the growing number of frail patients undergoing percutaneous procedures, who are potentially at higher risk of this complication.

On this background, the results of our analysis might be interesting. Considering a timely risk allocation for CI-AKI as an important goal, the use of the new score including FPG may improve the identification of patients at higher risk. Secondly, our findings might suggest a potential new strategy for the prevention of CI-AKI, since pre-PCI glycemia may represent a modifiable intervention target.

Only a few pharmacological preventive strategies are currently available for CI-AKI prevention. Intense hydration still remains the cornerstone approach (26), whereas pre-treatment with high-dose statins has been shown to protect against the development of CI-AKI in several randomized trials (27). The potential benefit of other agents has also been investigated with conflicting results (e.g., N-acetylcysteine, sodium bicarbonate, ascorbic acid, xanthine) (28). Of note, none of these strategies has been demonstrated to lower the CI-AKI risk in patients with diabetes mellitus (28).

Hence, restoring optimal glycemic control before PCI in order to provide a new prophylactic approach in preventing CI-AKI is worthy of further investigation. Strict glycemic control with insulin has been demonstrated to reduce the occurrence of acquired kidney injury (29). More recently, sodium-glucose transport protein 2 (SGLT2) inhibitors, a new class of glucose-lowering agents acting by promoting glycosuria, have demonstrated protective renal effects (30-32). Furthermore, these agents seem to significantly decrease the risk of acute kidney injury in diabetic patients (33). However, no data are available on a possible benefit regarding CI-AKI, and it is also unknown whether SGLT2 inhibitors may exert their renoprotective effects also in patients without diabetes.

Strengths And Limitations

We defined CI-AKI using the baseline and the peak SCr (24 or 48 hours after contrast use). Thus, CI-AKI occurrence may be underestimated since we cannot exclude the possibility that SCr reached its peak after discharge. However, we checked 48-hour SCr in all patients with even a mild increase at 24 hours and, as previously reported, even a slight (5 to 10% from baseline) SCr increase within 24 hours after the coronary procedure could predict CI-AKI occurrence with a high negative predictive value (34). We did not serially evaluate blood glucose levels in our patients, thus we do not know if an early spontaneous or pharmacological normalization of glycemic values was associated with a lower incidence of CI-AKI. However, our investigation may represent a hypothesis-generating study for further randomized studies exploring this issue. We validated the new risk score in a cohort of patients undergoing PCI for stable and unstable syndromes, but excluding patients with ST-elevation myocardial infarction. Thus, we have no data on the discriminatory performance of the GlyMehr score in the setting of primary PCI. However, hyperglycemia, as previously demonstrated, may have an even more important role for the development of CI-AKI after acute procedures.

Conclusions

Recognition of new potential risk factors for CI-AKI may allow early identification of patients at higher risk for this complication and possible future therapeutic targets. Adding FPG, an easily available and inexpensive marker, to procedural and clinical variables of the Mehran score in a new model increases the predictive value for CI-AKI compared with the Mehran score alone. Whether the GlyMehr may have a long-term prognostic role or whether specific tailored glucose-lowering interventions may reduce CI-AKI incidence should be addressed in further studies.

Abbreviations

CI-AKI= contrast-induced acute kidney injury

PCI= percutaneous coronary intervention

SCr= serum creatinine

FPG= fasting pre-procedural glycemia

NYHA = New York Heart Association

IABP = intra-aortic balloon pump

GFR = glomerular filtration rate

ROC = receiver operating characteristic

AUC = area under the curve

NRI = net reclassification improvement

Declarations

Ethics approval and consent to participate

Thus study was performed in accordance with the [Declaration of Helsinki](#) and has been approved by our local Ethic Committee (Ethical Committee of Campus Bio-Medico University of Rome). Due to the retrospective nature of this analysis performed by searching the prospectively assembled institutional database of the catheterization laboratory of our Institution, the requirement for patients' written informed consent was considered not necessary; however, all patients gave their agreement for the interventional procedure at the time of revascularization according to current guidelines.

Consent for publication

Not applicable

Availability of data and materials

The authors declare that all data supporting the findings of this study are available within the article and its supplementary information files.

Competing interests

The authors declare that they have no potential conflicts of interest relevant to this article.

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Author Contributions

A.N. contributed to the conception and design of the study, to the interpretation of the data and wrote the manuscript. F.M. contributed to the study design, statistical analysis and data interpretation and supported the writing of the manuscript. A.S., G.P., G.D. and S.G. contributed to data acquisition. E.R., R.M., P.G. and M.M. supported the statistical analysis and reviewed the manuscript. G.P.U. and F.G. reviewed/edited the manuscript. All authors read, commented, and approved the final version of the manuscript. A.N. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Tables

