Risk factors for acute kidney injury in elderly patients after coronary artery bypass grafting: A Chinese population

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Research Article

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Abstract

Background: Elderly patients are more likely to have adverse complications after coronary artery bypass grafting (CABG). There are few studies on the risk factors of acute kidney injury (AKI) after surgery in elderly patients, especially in the Asian population. This study retrospectively analyse the risk factors of AKI in Chinese elderly patients after CABG, and establish a risk prediction model to detect these risk factors early and take active intervention measures.

Methods: A total of 432 patients were included in this study from 2018 to 2019. AKI was defined according to the Kidney Disease Improving Global Outcomes (KDIGO) criteria. The patients were divided into AKI group and non AKI group. Multivariate logistic regression analysis was used to screen out the factors with $P < 0.05$. The receiver operating characteristic (ROC) curve was made for the predictive risk model. At the same time, the incidence of complications after CABG was compared between the two groups.

Results: Of 432 patients in the study, 119 (27.5%) developed AKI. The estimated glomerular filtration rate (eGFR), ≥ 3 coronary anastomoses, intra-aortic balloon pump (IABP) implantation and ventilation time were independent risk factors for AKI. The area of the ROC curve was (0.702, 95% confidence interval (CI) [0.643-0.761], $P < 0.001$). There were 7 deaths in the AKI group, which was significantly higher than that in the non AKI group. In addition, in the reoperation and postoperative myocardial infarction, the AKI group was also higher than the non AKI group.

Conclusion: The eGFR, ≥ 3 coronary anastomoses, IABP implantation and ventilation time are independent risk factors for AKI in elderly patients undergoing coronary artery bypass grafting. Early discovering these risk factors and taking intervention measures are helpful to reduce the occurrence of AKI after CABG and improve the prognosis of patients.

Background

The incidence of acute kidney injury after CABG is high. According to the definition of AKI, the incidence rate has been reported from 6.7% to 39% [1-3]. It is associated with increased complications and mortality after CABG [3-5], and further increases in the more severe stage of AKI; the acute kidney injury after cardiac surgery is independently associated with increased short-term and long-term mortality [4, 6-9]. It also increases intensive care unit (ICU) length of stay, and resource utilization [2, 10].

The development of AKI involves a variety of mechanisms, including ischemic reperfusion injury, renal toxin release, hemolysis, oxidative stress and cytokine secretion, which can cause systemic inflammatory response, endothelial damage and renal tubular cell damage [1, 11-13]. Many previous studies have shown that elderly, low ejection fraction, previous kidney history, and long-term cardiopulmonary bypass are important predictors of AKI development [6, 14-16].

With the popularization of CABG operations, more and more patients with complications receive CABG treatment. Due to postoperative complications, the results may be unfavorable. Especially for the elderly patients, due to the relatively poor basic renal function of elderly patients, adverse complications after CABG are more likely to occur [17]. However, there are few studies on the risk factors of AKI after CABG in elderly patients, especially in the Asian population. Therefore, this study retrospectively analyzed the risk factors of AKI in Chinese elderly patients after CABG, and established a risk prediction model. Early detecting of these risk factors and taking active intervention measures will help to reduce the occurrence of AKI after CABG and improve the prognosis of elderly patients.

Methods

Patients and Setting

A total of 500 patients aged over 70 years who underwent CABG only for the first time from 2018 to 2019 were included in this study. Among them, 68 cases were lacking in clinical data, and a total of 432 patients were finally included. According to the KDIGO diagnostic criteria of AKI [18], patients were divided into AKI group and non AKI group. There were 119 cases in AKI group and 313 cases in non AKI group.

We promised that our experiment for involving humans was in accordance to guidelines of the Declaration of Helsinki. This study was approved by the Ethics Committee of Beijing Anzhen Hospital (Approval Numbers: 2010043X). Informed consent was obtained from all individual participants included in the study.

Definition of AKI

AKI was defined according to the Kidney Disease Improving Global Outcomes (KDIGO) criteria: an increase in serum creatinine (Scr ≥ 0.3mg/dl), or an increase in Scr ≥1.5times baseline in 7 days after surgery.

