Characteristics for renal recovery after acute kidney injury in cohorts of elderly and non elderly: a multicenter retrospective cohort study

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Abstract

Background: Failure to recover renal function after acute kidney injury (AKI) is associated with an increase in long-term mortality. The characteristics of renal recovery in elderly and nonelderly cohorts are not clear. The purpose of this study was to explore the risk factors for renal nonrecovery among elderly and nonelderly patients with acute kidney injury (AKI).

Methods: A multicenter retrospective cohort of 583 critically ill patients with AKI was examined. All patients were divided into two cohorts, age < 63 and age ≥ 63 years old; on the basis of renal recovery at 30 days after AKI, the two patient cohorts were further divided into a renal recovery group and a renal nonrecovery group. Multivariate logistic regression was used to analyze the risk factors affecting renal recovery in the two cohorts.

Results: The 30-day renal recovery rate of patients aged < 63 years was 67.5% (191/283), multivariate analysis showed that the independent risk factors affecting renal nonrecovery in age < 63 years old included AKI stage, blood lactate level and hemoglobin level, the AUC for predicting renal nonrecovery was 0.876 (95% CI, 0.835-0.917). The 30-day renal recovery rate of patients aged ≥ 63 years was 32.3% (97/300), multivariate analysis showed that the independent risk factors for renal nonrecovery in age ≥ 63 years old included diabetes mellitus, surgery with general anesthesia, AKI stage, APACHE II score and hemoglobin level. The AUC for predicting renal nonrecovery was 0.863 (95% CI, 0.816-0.909).

Conclusions: The renal nonrecovery after AKI in patients aged ≥ 63 years was more strongly affected by multiple risk factors, such as diabetes mellitus, surgery with general anesthesia and APACHE II score, in addition to hemoglobin and AKI stage.

Introduction

Acute kidney injury (AKI) occurs in 7–25% of hospitalized patients [1–3], and the incidence of AKI among critically ill patients is as high as 30–60% [4, 5]. AKI increases the risk of chronic kidney disease (CKD) and mortality and leads to an enormous medical cost burden [4, 5]. Renal recovery after AKI is an independent factor that is associated with the survival of patients. Renal nonrecovery in the hospital or after discharge was found to be related to an increase in long-term mortality [6, 7]. Previous studies have suggested that age is an influencing factor for renal recovery, and advanced age is related to renal nonrecovery [8, 9]. However, the characteristics of AKI renal recovery in elderly and nonelderly patients are not clear. In this study, we first calculated the cutoff value of age predicting renal recovery among all patients. According to this cutoff value, the patients were divided into two age cohorts, and we investigated the risk factors for renal nonrecovery after AKI in the elderly and nonelderly cohorts.

Materials And Methods

Study design and population

This multicenter retrospective cohort study was conducted at four tertiary centers in China (Peking University People's Hospital, Gansu Provincial Hospital, The First Affiliated Hospital of Hunan University of Medicine and Handan First Hospital). The study was approved by the institutional review boards of Peking University People's Hospital (approval No. 2019PHB042-01). Informed consent was not required because no treatment interventions were provided and protected health information was not collected or analyzed. All data were processed anonymously before analysis. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines.

This study enrolled critically ill adult patients diagnosed with AKI in the intensive care units (ICUs) of four tertiary hospitals from January 2019 to January 2021. The exclusion criteria were patients with CKD stage 5 (estimated GFR [eGFR] < 15 ml/min per 1.73 m^2, chronic dialysis, prior kidney transplant) at baseline, pregnant or lactating women and patients with incomplete data. AKI was defined according to the creatinine component of the KDIGO criteria [10]: an increase in serum creatinine within 48 hours that was ≥ 0.3 mg/dl (≥ 26.5 μmol/L) or an increase in serum creatinine to 1.5 times or more the baseline level that was known or presumed to have occurred within the previous 7 days. The stage of AKI according to KDIGO guidelines was as follows [10]: stage 1 referred to an increase in serum creatinine of 1.5–1.9 times the baseline level or a serum creatinine increase to ≥ 0.3 mg/dl (≥ 26.5 μmol/L) or a decrease in urine volume to < 0.5 ml/(kg·h) for 6–12 hours; stage 2 referred to a serum creatinine increase to 2.0-2.9 times the baseline level or a decrease in urine volume to < 0.5 ml/(kg·h) for 12 hours or more; stage 3 referred to an increase in serum creatinine to 3.0 times the baseline level or to ≥ 4.0 mg/dl (≥ 353.6 μmol/L) or a decrease in urine volume to < 0.3 ml/(kg· h) for 24 hours or more or no urine for 12 hours or more or initiation of renal replacement therapy; for patients younger than 18 years, a decrease in eGFR to < 35 ml/(min·1.73 m^2).

