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Original Article

Residual Syntax score and percutaneous coronary intervention in diabetic patients with renal insufficiency

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Abstract: Objective: To investigate the correlation between residual Syntax score (rSS) and long-term prognosis in diabetic patients with renal insufficiency undergoing percutaneous coronary intervention (PCI). Methods: In this retrospective study, we included 510 patients with coronary heart disease, diabetes, and renal insufficiency who received PCI at the Third People's Hospital of Chengdu from July 2018 to December 2020. Patients were divided into three groups based on their eGFR levels: 113 patients with eGFR ≥ 60 mL/min/1.73 m^2, 256 patients with eGFR between 30 and 60 mL/min/1.73 m^2, and 141 patients with eGFR < 30 mL/min/1.73 m^2. Revascularization was quantified using the residual SYNTAX score (rSS), with an rSS > 8 indicating incomplete revascularization. We collected baseline data on cardiovascular adverse events and followed up with patients for 12 months, analyzing the correlations between rSS and biochemical markers such as blood glucose, uric acid, urea, serum creatinine, and eGFR, as well as the relationship between major adverse cardiovascular events (MACE) and rSS. Results: Univariate analysis identified myocardial infarction (MI), β-blocker use, and follow-up duration as factors significantly associated with the long-term prognosis of diabetic patients with renal insufficiency after PCI (P < 0.05). MI (OR=3.053, P=0.009), β-blocker use (OR=3.134, P=0.009), and follow-up duration (OR=0.998, P=0.05) were independent risk factors for long-term prognosis in these patients. rSS was positively correlated with blood glucose (r=0.973, P=0.000), uric acid (r=0.933, P=0.000), urea (r=0.907, P=0.000), serum creatinine (r=0.588, P=0.000), and eGFR (r=0.623, P=0.000). Syntax score was also positively correlated with long-term prognosis (OR=0.138, P=0.001). Conclusion: The rSS is a valuable tool for evaluating independent risk factors such as incomplete revascularization, MI, β-blocker use, and follow-up duration, all of which are positively correlated with the long-term prognosis of diabetic patients with renal insufficiency after PCI.

Keywords: Residual Syntax score, percutaneous coronary intervention, diabetes, renal insufficiency, long-term prognosis

Introduction

With the continuous improvement in living standards, coronary heart disease and diabetes have become increasingly prevalent in clinical practice. Both conditions have a chronic course and can significantly affect individuals' physical and mental well-being [1]. Although the mechanisms of coronary heart disease in diabetic patients differ, there is a clear correlation between the two conditions [2]. Diabetes can lead to kidney damage, clinically referred to as diabetic nephropathy [3]. According to relevant data, approximately 25% of diabetic patients in China concurrently experience varying degrees of kidney disease [4]. As the population ages, the prevalence of these diseases is rising, posing a significant threat to public health and increasing the burden on families and society.

Diabetes and coronary heart disease are metabolic disorders with shared risk factors that mutually influence each other [5]. Moreover, patients with coronary heart disease complicated by diabetes are at an increased risk of developing renal insufficiency, which adversely

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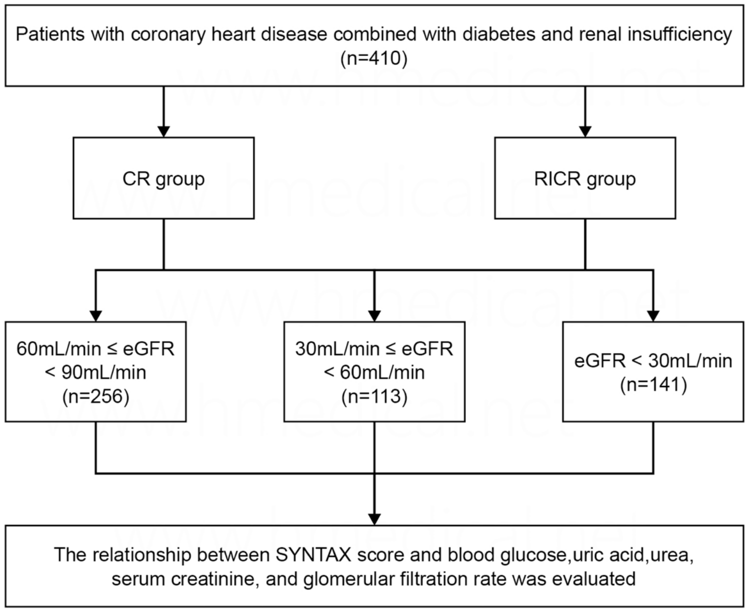

Figure 1. Flow chart. eGFR, estimated glomerular filtration rate; CR, complete revascularization; RICR, reasonable incomplete revascularization.

affects their health and quality of life. Coronary heart disease, also known as ischemic heart disease, has a high incidence [6]. Current treatment options include conventional drug therapy, percutaneous coronary intervention (PCI), and coronary artery bypass grafting (CABG) [7]. Among these, PCI is the most commonly utilized treatment. Advances in medical technology, particularly the widespread use of new eluting stents, have improved patient outcomes from PCI [8].

