

Incidence and Risk Factors of Acute Kidney Injury After Femoral Neck Fracture in Elderly Patients: A Retrospective Case-Control Study

Sizheng Zhan

Peking University People's Hospital

Wenyong Xie

Peking University People's Hospital

Ming Yang (✉ pku_ym@163.com)

Peking University People's Hospital

Dianying Zhang

Peking University People's Hospital

Baoguo Jiang

Peking University People's Hospital

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Abstract

Background: Hip fracture is highly associated with disability and consequently mortality in the elderly population. Postoperative acute kidney injury (AKI) is not unusual and is associated with considerable morbidity and mortality. We aimed to determine the incidence and potential risk factors for postoperative AKI in elderly patients with femoral neck fracture.

Methods: We retrospectively evaluated patients over 65 years of age who had been subjected to surgery for femoral neck fracture at Peking University People's Hospital from January 2015 to December 2019. Demographic characteristics and potential risk factors were collected. AKI was defined according to the Kidney Disease Improving Global Outcomes guidelines.

Results: A total of 308 elderly patients with femoral neck fracture were included in the study. The overall incidence of postoperative AKI was 12% (37 cases). Through binary logistic regression analysis, adjusted for age, intraoperative blood loss and BMI, we identified that early postoperative albumin, perioperative average hemoglobin and intraoperative hypotension are independent risk factors for postoperative AKI. The model considering the three factors can improve accuracy of predicting the possibility of developing AKI.

Conclusion: The incidence of postoperative AKI in elderly patients with femoral neck fracture was 12%. Independent risk factors included early postoperative albumin, perioperative average hemoglobin and intraoperative hypotension. Taking multiple possible factors into consideration can better predict the possibility of developing AKI after surgery for elderly patients.

Introduction

Hip fracture is highly associated with disability and consequently mortality^(1,2). Although age-standardized annual incidences of hip fracture are gradually decreasing in many countries, they are high in the ageing population⁽¹⁾. Various studies have reported on hip fracture associated mortalities, however, its mechanisms have not been elucidated^(3,4).

Acute kidney injury (AKI) refers to the rapid deterioration (hours to days) of renal functions. Perioperative AKI is not unusual and is associated with considerable morbidity and mortality⁽⁵⁾. Surgical therapy in itself, especially emergency and major surgery among the critically ill, is associated with a high incidence of AKI⁽⁶⁾.

Several studies on AKI following hip fracture have evaluated the incidences and risk factors for postoperative AKI⁽⁶⁻¹¹⁾. Multiple studies^(6,10) have also reported that AKI following surgery in hip fracture elderly patients is associated with increased mortality after 3 months or 1 year. Common types of hip fractures include femoral neck fractures and intertrochanteric fractures, with femoral neck fractures being the most common. The two types of fractures exhibit significant differences in their mechanisms of

fracture injury, surgical methods and postoperative rehabilitation^(12, 13). Therefore, it is necessary to clinically distinguish the two in order to guide therapy.

This study aimed at determining postoperative AKI incidences following femoral neck fractures and the possible predictive factors for AKI in Beijing, China.

Materials And Methods

Population

We retrospectively evaluated patients over 65 years of age who had been subjected to surgical therapy for femoral neck fractures at Peking University People's Hospital from January, 2015 to December, 2019. Prior to the start of the study, the protocol was approved by the Ethics Review Committee of Peking University People's Hospital. The inclusion criteria for this study were: i. Patients with femoral neck fractures without other combined fractures; ii. Aged over 65 years, irrespective of sex; iii. Patients subjected to surgical therapy involving total hip arthroplasty (THA), hemi-hip arthroplasty and internal fixation. Patients whose detailed and comprehensive medical records were available. The exclusion criteria for this study were: i. History of routine dialysis; ii. History of mental illness; iii. Long-term use of nephrotoxic drugs; iv. Severe preoperative infection complications; and v. Unstable vital signs with death soon after surgery (within 3 days);

Date collection

Demographic characteristics

Standard clinical demographics collected include age, sex, body mass index (BMI), the period between injury date and surgical date, comorbidities such as dementia, hypertension, diabetes mellitus, pre-existing cardiovascular diseases, chronic obstructive pulmonary disease and chronic kidney disease.

