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Association between Body Mass Index and Acute Kidney Injury in Patients who Underwent Coronary Revascularization: A Retrospective Cohort Study from the MIMIC-IV Database

Aim	Acute kidney injury (AKI) remains a common complication of coronary artery revascularization surgery and is associated with adverse outcomes in critically ill surgical patients. Body mass index (BMI) is associated with various diseases. This study aimed to evaluate the association between BMI and the risk of AKI in patients undergoing coronary artery revascularization surgery.
Material and methods	In this retrospective cohort study, data were extracted from the Medical Information Mart for Intensive Care (MIMIC) – IV database from 2008 to 2019 for patients undergoing coronary artery revascularization surgery. The outcome was the occurrence of AKI after ICU admission. Covariates were selected using LASSO regression. Univariable and multivariable logistic regression models were utilized to assess the association between BMI and the odds of developing AKI in patients undergoing coronary artery revascularization surgery, with results presented as odds ratios (OR) and 95% confidence intervals (CI). Subgroup analyses were performed based on age, surgery, anticoagulant use, and the Sequential Organ Failure Assessment (SOFA) score was computed to further explore the association between BMI and AKI.
Results	This study included 3017 patients who underwent coronary artery revascularization surgery, of whom 2172 (72.8%) developed AKI. Increasing BMI was significantly associated with elevated odds of AKI in patients undergoing coronary revascularization (OR = 1.10, 95% CI: 1.08–1.12), indicating a 10% increase in AKI risk for each unit increase in BMI, adjusted for demographic variables (age and gender) in Model 1. After further adjustment in Model 2 for significant baseline characteristics including comorbidities (type 2 diabetes, heart failure, malignant tumors, and chronic kidney disease) and ICU scoring systems (SOFA, APS III, SAPS II, OASIS, and CCI), the association remained significant with an 11% increased risk of AKI per BMI unit increase (OR = 1.11, 95% CI: 1.08–1.13).
Conclusion	BMI may be a promising parameter for assessing the risk of AKI in paty revascularization surgery, providing valuable information for risk stratification and management of ICU patients undergoing such procedures.

Keywords	Acute kidney injury; body mass index; coronary artery revascularization surgery; ICU patients; risk stratification
For citations	Yan Zhang, Xiaofei Jia, Wenxu Fan, Feng Gao, Hang Cui. Association between Body Mass Index and Acute Kidney Injury in Patients who Underwent Coronary Revascularization: A Retrospective Cohort Study from the MIMIC-IV Database. Kardiologiia. 2025;65(4):10–15. [Russian: Янь Чжан, Сяофэй Цзя, Вэньсюй Фань, Фэн Гао, Хан Цуй. Связь между индексом массы тела и острым повреждением почек у пациентов, перенесших коронарную реваскуляризацию: ретроспективное когортное исследование на основании базы данных MIMIC-IV. Кардиология. 2025;65(4):10–15].
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Introduction

Coronary artery disease is a leading cause of morbidity and mortality worldwide, with revascularization surgery being a critical therapeutic intervention for managing severe cases [1, 2]. Despite advancements in surgical techniques and perioperative care, acute kidney injury (AKI) defined as a rapid decrease in kidney function characterized by an increase in serum creatinine ≥0.3 mg/dL within 48 hours or ≥1.5 times baseline within 48 hours, or urine output <0.5 mL/kg/h for 6 hours according to KDIGO criteria, continues to be a prevalent and significant complication following these procedures [3, 4]. AKI not only prolongs hospital stay but also increases the risk of mortality and long-term morbidity, imposing a substantial burden on healthcare systems.