The Syntax score, a novel scoring method, predicts blood flow from the coronary arteries to the left ventricle [9]. It provides a semi-quantitative analysis of the anatomic characteristics of coronary heart disease and offers a reliable basis for deciding between PCI and CABG in patients with left main artery or multi-vessel disease. Additionally, it serves as a dependable predictor of long-term prognosis in patients with coronary artery disease [10]. Research [11] indicates that lower Syntax scores are associated with better cardiovascular outcomes compared to moderate or high Syntax scores. However, as complete revascularization has become the focus of PCI treatment, there is a lack of large-scale studies examining the impact of incomplete revascularization on patient outcomes [11]. The residual Syntax score (rSS) can be used to assess incomplete revascularization and has been shown to be a valuable prognostic factor in patients undergoing PCI. However, there is still a lack of relevant clinical research on the impact of rSS on the long-term prognosis of patients with chronic total occlusion [12]. Therefore, the rSS was used for related research analysis in this retrospective study.

Materials and methods

Study population

In our study, we strategically examined a cohort of 510 patients with coronary heart disease, diabetes, and renal insufficiency, admitted to the Third People's Hospital of Chengdu from July 2018 to December 2020. The patients were categorized into three groups based on their estimated glomerular filtration rate (eGFR) levels: 113 patients with eGFR ≥ 60 mL/min per 1.73 m^2, 256 patients with eGFR between 30 and 60 mL/min per 1.73 m^2, and 141 patients with eGFR < 30 mL/min per 1.73 m^2. These groups correspond to the higher eGFR group, the moderate eGFR group, and the lower eGFR group, respectively. The study utilized a convenience sampling method, and the patient selection process is detailed in **Figure 1**.

Inclusion criteria

① Age between 18 and 80 years; ② The diagnosis of type 2 diabetes mellitus (T2DM) is based on a fasting blood glucose level ≥ 7.0 mmol/L, a 2-hour blood glucose level v 11.1 mmol/L after an oral glucose tolerance test, and a random blood glucose level v 11.1 mmol/L, with classic symptoms of hyperglycemia or hyperglycemic crisis; ③ Diagnosis of coronary heart disease [13]; ④ Diagnosis of renal insufficiency (estimated glomerular filtration rate (eGFR) < 90 ml/min/1.73 m^2, CKD-EPI creatinine method) undergoing PCI; ⑤ Availability of complete medical records, interventional surgery reports, and relevant imaging data [14].

Exclusion criteria

① Patients lacking essential baseline information [15]; ② Patients who died during early hospitalization; ③ Patients with a history of CABG; ④ Patients without effective follow-up information; ⑤ Patients with severe mechanical complications, valve dysfunction, or cardiomyopathy; ⑥ Patients with severe chronic lung disease, liver disease, hematologic disorders, malignant tumors, or a life expectancy of less than one year.

Data

Data collection

Data collection was designed by the researchers after consulting relevant literature and experts. The collected data included general patient information (e.g., age, gender, height, weight, body mass index [BMI], and smoking history), medical history, and comorbidities (e.g., PCI, stroke, chronic obstructive pulmonary disease, hypertension, and atrial fibrillation). Clinical data related to coronary heart disease include the types of coronary heart disease (e.g., stable angina pectoris, unstable angina pectoris, non-ST elevation myocardial infarction (MI), and ST elevation MI). Laboratory tests include hemoglobin, brain natriuretic peptide (BNP), eGFR, glycated hemoglobin (HbA1c), total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C). Auxiliary examinations include color Doppler echocardiography to assess left ventricular ejection fraction (LVEF), left ventricular end-diastolic diameter (LVED), and left ventricular end-systolic diameter (LVSD). Coronary angiography results include the number, severity, location, and pathologic features of diseased vessels, as well as PCI surgical data such as interventional therapy details, including the number, diameter, and length of implanted stents.

Scoring methods

The baseline SYNTAX score (bSS) and residual rSS were assessed based on pre- and post-coronary angiography results using the SYNTAX score calculator (Version 2.28) from www.syntaxscore.com. The scoring was conducted by two coronary intervention specialists. A lower rSS indicates more favorable outcomes. For patients scheduled for and undergoing short-term revascularization, the relative oversaturation after the final revascularization procedure is considered. A coronary artery diameter ≥ 1.5 mm with stenosis a 50% is defined as a diseased vessel, and the presence of one lesion is considered a positive result in coronary angiography.

Data collection method

The primary data source for this study was electronic medical and nursing records from the hospital information system. A retrospective collection of records for all hospitalized patients from July 2018 to December 2020 was conducted. Research subjects were selected by the researchers based on the inclusion and exclusion criteria, with data extraction completed independently. In case of conflicting opinions during data extraction, the research team resolved them. After completing data extraction, further verification of the research materials was conducted by the researchers.

Follow-up

The endpoint clinical follow-up is scheduled at 1, 3, 6, and 12 months, followed by annual clinical visits or telephone contacts. The primary endpoints include all-cause mortality and cardiac mortality, where any death not attributable to non-cardiac causes is classified as cardiac death. Secondary endpoints include MI, stroke, unplanned revascularization, readmission rates (with a review of inpatient medical records to identify any adverse events for readmitted patients), and major adverse cardiovascular events (MACCE), defined as a composite endpoint comprising all-cause death, MI, stroke, and unplanned revascularization.

All endpoints are evaluated by two independent cardiologists, with discrepancies resolved through consensus.

Main observation indicators and endpoint events

Main observation indicators: The primary endpoint is defined as a composite event of major adverse cardiovascular events (MACE), including all-cause mortality, recurrent MI, and unplanned revascularization during the follow-up period.