Table1. Baseline characteristics of the Derivation and Validation cohorts

	Overall (n=1344)	Derivation (n=671)	Validation (n=673)	P value
Age (years)	69 [63,76]	69 [63,75]	69 [62,76]	0.314
Female gender	292 (22)	153 (23)	139 (21)	0.340
BMI (kg/m ²)	26 [24,30]	27 [25,30]	26 [24,30]	0.105
Dyslipidemia	1180 (88)	548 (82)	632 (94)	<0.001
Hypertension	1210 (90)	603 (90)	607 (90)	0.841
Diabetes	464 (35)	248 (37)	216 (32)	0.060
Insulin-treated	87 (6)	62 (9)	25 (4)	<0.001
Smoking	888 (66)	470 (70)	418 (62)	<0.001
NSTE-ACS	487 (36)	227 (34)	260 (39)	0.067
Multivessel disease	639 (48)	309 (46)	330 (49)	0.825
LVEF (%)	55.2±9.0	55.4±8.8	55.0±9.2	0.373
Congestive heart failure	73 (5)	33 (5)	40 (6)	0.407
Hemoglobin (g/dl)	13.2 [12.1,14.4]	13.2 [12.0,14.3]	13.3 [12.2,14.4]	0.138
Hematocrit (%)	39.7 [36.9,42.7]	39.6 [36.6,42.7]	39.8 [37.1,42.8]	0.202
Anemia	479 (36)	245 (37)	234 (35)	0.505
Creatinine (mg/dl)	0.94 [0.80,1.12]	0.94 [0.80,1.12]	0.94 [0.81,1.11]	0.814
GFR (ml/min/1.73 m ²)	68.9 [46.3,85.0]	67.2 [45.4,84.6]	69.7 [48.8,85.6]	0.263
Chronic kidney disease	75 (6)	39 (6)	36 (5)	0.716
FPG (mg/dl)	99 [89,116]	100 [89,118]	98 [89,113]	0.132
Statins	1142 (85)	577 (86)	565 (84)	0.296
Beta-blockers	921 (69)	470 (70)	451 (67)	0.232
ACE-inhibitors	1082 (81)	550 (82)	532 (79)	0.177
Diuretics	502 (37)	260 (39)	242 (36)	0.290
Calcium-channel inh.	522 (39)	266 (40)	256 (38)	0.546
Biguanides	302 (22)	161 (24)	141 (21)	0.181
Sulfonylureas	135 (10)	74 (11)	61 (9)	0.231
Meglitinides	61 (4.5)	34 (5)	27 (4)	0.353

SGLT2 inhibitors	67 (5.0)	20 (3)	47 (7)	<0.001
DPP-4 inhibitors	88 (6.5)	27 (4)	61 (9)	<0.001
GLP-1 receptor agonists	65 (4.8)	2 (0.3)	63 (9)	<0.001
Contrast volume (ml)	150 [118,200]	150 [116,200]	150 [120,193]	0.892
Hypotension	9 (0.7)	3 (0.4)	6 (0.9)	0.318
IABP	0	0	0	-
CI-AKI	48 (3.6)	30 (4.5)	18 (2.7)	0.076
Mehran score	4 [1,7]	4 [1,7]	4 [2,7]	0.793

Values are mean $\pm$ SD, median [Q1, Q3] or n (%).

ACE, angiotensin-converting enzyme; BMI, body mass index; CI-AKI, contrast-induced acute kidney injury; DPP-4, dipeptidylpeptidase-4; FPG, fasting pre-procedural glycemia; GLP-1, glucagon-like peptide-1; GFR, glomerular filtration rate; IABP, intra-aortic balloon pump; LVEF, left ventricular ejection fraction; NSTEMI-ACS, non-ST elevation acute coronary syndrome; SGLT2, sodium-glucose transporter-2.

Figures

Figure 1

Title: Incidence of CI-AKI according to pre-procedural glycemia. Legend: CI-AKI occurrence in patients with FPG ≥ 124 mg/dl and FPG < 124 mg/dl among diabetics and non-diabetics. CI-AKI=contrast-induced acute kidney injury; FPG= fasting pre-procedural glycemia; DM=diabetes mellitus.

Figure 2

Title: Mehran and GlyMehrf scores for the prediction of CI-AKI. Legend: Comparison of receiver operating characteristic curves for CI-AKI between Mehran and GlyMehrf scores in the Derivation cohort. CI-AKI= contrast-induced acute kidney injury.

Figure 3

Title: Incidence of CI-AKI according to the Mehran and GlyMehrscore tertiles. Legend: In the Derivation cohort an increased incidence of CI-AKI was observed in the highest tertile of the GlyMehrscore compared with the highest tertile of the Mehran score, suggesting a greater prediction accuracy of the new model. CI-AKI= contrast-induced acute kidney injury.

Figure 4

Title: CI-AKI prediction ability of the GlyMehr score according to diabetic status or unstable/stable coronary syndromes. Legend: A - Receiver operating characteristic curves of the GlyMehr score in diabetic and not-diabetic subgroups ($p=0.0034$ for AUC comparison with Mehran score among diabetics and $p=0.0012$ for AUC comparison among non-diabetic patients). B - Receiver operating characteristic curves of the GlyMehr score in patients with NSTE-ACS and stable CAD ($p=0.0001$ and $p=0.0272$ for AUC comparison with Mehran score in the NSTE-ACS and stable CAD subgroups, respectively). CAD= coronary artery disease; CI-AKI= contrast-induced acute kidney injury; NSTE-ACS= non-ST elevation acute coronary syndromes.

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