Perioperative management

Serum hemoglobin, albumin and creatinine levels were preoperatively determined. Anesthesia method, surgical method, surgical time, intraoperative blood loss and intraoperative hemodynamic changes were recorded. Intraoperative hypotension was defined as systolic blood pressure <80 mmHg or mean blood pressure <55–60 mmHg lasting for 5 min⁽¹⁴⁾. Hemoglobin, albumin and serum creatinine (SCr) levels were measured on the first day after surgery and periodically during the 7-day postoperative period. Postoperative blood transfusion history and postoperative complications were also recorded. Early postoperative albumin was defined the lowest serum albumin level on the first day after surgery while perioperative average hemoglobin was defined as mean hemoglobin levels in the preoperative period and within seven days postoperatively, with or without blood transfusion.

Definition of AKI

The latest diagnostic criteria for AKI are included in the Kidney Disease Improving Global Guidelines (KDIGO) Clinical Practice Guidelines for Acute Kidney Injury of 2012⁽¹⁵⁾. Patients were diagnosed with AKI if any one of the following conditions were met: An increase in serum creatinine levels by ≥ 0.3 mg/dl (≥ 26.5 $\mu\text{mol/L}$) within 48 h; An increase in serum creatinine levels by ≥ 1.5 times the baseline level within the previous 7 days; and Urine volume ≤ 0.5 ml/kg/h for 6 h (Table 1). We selected changes in serum creatinine levels as the diagnostic criteria due to the actual situation that only the serum creatinine can be obtained retrospectively.

Statistical analysis

All analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, N.Y., USA). Between-group comparisons of variables were performed by chi-square test and Fishers exact test, whereas between-group comparisons of continuous variables were performed by T-test. After adjusting for confounding variables, a generalized binary logistic regression analysis was performed. The alpha level was set to be $p \leq 0.05$. The SPSS26.0 and STATA 15.0 were used to draw the ROC curves.

Results

Patient characteristics

Comparisons of demographic characteristics between AKI and non-AKI groups is shown in Table 2. A total of 308 elderly patients with femoral neck fractures, including 216 (70.1%) females and 92 (29.9%) males with a mean age of 79.06 ± 7.3 years were recruited in this study. The overall incidence of postoperative AKI was 12% (37 cases). There were no significant differences in age and sex between the two groups, nor were there differences in other characteristics such as preoperative comorbidities, BMI or surgical time.

Potential risk factors

The potential risk factors for postoperative AKI are presented in Table 3. The early postoperative level of serum albumin, perioperative average hemoglobin and intraoperative hypotension were identified as significant risk factors for AKI ($p < 0.01$). Compared to the non-AKI group, the AKI group exhibited more intraoperative blood loss ($p=0.036$). There were no significant differences in preoperative creatinine levels, preoperative albumin levels, anesthesia methods, surgical methods, surgical time, blood transfusion history and postoperative complications between the two groups. After adjusting for age and BMI, early postoperative albumin levels, perioperative average hemoglobin levels and intraoperative hypotension were found to be independent risk factors for postoperative AKI (Table 4).

ROC curves for the significant risk factors

Figure 1 shows the ROC curves of perioperative average hemoglobin levels predicting AKI. The areas under curve (AUC) were 0.729. The cutoff value of the average hemoglobin level was <107 g/L with a

sensitivity of 73.0% and a specificity of 63.5%. Figure 2 shows the ROC curves of postoperative albumin levels predicting AKI. The area under curve (AUC) was 0.859. The cutoff value of postoperative albumin levels was <29.6 g/L with a sensitivity of 83.8% and a specificity of 78.2%. Based on the cut-off value, we re-performed logistic regression analyses (Table 5). Then using the Beta factors of the previous binary logistic regression, we proposed a formula for predicting the risk of postoperative AKI, model=12 -0.06*average hemoglobin (g/L) -0.4* postoperative albumin (g/L) +2* intraoperative hypotension (Yes, 1; No, 0). ROC curves of the model and other three independent risk factors are shown in Figure 3. The model is significantly superior to the postoperative albumin (p=0.0375) and other independent risk factors.

Discussion

In our study population, the incidence of postoperative AKI was 12%, slightly lower than the 11.8%-28.4% reported by previous studies for hip fracture patients. These differences can be attributed to various factors, such as varied definitions of AKI, varied monitoring periods, and heterogeneity of the selected patients. However, we do agree that elderly patients with hip fractures or femoral neck fractures are at a greater risk of post-surgical AKI.