Data collection

The data were collected retrospectively. All the data were obtained from electronic medical records. The data input was completed by trained doctors and research nurses. They were not aware of the study and did not participate in the management or care of the patients. Data quality was assessed by reviewing a random sample of 10% of all medical records. All reported events were confirmed by looking at the hospital chart or contacting the doctor. All patients were followed up through medical records or telephone interviews.

We retrieved all the demographic and clinical data of all subjects in this study, including age, sex, past medical history (hypertension, coronary heart disease, diabetes mellitus, chronic obstructive pulmonary disease and chronic hepatitis B), laboratory values (hemoglobin level, blood lactic acid level, creatinine level, total bilirubin level, albumin level, D-dimer level, C-reactive protein level and PO_2/FiO_2 ratio) at the time of AKI diagnosis and surgery under general anesthesia, sepsis and vasopressor drugs (epinephrine, norepinephrine, vasopressin, dopamine, and phenylephrine) used before AKI occurred. The Sequential Organ Failure Assessment (SOFA) score and Acute Physiologic Assessment and Chronic Health Evaluation (APACHE) II score within 24 hours after AKI diagnosis were also recorded.

A history of hypertension was defined as systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg and/or treatment with antihypertensive drugs. The definition of a history of coronary heart disease was as follows: 1) patients with stable angina pectoris or other symptoms related to coronary heart disease; 2) those who had a known infarct or noninfarct coronary heart disease symptoms in the past and had no symptoms after treatment; and 3) those with a history of acute coronary syndrome (including ST segment elevation acute myocardial infarction, non-ST segment elevation acute myocardial infarction and unstable angina pectoris) but no acute coronary event within 12 months. A history of diabetes mellitus was defined as previous diabetes dietary control, oral antidiabetic drugs or insulin treatment or glycosylated hemoglobin greater than 6.5%. Chronic obstructive pulmonary disease was defined as a previous pulmonary function examination showing forced expiratory volume in one second (FEV1)/forced vital capacity (FVC) < 0.7 after inhalation of a bronchodilator. A history of chronic hepatitis B referred to a previous diagnosis of hepatitis B, with the patient having a current status of virus carrier. Sepsis was defined according to the Third International Consensus Definitions for Sepsis and Septic Shock (sepsis-3) [11].

Outcomes

The outcome was renal recovery 30 days after AKI. Renal recovery after AKI was defined as no blood purification treatment being required after AKI, and the patient's serum creatinine level was stable below 1.25 times the baseline [12]. Patients who experienced recurrence after renal recovery or died during the follow-up period were considered to have no renal recovery. Baseline creatinine was defined as the most recent creatinine measurement before admission or an estimation using the Modification of Diet in Renal Disease (MDRD) study equation (assuming a patient's eGFR of 75 ml/min/1.73 m^2) [10, 13].

Statistical analyses

Normally distributed continuous variables are described with the mean ± standard deviation, and an independent sample *t test* was used for analysis; nonnormally distributed continuous variables are described with the median (25th percentile, 75th percentile), and the nonparametric Mann–Whitney *U* test was used for analysis. Categorical variables are described with the percentage, and the Pearson $\chi 2$ test was used for analysis. The missing data rate of all variables was < 1%, missing continuous variables were inferred as the median of nonmissing values, and missing categorical covariates were inferred as the most frequent categorical values.