Secondary observation indicators: Secondary endpoints include all-cause mortality, death from cardiac causes, recurrent MI, and unplanned revascularization.

Relevant definitions

MI: Type 1: Characterized by the rupture, ulceration, or erosion of atherosclerotic plaque, leading to intracoronary thrombosis in one or more coronary arteries, resulting in decreased myocardial blood flow and/or distal embolism, ultimately causing MI. Type 2: Myocardial necrosis caused by an imbalance of myocardial oxygen supply and demand due to reasons other than unstable coronary plaque. Type 3: MI where no elevation of myocardial markers is detected, but the cause of death is confirmed as a heart attack. Type 4: MI related to PCI for treating coronary artery disease [16].

Diabetes: Glycosylated hemoglobin A1c 1 6.5%. Fasting blood glucose (FPG) c 7.0 mmol/L (fasting is defined as no calorie intake for at least 8 hours). 2-hour blood glucose d as nommol/L during an oral glucose tolerance test. In patients with typical hyperglycemia or hyperglycemic crisis, random blood glucose m><remommol/L [13].

Renal insufficiency: Defined as an estimated glomerular filtration rate (eGFR) of less than 90 ml/min/1.73 m^2, calculated using the CKD-EPI creatinine method.

Cardiogenic death: Refers to death resulting from MI, exacerbation of heart failure, malignant arrhythmia events, or sudden unexplained death [9].

Unplanned revascularization: Refers to the need for ischemia-driven revascularization (PCI or CABG) during the follow-up period, excluding second-stage revascularization that is part of the short-term treatment plan.

New-onset stroke: Defined as the occurrence of an ischemic or hemorrhagic stroke during the follow-up period, confirmed by imaging and diagnosed by a neurologist [17].

Statistical methods

The study employed SPSS 23.0 and GraphPad Prism for data analysis and visualization. Continuous variables were assessed for normality and compared among groups using analysis of variance, while categorical variables were analyzed with the chi-square test. Kendall's tau correlation was applied to examine the relationship between the Syntax score and MACCE. Logistic regression identified independent risk factors for prognosis. The ROC curve's AUC assessed the predictive accuracy of the Syntax score, with significance set at $P < 0.05$.

Results

Univariate analysis of long-term prognosis in diabetic patients with renal insufficiency after PCI

Univariate analysis revealed that MI, β-blocker usage, and follow-up duration were significantly associated with the long-term prognosis of diabetic patients with renal insufficiency after treatment (both $P < 0.05$) (**Figure 2**). No significant differences were observed between other baseline data and long-term prognosis (all $P > 0.05$), (**Table 1**).

Multivariate regression analysis of long-term prognosis in diabetic patients with renal insufficiency after PCI

Logistic regression analysis included significant factors identified from the univariate analysis as covariates to determine their association with the likelihood of the outcome variable. The analysis revealed that MI (OR=3.053, P=0.009), β-blocker usage (OR=3.134, P=0.009), and follow-up duration were significantly associated with long-term outcome (**Table 2**).

Correlation between rSS and blood sugar, uric acid, urea, serum creatinine, and eGFR

Linear regression analysis was conducted to examine the correlation between rSS and blood sugar, uric acid, urea, serum creatinine, and glomerular filtration rate in diabetic patients with renal insufficiency following PCI. The analysis revealed significant positive correlations between rSS and blood sugar (r=0.973; P=0.000), uric acid (r=0.933; P=0.000), urea (r=0.907; P=0.000), serum creatinine (r=0.588; P=0.000), and glomerular filtration rate (r=0.623; P=0.000). These findings are depicted in **Figure 3**. The AUC for the Syntax score was 0.604, with a sensitivity of 46.6% and a specificity of 72.5%. Notably, the specificity outperformed other evaluation factors, including