Body mass index (BMI), a widely used indicator of body weight relative to height, has been implicated in a myriad of health conditions, ranging from cardiovascular diseases to metabolic disorders [5, 6]. The relationship between BMI and AKI, particularly in the context of coronary revascularization, has been a subject of growing interest. While obesity has been traditionally associated with a higher

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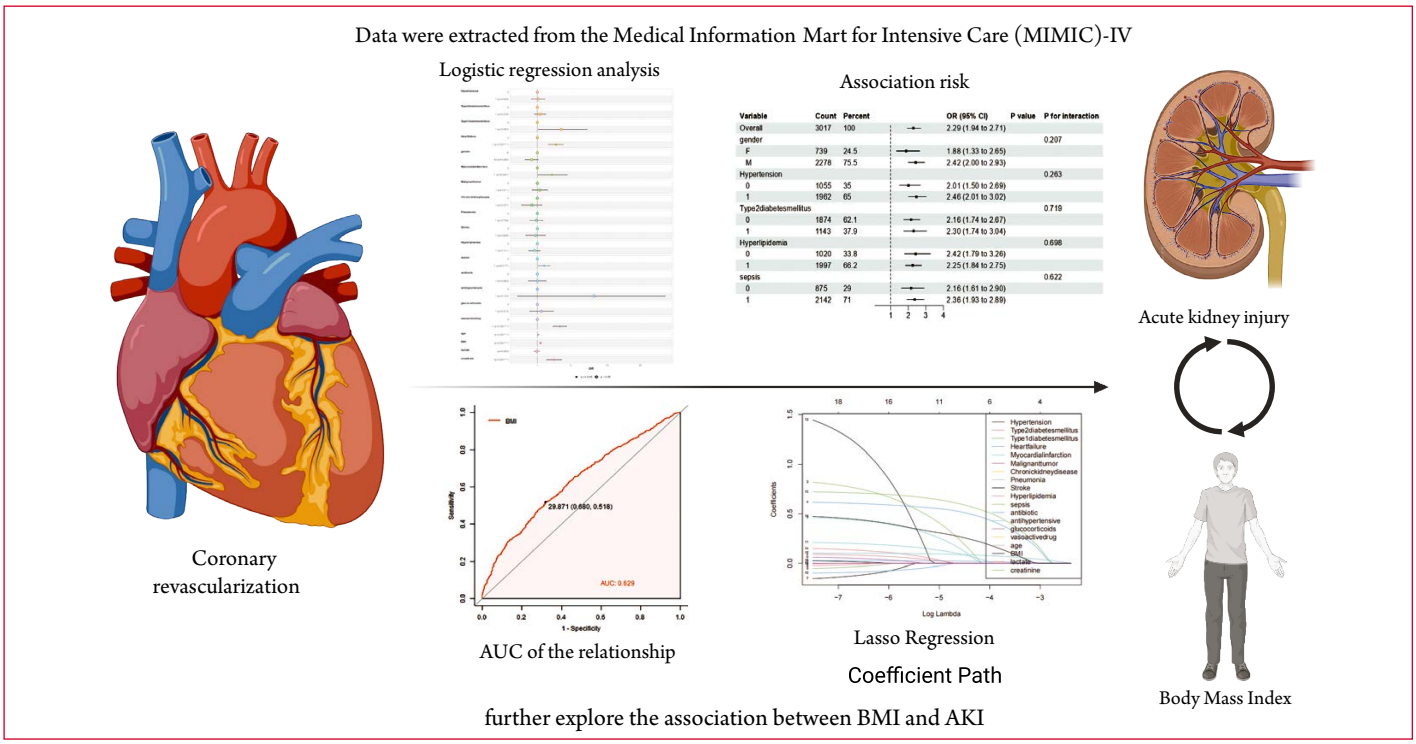
Central illustration. Association between Body Mass Index and Acute Kidney Injury in Patients who Underwent Coronary Revascularization: A Retrospective Cohort Study from the MIMIC-IV Database



risk of AKI, the underlying mechanisms and the extent to which BMI influences the development of AKI in this specific patient population remain to be fully elucidated.