We performed logistic regression analysis on all patients and found that age was an independent risk factor for renal nonrecovery after AKI. The best cutoff value for predicting renal recovery by age was 63 years old. According to this cutoff value, all patients were divided into two cohorts: age < 63 years old and age ≥ 63 years old. Univariate analysis was used to screen out meaningful risk factors in each cohort, and all risk factors were evaluated by collinearity diagnostics. If any conditional index was greater than or equal to 30, a bivariate correlation matrix was constructed to evaluate the pairwise correlation. The variables with pairwise correlation greater than or equal to 0.70 were considered to show a high level of collinearity, which was resolved by one of two options: merging the two variables into one variable or deleting one of the two variables from the model. The remaining variables entered the logistic regression model to identify the meaningful independent risk factors for renal nonrecovery after AKI. The logistic regression model was constructed using a forward stepwise selection procedure. On the basis of univariate analysis ($P < 0.05$) and collinearity between variables (conditional index > 30), the independent variables were selected to establish the logistic regression model. ORs and 95% confidence intervals were calculated. The area under the receiver operating characteristic (ROC) curve (AUC) was used to evaluate the discrimination ability of the prediction models.

For all analyses, a 2-sided *P* value < 0.05 was considered statistically significant. Statistical analysis was performed using SPSS 26.0 for Windows (SPSS, Chicago, IL).

Results

Among 667 critically ill patients diagnosed with AKI, 84 patients (24 who had CKD stage 5, 34 who were pregnant or lactating, 5 who had incomplete data and 21 who dropped out during the follow-up) were excluded. A total of 583 patients were included in the final analysis. Finally, 288 patients with renal recovery and 295 patients with no renal recovery were identified. There were 283 patients in the age < 63 years cohort and 300 patients in the age ≥ 63 years cohort. The flow chart of selected patients is shown in Fig. 1.

Among the age < 63 years cohort, the 30-day renal recovery rate of AKI was 67.5% (191/283). The proportion of participants with a history of diabetes mellitus, use of vasopressor drugs and sepsis and the levels of blood lactic acid, serum creatinine level, C-reactive protein level, D-dimer, AKI stage, APACHE II score and SOFA score in the no renal recovery group were higher than those in the renal recovery group. The PO2/FiO2 ratio, hemoglobin and albumin in the no renal recovery group were lower than those in the renal recovery group, and the difference was statistically significant (P < 0.05) (See Table 1).

Table 1
Comparison of demographic and clinical characteristics for the study population.

	age < 63 year cohort			age ≥ 63 year cohort		
	renal recovery n = 191	no renal recovery n = 92	*P* value	renal recovery n = 97	no renal recovery n = 203	*P* value
Age (years, M[P_{25}-P_{75}])	51.0(44.0,56.0)	52.0(46.0,55.0)	0.968	69.0(66.0,77.0)	70.0(66.0,77.0)	0.996
Male sex (n[%])	71(73.2)	138(68.0)	0.358	71(73.2)	138(68.0)	0.358
Past medical history [n (%)]						
Hypertension	28(14.7)	20(21.7)	0.137	21(21.6)	89(43.8)	< 0.001
Diabetes mellitus	14(7.3)	15(16.3)	0.020	17(17.5)	71(35.0)	0.002
Coronary heart disease	19(9.9)	14(15.2)	0.196	30(30.9)	67(33.0)	0.719
Liver disease	10(5.2)	8(8.7)	0.264	5(5.2)	14(6.9)	0.562
Lung disease	11(5.8)	10(10.9)	0.124	10(10.3)	28(13.8)	0.396
Vasopressor drugs (n[%])	42(22.0)	31(33.7)	0.035	25(25.8)	94(46.3)	0.001
Surgery under general anesthesia (n[%])	48(25.1)	35(38.0)	0.025	23(23.7)	78(38.4)	0.012
Sepsis (n[%])	29(15.2)	30(32.6)	0.001	16(16.5)	64(31.5)	0.006
AKI stage (n[%])						
1	82(42.9)	6(6.5)	< 0.001	65(67.0)	46(22.7)	< 0.001
2	77(40.3)	22(23.9)		24(24.7)	64(31.5)	
3	32(16.8)	64(69.6)		8(8.2)	93(45.8)	
APACHE Ⅱ score (M[P_{25}-P_{75}])	14.0(12.0,18.0)	15.0(12.0,20.0)	0.022	17.0(15.0,19.0)	18.0(17.0,21.0)	0.004
SOFA score (M[P_{25}-P_{75}])	6.0(5.0,7.0)	7.0(6.0,8.0)	< 0.001	6.0(4.0,8.0)	6.0(5.0,8.0)	0.046
Laboratory data						
PO_2/FiO_2 ratio (M[P_{25}-P_{75}])	254.0(189.0,316.0)	229.0(198.8,268.7)	0.072	231.0(200.7,253.5)	198.0(166.0,245.0)	0.001