Shin et al.⁽⁹⁾ and Kang et al.⁽⁷⁾ reported that early postoperative hypoalbuminemia is an independent risk factor for AKI, a finding that is in tandem with our results. In this study, early postoperative albumin levels in the AKI group were significantly low than in the no-AKI group (27.54 vs 32.21, p < 0.001). Through ROC curve analysis (AUC: 0.859), the cutoff value of the postoperative albumin level was 29.6 g/L with a sensitivity of 83.8% and a specificity of 78.2%. Moreover, logistic regression analysis indicated that AKI incidences in patients with early postoperative albumin lower than 29.6 g/L were 17.94 times higher than those in patients with more than 29.6 g/L postoperative albumin levels. Therefore, when albumin levels are less than 29.6 g/L in the early postoperative period, albumin should be supplemented in time to protect against postoperative AKI.

Jang et al.⁽⁸⁾ reported that intraoperative hypotension is a risk factor for AKI, in accordance with our study. Logistic regression analysis revealed that intraoperative hypotension enhanced the risk of AKI by a factor of 10. In a study involving 138,021 patients, Mathis et al.⁽¹⁶⁾ found that the postoperative AKI in adult patients undergoing non-cardiac surgery exhibited varying associations with distinct hypotension levels. Therefore, it is necessary to monitor and control blood pressure during surgery.

We identified perioperative average hemoglobin to be an independent risk factor for postoperative AKI. Kang et al.⁽⁷⁾ reported that postoperative AKI was correlated with blood loss after surgery, and to a certain extent, our results are consistent. Therefore, we recommend blood transfusion for patients who meet transfusion indications. Some studies⁽¹⁷⁻¹⁹⁾ have reported that blood transfusion is also a risk factor for postoperative AKI in hip fracture patients. However, prospective large sample studies are needed to confirm these findings.

Many other risk factors for AKI after hip surgery, such as age, preoperative albumin levels, BMI, preoperative complications, and postoperative complications have been reported^(18, 20, 21). In this study, these indicators were not found to be significantly different between the AKI and no-AKI groups. These outcomes could be attributed to differences in populations for different studies. We cannot deny that these factors are high risk factors for postoperative AKI in patients with femoral neck fractures. Therefore, they should be taken into account in clinical work to prevent AKI. More prospective large sample studies are needed to confirm these possible risk factors.

The proposed prediction formula was confirmed by the ROC curve. Its predictive ability was superior to that of perioperative average hemoglobin levels, early postoperative hypoalbuminemia and intraoperative hypotension alone. Using this formula, we intend to demonstrate that multiple factors should be integrated and analyzed to evaluate patients' risk for postoperative AKI.

The limitations of this study are as follows. First, it is a retrospective study, therefore, it is necessary to perform a large-scale prospective study to confirm our findings. Second, since this is a retrospective study, long-term follow-up of patients was not possible to observe changes in long-term creatinine levels and patient survival. Third, due to the limited sample size, staging and related studies of postoperative AKI were not performed. Fourth, the sCr can be influenced by volume overload, nutrition, steroids, and muscle trauma⁽²²⁾. The immediate postoperative period sCr concentrations can be lower than baseline as a result of hemodilution after massive fluid administration and fluid shifts. Biomarkers for the early detection of AKI^(23, 24) should be evaluated in future studies.

Conclusion

The incidence of postoperative AKI in elderly patients with femoral neck fracture was 12%. Independent risk factors for postoperative AKI included perioperative average hemoglobin levels, early postoperative hypoalbuminemia and intraoperative hypotension. Taking multiple possible factors into consideration can better predict the possibility of developing AKI after surgery in elderly patients.

Abbreviations

AKI, acute kidney injury; THA, total hip arthroplasty; BMI, body mass index; SCr, serum creatinine; KDIGO, Kidney Disease Improving Global Guidelines; AUC, The areas under curve;

Declarations

Ethics approval and consent to participate

The Ethics Review Committee of Peking University People's Hospital approved this study. The consent was not applicable for this study as the Ethics Review Committee of Peking University People's Hospital requested. All authors confirm that all methods were performed in accordance with the relevant guidelines and regulations

Consent for publication

Not Applicable.

Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available due to the data also forms part of an ongoing study but are available from the corresponding author on reasonable request

Competing interests

The authors declare no conflicting interests

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Authors' contributions

DY.Z and BG.J were responsible for research design. M.Y, SZ.Z and WY.X collected and analyzed the patient clinical and hematological data. SZ.Z and WY.X were major contributors to writing the manuscript and should be listed as to co-first authors.

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Tables

Table1: KDIGO staging of AKI

Stage	Serum creatinine
1	1.5–1.9 times baseline or ≥0.3 mg/dl (≥26.5 mol/l) increase
2	2.0–2.9 times baseline
3	3 times baseline or ≥4.0 mg/dl (≥353.6 mol/l) increase or initiation of RRT or in patients <18 years a decrease in eGFR <35 ml/min/1.73 m ²

Abbreviation: KDIGO, Kidney Disease Improving Global Guidelines; RRT, renal replacement therapy;

Table 2: Demographics of patients

	Overall N=308	With AKI N=37	Without AKI N=271	P-Value
Age (mean ± SD)				0.052
	79.06±7.30	81.24±7.32	78.76±7.26	
Gender n (%)				1.000
Female	216 (70.1%)	26 (70.3%)	190 (70.1%)	
Male	92 (29.9%)	11 (29.7%)	81 (29.9%)	
Complications n (%)				0.953
Dementia	15 (4.9%)	3 (8.1%)	12 (4.4%)	
Hypertension	171 (55.5%)	20 (54.1%)	151 (55.7%)	
Diabetes mellitus	83 (26.9%)	10 (27.0%)	73 (27.0%)	
CHD	60 (19.5%)	8 (21.6%)	52 (19.2%)	
CVA	62 (20.1%)	8 (21.6%)	54 (20.0%)	
COPD	7 (2.3%)	1 (2.7%)	6 (2.2%)	
CRF	9 (2.9%)	1 (2.7%)	8 (3.0%)	
BMI (mean ± SD)				0.820
	24.10+3.31	24.09+3.32	24.22+3.31	
Time to surgery (mean ± SD)				0.842
	7.29+5.98	7.11+6.00	7.32+5.99	

Abbreviation: CHD, coronary heart disease; CVA, cerebrovascular accident; COPD, chronic obstructive pulmonary disease; CRF, chronic renal insufficiency; BMI, body mass index.

Table 3: Potential risk factors

	Overall N=308	With AKI N=37	Without AKI N=271	P-Value
Preoperative creatinine				0.643
	76.66+41.28	73.70+29.46	77.07+42.67	
Preoperative albumin				0.402
	36.43+4.17	35.89+4.81	36.50+4.07	
Postoperative albumin				0.000
	31.64+3.90	27.54+2.60	32.21+3.71	
Average hemoglobin				0.003
	111.42+16.97	103.72+12.60	112.47+17.24	
Anesthesia				1.000
General anesthesia	71 (23.1%)	8 (21.6%)	63 (23.2%)	
Lumbar anesthesia	237 (76.9%)	29 (78.4%)	208 (76.8%)	
Surgery				0.681
Internal fixation	52 (16.9%)	8 (21.6%)	44 (16.2%)	
Hemi-hip arthroplasty	204 (66.2%)	24 (64.9%)	180 (66.4%)	
THA	52 (16.9%)	5 (13.5%)	47 (17.3%)	
Operation time				0.163
	91.96+36.05	99.73+27.59	90.90+36.97	
Intraoperative blood loss				0.036
	126.24+126.58	167.03+152.24	120.65+121.92	
Intraoperative hypotension				0.000
	25 (8.1%)	13 (35.1%)	12 (4.4%)	
Blood transfusion				0.169
	181 (59%)	25 (67.6%)	156 (57.8%)	
Postoperative complications				0.353
Infection	32 (10.4%)	4 (10.8%)	28 (10.3%)	
Cerebral infarction	1 (3.2%)	1 (2.7%)	0 (0.0%)	
Pulmonary embolism	1 (3.2%)	0 (0.0%)	1 (2.7%)	
Delirium	1 (3.2%)	0 (0.0%)	1 (2.7%)	

Poor wound healing 1 (3.2%) 0 (0.0%) 1 (2.7%)

Abbreviation: THA, total hip arthroplasty;

Table 4: Binary logistic regression analysis, adjusted for age and BMI

AKI vs no-AKI	Beta	Odds Ratio	P-value
Postoperative albumin	-0.402	0.669	<0.01
Average hemoglobin	-0.058	0.944	0.02
Intraoperative hypotension	2.11	8.245	<0.01
Blood loss	0	1	0.806
Age	0.02	1.02	0.564
BMI	0.089	1.09	0.174
constant	11.992	-	-

Table 5: Binary logistic regression analysis according to the cut-off valve.