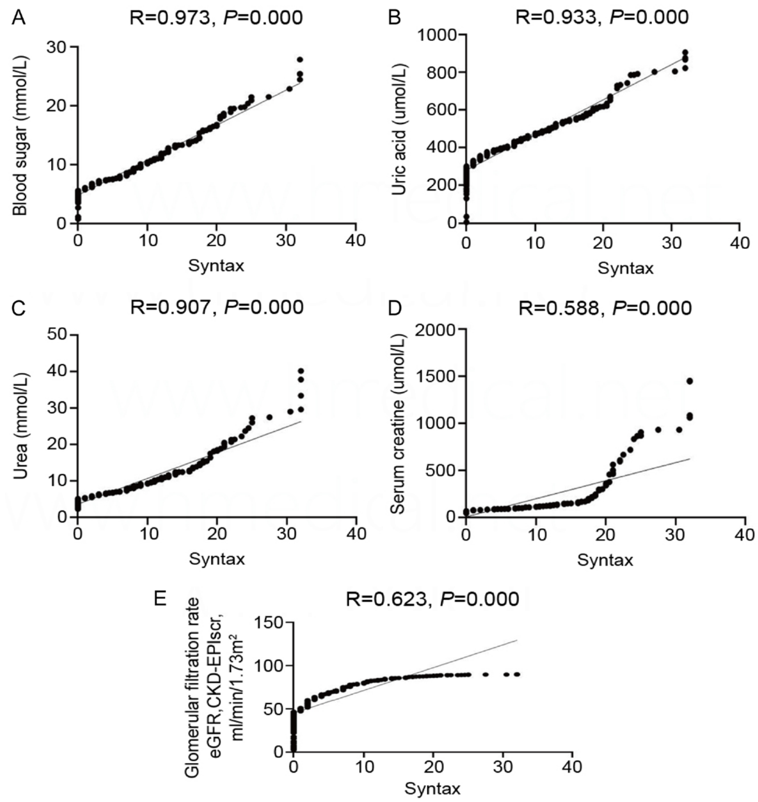

Figure 2. Correlation between residual Syntax score and blood sugar, uric acid, urea, serum creatinine and glomerular filtration rate. A. Correlation between Residual Syntax Score and Blood Glucose; B. Correlation between residual Syntax score and uric acid; C. Correlation between residual Syntax score and urea; D. Correlation between residual Syntax score and serum creatinine; E. Correlation between residual Syntax score and estimated glomerular filtration rate.

blood sugar (54.1%), uric acid (68.2%), urea (49.6%), serum creatinine (72.0%), and eGFR (65.5%) (**Table 3**).

Correlation analysis of long-term prognosis in diabetic patients with renal insufficiency after PCI

Kendall's analysis was used to examine the association between the Syntax score and the long-term prognosis of diabetic patients with renal insufficiency following PCI. The study revealed a significant positive correlation between Syntax score and long-term prognosis (OR=0.138; P=0.001), as shown in **Table 4** and **Figure 4**.

Discussion

Coronary heart disease, atherosclerotic heart disease of the coronary arteries, is one of the most prevalent and deadly non-communicable chronic diseases globally [18]. According to the "2020 China Cardiovascular Health and Disease Report", there are 11.39 million coronary heart disease patients in China, and this number continues to rise [19]. High blood sugar in diabetic patients can lead to inflammation and endothelial dysfunction under oxidative stress, altering lipids and other nutrients, promoting the progression of atherosclerosis, and accelerating the deterioration of coronary heart disease [20].

The incidence and mortality rates of diabetes and coronary heart disease are steadily rising in our country, contributing to an increasingly severe burden of these combined conditions. Research indicates [10] that the prevalence of diabetes has reached 11.2%, affecting 110 million individuals, with 43.2% of diabetic patients dying from cardiovascular diseases and 18.7% specifically from ischemic heart disease. Renal insufficiency is frequently observed in diabetic patients and is the most common cause of renal failure [19]. Cardiovascular disease remains the leading cause of morbidity and mortality in diabetic patients, with renal insufficiency further elevating the risk of cardiovascular complications [21]. As a result, diabetic patients with renal insufficiency are at an increased risk of developing cardiovascular disease [22].

PCI is a minimally invasive diagnostic and therapeutic procedure that plays a crucial role in managing coronary heart disease. PCI effectively addresses vascular diseases, enhances the quality of life in patients with coronary heart disease, and significantly reduces mortality rates. It is widely used globally, with over 900,000 cases treated annually in China alone [23]. While PCI presents challenges in treating complex anatomical structures, such as left main lesions, multivessel disease, calcifications, and chronic total occlusion, ample clini-

Table 1. Univariate analysis of long-term prognosis in diabetic patients with renal insufficiency after PCI

	eGFR grouping	N	Mean value	Standard deviation	F	p
Gender (0= male; 1= female)	Higher	36	0.44	0.504	1.566	0.21
	Moderate	105	0.46	0.501		
	lower	248	0.36	0.482		
age	Higher	36	71.72	9.617	0.252	0.777
	Moderate	106	72.44	9.881		
	Lower	248	72.79	8.299		
Nationality (0= Han; 1= ethnic minorities)	Higher	21	0	0	0.221	0.802
	Moderate	60	0.02	0.129		
	Lower	147	0.02	0.142		
BMI	Higher	34	24.699	2.714	0.008	0.992
	Moderate	102	24.680	4.171		
	Lower	239	24.735	3.561		
Diabetes mellitus (0= none, 1= yes)	Higher	36	1	0	-	-
	Moderate	106	1	0		
	Lower	248	1	0		
Hypertension (0= none, 1= yes)	Higher	35	0.94	0.236	5.194	0.006
	Moderate	104	0.9	0.296		
	Lower	242	0.79	0.409		
Myocardial infarction (0, 1)	Higher	36	0.67	0.478	5.156	0.006
	Moderate	106	0.49	0.502		
	Lower	248	0.4	0.491		
Diagnosis (0= angina; 1-NSTEMI, 2= STEMI)	Higher	36	1.61	0.838	0.83	0.437
	Moderate	106	1.55	0.947		
	Lower	248	1.44	1.008		
Length of stay	Higher	35	12.57	7.559	3.749	0.024
	Moderate	104	11.35	6.743		
	Lower	246	10.22	4.354		
Smoking (1= no; 2= quit smoking; 3= active smoking)	Higher	35	1.57	0.778	0.005	0.995
	Moderate	105	1.58	0.852		
	Lower	246	1.59	0.827		
Previous PCI history (0= no; 1= Yes)	Higher	35	0.11	0.323	0.235	0.791
	Moderate	105	0.14	0.352		
	Lower	247	0.12	0.323		
History of CABG surgery (0= no; 1= Yes)	Higher	35	0	0	-	-
	Moderate	105	0	0		
	Lower	247	0	0		
History of COPD (0= no; 1= Yes)	Higher	35	0.03	0.169	0.36	0.698
	Moderate	104	0.06	0.234		
	Lower	246	0.04	0.198		
History of cardiac insufficiency (0= no; 1= Yes)	Higher	35	0.23	0.426	8.975	0
	Moderate	105	0.1	0.295		
	Lower	247	0.04	0.197		
History of atrial fibrillation (0= no; 1= Yes)	Higher	35	0.06	0.236	0.429	0.652
	Moderate	105	0.03	0.167		
	Lower	247	0.05	0.215		