AKI, Acute Kidney Injury; APACHE II, Acute Physiologic Assessment and Chronic Health Evaluation II; SOFA, Sequential Organ Failure Assessment.

	age < 63 year cohort			age ≥ 63 year cohort		
	renal recovery n = 191	no renal recovery n = 92	*P* value	renal recovery n = 97	no renal recovery n = 203	*P* value
Blood lactic acid (mmol/L, M[P_{25}-P_{75}])	1.7(1.3,2.2)	2.3(1.2,3.6)	0.001	2.4(1.8,2.9)	2.7(1.9,3.6)	0.015
Hemoglobin (g/L, M[P_{25}-P_{75}])	108.0(89.0,123.0)	83.0(76.2,101.5)	< 0.001	97.0(85.0,107.5)	75.0(67.0,96.0)	< 0.001
Albumin (g/L, M[P_{25}-P_{75}])	28.7(25.9,32.7)	27.6(25.9,29.7)	0.033	27.1(25.0,31.0)	26.0(24.0,28.2)	0.011
Bilirubin (μmol/L, M[P_{25}-P_{75}])	18.4(13.2,23.8)	19.1(13.0,24.9)	0.637	21.0(16.1,33.0)	21.9(13.8,37.2)	0.922
Creatinine (μmol/L, M[P_{25}-P_{75}])	144.0(105.0,202.0)	236.5(139.7,347.0)	< 0.001	220.0(201.0,264.9)	311.0(254.0,373.0)	< 0.001
D-Dimer (ng/L, M[P_{25}-P_{75}])	1400.0(497.0,3171.0)	2118.0(882.5,4430.0)	0.020	1243.0(658.5.0,2615.0)	2003.0(978.0,4270.0)	0.001
C-reactive protein (mg/L, M[P_{25}-P_{75}])	102.8(45.9,177.9)	171.8(66.1,187.9)	0.015	64.3(23.6,114.5)	123.0(45.3,185.3)	< 0.001

AKI, Acute Kidney Injury; APACHE II, Acute Physiologic Assessment and Chronic Health Evaluation II; SOFA, Sequential Organ Failure Assessment.

In the age ≥ 63 years cohort, the 30-day renal recovery rate of AKI was 32.3% (97/300). The proportion of participants with a history of diabetes mellitus, history of hypertension, surgery under general anesthesia, use of vasopressor drugs, and sepsis and levels of blood lactic acid, serum creatinine, D-dimer, C-reactive protein, AKI stage, APACHE II score and SOFA score in the no renal recovery group were higher than those in the renal recovery group. The PO2/FiO2 ratio, hemoglobin and albumin in the no renal recovery group were lower than those in the renal recovery group, and the difference was statistically significant ($P < 0.05$). (See Table 1).

Multivariate logistic regression analysis showed that the independent risk factors affecting the renal recovery after AKI in the age < 63 years cohort included AKI stage, blood lactic acid and hemoglobin. AKI stage and blood lactic acid were negatively correlated with renal recovery, and hemoglobin was positively correlated with renal recovery (Table 2). In the age < 63 years cohort, the AUC for the prediction of renal recovery after AKI was 0.876 (95% CI, 0.835–0.917) for all independent risk factors (Fig. 2a).

