

# Analysis of Prognostic Risk Factors for Operative Common Peroneal Nerve: A Nest Case-Control Study

Zhenhui Liu

Xinjiang Medical University

Maimaiali Yushan

Xinjiang Medical University

Yanshi Liu

Xinjiang Medical University

Aihemaitijiang Yusufu (✉ [ahmatjang@163.com](mailto:ahmatjang@163.com))

Xinjiang Medical University

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## Research article

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# Abstract

**Background** Common peroneal nerve (CPN) injury is one of the most common nerve injuries in the lower extremities and the motor functional recovery of injured common peroneal nerve (CPN) was often unsatisfactory, the mechanism of which is still controversial. The purpose of this retrospective study was to determine the factors associated with the neural recovery of injured CPN in patients undergoing surgical exploration of CPN.

**Methods** This is a retrospective cohort study of all patients who underwent neural exploration for injured CPN from 2009 to 2019. A total of 387 patients with postoperative follow-up more than 12 months were included in the final analysis. We used univariate logistics regression analyses to assess which explanatory variables are associated with recovery of neurological function. We used multivariable logistic regression analysis to determine variables incorporated into clinical prediction model, developed a nomogram by the selected variables, and then assessed discrimination of the model by the area under the curve (AUC) of the receiver operating characteristic (ROC) curve.

**Results** There were 67 patients divided into case group and 320 patients divided into control group. In multivariate logistic regression analysis, we found that city area (OR = 3.35), labor occupation (OR = 4.39), diabetes (OR = 11.68), cardiovascular disease (OR = 51.35), knee joint dislocation (OR = 14.91), proximal fibula fracture (OR = 3.32), tibial plateau fracture (OR = 9.21), vascular injury (OR = 5.37) and hip arthroplasty (OR = 75.96) injury increased the risk of poor motor functional recovery of injured CPN, while high preoperative muscle strength (OR = 0.18) and postoperative knee joint immobilization (OR = 0.11) decreased this risk of injured CPN. AUC of the nomogram was 0.904 and 95% CI was 0.863–0.946.

**Conclusions** City area, labor occupation, diabetes, cardiovascular disease, knee joint dislocation, proximal fibula fracture, tibial plateau fracture, vascular injury and hip arthroplasty injury are independent risk factors of motor functional recovery of injured CPN, while high preoperative muscle strength and postoperative knee joint immobilization are protective factor of motor functional recovery of injured CPN. The prediction nomogram can be used to predict the prognosis of injured CPN.

## Background

Common peroneal nerve (CPN) injury is one of the most common nerve injuries in the lower extremities, which can lead to loss of sensation of the anterolateral foot, and/or a foot drop and result in gait disturbances followed by serious consequences for patients who were not treated properly. Attributed to various factors, including its internal organization, blood supply, superficial topography over the fibular head, and its location, CPN seems particularly prone to injury from iatrogenic accidents, motor vehicle accidents, sport injuries, and gunshot wounds[1–4]. Compression and entrapment lesions are probably the most frequent causes of peroneal neuropathy[5]. The CPN may be compressed by a ganglion cyst, cysts of lateral meniscus, or a tumor of the head of the fibula.

Injured CPN caused by a variety of factors led to foot drop and loss of function of thumb and toe extension, as well as sensory disturbance of innervated region, which affect tremendously on patient's daily life. Although the regeneration ability of the peripheral nerve is stronger than that of the central nerve system and the function of peripheral nerve can be recovered to a certain extent, the injured peripheral nerve cannot recover under some circumstances[6, 7]. However, there are significant differences in prognosis of different peripheral nerve injuries. While previously published papers showed encouraging clinical results[1, 8–10], some recent studies showed pessimistic results with CPN injuries. Compared with injured tibial nerve, the functional recovery of injured CPN was often unsatisfactory, the mechanism of which was still not clear[11–16]. Terzis showed that associated fractures and/or vascular injury, the mechanism and type of injury, denervation time, nerve gap and graft length, and the surgical strategies might affect the functional outcome of CPN[17]. Nevertheless, the factors influencing the prognosis of CPN were controversial.

The purpose of this retrospective study was to determine the factors associated with the motor functional recovery of injured CPN in patients undergoing surgical exploration of CPN and assess their effect on clinical outcomes.

## Methods

Patients who underwent neural exploration of injured CPN from January 2009 to January 2019 were included in this retrospective cohort study which was approved by the Ethics Committee of our institution. All the subjects signed the informed consent form. Inclusion criteria consisted of (1) patients with open CPN injuries, (2) patients with closed fracture who had clinical symptoms of CPN injury and underwent surgical exploration during the treatment of fracture, (3) patients with definitive CPN injuries without improvement after 3 months of conservative treatment, and (4) patients with follow-up period more than 12 months after surgery. Exclusion criteria were constitutive of (1) patients with incomplete medical record, (2) patients with follow-up period less than 12 months or loss of follow up after treatment, (3) patients with diabetic peripheral neuropathy, (4) patients presented with foot drop caused by central nerve disease, (5) patients with definitive CPN injuries without motor dysfunction, and (6) patients underwent ankle arthrodesis or amputation due to severe trauma.

A total of 568 patients with injured CPN were admitted in our hospital from January 2009 to January 2019, of which 181 cases were excluded from the study based on our exclusion criteria. The remaining 387 patients were divided into control group with good result (n = 320) and case group with poor result (n = 67) according to the BMRC grading system according to the last follow-up evaluation[18, 19] (Fig. 1).

The basic information of patients was collected which included age, sex, living area (village and city), occupation (manual and mental work), educational background (low and high level), medical history (diabetes, hypertension and cardiovascular disease), drinking history, smoking history, weight and height. Patients with college or higher education background were defined as high education level, while the others were defined as low education level. The formula ( $BMI = \text{weight (kg)} / \text{height (m}^2\text{)}$ ) was used to

calculate the body mass index (BMI)<sup>[20]</sup>. Patients with BMI lower than 18.5 were defined as thin, between  $18.5 < \text{BMI} < 24 \text{ kg/m}^2$  as normal, BMI between 24 and  $28 \text{ kg/m}^2$  as overweight, and  $\text{BMI} \geq 28 \text{ kg/m}^2$  as obesity.