History of hypertension (0= no, 1= yes)	Higher	35	0.89	0.323	6.958	0.001
	Moderate	105	0.84	0.37		
	Lower	245	0.68	0.467		
History of diabetes (0= no, 1= yes)	Higher	35	0.89	0.323	0.105	0.901
	Moderate	105	0.87	0.342		
	Lower	247	0.86	0.349		
History of stroke (0= no; 1= Yes)	Higher	35	0.06	0.236	1.042	0.354
	Moderate	105	0.05	0.214		
	Lower	244	0.09	0.287		
History of abnormal renal function (0= no; 1= Yes)	Higher	35	0.63	0.49	124.883	0
	Moderate	103	0.1	0.298		
	Lower	245	0	0.064		
Chronic kidney disease (0= no; 1= Yes)	Higher	34	0.59	0.5	116.24	0
	Moderate	103	0.08	0.269		
	Lower	245	0	0.064		
History of renal dialysis (0= no, 1= yes)	Higher	35	0.371	0.4902	102.013	0
	Moderate	103	0	0		
	Lower	245	0	0		
Systolic blood pressure	Higher	35	132.54	30.666	1.079	0.341
	Moderate	105	131.26	22.853		
	Lower	247	135.09	21.877		
Diastolic blood pressure	Higher	35	70.69	16.128	3.209	0.041
	Moderate	105	73.63	14.556		
	Lower	247	76.12	12.502		
Heart rate	Higher	35	79.51	21.07	0.195	0.823
	Moderate	105	78.55	15.761		
	Lower	247	77.91	14.568		
Cardiogenic shock (0= no; 1= Yes)	Higher	35	0.23	0.731	7.363	0.001
	Moderate	105	0.05	0.214		
	Lower	245	0.03	0.178		
Cardiac arrest (0= no; 1= Yes)	Higher	35	0	0	1.34	0.263
	Moderate	105	0.01	0.098		
	Lower	246	0	0		
Mechanical complications (0= no; 1= Yes)	Higher	35	0	0	-	-
	Moderate	105	0	0		
	Lower	246	0	0		
Serum creatinine (umol/L)	Higher	36	508.725	384.11467	211.94	0
	Moderate	106	121.1264	24.31825		
	Lower	248	80.6041	13.91188		
Glomerular filtration rate eGFR, CKD-EPIscr method, ml/min/1.73 m^2	Higher	36	13.88194	9.542039	1103.085	0
	Moderate	106	47.15961	8.036214		
	Lower	248	76.86808	8.607524		
CystatinC (mg/L)	Higher	33	4.5255	2.39087	1.203	0.301
	Moderate	101	2.777	9.09857		
	Lower	231	1.938	10.11731		
Blood sugar (mmol/L)	Higher	36	8.9928	4.52914	0.829	0.437
	Moderate	104	9.0252	4.64898		
	Lower	245	8.466	3.67347		

Triglycerides (mmol/L)	Higher	34	2.0071	0.98164	0.375	0.688
	Moderate	104	1.9387	1.41477		
	Lower	236	1.8499	1.13331		
Total cholesterol (mmol/L)	Higher	34	4.27429	1.197683	0.582	0.559
	Moderate	104	4.41788	1.259396		
	Lower	236	4.25797	1.284429		
HDL-C (mmol/L)	Higher	34	1.0656	0.29516	2.086	0.126
	Moderate	104	1.1907	0.32945		
	Lower	236	1.153	0.30572		
Lp (a) (mg/L)	Higher	32	335.6344	344.0388	1.179	0.309
	Moderate	94	243.9319	304.1704		
	Lower	219	241.42	335.71296		
Homocysteine (μmol/L)	Higher	29	24.1207	10.76241	20.315	0
	Moderate	92	19.3413	7.37967		
	Lower	216	15.0507	8.29136		
Myocardial infarction (0= no, 1= yes)	Higher	23	0.65	0.487	0.194	0.823
	Moderate	68	0.54	0.502		
	Lower	159	0.55	0.862		
Multibranch disease	Higher	35	0.86	0.355	0.85	0.428
	Moderate	102	0.78	0.413		
	Lower	242	0.76	0.428		
calcification	Higher	35	0.29	0.458	1.236	0.292
	Moderate	102	0.27	0.448		
	Lower	242	0.21	0.406		
thrombus	Higher	35	0.03	0.169	1.148	0.318
	Moderate	102	0.06	0.236		
	Lower	242	0.09	0.288		
Chronic total occlusion	Higher	35	0.37	0.49	2.228	0.109
	Moderate	102	0.2	0.399		
	Lower	242	0.24	0.425		
Diffuse long lesion	Higher	10	1	0	-	-
	Moderate	28	1	0		
	Lower	52	1	0		
Diffuse long lesion	Higher	34	1.147	0.3595	2.04	0.132
	Moderate	97	1.103	0.3057		
	Lower	221	1.057	0.2571		
Number of implanted stents (1=1, 2=2, 3=≥ 3)	Higher	17	1.176	0.7276	0.904	0.407
	Moderate	45	1.022	0.2601		
	Lower	104	1.087	0.4029		
Number of implanted stents (1=1, 2=2, 3=≥ 3)	Higher	5	0.8	0.447	1.246	0.297
	Moderate	13	1.15	0.555		
	Lower	31	1.06	0.359		
Total length of stent implantation (mm)	Higher	4	27.75	8.057	1.425	0.251
	Moderate	13	32.46	10.952		
	Lower	31	27.29	8.757		
Number of implanted stents (1=1, 2=2, 3=≥ 3)	Higher	2	1	0	0.242	0.79
	Moderate	2	1	0		
	Lower	7	1.29	0.756		