Table 2
Multivariate logistic regression analysis for renal recovery in AKI cohorts of different ages

	age < 63 year cohort		age ≥ 63 year cohort	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value
AKI stage 1		< 0.001		0.003
AKI stage 2	0.319(0.117–0.868)	0.025	0.427(0.211–0.866)	0.018
AKI stage 3	0.043(0.016–0.115)	< 0.001	0.210(0.080–0.550)	0.001
Hemoglobin (g/L)	1.035(1.020–1.051)	< 0.001	1.031(1.014–1.048)	< 0.001
Blood lactic acid (mmol/L)	0.687(0.551–0.856)	0.001		
Diabetes mellitus			0.396(0.191–0.824)	0.013
Creatinine (μmol/L)			0.991(0.985–0.996)	0.001
Surgery under general anesthesia			0.457(0.227–0.918)	0.028
APACHE II score			0.887(0.806–0.977)	0.015
AKI, Acute Kidney Injury; APACHE II, Acute Physiologic Assessment and Chronic Health Evaluation II.				

Multivariate logistic regression analysis showed that the independent risk factors affecting renal recovery in the ≥ 63-year cohort included history of diabetes mellitus, surgery under general anesthesia, AKI stage, APACHE II score and hemoglobin. The APACHE II score, AKI stage, serum creatinine and surgery under general anesthesia were negatively correlated with renal recovery, and hemoglobin was positively correlated with renal recovery (Table 2). In the age ≥ 63 years cohort, the AUC for the prediction of renal recovery of AKI was 0.863 (95% CI, 0.816–0.909) for all independent risk factors (Fig. 2b).

Discussion

Previous studies have reported that the renal recovery rate after AKI is between 33% and 90% [14]. In this study, the overall renal recovery rate of all patients was 49.4%. The difference in renal recovery was related to the different recruited cohorts, diagnostic criteria for AKI, definition of renal recovery and follow-up time. At present, there is no unified consensus on the definition of renal recovery and the duration of follow-up. Long et al. [12] used serum creatinine as the research index to contrast the effect of the definition of four different degrees of renal recovery on the progression to CKD and survival. Their study showed that the optimal definition of renal recovery to predict survival was a reduction in blood creatinine to within 1.5 times baseline within 30 days. Patients whose serum creatinine decreased to 1.5 baseline had significantly better 1-year survival than patients with no renal recovery within 30 days; the risk of developing and progressing to CKD within 5 years was significantly increased if the patient's renal recovery was limited to serum creatinine falling to 1.25–1.5 times the baseline within 30 days. Their study served as an important reference for our definition of renal recovery criteria and the duration of follow-up.

Previous studies have suggested that advanced age is an unfavorable factor for renal recovery [8, 9]. To elaborate on the characteristics of renal recovery in elderly and nonelderly cohorts, we used the Youden index to find the cutoff value of age affecting renal recovery of 63 years, which was used to divide all patients into two cohorts, elderly and nonelderly. These two cohorts were analyzed separately for risk factors influencing renal nonrecovery after AKI, which had not been reported in previous studies. We found that AKI stage and hemoglobin were common risk factors in both cohorts. Forni et al. [14] reviewed previous studies and found that the AKI stage was negatively correlated with renal recovery, and the higher the stage of AKI was, the lower the rate of renal recovery. A total of 288 patients had renal recovery in this study, including 51.0% of patients with stage 1 AKI, 35.1% of patients with stage 2 AKI, and 13.9% of patients with stage 3 AKI, which suggested that patients with higher AKI stages had a lower rate of renal recovery. Dividing all renal recovery patients into two groups with 63 years as the cutoff point, a lower percentage of patients with higher AKI stages could still be found in both groups, with 16.7% of AKI stage 3 patients in the age < 63 years cohort and 8.2% of AKI stage 3 patients in the age ≥ 63 years cohort. Few studies have evaluated the role of anemia in renal recovery after AKI. Our study found that among all patients, the level of hemoglobin was a risk factor associated with renal nonrecovery. In a retrospective single-center study [15] that enrolled 41 patients with AKI requiring renal replacement therapy, anemia was associated with renal recovery at discharge. Another retrospective study [16] that

included 211 patients with AKI suggested that the effects of anemia may be more pronounced in severe cases of AKI, in which case the effects of prolonged hypoxia may interfere with the extent and rate of renal recovery.