AKI vs no-AKI	Odds Ratio	P-value
Postoperative albumin	17.94	<0.01
Average hemoglobin	2.348	0.04
Intraoperative hypotension	10.06	<0.01

Figures

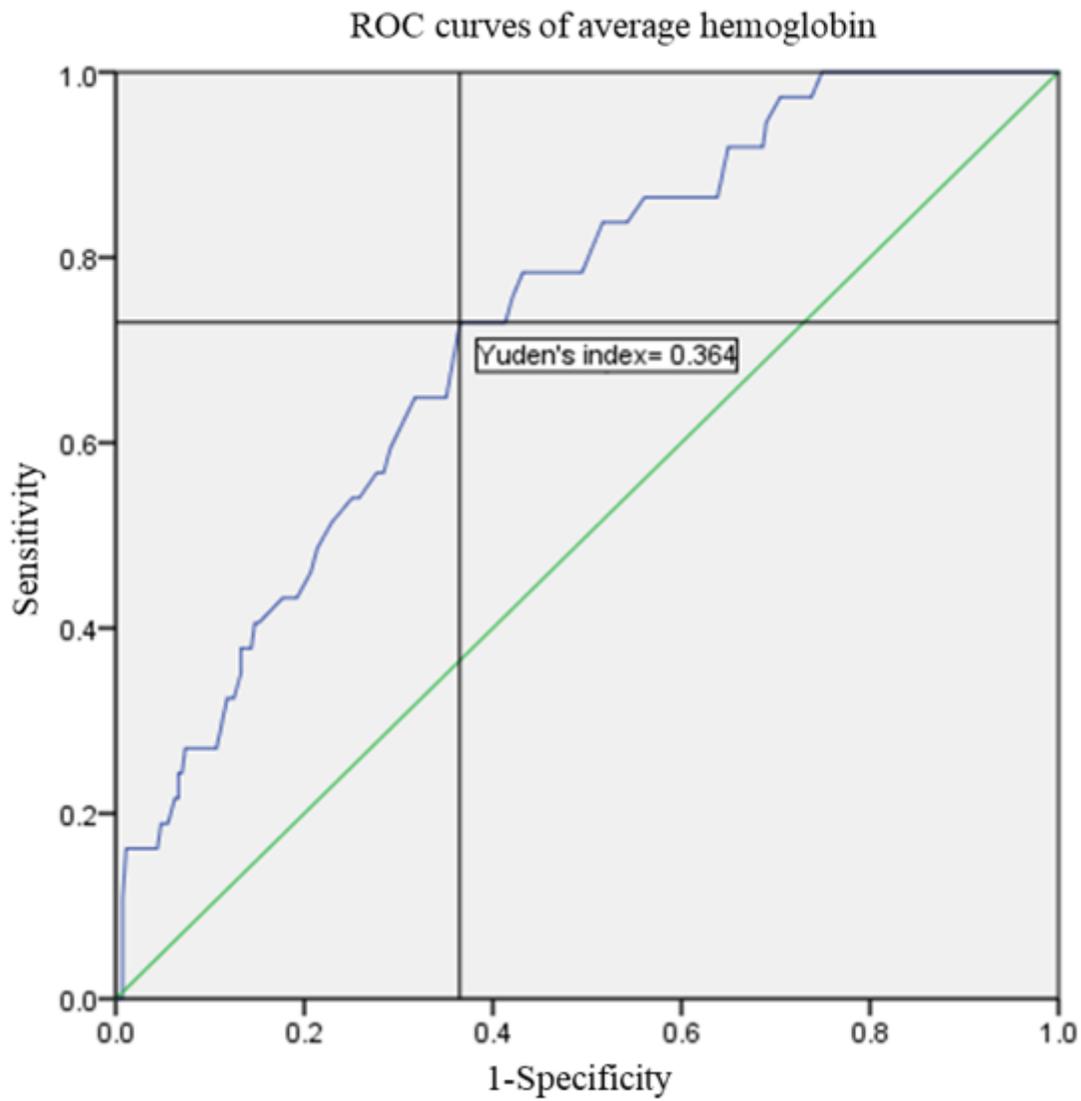


Figure 1

ROC curves of average hemoglobin levels predicting AKI. AUG: 0.729; Yuden's index: 0.364; The cutoff value of the average hemoglobin was <107 g/L; Sensitivity: 73.0%; Specificity: 63.5%.