Data Collection

Detailed clinical information: this information includes age, gender, body-mass index(BMI), symptom status (New York Heart Association (NYHA) classification), previous cardiac history (previous myocardial infarction, and previous percutaneous coronary intervention(PCI)), diabetes, hypertension, hyperlipidemia, peripheral vascular disease, previous stroke or chronic obstructive pulmonary disease, smoking, and baseline renal function (eGFR), left ventricular ejection fraction (LVEF), anemia, proteinuria. The information recorded during the operation included the left main disease, ≥3 coronary artery lesions, ≥ 3 coronary anastomoses, operation time, on-pump CABG, and emergency surgery. Postoperative information included the use of blood products, ventilator time, ICU stay time, and the use of IABP. And related information about surgical complications (death, reoperation, perioperative myocardial infarction, respiratory complications, atrial fibrillation, stroke) were also included.

Outcome Measures

First, single factor analysis was used to find out the factors with *P* value less than 0.02 or clinically closely related to AKI. Then, multivariate logistic regression analysis was used to screen out the factors with $P < 0.05$. Finally, ROC curve is made for the selected risk factors to obtain the prediction risk model. At the same time, the incidence of complications after CABG was compared between the two groups.

Statistical:

SPSS 22.0 for Mac (IBM SPSS Statistics) was used for statistical analyses. Continuous variables were reported as the mean +/− standard deviation or median (interquartile range) (IQR). Categorical variables were reported as the absolute frequency and as a percentage. The Student *t*-test was applied for continuous data with equal or unequal variances. The Mann-Whitney U test was applied for continuous data that were not normally distributed. Pearson's *2* and Fisher's exact tests were used for categorical data. All meaningful variables were included in a multiple logistic regression analysis. Logistic regression analysis was repeated using variables that were significant in the previous analysis[15]. Then the predictive risk model was calculated by the area under the ROC curve analysis. $P < 0.05$ was considered to be statistically significant.

Results

The baseline clinical data on age, sex, body-mass index, smoking, left ventricular ejection fraction, and so on are shown in Table 1. The incidence of AKI was 27.5%.

Table 1. Characteristics of the Patients at Baseline

es	N=432	Non-AKI (N=313)	AKI (N=119)	*P*-value
ars)	74.7±4.0	74.4±3.8	75.42±4.5	0.019
n (%)	139(32.2)	103(32.9)	36(30.3)	0.598
(kg/m^2), n (%)	223(51.8)	162(51.8)	61(51.3)	0.926
ension, n (%)	297(68.8)	209(66.8)	88(73.9)	0.151
s mellitus, n (%)	170(39.4)	120(38.3)	50(42.0)	0.484
lemia, n (%)	112(25.9)	83(26.5)	29(24.4)	0.649
n (%)	43(10.0)	32(10.2)	11(9.2)	0.761
ral vascular disease, n	93(21.5)	64(20.4)	29(24.4)	0.376
g, n (%)	212(49.1)	163(52.1)	49(41.2)	0.043
n (%)	38(8.8)	28(8.9)	10(8.4)	0.859
II-IV, n (%)	91(21.1)	69(22.0)	22(18.5)	0.418
s MI, n (%)	55(12.7)	39(12.5)	16(13.4)	0.784
s PCI, n (%)	59(13.7)	43(13.7)	16(13.4)	0.934
%), median (IQR)	59(56,64)	59(56,61)	59(57,68)	0.017
mean ± SD	85.08±15.25	87.13±13.52	79.66±18.05	<0.001
nol/L), mean ± SD	74.20±19.22	74.77±18.33	72.71±21.41	0.321
, n (%)	31(7.2)	19(6.1)	12(10.1)	0.149
uria, n (%)	91(21.1)	57(18.2)	34(28.6)	0.018
in disease, n (%)	97(22.5)	76(24.3)	21(17.6)	0.140
nary anastomoses, n (%)	394(91.2)	289(92.3)	105(88.2)	0.179
erative				
ncy surgery, n (%)	16(3.7)	13(4.2)	3(2.5)	0.605
y duration(min), median	220(185,260)	215(185,260)	220(185,255)	0.581
p CABG, n (%)	74(17.1)	57(18.2)	17(14.3)	0.333
grafts, n (%)	356(82.4)	271(86.6)	85(71.4)	<0.001

rative				
plantation, n (%)	65(15.0)	33(10.5)	32(26.9)	<0.001
ansfusion, n (%)	72(16.7)	39(12.5)	33(27.7)	<0.001
ion time(h), median	19.4(15.1,25.8)	19.0(15.0,23.8)	20.0(16.0,43.2)	0.013
y(h), median (IQR)	37.0(21.6,51.0)	34.8(22.0,49.0)	42.0(20.8,77.0)	0.101