The APACHE II score and SOFA score are currently in widespread clinical use to predict outcomes in critically ill patients. In this study, we used these two scores as possible risk factors associated with renal nonrecovery, and we found that these two scores in the age < 63 years cohort were significantly different in univariate analysis, but neither score was a risk factor for renal nonrecovery in multivariate analysis. However, it was different in the age ≥ 63 years cohort, and the APACHE II score was an independent risk factor for renal nonrecovery. Mehta et al. [17] suggested that higher APACHE III scores were associated with a lower rate of renal recovery in acute renal failure patients. A meta-analysis [18] that included 14 studies with 4405 patients with AKI found that SOFA scores were associated with renal recovery among patients who required continuous renal replacement therapy for AKI. This illustrated that older patients aged ≥ 63 years may have lower rates of renal recovery with greater disease severity.

Past medical history was also considered an important factor associated with renal recovery, and the most common factors were hypertension, diabetes mellitus, and coronary heart disease [14]. Univariate analysis in this study found that diabetes mellitus was a risk factor for renal nonrecovery in all patients, but multivariate analysis was performed and showed that diabetes mellitus was independently associated with renal recovery only in the elderly cohort. This suggested that diabetes mellitus caused more damage than other chronic diseases. Some studies [19] suggested that once diabetes mellitus occurs, most patients continue to manifest progressive renal damage even if glycemia is tightly controlled. This suggested that key pathogenic mechanisms involved in the induction and progression of diabetic nephropathy remain active, and no effective treatment is currently available. Studies have suggested that the reason diabetes mellitus emerges as an independent risk factor among patients of advanced age is because there was a positive correlation between the damage to the kidneys caused by diabetes mellitus and the length of the disease course [20].

Serum creatinine has been widely used for the evaluation of renal recovery after AKI, and most studies chose to use the creatinine value before AKI as the baseline; however, individual studies varied in their choice of time point before AKI considered to be the baseline. This study used the creatinine value at the time of AKI diagnosis as the observation index. Univariate analysis found lower creatinine values in the renal recovery group than in the no renal recovery group among all patients, and multivariate analysis found that creatinine values were a predictor of renal recovery after AKI only in the age ≥ 63 years cohort.

It is well known that surgery under general anesthesia increases the burden on renal function, but we do not know whether undergoing surgery under general anesthesia before AKI affects renal recovery. Our study found that among all patients, the proportion of surgery in the group without renal recovery was significantly higher than that in the renal recovery group, but multivariate analysis suggested that surgery under general anesthesia was associated with renal recovery only in patients aged ≥ 63 years, which may be related to decreased organ function reserve leading to decreased tolerance to surgery under general anesthesia in elderly patients.

There are certain limitations of this study. First, we included more independent variables, but our sample size was relatively small after grouping, although it basically satisfied the requirement of ten times the number of independent variables. Second, this was a retrospective observational study, which may have generated selection bias, although we included patients from multiple centers and employed multivariate regression analysis to correct for confounders. Third, we had a shorter follow-up of our patients, and there are studies that considered a follow-up of three months to be more appropriate. These factors all may generate bias, which still needs further validation by large-scale prospective studies in the future.

Conclusions

This study found that elderly patients had lower rates of renal recovery after AKI than younger patients. AKI stage and hemoglobin were common risk factors among all patients, and renal recovery after AKI was associated with more risk factors among older patients than among younger patients. Maintenance of higher hemoglobin levels in clinical practice contributes to renal recovery among all patients.