The Medical Information Mart for Intensive Care (MIMIC) – IV database offers a unique opportunity to conduct large-scale, retrospective cohort studies, providing a rich source of de-identified data from critically ill patients, including those who have undergone coronary artery revascularization surgery [7, 8]. By leveraging this extensive dataset, we aimed to investigate the potential association between BMI and the risk of AKI in patients undergoing coronary artery revascularization, with the goal of identifying modifiable risk factors and informing clinical decision-making.

This study employs a retrospective cohort approach to analyze data from a large and diverse patient population, offering insights into the complex interplay between BMI, AKI, and coronary artery revascularization surgery. By examining the relationship between BMI and AKI in this context, we aimed to contribute to the existing body of knowledge and potentially enhance risk stratification and management strategies for patients undergoing these critical procedures.

Material and methods

Research design and participants

In this retrospective cohort study, data of patients who underwent coronary artery bypass surgery (CABG) were extracted from the database maintained by intensive care unit (ICU) of the Boston Tertiary Academic Medical Center. This database is a single-center and open-access database including de-identified, relevant data of patients admitted to the ICU from 2008 to 2019. The database was approved by the review boards of the Boston Beth Israel Deaconess Medical Center and the Massachusetts Institute of Technology. To protect patient privacy, personal information in the database was anonymized. All methods were carried out in accordance with relevant guidelines and regulations.

Inclusion criteria were: 1) age ≥ 18 yr; 2) patients who underwent isolated, primary CABG surgery (on-pump or off-pump); 3) admission to ICU post-CABG with expected ICU stay of at least 24 hours post-surgery; 4) baseline renal function: preoperative serum creatinine < 1.5 mg/dL and eGFR > 60 mL/min/1.73m^2; 5) available complete BMI data measured within 24 hours before surgery; 6) availability of complete laboratory data for AKI assessment using KDIGO criteria. Exclusion criteria were: 1) ICU stay of less than 24 h; 2) missing hematocrit and hemoglobin data upon ICU admission; 3) missing AKI assessment data post-surgery during ICU stay; 4) diagnosis of AKI before ICU admission; 5) diagnosis with end-stage renal disease (ESRD); 6) missing weight data; 7) polycythemia upon ICU admission.

Primary endpoint and follow-up

AKI was defined according to the Kidney Disease Global Improvement Goals (KDIGO), including: 1) an increase

in serum creatinine (SCr) level of ≥0.3 mg/dl within 48 h; 2) an increase in SCr level to ≥1.5 times the ICU admission level within 48 h; 3) urine output <0.5ml/kg/h for consecutive 6 h. Additionally, AKI was staged according to KDIGO severity criteria. Stage 1 was defined as SCr increase 1.5–1.9 times baseline or ≥0.3 mg/dl (≥26.5 μmol/l), or urine output <0.5 ml/kg/h for 6–12 hours. Stage 2 was defined as SCr increase 2.0–2.9 times baseline, or urine output <0.5 ml/kg/h for ≥12 hours. Stage 3 was defined as SCr increase ≥3.0 times baseline, or increase to ≥4.0 mg/dl (≥353.6 μmol/l), or initiation of renal replacement therapy, or urine output <0.3 ml/kg/h for ≥24 hours or anuria for ≥12 hours. The outcome was the occurrence of AKI after ICU admission. The follow-up endpoint was AKI occurring during ICU stay or at discharge. The median follow-up time was 0.86 (0.60, 1.25) days.

Statistical analysis

Normally distributed, continuous variables are described as mean ± standard deviation (SD), and between-group means were compared using Student's t-test or Satterthwaite t-test. Skewed, distributed continuous variables are presented as median and quartiles [M (Q1, Q3)], and means were compared using the Mann–Whitney U test. Categorical variables are expressed as numbers and percentages [n (%)], and between-group comparisons were made using chi-square tests or Fisher exact probability tests. Logistic regression analysis was performed to calculate odds ratios (OR) with 95% confidence intervals (CI) to assess the association between variables. Receiver operating characteristic (ROC) curve analysis was conducted to evaluate predictive performance of BMI, and the area under the curve (AUC) was calculated to assess discriminative ability. Subgroup analyses were performed based on age, surgery, anticoagulant use, and the Sequential Organ Failure Assessment (SOFA) score was computed to further explore the association between BMI and AKI.