BMI: Body mass index; COPD: Chronic obstructive pulmonary diseases; MI: Myocardial infarction; PCI: Percutaneous coronary intervention; LVEF: Left ventricular ejection fraction; IQR: Interquartile range; eGFR: Estimated glomerular filtration rate; CABG: Coronary artery bypass grafting; IABP: Intra-aortic balloon pump; ICU: Intensive care unit

According to the results of univariate analysis and clinical significance, the following factors were included in the regression analysis. Age, hypertension, smoking, eGFR, LVEF, anemia, proteinuria, left main disease, ≥3 coronary artery lesions, ≥ 3 coronary anastomoses, IABP implantation , blood transfusion, ventilator time. As shown in Table 2.

Table 2. Univariate analysis of risk associated with AKI after CABG

isk factors	B-coefficient	OR	95% CI	*P*-value
ge	0.034	1.035	0.977-1.097	0.246
ypertension	0.134	1.143	0.675-1.938	0.618
moking	-0.365	0.694	0.432-1.117	0.132
GFR	-0.025	0.976	0.960-0.991	0.002
VEF	0.026	1.026	0.994-1.059	0.109
nemia	-0.039	0.962	0.385-2.406	0.934
roteinuria	0.354	1.425	0.816-2.490	0.213
eft main disease	-0.435	0.647	0.355-1.181	0.157
3 coronary artery disease	-0.346	0.707	0.321-1.558	0.390
3 coronary anastomoses	-0.834	0.434	0.245-0.769	0.004
ABP implantation	0.676	1.965	1.010-3.824	0.047
lood transfusion	0.448	1.565	0.847-2.894	0.153
entilation time	0.021	1.021	1.002-1.041	0.029

OR: Odds ratio

The results showed that, eGFR, (OR=0.972, 95% CI=0.958-0.987, *P*<0.001), ≥ 3 coronary anastomoses (OR=0.400, 95% CI=0.230-0.693, *P*=0.001), IABP implantation (OR=1.92, 95% CI=1.006-3.664, *P*=0.048) and ventilation time (OR=1.016, 95% CI=1.007-1.026, *P*=0.001) were independent risk factors for AKI. The results of multivariate regression analysis of these risk factors are shown in Table 3. The area of ROC curve is 0.702, 95% CI [0.643-0.761], *P* < 0.001. (Figure 1).

Table 3. Multivariate analysis of risk factors associated with AKI after CABG

Risk factors	B-coefficient	OR	95%CI	*P*-value
eGFR	-0.028	0.972	0.958-0.987	<0.001
≥3 coronary anastomoses	-0.917	0.400	0.230-0.693	0.001
IABP implantation	0.652	1.920	1.006-3.664	0.048
Ventilation time	0.016	1.016	1.007-1.026	0.001

Postoperative complications indicated that 7 cases died in AKI group, which was significantly higher than that in non AKI group (7(5.9%) vs 0(0%) *p*<0.001. In addition, in the reoperation (10(8.4%) vs 4(1.3%) *p*=0.001) and postoperative myocardial infarction (34(28.6) vs 26(8.3%) *p*<0.001, the AKI group was also higher than non AKI group. There was no significant difference in other complications between the two groups. As shown in Table 4.