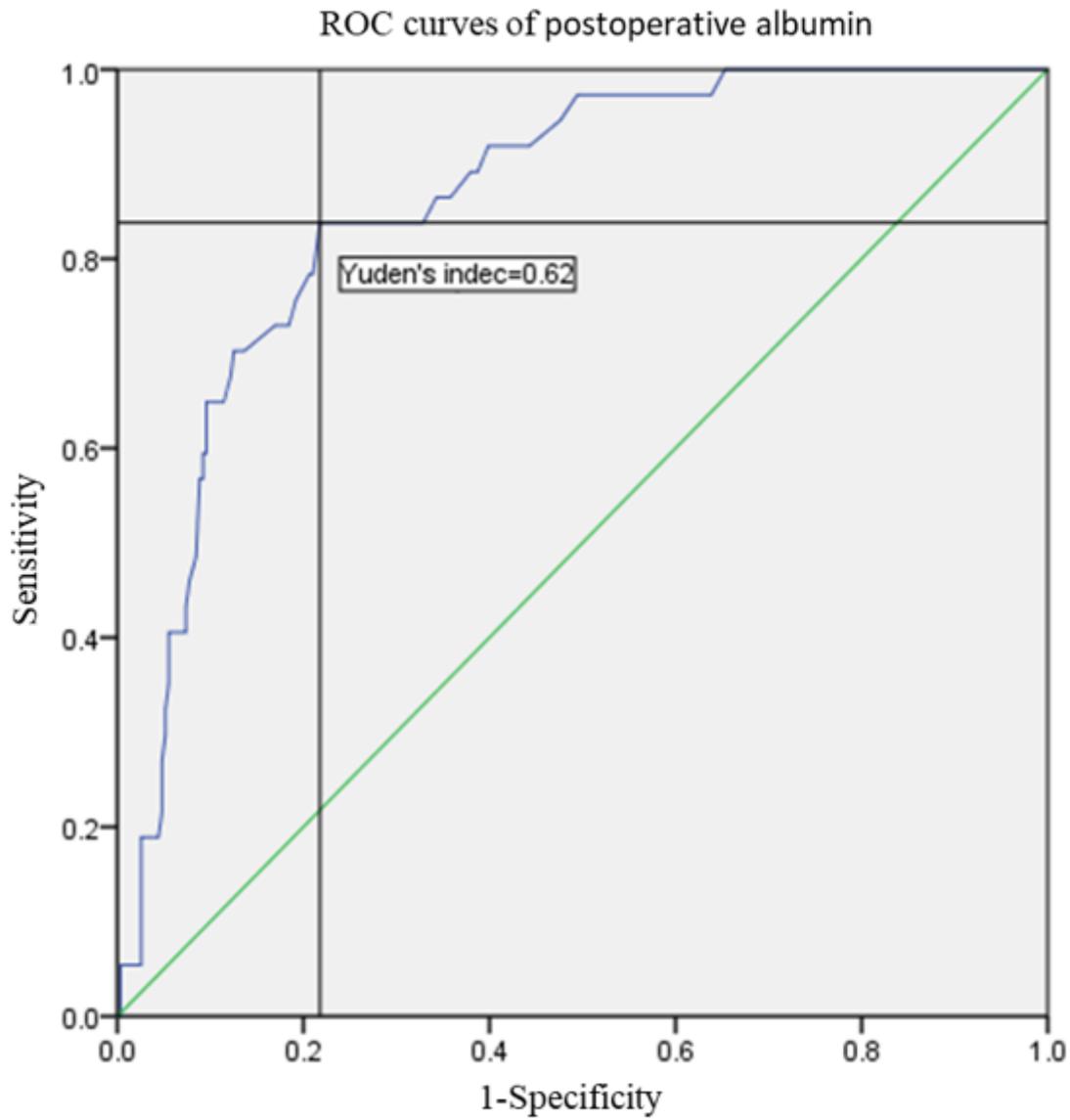


Figure 2

ROC curves of average hemoglobin levels predicting AKI. AUG: 0.859; Yuden's index: 0.62; The cutoff value of the average hemoglobin was <29.6 g/L; Sensitivity: 83.8%; Specificity: 78.2%.