Results

Characteristics of patients who underwent coronary revascularization

This study included a total of 3017 critically ill patients with concomitant kidney injury after CABG. Compared with the non AKI group, AKI patients exhibited significantly higher age, BMI values, and proportion of females. Regarding comorbidities, the AKI group demonstrated significantly higher rates of type 2 diabetes, heart failure, and chronic kidney disease, while showing a significantly lower prevalence of malignant tumors. Other comorbidities and vital signs did not differ significantly between the groups. Laboratory investigations revealed that the AKI group had significantly higher white blood cell count, platelet count, RDW-CV values, serum potassium, blood glucose, prothrombin time, and INR levels compared to the non-AKI group. Furthermore, the AKI group exhibited significantly elevated scores across multiple clinical assessment tools,

Table 1. Baseline patient characteristics

Variable	No-AKI CABG Patients (n=845)	AKI-CABG Patients (n=2172)	p value
Age, Mean±SD	67.1±10.3	70.2±11.2	<0.001
BMI (kg/m²), Mean±SD	27.6±4.2	31.0±5.8	<0.001
Gender, n (%)			0.013
Female	180 (21.3)	559 (25.7)	
Male	665 (78.7)	1613 (74.3)	
Hypertension, n (%)			0.089
No	275 (32.5)	780 (35.9)	
Yes	570 (67.5)	1392 (64.1)	
Type 1 diabetes mellitus, n (%)			0.115
No	836 (98.9)	2129(98.0)	
Yes	9 (1.1)	43(2.0)	
Type 2 diabetes mellitus, n (%)			<0.001
No	575 (68)	1299(59.8)	
Yes	270 (32)	873(40.2)	
Heart failure, n (%)			<0.001
No	727 (86)	1592 (73.3)	
Yes	118 (14)	580 (26.7)	
Malignant tumor, n (%)			<0.001
No	736 (87.1)	2163 (99.6)	
Yes	109 (12.9)	9 (0.4)	
Chronic kidney diseases, n (%)			0.001
No	753 (89.1)	1835 (84.5)	
Yes	92 (10.9)	337 (15.5)	
Cirrhosis, n (%)			0.327
No	843 (99.8)	2159 (99.4)	
Yes	2 (0.2)	13 (0.6)	
Tuberculosis, n (%)			0.230
No	836 (98.9)	2134 (98.3)	
Yes	9 (1.1)	38 (1.7)	
Pneumonia, n (%)			0.583
No	674 (79.8)	1711 (78.8)	
Yes	171 (20.2)	461 (21.2)	
Stroke, n (%)			0.888
No	782 (92.5)	2005 (92.3)	
Yes	63 (7.5)	167 (7.7)	
Hyperlipidaemia, n (%)			0.224
No	271 (32.1)	749 (34.5)	
Yes	574 (67.9)	1423 (65.5)	
Heart rate (bpm), Mean±SD	79.7±5.5	80.0±5.2	0.133
Respiratory rate, Mean±SD	13.9±1.7	14.0±1.7	0.140
MAP (mmHg), Mean±SD	70.6±6.3	70.0±6.1	0.015
SpO2 (%), Median (Q1, Q3)	100.0 (99.0, 100)	100.0 (99.0, 100)	0.472