IABP (0= no, 1= yes)	Higher	14	0.14	0.363	1.648	0.197
	Moderate	28	0.04	0.189		
	Lower	87	0.03	0.184		
Temporary pacemaker (0= no, 1= yes)	Higher	12	0	0	0.209	0.812
	Moderate	28	0.04	0.189		
	Lower	89	0.03	0.181		
Spinning mill (0= no, 1= yes)	Higher	13	0.08	0.277	0.008	0.992
	Moderate	28	0.07	0.262		
	Lower	89	0.08	0.271		
IVUS	Higher	16	0.19	0.403	1.261	0.287
	Moderate	30	0.1	0.305		
	Lower	90	0.07	0.251		
Thrombus aspiration (0= no, 1= yes)	Higher	13	0.08	0.277	0.031	0.97
	Moderate	30	0.1	0.305		
	Lower	92	0.1	0.299		
Preoperative syntax	Higher	36	20.083	11.6512	2.218	0.11
	Moderate	106	17	9.473		
	Lower	247	16.549	9.0124		
Preoperative grouping of syntax	Higher	36	2.86	0.351	0.515	0.598
	Moderate	106	2.86	0.35		
	Lower	248	2.82	0.397		
Syntactic operation	Higher	36	6.986	6.4282	0.262	0.769
	Moderate	106	6.642	6.7198		
	Lower	247	6.259	6.6225		
Classification of revascularization degree (1= CR, 2= rIR (0-8), 3= IR)	Higher	35	2.29	0.75	0.915	0.401
	Moderate	102	2.12	0.722		
	Lower	242	2.1	0.758		
aspirin	Higher	35	0.91	0.284	0.979	0.377
	Moderate	104	0.97	0.168		
	Lower	246	0.95	0.216		
Clopidogrel/Ticagrelor	Higher	35	0.97	0.169	1.232	0.293
	Moderate	104	0.97	0.168		
	Lower	246	0.99	0.09		
Lipid-lowering drugs (0, 1)	Higher	35	0.94	0.236	2.614	0.075
	Moderate	104	0.95	0.215		
	Lower	246	0.99	0.11		
β-Blocker (None, metoprolol, Bisoprolol, others --)	Higher	34	0.74	0.448	0.444	0.642
	Moderate	103	0.7	0.461		
	Lower	245	0.67	0.473		
Diuretics (none, spirolactone, furosemide, azine chlorothiazide, others --)	Higher	33	0.45	0.506	7.756	0.001
	Moderate	103	0.39	0.49		
	Lower	241	0.22	0.415		
ACEI/ARB (none)	Higher	34	0.32	0.475	3.683	0.026
	Moderate	104	0.59	0.495		
	Lower	245	0.54	0.499		
CCB (none)	Higher	35	0.6	0.497	5.345	0.005
	Moderate	102	0.44	0.499		
	Lower	246	0.34	0.474		

Aldosterone receptor antagonists (none, spironolactone, others)	Higher	35	0.17	0.382	0.344	0.709
	Moderate	101	0.15	0.357		
	Lower	245	0.13	0.333		
Insulin (No)	Higher	35	0.51	0.507	6.542	0.002
	Moderate	103	0.34	0.476		
	Lower	246	0.24	0.428		
Hypoglycemic agents (none, metformin, dagliazine, acarbose, others)	Higher	34	0.24	0.431	20.141	0
	Moderate	101	0.74	0.439		
	Lower	242	0.74	0.442		
Follow-up duration (days)	Higher	35	550.06	228.034	0.846	0.43
	Moderate	102	545.81	238.145		
	Lower	242	579.54	235.063		
Follow-up duration (month)	Higher	35	18.335	7.601	0.846	0.43
	Moderate	102	18.194	7.938		
	Lower	242	19.318	7.836		
Follow-up duration (month)	Higher	36	0.17	0.447	1.919	0.148
	Moderate	106	0.16	0.439		
	Lower	248	0.08	0.332		
cardiogenic	Higher	22	0.18	0.395	2.31	0.102
	Moderate	69	0.1	0.304		
	Lower	143	0.06	0.231		
Stroke or not	Higher	35	0	0	1.143	0.32
	Moderate	97	0.03	0.174		
	Lower	239	0.05	0.219		
Recurrent myocardial infarction (Yes/No)	Higher	35	0.09	0.284	1.47	0.231
	Moderate	97	0.03	0.174		
	Lower	239	0.03	0.169		
Time to repeat myocardial infarction	Higher	1	43719	-	0.213	0.838
	Moderate	2	43765	72.1249		
	Lower	1	43717	-		
Neostenosis (0= no, 1= yes)	Higher	1	1	-	9	0.007
	Moderate	4	0.25	0.5		
	Lower	7	1	0		
Intrastent restenosis (0= no, 1= yes)	Higher	1	1	-	0.333	0.667
	Moderate	2	0.5	0.707		
	Lower	0	-	-		
Smoking status (Yes/quit/No)	Higher	0	-	-	1.875	0.22
	Moderate	3	0.33	0.577		
	Lower	5	0	0		
MACCE (All-cause death + stroke + unplanned revascularization + myocardial infarction)	Higher	35	0.34	0.482	2.541	0.08
	Moderate	103	0.27	0.447		
	Lower	244	0.2	0.398		