Abbreviations

AKI: acute kidney injury; ROC: receiver operating characteristic curve; CKD: chronic kidney disease; ICUs: intensive care units; eGFR: estimated glomerular filtration rate; KDIGO: Kidney Disease Improving Global Outcomes; SOFA; Sequential Organ Failure Assessment; APACHE; Acute Physiologic Assessment and Chronic Health Evaluation.

Declarations

Acknowledgements

Not applicable.

Authors' contributions

XZ and CL substantially contributed to the conception and design of the study and were major contributors in writing the original manuscript. FZ and SL also substantially contributed to the conception and design of the study and were contributors to the revision of the manuscript. YL, FG, HX, YJ, SL, MC, TD and ZW substantially contributed to the acquisition and analysis of the data. All authors read and approved the final manuscript.

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Ethics approval and consent to participate

Our protocols were approved by the institutional review boards of Peking University People's Hospital (approval No. 2019PHB042-01) and performed according to the recommendations of the Declaration of Helsinki for Biomedical Research involving human subjects. The institutional review boards of Peking University People's Hospital approved to waive of the need for an informed consent and to use the opt-out approach in the study, because the data were retrospectively and anonymously analyzed.

Consent for publication

Not applicable.

Availability of Data and Materials

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

Competing interests

The authors declare that they have no competing interests.