MAP, mean artery pressure; SpO_2, hemoglobin O_2 saturation

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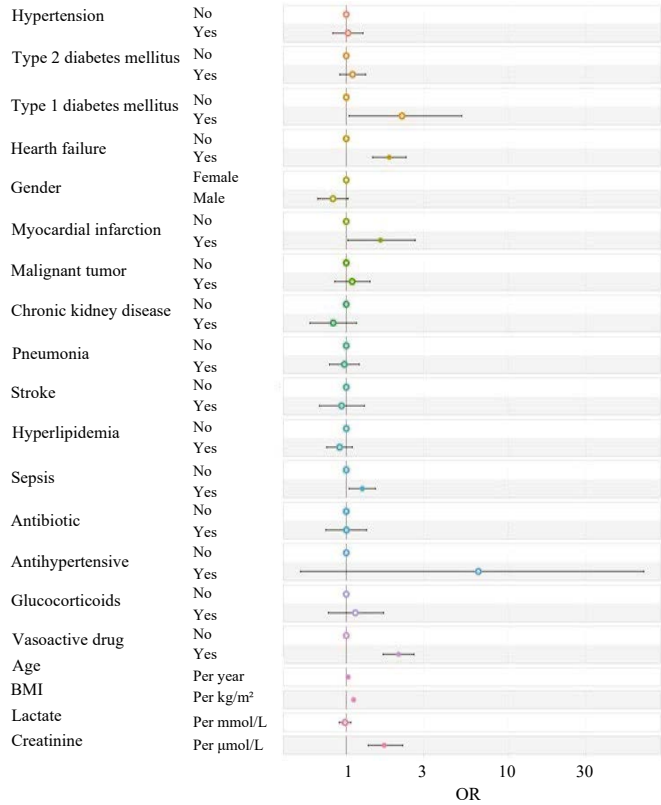
Table 2. Organ function and fluid intake and output

Variable	no-AKI (n=845)	AKI (n=2172)	p value
WBC (10^9/L), Mean±SD	11.5±2.7	12.1±3.0	<0.001
Platelet count (10^9/L), Mean±SD	151.3±29.5	160.1±29.7	<0.001
Hemoglobin (g/ dl), Mean±SD	9.8±1.1	9.8±1.2	0.460
RDW-CV (%), Mean±SD	13.4±0.5	13.8±0.6	<0.001
Hematocrit (%), Mean±SD	28.8±3.2	28.5±3.2	0.019
Sodium (mmol/l), Mean±SD	138.9±1.3	139.0±1.3	0.140
Potassium (mmol/l), Mean±SD	4.1±0.3	4.2±0.3	<0.001
Total calcium (mg/dl), Mean±SD	8.3±0.3	8.3±0.3	0.128
Chloride (mg/dl), Mean±SD	109.9±1.7	109.0±2.2	<0.001
Anion gap (mmol/l), Mean±SD	10.9±1.3	11.0±1.3	0.139
Glucose (mg/dl), Mean±SD	115.3±12.6	118.1±14.4	<0.001
pH, Median (Q1, Q3)	7.4 (7.4, 7.4)	7.4 (7.4, 7.4)	0.677
PaCO2 (mmHg), Median (Q1, Q3)	40 (36, 44)	41 (37, 45)	0.066
PaO2 (mmHg), Median (Q1, Q3)	353 (291, 408)	346 (280, 402)	0.099
Lactate (mmol/l), Mean±SD	2.0±0.5	2.0±0.6	0.146
Total CO2 (mmol/l), Mean±SD	25.9±1.3	27.0±1.3	<0.001
Free calcium (mg/dl), Mean±SD	1.2±0.1	1.2±0.1	0.139
Prothrombin time (sec), Mean±SD	14.9±1.0	15.1±1.2	<0.001
Fibrinogen(mg/dl), Median (Q1, Q3)	197 (162, 244)	215 (173, 266.0)	<0.001
PTT (sec), Mean±SD	31.0±3.5	30.8±3.7	<0.001
INR, Median (Q1, Q3)	1.3 (1.2, 1.5)	1.4 (1.2, 1.5)	0.004
Scores			
SOFA, Median (Q1, Q3)	4 (2, 6)	5 (3, 7)	<0.001
APS III, Median (Q1, Q3)	29 (23, 37)	35 (27, 45)	<0.001
SAPS II, Median (Q1, Q3)	34 (29, 40)	37 (32, 44)	<0.001
OASIS, Median (Q1, Q3)	31 (28, 36)	34 (29, 38)	<0.001
GCS, Median (Q1, Q3)	15 (14, 15)	15 (14, 15)	0.045
CCI, Median (Q1, Q3)	4 (2, 5)	4 (3, 6)	<0.001
Day 1 fluid balance (ml), Median (Q1, Q3)	1965.4 (348.7, 3150.6)	3295.2 (1765.4, 4572.3)	<0.001
Day 1 fluid balance (ml), Median (Q1, Q3)	-667.9 (-1521.6, 122.3)	-703.3 (-1648.2, 107.0)	<0.001