Note: EGFR: Estimated Glomerular Filtration Rate; BMI: Body Mass Index; T2DM: Type 2 Diabetes Mellitus; MI: Myocardial Infarction; NSTEMI: Non-ST Elevation Myocardial Infarction; STEMI: ST Elevation Myocardial Infarction; COPD: Chronic Obstructive Pulmonary Disease; LVEF: Left Ventricular Ejection Fraction; LVED: Left Ventricular End-Diastolic Diameter; LVSD: Left Ventricular End-Systolic Diameter; PCI: Percutaneous Coronary Intervention; CABG: Coronary Artery Bypass Graft; BS: Blood Sugar; TC: Total Cholesterol; TG: Triglycerides; HDL-C: High-Density Lipoprotein Cholesterol; Lp(a): Lipoprotein(a); IVUS: Intravascular Ultrasound; MACCE: Major Adverse Cardiovascular and Cerebrovascular Events, a composite of all-cause death, stroke, unplanned revascularization, and myocardial infarction.

Table 2. Multivariate logistic regression analysis of long-term prognosis of diabetic patients with renal insufficiency after percutaneous coronary intervention

factor	β	SE	Wald	OR	95% CI	*P*
Myocardial infarction	1.116	0.428	6.799	3.053	1.319~7.063	0.009
β-Blocker	1.142	0.439	6.765	3.134	1.325~7.414	0.009
Follow-up duration	-0.002	0.001	3.857	0.998	0.996~1.000	0.05

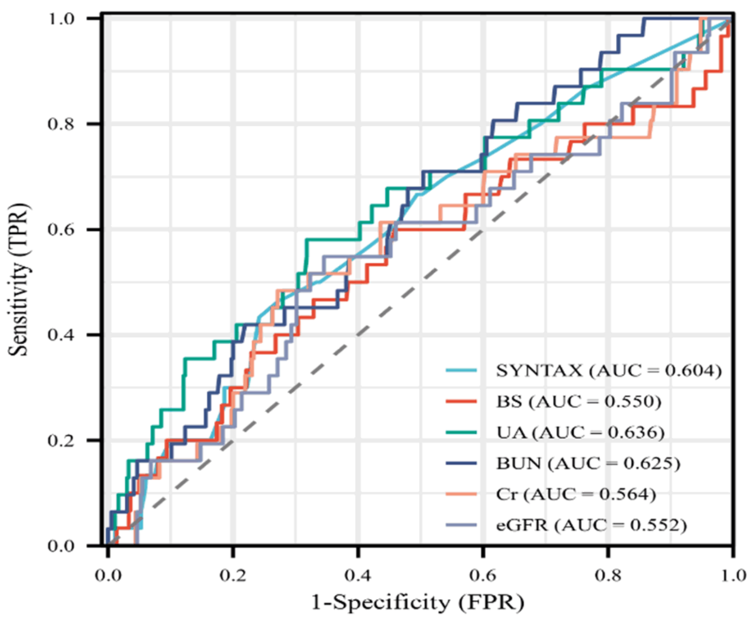

Figure 3. ROC Curve Analysis of residual Syntax score and blood sugar, uric acid, urea, serum creatinine and glomerular filtration rate. BS, blood glucose; UA, uric acid; BUN, blood urea nitrogen; Cr, Creatinine; eGFR, estimated Glomerular filtration rate.

cal evidence supports the feasibility of PCI in these complex cases [24]. Advances in postoperative antithrombotic therapy and the extensive use of drug-eluting stents have significantly mitigated the long-term adverse effects of blood flow reconstruction in patients undergoing PCI [25]. Consequently, PCI is widely recommended as a treatment option globally, with its efficacy considered equivalent to that of CABG in many cases.

The SYNTAX score (http://www.syntaxscore.com) is an anatomically based tool used to objectively determine the complexity of coronary artery disease [26]. This study represents one of the first clinical investigations comparing the efficacy of drug-eluting stents and CABG in patients with three-vessel or left main coronary artery disease. The SYNTAX score has become a widely used tool for stratifying patients who may benefit from PCI or CABG, potentially identifying those most suited for standalone PCI. The analysis demonstrates the potential advantages of the SYNTAX score and its applications in interventional cardiology [27]. Current findings suggest that lower SYNTAX scores are significantly associated with reduced adverse cardiovascular outcome compared to moderate or higher SYNTAX scores. Additionally, research indicates that lower SYNTAX scores predict a lower incidence of MACE [28].