Factors related to the CPN injuries were also collected which include the injured side, etiology of injuries, duration of symptoms and innervated muscle strength. Etiology of injury[5, 21, 22] consisted of (1) scar formation, including skin scar and posttraumatic scar formed by connective tissue, (2) knee injuries, including direct or indirect trauma, open injuries, knee dislocation and fracture of the fibular head and tibial plateau, (3) anatomic factors, which caused secondary entrapment due to a fibrous band at the origin of the peroneus longus, (4) external compression sources, for example, tight splint/cast and compression wrapping/bandage, (5) iatrogenic injury from hip arthroplasty injury or knee arthroplasty injury, (6) hip fracture, including acetabular fracture, femoral neck fractures and intertrochanteric fracture, and (7) vascular injury, caused by femoral artery embolization or popliteal embolization.

Laboratory results on the day of admission were collected and analyzed. White blood cells (WBC), red blood cells (RBC), hemoglobin (HGB), and platelets (PLT) were performed by an automated hematology analyzer (SYSMEX 2000; Sysmex Corp., Kobe, Japan). Total protein (TP) and albumin (ALB), triglyceride (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), apolipoproteins A1 (Apoa1), apolipoproteins B (Apob), blood glucose (Glu), serum potassium ion (K), serum sodium (Na), serum calcium (Ca), serum phosphorus (P) and serum magnesium (Mg) were measured by the Dimension AR/AVL Clinical Chemistry System (Newark, NJ, USA) and its supporting reagents. All of tests were operated in the clinical laboratory of our institution.

The CPN was explored under the operating microscope. According to the intraoperative findings, the external compression factors causing the nerve entrapment were released completely. Patients with severe adhesion among nerve bundles caused by scar or hematoma were treated with endoneurolysis. Patients with obvious edematous nerve, blurred or disappeared neurovascular network were treated with epineural neurolysis. The released peroneal nerve was placed in a soft tissue bed with enough blood supply. Neuroma was resected and end-to-end neural anastomosis was performed. Soleus muscle branch of the tibial nerve was transfer to the distal CPN when nerve defect could not be directly sutured even under joint flexion position. Patients with atrophy of anterior tibial muscle or extensor digitorum longus muscle were treated with posterior tibial tendon transfer at the same time of neurolysis. Patients with shortened Achilles tendon with malformation, were treated with Achilles tendon lengthening at the same time of neurolysis. According to Classification of Nerve Injuries described by Sunderland[18, 19], the injured nerves was divided into five types in line with the intraoperative observation.

Plaster immobilization of the knee joint was performed in patients with unstable fracture, neurorrhaphy or soleus muscle branch transfer for 4 weeks after operation. And, plaster fixation in dorsal extension of ankle was performed in patients with Achilles tendon lengthening or posterior tibial tendon transfer. All the patients were treated with oral Vitamin B for 3 months and underwent physiotherapy.

Muscular strength of ankle dorsiflexion and toe dorsal extension was assessed according to the British Medical Research Council (BMRC) scoring system at patient's last visit. The clinical outcomes were categorized as poor (case group) if the muscular strength of ankle dorsiflexion or toe extension  $\leq$  M2, and as good (control group) if the muscular strength ankle dorsiflexion and toe extension  $\geq$  M3 [14].

## Statistical analysis

The collected data were independently recorded, verified and corrected by two staff members using EpiData 3.1 software (EpiData Association, Odense, Denmark). Statistical analyses were implemented by R Studio (Version 1.2.5001) with rms, ROCR, gplots and forestplot packages. Variables included were tested for normality, and the skewed distribution variables were transformed by natural logarithm. The continuous variables, analyzed using the Student *t* test, were expressed as mean  $\pm$  standard deviation (SD), and the count variables, detected using the Chi-square or Fisher's test, were expressed as number (%). Two-tailed analysis with *p*-value  $< 0.05$  was considered as statistically significant level.

Taking outcomes as bivariate dependent variables and the other factors as independent variables, we used univariate logistics regression analyses to assess which explanatory variables are associated with recovery. Variables with statistical significance were fitted to regression model 1. We incorporated the variables of *p*-value ( $< 0.1$ ) in univariate analysis into multivariate logistic regression analysis by stepwise method. The variables with low contribution (*p*-value  $< 0.05$ ) to the model were eliminated by stepwise selection method. Reserved variables were fitted to regression model 2. Better model selected by sensitivity analysis was used to develop the nomogram. The neural function recovery discrimination was assessed by the area under the curve (AUC) of the receiver operating characteristic (ROC) curve.

## Results

### Patients

Three hundred eighty-seven patients with injured CPN were included in the final analysis. The case group consisted of 67 (17.31%) patients with a mean age of (43.03  $\pm$  15.73) years and a mean BMI of (23.55  $\pm$  4.30) kg/m<sup>2</sup>, while the control group consisted of 320 (82.69%) patients with a mean age of (33.41  $\pm$  14.52) years and a mean BMI of (23.32  $\pm$  4.06) kg/m<sup>2</sup>. Patients with age of (20–29) years and normal BMI had highest percentage in both case group and control group. However, there were no statistical difference of component percentage of age subgroups and BMI subgroups between case group and control group. Approximately 74.63% of case group and 76.25% of control group were male. The percentage of patients from countryside in case group (23.88%) was lower than that in control group (53.44%), and the percentage of patients engaged in manual work in case group (35.82%) was lower than that in control group (49.69%). The constituent ratios of patients with smoking history, drinking history and hypertension history in case group and control group had no statistical difference. Approximately 13.43% of case group and 1.88% of control group had type 2 Diabetes history. Compared with control group, case group had a higher rate (13.43%) with cardiovascular disease. (Table 1)