APS III, a component of the acute physiology and chronic health evaluation II score; CCI, Charlson comorbidity index; GCS, Glasgow coma scale; INR, international normalized ratio; OASIS, Oxford acute severity of illness score; PTT partial thromboplastin time; SAPS II, simplified acute physiology score II; SOFA, sequential organ failure assessment.

Figure 1. Results of logistic regression analysis to identify factors affecting the incidence of AKI in CABG



including SOFA, APS III, SAPS II, OASIS, and CCI. For details, refer to Tables 1 and 2.

The relationship between BMI and AKI incidence in patients undergoing coronary revascularization

Table 1 shows the relationship between BMI and the incidence of AKI in patients undergoing coronary revascularization. We applied two logistic regression models to evaluate the relationship between BMI and AKI risk in patients undergoing coronary revascularization. In Model 1, after adjusting for demographic variables (age and gender), each unit increase in BMI was associated with a significantly higher risk of AKI (OR=1.1, p<0.001) (Table 3). In Model 2, which further adjusted for baseline

Figure 2. The association between BMI and AKI risk in patients undergoing coronary revascularization surgery in subgroups

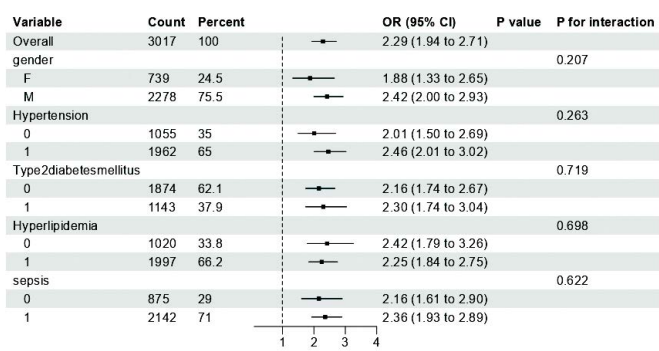
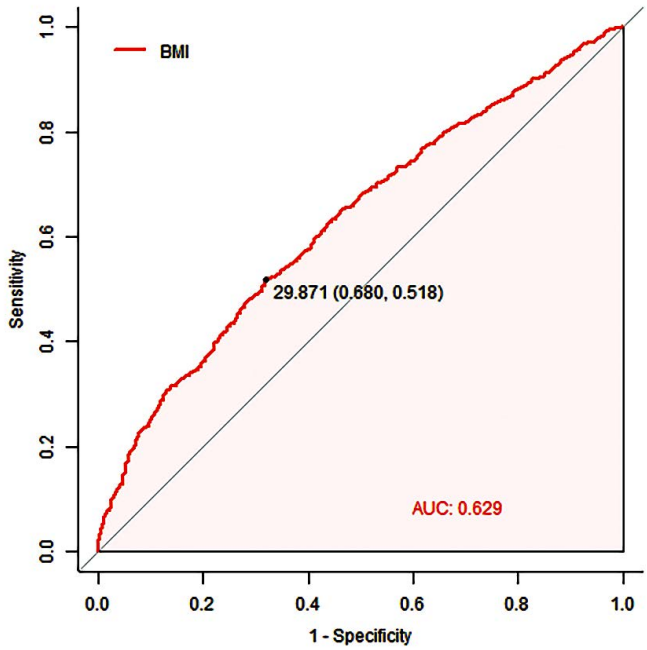