Table 4. Comparison of Early Results in Hospital

erative mortality	N=432	Non-AKI (N=313)	AKI (N=119)	*P*-value
n (%)	7(1.6)	0(0)	7(5.9)	<0.001
ration, n (%)	14(3.2)	4(1.3)	10(8.4)	0.001
rdial infraction, n (%)	60(13.9)	26(8.3)	34(28.6)	<0.001
atory complication, n (%)	38(8.8)	24(7.7)	14(11.8)	0.179
fibrillation, n (%)	37(8.6)	22(7.0)	15(12.6)	0.064
, n (%)	2(0.5)	1(0.3)	1(0.8)	0.476

Discussion

Our results suggest that eGFR, ≥ 3 coronary anastomoses, IABP implantation and ventilation time are independent risk factors for AKI in elderly patients undergoing CABG.

Similar to previous studies, the incidence of AKI was 27.5% in our study. The incidence of AKI in elderly patients was lower than that in Wilko Reents' Study [19]. On the one hand, the reason may be that 40% of the patients with renal insufficiency before operation in the Wilko Reents' Study. On the other hand, cardiopulmonary bypass surgery is closely related to acute kidney injury [14], and only 17.1% (74 / 432) of the patients in this study received coronary artery bypass grafting under cardiopulmonary bypass, while more than half of the patients in the Wilko Reents' Study received cardiopulmonary bypass surgery.

Previous studies have shown that preoperative anemia, proteinuria were also independent risk factors for AKI after surgery [20, 21]. According to the latest literature, these indicators were included in this study, but the final results were not consistent with previous studies. On the one hand, the result may not be reflected in the elderly patients, on the other hand, the sample size of this study was not insufficient.

eGFR is a risk factor in this study, which is consistent with many previous studies. IABP implantation is an independent risk factor, which indicates that the use of IABP in elderly patients has greater damage to renal function. IABP implantation is an invasive operation, which will damage the arteries. Moreover, the application of IABP implantation will also increase the use of anticoagulants. These factors together increase the incidence of AKI. In addition, revascularization of more than 3 coronary anastomoses is a protective factor for AKI, which suggests that complete revascularization can not only benefit the heart, but also benefit the renal function. The prolonged ventilator time can increase the incidence of AKI, which suggests that patients can reduce the occurrence of AKI if they can recover from spontaneous breathing as soon as possible. This suggests that preoperative pulmonary function exercise is quite important.

In terms of postoperative complications, the mortality, postoperative myocardial infarction and reoperation in AKI group are higher than those in non AKI group. Previous studies showed acute kidney injury after coronary artery bypass grafting was associated with long-term risk of myocardial infarction. There was 3% - 7% of patients undergoing CABG occurring myocardial infarction within one year after surgery [22]. Therefore, our study also suggests that the AKI may be closely related to the occurrence of myocardial infarction, and even affect postoperative death.

The limitations of this study were: on the one hand, this study was a single center, retrospective study, with certain selection bias; On the other hand, the sample size of this study was small, and more samples needed to be included for research and analysed in the future. Finally, in this study, the diagnosis of AKI was based on KDIGO standard. Because many patients have used diuretics after operation, urine volume was not used as one of the diagnostic criteria of AKI.

Conclusions

The eGFR, $\geq$ 3 coronary anastomoses, IABP implantation and ventilation time are independent risk factors for AKI in elderly patients undergoing coronary artery bypass grafting. Early intervention is of importance.

Abbreviations

CABG: Coronary artery bypass grafting; AKI: Acute kidney injury; KDIGO: Kidney Disease Improving Global Outcomes; ROC: Receiver operating characteristic; eGFR: Estimated glomerular filtration rate; IABP: Intra-aortic balloon pump; CI: Confidence interval; ICU: Intensive care unit; BMI: Body mass index; NYHA: New York Heart Association; PCI: Percutaneous coronary intervention; LVEF: Left ventricular ejection fraction; IQR: Interquartile range; OR: Odds ratio.

Declarations

Ethics approval and consent to participate

The study has been approved by the Ethics Committee of Beijing Anzhen Hospital (Approval Numbers: 2010043X). All participants signed informed consent forms.

Consent for Publication

Not applicable.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of interest

It should be recognized that none of the authors have any financial or scientific conflicts of interest with regard to the research described in this manuscript.

Authors' contributions

Yang Li and Ran Dong were responsible for the design, supervision of the study, and revision of the manuscript. Xuejian Hou drafted the manuscript. Shijun Xu and Zhuhui Huang designed a statistical plan. Yang Li and Taoshuai Liu participated in the revision of the manuscript and the coordination of the study. Xuejian Hou and Zhuhui Huang participated in data acquisition. All authors read and agreed to the final manuscript.