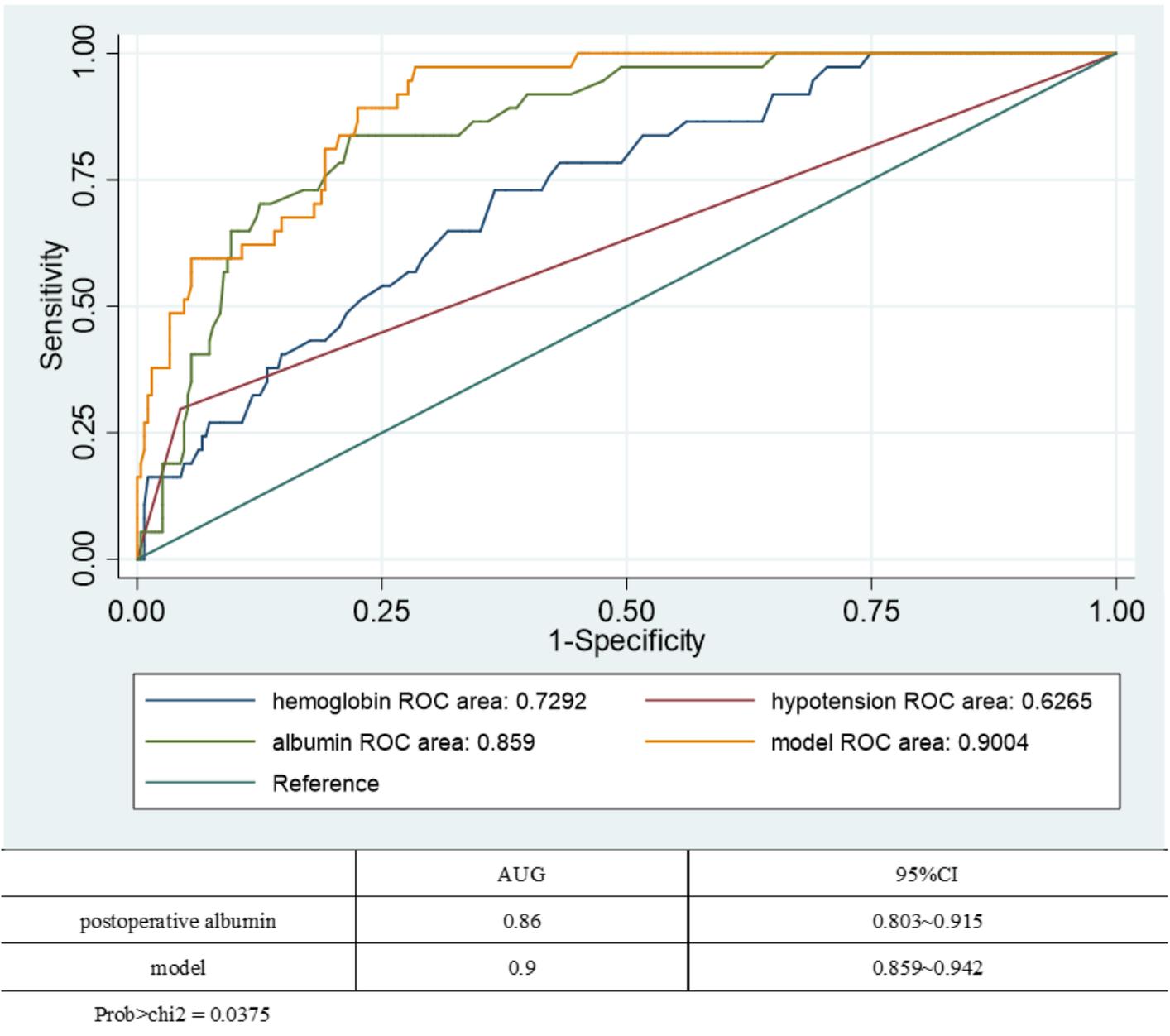


Figure 3

The ROC curves of the model and postoperative albumin, average hemoglobin and intraoperative hypotension