Table 1  
Socio-demographic characteristics of patients in case and control group

Variable	Total (n = 387)	Case group (n = 67)	Control group (n = 320)	P-value
Age (years)**	35.07 ± 15.16	43.03 ± 15.73	33.41 ± 14.52	< 0.001
0~	63 (16.28)	1 (1.49)	62 (19.38)	0.263
20~	91 (23.51)	24 (35.82)	67 (20.94)	
30~	83 (21.45)	16 (23.88)	67 (20.94)	
40~	71 (18.35)	11 (16.42)	60 (18.75)	
50~	53 (13.70)	11 (16.42)	42 (13.12)	
60~	26 (6.72)	4 (5.97)	22 (6.87)	
Gender				
Male	294 (75.97)	50 (74.63)	244 (76.25)	
Female	93 (24.03)	17 (25.37)	76 (23.75)	
Areas**				< 0.001
Countryside	187 (48.32)	16(23.88)	171(53.44)	
City	200 (51.68)	51(76.12)	149(46.56)	
Occupation*				0.039
Mental workers	183 (47.29)	24 (35.82)	159 (49.69)	
Manual workers	204 (52.71)	43 (64.18)	161 (50.31)	
Education				0.614
High	78 (20.16)	12 (17.91)	66 (20.63)	
Low	309 (79.84)	55 (82.09)	254 (79.37)	
Smoking	42 (10.85)	4 (5.97)	38 (11.88)	0.158
Drinking	4 (1.03)	3 (4.48)	1 (0.031)	0.131
Type 2 Diabetes**	12 (3.10)	9 (13.43)	3 (0.94)	< 0.001
Hypertension	9 (2.33)	3 (4.48)	6 (1.88)	0.401
Cardiovascular disease **	10 (2.58)	9 (13.43)	1 (0.031)	< 0.001
BMI	23.36 ± 4.06	23.55 ± 4.30	23.32 ± 4.06	0.677
Thin	34 (8.79)	8 (11.94)	26 (8.12)	0.626

<b>Variable</b>	<b>Total (n = 387)</b>	<b>Case group (n = 67)</b>	<b>Control group (n = 320)</b>	<b>P-value</b>
Normal	198 (51.16)	28 (41.79)	170 (53.13)	
Overweight	119 (30.75)	24 (35.82)	95 (29.69)	
Obesity	36 (9.30)	7 (10.45)	29 (9.06)	
*P < 0.05, **P < 0.01				
Values presented as mean ± SD or frequencies and percentages, n (%).				

Table 2 presented factors associated with CPN injury. Case group had significantly higher rate of tibial plateau fracture, knee dislocation, fracture of the proximal fibula anatomic factors, hip arthroplasty injury, knee arthroplasty injury, hip fracture, and vascular injury, while control group had higher rate of myodynamia. Type of nerve injury on basis of Sunderland type had statistical difference between case group and control group. The details were shown on Table 2. The cases and controls differed on preoperative laboratory test results including TP, Glu, Na and Ca, the details of which were demonstrated on Table 3. The differences of treatment characteristics between case and control group shown on Table 4. Constituent ratio of surgery type had statistical difference between case group and control group. There was no statistical difference of follow-up time between case group and control group. Compared with case group, control group had higher knee immobilization rate.

Table 2  
Common peroneal nerve injuries characteristics of patients in case and control group

Variable	Total (n = 387)	Case group (n = 67)	Control group (n = 320)	P-value
Side				0.989
Left	214 (53.77)	37 (55.22)	177 (55.31)	
Right	173 (43.47)	30 (44.78)	143 (44.68)	
Duration (months)	11.43 ± 21.18	12.42 ± 22.74	11.23 ± 20.97	0.519
Scar compression				0.739
No	195 (48.99)	35 (52.24)	160 (50.00)	
Yes	192 (48.24)	32 (47.76)	160 (50.00)	
knee injury				
Tibial plateau fracture **	16 (4.02)	8 (11.94)	8 (2.50)	<b>0.001</b>
Knee dislocation *	16 (5.00)	12 (3.10)	4 (5.97)	<b>&lt; 0.001</b>
Direct injury	187 (46.98)	30 (44.78)	157 (49.06)	0.523
Fracture of the proximal fibula*	90 (23.26)	30 (44.78)	60 (18.75)	<b>&lt; 0.001</b>
Anatomic factors *				0.039
No	356 (89.45)	64 (95.52)	12 (3.75)	0.495
Yes	31 (7.79)	3 (44.78)	4 (0.94)	0.466
External compression				
Plint/cast	16 (4.13)	4 (5.97)	12 (3.75)	0.495
Wrapping/bandage	4 (1.03)	0 (0.00)	4 (1.25)	0.466
Iatrogenic injury				
Hip arthroplasty injury **	7 (1.81)	6 (8.96)	1 (0.31)	<b>&lt; 0.001</b>
Knee arthroplasty injury**	13 (3.40)	8 (11.94)	5 (1.56)	<b>&lt; 0.001</b>
Hip fracture **	9 (2.26)	5 (7.46)	4 (1.25)	<b>0.009</b>
Vascular injury **	22 (5.68)	15 (2.39)	7 (2.19)	<b>&lt; 0.001</b>
Muscle strength **	233 (60.21)	27 (40.30)	206(64.38)	<b>&lt; 0.001</b>
*P < 0.05, **P < 0.01				
Values presented as mean ± SD or frequencies and percentages, n (%).				