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Figures

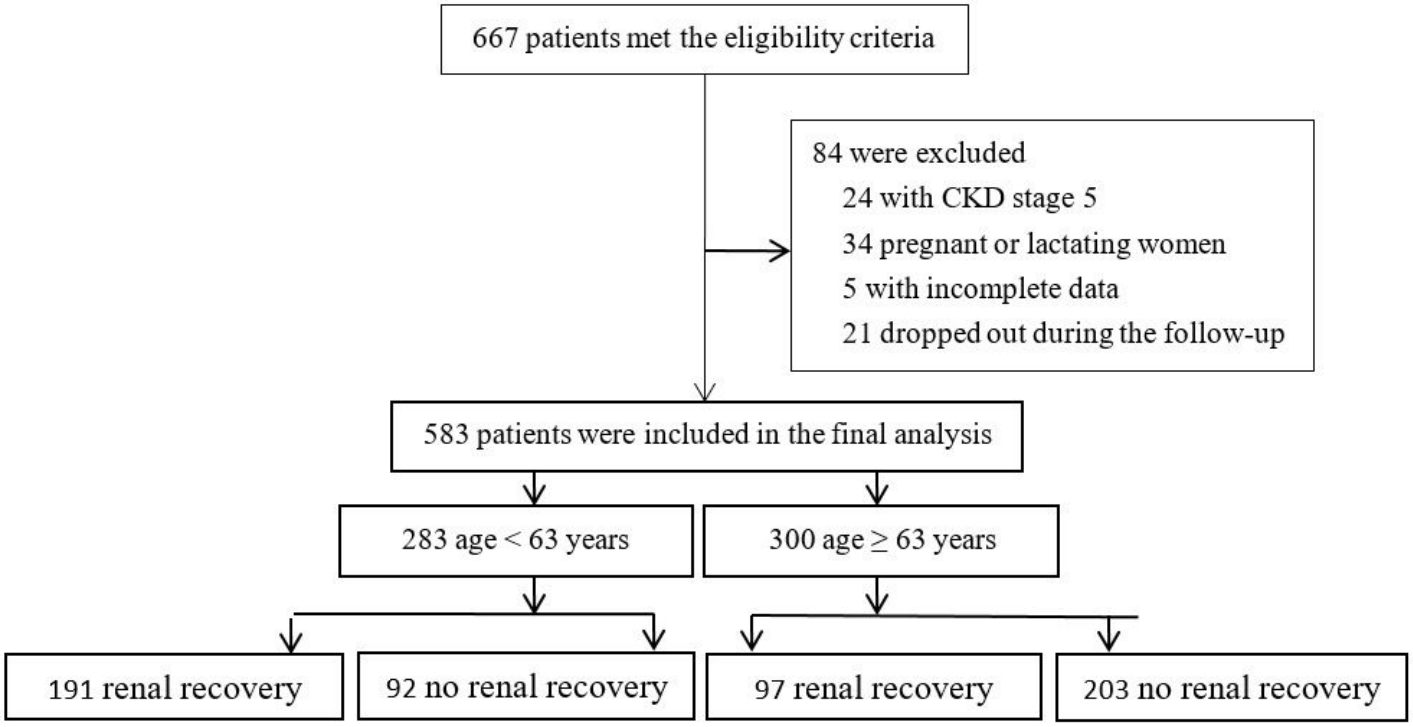

Figure 1

Flow chart of selected patients.

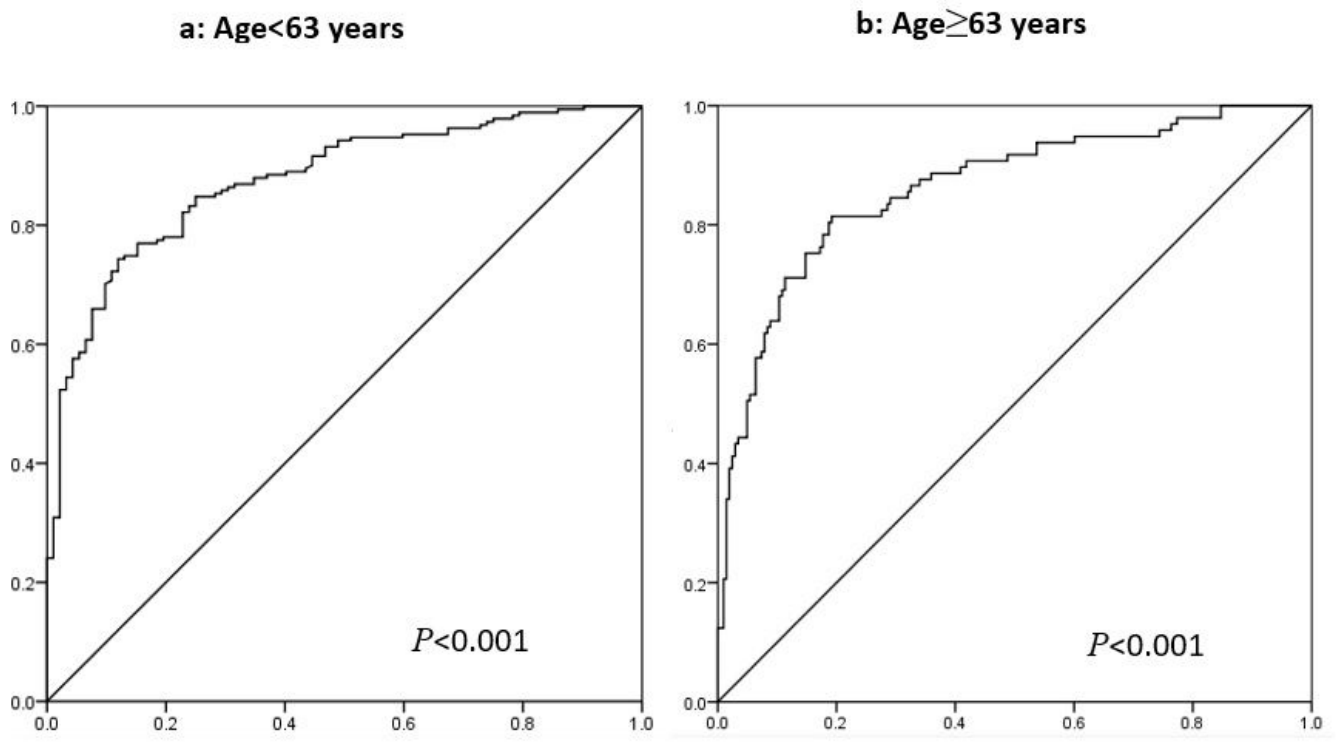

Figure 2

The ROC curve of the predictive ability of the renal recovery model of AKI.