Table 3. Odds Ratios for BMI Comparing AKI versus Non-AKI Groups After Coronary Revascularization Based on Two Different Multivariable Logistic Regression Models

Groups	Model 1		Model 2	
	OR (95%CI)	p value	OR (95%CI)	p vaue
No-AKI	Ref.	-	Ref.	-
AKI	1.10 (1.08-1.12)	<0.001	1.11 (1.08-1.13)	<0.001

Model 1: Adjusted only for age and gender; Model 2: Adjusted for age, gender, comorbidities (type 2 diabetes, heart failure, malignant tumors, and chronic kidney disease), and ICU scoring systems (SOFA, APS III, SAPS II, OASIS, and CCI)

Figure 3. AUC of the relationship between BMI and AKI in CABG



characteristics with significant between-group differences including comorbidities (type 2 diabetes, heart failure, malignant tumors, and chronic kidney disease) and ICU scoring systems (SOFA, APS III, SAPS II, OASIS, and CCI), the association remained significant with each unit increase in BMI corresponding to a 11% increased risk of AKI (OR=1.11, p<0.001) (Table 3).

The association between BMI and AKI risk in patients undergoing coronary revascularization surgery in subgroups of different genders, blood pressure, and complications

This association was further explored in subgroups of different genders, blood pressure, and complications. In Figure 1, logistic regression results showed that the high incidence of AKI was associated with the presence of heart failure (p<0.01), sepsis (p=0.017), and the use of vasopressors in patients undergoing CABG. Subgroup analysis demonstrated the reliability of the results, as shown in Figure 2. We used ROC analysis to evaluate the clinical significance of BMI. The AUC of BMI was 0.629 (p<0.01), with critical values of 29.87 (Figure 3), used to predict the incidence of AKI.

Discussion

The current study evaluated the relationship between BMI and the risk of AKI in patients undergoing coronary revascularization. The findings indicate that high BMI is associated with a higher incidence of AKI in patients undergoing CABG. We also found that high BMI is associated with a higher incidence of AKI in patients under the age of 65 who undergo CABG.

BMI, which assesses an individual's body weight relative to their height, is a widely recognized and utilized metric in the field of public health and medicine. Higher BMI, particularly in the range classified as overweight and obese, is strongly associated with an increased risk of various cardiovascular diseases [9, 10]. This includes coronary artery disease, heart failure [11, 12], hypertension [13], and stroke [14]. The mechanisms linking obesity to cardiovascular issues are multifactorial and include increased arterial stiffness, endothelial dysfunction, inflammation, and dyslipidemia [15–17].

Excess adipose tissue, especially visceral fat, releases cytokines and other substances that can impair vascular function and contribute to atherosclerosis [18, 19]. Weight loss has been shown to reduce cardiovascular risk factors [20]. Even modest weight reduction can lead to improvements in blood pressure, cholesterol levels, and insulin sensitivity, thereby lowering the risk of CVD.

Our study included 3017 patients undergoing coronary artery revascularization surgery, of whom 2 172 (72.8%) developed AKI. Compared with coronary artery bypass grafting, percutaneous coronary intervention increased the incidence of major adverse cardiovascular and cerebrovascular events within one year. Due to the small sample size of these subgroups, there may be population bias, and a large number of specific population samples will be needed in the future to validate these results.

Conclusion

This study evaluated the relationship between BMI and the incidence of AKI in patients undergoing coronary revascularization. We found that high BMI is associated with a higher incidence of AKI in patients undergoing coronary revascularization. The research results may provide reference for risk stratification and management of patients undergoing coronary artery revascularization.

No conflict of interest is reported.

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