Variable	Total (n = 387)	Case group (n = 67)	Control group (n = 320)	P-value
Sunderland classification				< 0.001
□	73 (18.86)	15 (22.39)	58 (18.13)	
□	86 (22.22)	3 (4.48)	83 (25.94)	
□	135 (34.88)	37 (55.22)	37 (55.22)	
□	27 (6.98)	18 (5.63)	9 (13.43)	
□	66 (17.05)	3 (4.48)	63 (19.69)	
*P < 0.05, **P < 0.01				
Values presented as mean ± SD or frequencies and percentages, n (%).				

Table 3  
Blood routine and biochemical profiles of patients in case and control group

<b>Variable</b>	<b>Total (n = 387)</b>	<b>Case group (n = 67)</b>	<b>Control group (n = 320)</b>	<b>P-value</b>
WBC (10 <sup>9</sup> /L)	7.49 ± 2.51	7.99 ± 2.30	7.39 ± 2.54	0.075
RBC (10 <sup>12</sup> /L)	4.61 ± 2.17	4.63 ± 0.82	4.60 ± 2.36	0.930
HGB (g/L)	131.38 ± 22.84	131.43 ± 22.96	131.37 ± 22.85	0.984
PLT (10 <sup>9</sup> /L)	260.28 ± 97.10	275.70 ± 77.29	257.06 ± 100.56	0.153
TP (g/l) *	65.40 ± 8.99	68.37 ± 6.20	65.40 ± 8.99	<b>0.010</b>
ALB (g/l)	38.72 ± 5.94	38.44 ± 5.50	38.76 ± 6.04	0.680
TG (mmol/l)	2.01 ± 6.12	1.65 ± 0.90	2.08 ± 6.71	0.599
TC (mmol/l)	4.09 ± 3.48	3.97 ± 1.11	4.12 ± 3.79	0.758
HDL-c (mmol/l)	1.05 ± 0.30	1.01 ± 0.29	1.06 ± 0.31	0.194
LDL-c (mmol/l)	3.72 ± 18.07	2.65 ± 0.93	3.95 ± 19.87	0.594
Apoa1 (g/l)	1.06 ± 0.23	1.05 ± 0.23	1.07 ± 0.23	0.539
Apob (g/l)	0.92 ± 1.66	0.91 ± 0.27	0.92 ± 1.82	0.952
Glu (mmol/l) **	5.34 ± 1.56	6.00 ± 2.26	5.20 ± 1.33	<b>&lt; 0.001</b>
K (mmol/l)	3.96 ± 0.40	3.98 ± 0.32	3.95 ± 0.42	0.624
Na (mmol/l)**	139.34 ± 3.46	138.24 ± 3.49	139.57 ± 3.42	<b>0.004</b>
Ca (mmol/l) **	2.2 ± 0.24	2.13 ± 0.44	2.24 ± 0.17	<b>0.001</b>
P (mmol/l)	1.241 ± 0.31	1.27 ± 0.29	1.23 ± 0.31	0.440
Mg (mmol/l)	0.85 ± 0.09	0.85 ± 0.08	0.85 ± 0.09	0.921
Values presented as mean ± SD				
*P < 0.05, **P < 0.01				

Table 4  
Treatment characteristics of patients in case and control group

Variable	Total (n = 387)	Case group (n = 67)	Control group (n = 320)	P-value
Surgery				< 0.001
Neurorrhaphy	48 (12.40)	2 (2.99)	46 (14.36)	
Neurolysis	286 (73.90)	63 (94.03)	223 (69.69)	
Nerve Transfers and neurolysis	13 (3.36)	2 (2.99)	11 (3.44)	
Tendon transfers and neurolysis	30 (7.75)	0 (0)	30 (9.37)	
Achilles tendon lengthening and neurolysis	10 (2.58)	0 (0)	10 (3.14)	
Postoperation				
Follow-up time (months)	15.29 ± 2.60	14.67 ± 2.81	15.37 ± 1.93	0.791
Knee Immobilization **	122 (31.52)	6 (8.96)	116 (36.25)	< 0.001
Values presented as mean ± SD or frequencies and percentages, n (%).				
*P < 0.05, **P < 0.01				

## Univariate logistic regression analysis

In Univariate logistic regression analysis, city area, age, labor occupation, T2 diabetes, cardiovascular disease, knee joint dislocation, proximal fibula fracture, tibial plateau fracture, hip fracture, vascular injury, hip joint arthroplasty injury, knee joint arthroplasty injury, high total protein concentration and high blood glucose concentration increased the risk of poor motor functional recovery of injured CPN. High preoperative muscle strength, knee immobilization, high serum calcium concentration, and serum sodium concentration reduce this risk of CPN (Fig. 2). Those variates of statistical difference ( $p < 0.05$ ) were fitted into model 1.

## Multivariate logistic regression analysis

In the multivariate logistic regression analysis, city area (OR = 3.35, 95% CI 1.48–7.19), labor occupation (OR = 4.39, 95% CI 1.91–10.85), diabetes (OR = 11.68, 95% CI 2.41–69.08), cardiovascular disease (OR = 51.35, 95% CI 5.53–1159.94), knee joint dislocation (OR = 14.91, 95% CI 2.7–89.8), proximal fibula fracture (OR = 3.32, 95% CI 1.49–7.48), tibial plateau fracture (OR = 9.21, 95% CI 1.38–70.02), vascular injury (OR = 5.37, 1.58–18.81) and hip arthroplasty (OR = 75.96, 95% CI 3.72–2694.40) injury increased the risk of poor motor functional recovery of injured CPN, while high preoperative muscle strength (OR = 0.18, 95% CI

0.08–0.39) and postoperative knee joint immobilization (OR = 0.11, 95% CI 0.03–0.33) decreased this risk of CPN (Fig. 3). We fitted those variates of statistical difference ( $p < 0.05$ ) into model 2.

## Establishment of clinical prediction nomogram

The sensitivity of model 1 and model 2 was analyzed by chi-square test. The results ( $P = 0.27$ ) showed that the increased variables (age, hip fracture, knee arthroplasty injury, total protein concentration, blood glucose concentration, blood sodium concentration, blood calcium concentration) in model 1 did not increase the accuracy of the model, so we used the simpler model 2 to construct clinical predictive model and the nomogram (Fig. 4). AUC of this predictive model was 0.904, and the 95% CI was 0.863–0.946 (Fig. 5).