This study stratifies patient risk using the SYNTAX score, providing a foundation for vascular reconstruction planning by physicians. The rSS has been widely recognized and utilized by current researchers, offering valuable guidance in formulating vascular reconstruction strategies and assessing prognosis. The rSS allows for accurate and quantitative evaluation of the characteristics of residual coronary artery disease and myocardial ischemic burden [29]. Additionally, research by Song et al. found a significant correlation between rSS and exercise tolerance in patients with coronary heart disease following PCI [28].

Our research indicates that β-blockers (OR=3.053, P=0.009), β-receptor blockers (OR=3.134, P=0.009), and follow-up duration (OR=0.998, P=0.05) are independent risk factors affecting the long-term prognosis of diabetic patients with renal insufficiency after PCI. The study also found that rSS was positively correlated with blood glucose (r=0.973; P=0.000), uric acid (r=0.933; P=0.000), urea (r=0.907; P=0.000), serum creatinine (r=0.588; P=0.000), and glomerular filtration rate (r=

Table 3. The SYNTAX score was analyzed in relation to blood sugar, uric acid, urea, creatinine, and glomerular filtration rate using ROC curve analysis

	AUC	95% (CI)		Cut-ff	Sensitivity (%)	Specificity (%)
		Lower Limit	Upper Limit			
SYNTAX	0.604	0.499	0.709	8.75	46.6%	72.5%
BS	0.550	0.430	0.670	7.68	60%	54.1%
UA	0.636	0.525	0.747	436.6	58.1%	68.2%
BUN	0.625	0.527	0.723	6.625	70.9%	49.6%
Cr	0.564	0.449	0.679	107.45	48.4%	72.0%
eGFR	0.552	0.439	0.666	59.805	54.8%	65.5%

Note: P < 0.05 was considered significant. Abbreviations: BS, blood glucose; UA, uric acid; BUN, blood urea nitrogen; Cr, Creatinine; eGFR, estimated glomerular filtration rate.

Table 4. Correlation analysis of long-term prognosis of diabetic patients with renal insufficiency after percutaneous coronary intervention

Index	Kendall correlation	Significance (bilateral)	N	Standard error	95% Confidence interval	
					lower limit	upper limit
Syntax score	0.138**	0.001	382	0.04	0.061	0.214

Note: ** refers to P < 0.001 and shows a significant difference.

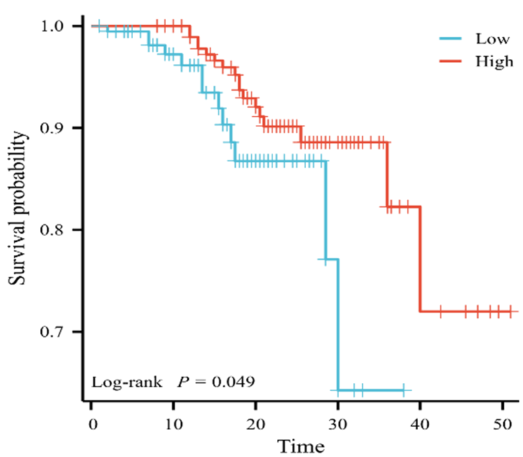

Figure 4. Prognosis of the Syntax score.

0.623; P=0.000). Furthermore, the study indicated that a higher rSS was associated with a worse long-term prognosis for diabetic patients with renal insufficiency after PCI, which aligns with the findings of Lee et al. [29].

The introduction of the SYNTAX score has renewed interest in the risk stratification of patients undergoing PCI. Including clinically significant variables in the SYNTAX score allows for an individualized assessment of mortality risk associated with different revascularization strategies [30].

However, the SYNTAX score has inherent limitations, including low intra- and inter-observer reproducibility. First, its retrospective nature prevents establishing a causal relationship between diabetes with renal insufficiency and the SYNTAX score. Second, variables such as dietary habits, medication therapy, and exercise patterns may not have been fully accounted for. Last, our study results are limited to a specific local population with a relatively small sample size, which restricts their generalizability. Therefore, further large-scale studies are needed to confirm the clinical value of the SYNTAX score in predicting the long-term prognosis of patients with diabetes and concomitant renal insufficiency undergoing PCI.

In conclusion, rSS can be used to evaluate incomplete revascularization. This study suggests that MI, β-blocker use, and follow-up duration are independent factors influencing the long-term prognosis of diabetic patients with renal insufficiency. Therefore, dynamic monitoring of these factors during PCI in diabetic patients with renal insufficiency can provide clinicians with evidence to guide treatment and holds significant clinical application and promotion value.

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Disclosure of conflict of interest

None.

Abbreviations

rSS, Residual Syntax Score; MACE, correlation between cardiovascular adverse events; PCI, percutaneous coronary intervention; CTO, chronic total occlusion; CABG, coronary artery bypass grafting; MI, myocardial infarction; MACCE, Major Adverse Cardiovascular and Cerebrovascular Events; eGFR, estimated glomerular filtration rate; T2DM, type 2 diabetes mellitus; BMI, body mass index; BNP, brain natriuretic peptide; HbA1c, glycated hemoglobin; TC, total cholesterol; TG, triglycerides; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; LVEF, left ventricular ejection fraction; LVED, left ventricular end-diastolic diameter; LVSD, left ventricular end-systolic diameter; bSS, baseline SYNTAX score; FPG, fasting blood glucose; ROC, Receiver Operating Characteristic; AUC, area under the curve.

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