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Figures

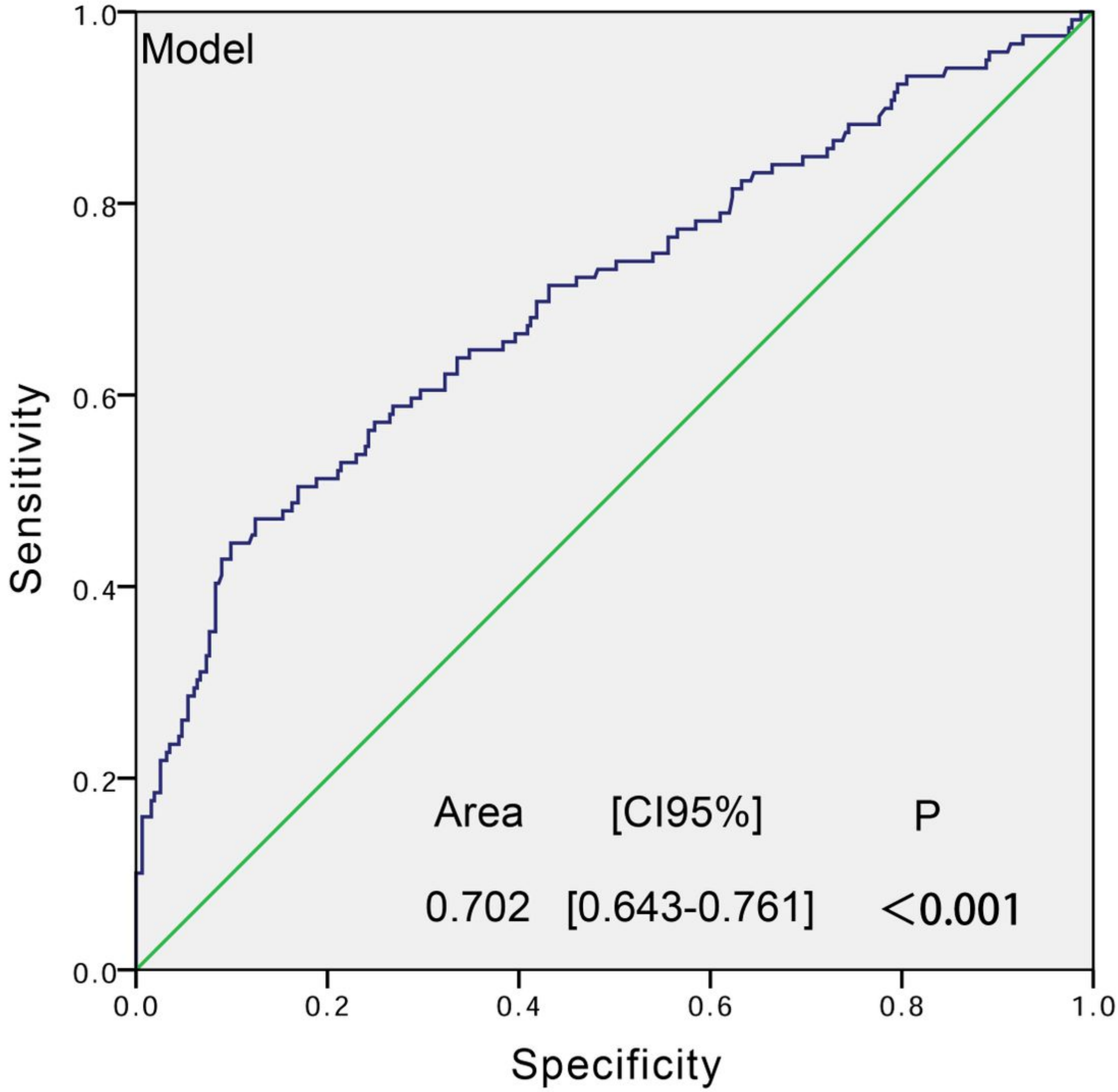
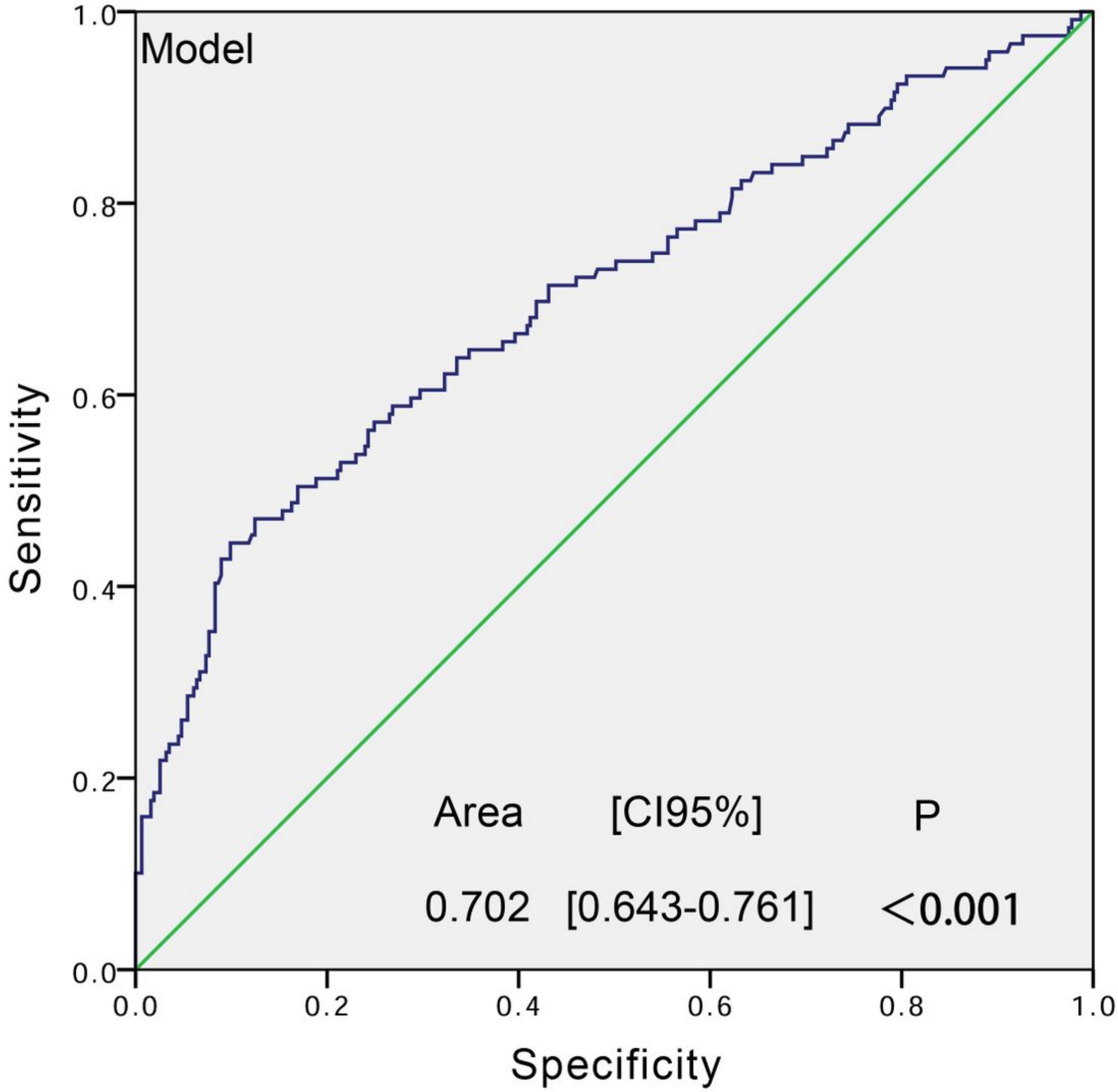


Figure 1

ROC curves using eGFR, ≥3coronary anastomoses, IABP implantation, ventilation time for predicting postoperative AKI



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ROC curves using eGFR, ≥3coronary anastomoses, IABP implantation, ventilation time for predicting postoperative AKI