## Discussion

In this study, We found that city area, labor occupation, diabetes, cardiovascular disease, knee joint dislocation, proximal fibula fracture, tibial plateau fracture, vascular injury and hip arthroplasty injury are independent risk factors of motor functional recovery of CPN, while high preoperative muscle strength and postoperative knee joint immobilization are protective factor of motor functional recovery of CPN. Using those selected factors, we developed a clinic prediction nomogram which could predict the prognosis of injured CPN.

The effect of the blood supply to the CPN on prognosis was highlighted after multifactor logistic regression analysis. Reports had found the prognosis of injured CPN at the thigh level was slightly better than that at the hip area[16]. In recent years, a growing number of reports found that the peroneal nerve of the sciatic nerve was more vulnerable and difficult to recover [4, 14, 17]. We also found CPN injuries after hip arthroplasty had better prognosis than that of knee arthroplasty. It was not clear whether this was due to more severe damage to the CPN because of its anatomical location or other factors[15, 21]. Blood supply of CPN had drawn attention of researchers[21, 23–26]. The nutrient arteries of the peripheral nerves are anatomically located in the connective tissue sheath, the nerve bundles and inside the nerve fibers which guaranteed sufficient blood supply in cases that the vessels were interrupted[27]. The extraneural arterial chain of the sciatic nerve consist of 2–6 nutritive arteries at certain intervals which originated from inferior gluteal artery and popliteal artery branches[28]. The extraneural arterial chain of the tibial nerve was supported by 2–5 nutritive arteries formed by branch of the tibiofibular trunk, peroneal artery, and posterior tibial artery[28]. Thus, one or more of those nutritive arteries interruption had no significant effect on the blood of sciatic nerve and tibial nerve. However, the part of the CPN from the terminal division of the sciatic nerve to the fibular neck were supplied by a single blood vessel (97.2%) [26]. Hence, the CPN tended to have a poor prognosis after injuries with the necrosis of nerve ischemic edema, Wallerian degeneration, and the formation of fibrous scar[14, 16].

We believed that knee joint dislocation, proximal fibula fracture, tibial plateau fracture and hip arthroplasty injury affect the functional recovery because of limited blood supply interruption rather than nerve fiber damage. We also observed that vascular injury diseases, including femoral and popliteal

artery embolization, were a risk factor both in univariate and multifactorial analyses, which could be explained by vascular thrombosis or embolism of the CPN associated with inadequate collateral circulation[25, 26].

The fact that diabetic patients were vulnerable to peripheral nerve damage had been reached an agreement[29, 30]. Cardiovascular disease and diabetes had been found to increase the incidence of CPN in cardiothoracic operations [23]. Patients with cardiovascular disease may have systemic vascular sclerosis, so that blood supply was not easy to restore after nerve injury. Nerve regeneration of injured nerve in diabetic patients was often impaired because of microangiopathic involvement of the vasa nervorum [31].

We found few reports about the influence of labor work groups on the recovery of the CPN. Compared with mental work groups, labor work groups maybe have a greater demand on blood supply or tibialis posterior muscle in labor work groups were stronger, so that limited recovery of CPN function could not confront the tibialis posterior muscle. We did not find studies on why patients living in city had poor neurological prognosis, which may be due to interaction of economy, nutritional status and environment. Both the two factors needed further investigation.

Our research found that high preoperative muscle strength, and postoperative knee joint immobilization decrease the risk of poor recovery of CPN injury. The prognosis of patients was better with higher preoperative muscle strength, because residual innervation could avoid muscle atrophy, thus enabling better recovery of reinnervation. Knee joint immobilization flexion position could avoid the repeated stimulation of swollen nerves, reduce the probability of vascular occlusion, and reduce the duration and degree of edema, which resulted in shortening the time and degree of ischemia.

Obesity seemed to have higher complication rates related to nerve surgery[32, 33]. however, obese patients with higher prevalence of neuro injuries did not have worse prognosis compared with normal patients[1]. We also found no difference of neuro recovery among patient with different BMI. The adverse effects of cigarette smoking was found on the functional recovery of peripheral nerves after ischemia/reperfusion injuries in rats[34]. Therefore, cigarette smoking was thought to have limited impaction on the recovery of nerve injuries[1], as we found in this study.

In multifactor logistic regression analysis, surgical methods had no effect on the prognosis of patients. The severity of nerve injuries and intraoperative findings determined the type of surgical methods, which decrease the relative efficacy of surgical approach[15].

To our knowledge, this study is the first to assess factors associated with injured CPN and establish a prediction model to predict the prognosis of injured CPN by using a nomogram. It is generally believed that the model with AUC of 0.50–0.75 is acceptable, and AUC > 0.75 indicates that the discrimination of model is prominent [35]. AUC of our prediction model is 0.904, so this nomogram can be used to predict the prognosis of injured CPN well. Our study was carried out in high-risk patients of poor prognosis, which

could improve the efficiency of model for risk factors. Besides, selected factors used to construct prediction model are relatively objective, which is helpful for further application of this model.

There are limitations of our study that are notable. First, this study was limited as a monocentric analysis. Although there are a lot of cases, we still need evidence from other centers to verify this model. In subsequent research work, therefore, we will persuade other medical center to join in this research project, and provide the corresponding clinical data for further evaluation and validation of the prediction model. Second, our cohort was limited to patients with injured CPN and requirement of surgical treatment.

## Conclusions

We found that city area, labor occupation, diabetes, cardiovascular disease, knee joint dislocation, proximal fibula fracture, tibial plateau fracture, vascular injury and hip arthroplasty injury are independent risk factors of motor functional recovery of CPN, while high preoperative muscle strength and postoperative knee joint immobilization are protective factor of motor functional recovery of CPN. The blood supply to the CPN is a significant factor worth paying more attention to for better neurological prognosis. The prediction nomogram can be used to predict the prognosis of injured CPN.

## Abbreviations

ALB: albumin; Apoa1: apolipoproteins A1; Apob: apolipoproteins B; AUC: area under the curve; BMI: body mass index; BMRC: British Medical Research Council; Ca: serum calcium; CI: Confidence intervals; CPN: Common peroneal nerve; Glu: blood glucose; HGB: hemoglobin; HDL-c: high-density lipoprotein cholesterol; K: serum potassium ion; LDL-c: low-density lipoprotein cholesterol; Mg: serum magnesium; Na: serum sodium; P: serum phosphorus; PLT: platelets; RBC: red blood cells; ROC: receiver operating characteristic; SD: standard deviation; TC: total cholesterol; TG: triglyceride; TP: total protein; WBC: white blood cells.

## Declaration

This study was approved by Institutional Review Board of the first affiliated hospital of Xinjiang Medical University. All the subjects signed the informed consent form.

### Consent for publication

All the authors are consent for publication.

### Availability of data and materials

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

### Competing interests

The authors declare no conflicts of interest.

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## Contributions

Zhenhui Liu: Lead author; Data collection, Data analysis, Software, Writing the manuscript, Final approval of the manuscript.

Maimaiaili·Yusan: Conceptualization, Writing the manuscript, Final approval of the manuscript.

Yanshi Liu: Data collection, Methodology, Writing the manuscript, Final approval of the manuscript.

Aihemaitijiang·Yusufu: Corresponding author; Performed surgeries, Conceptualization, Writing the manuscript, Final approval of the manuscript.

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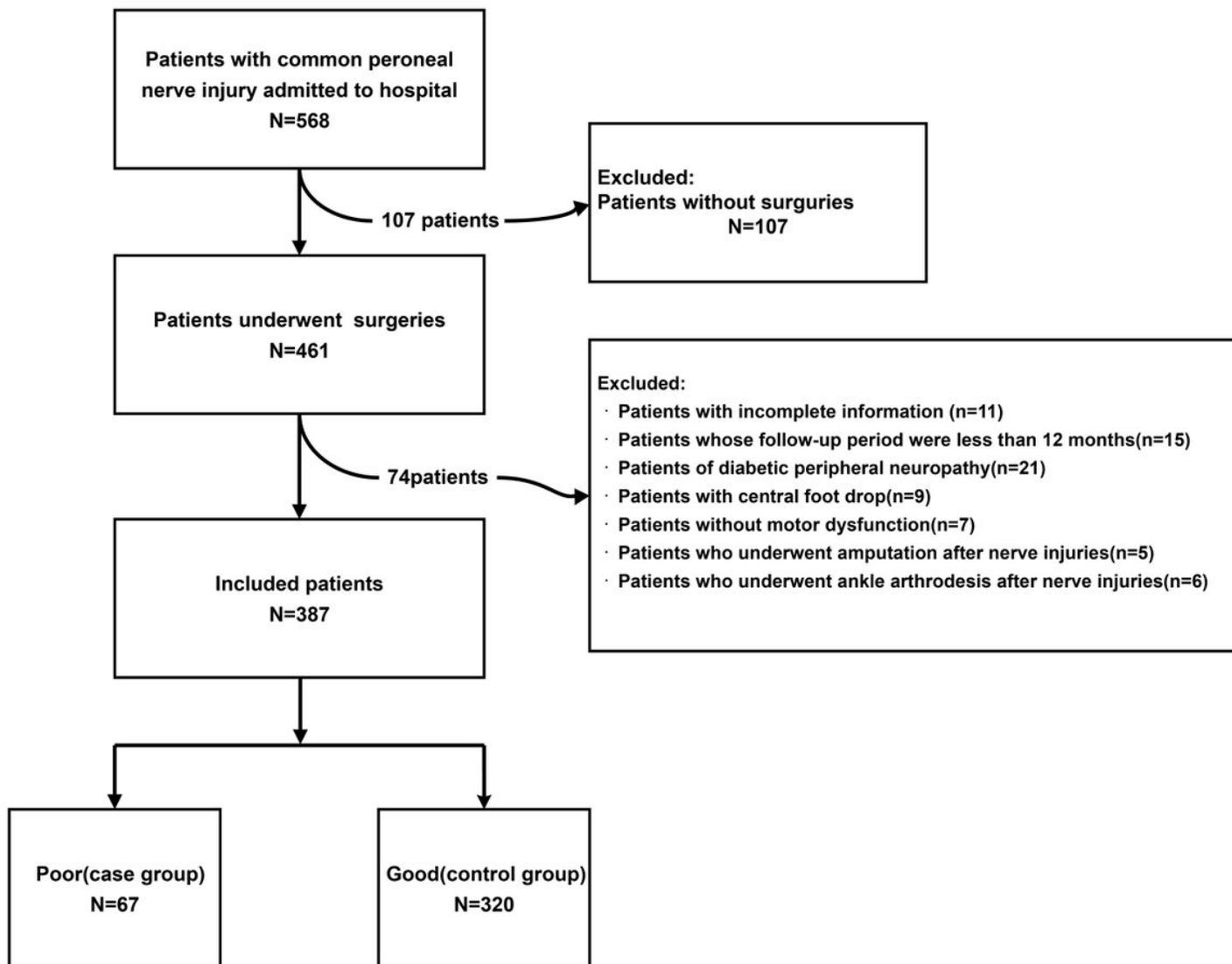
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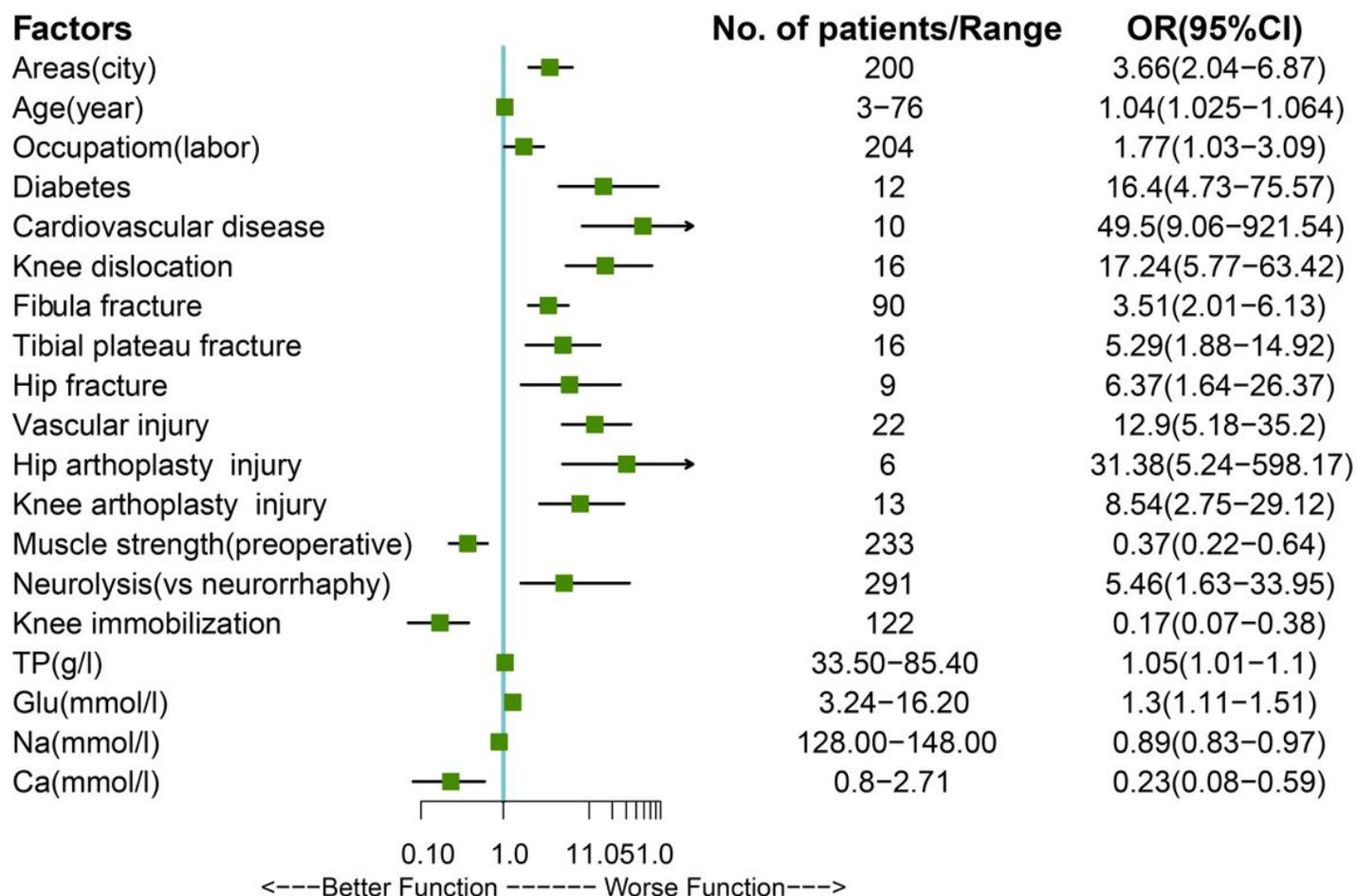
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## Figures



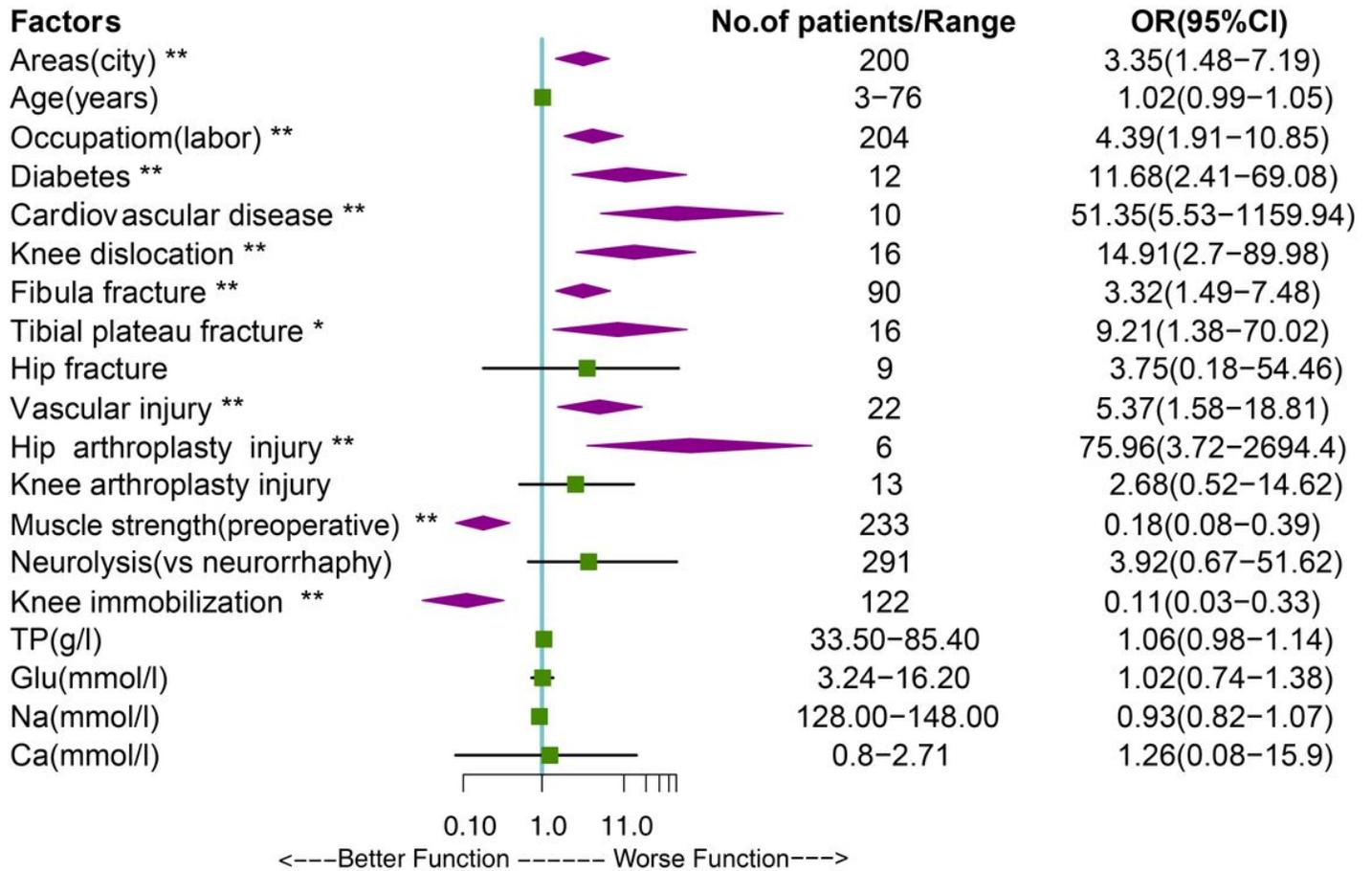
**Figure 1**

Flowchart of participants



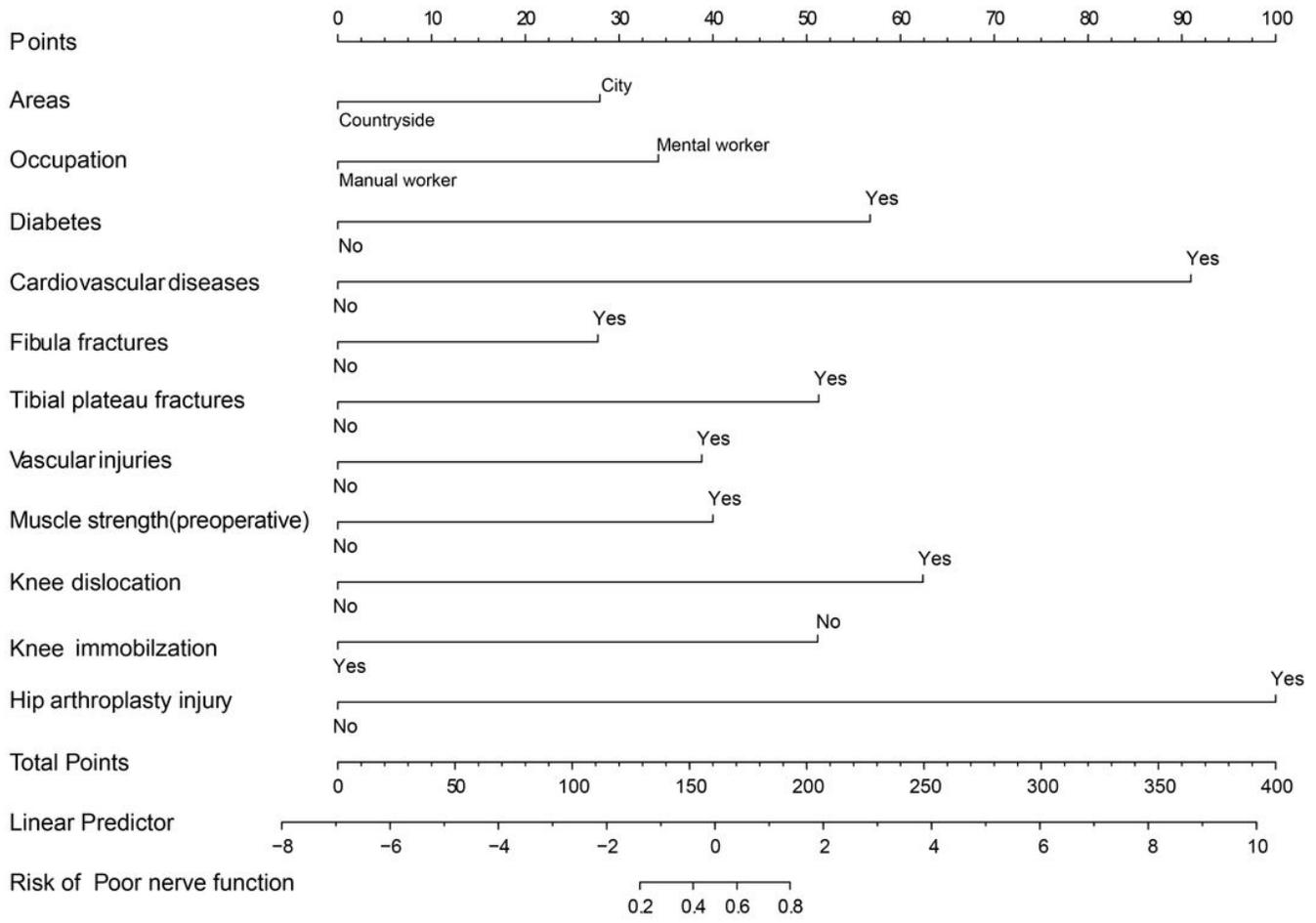
**Figure 2**

Results of univariate logistic regression analysis



**Figure 3**

Results of multivariate logistic regression analysis



**Figure 4**

Nomogram to predict the probability of poor nerve function in the patient with common peroneal

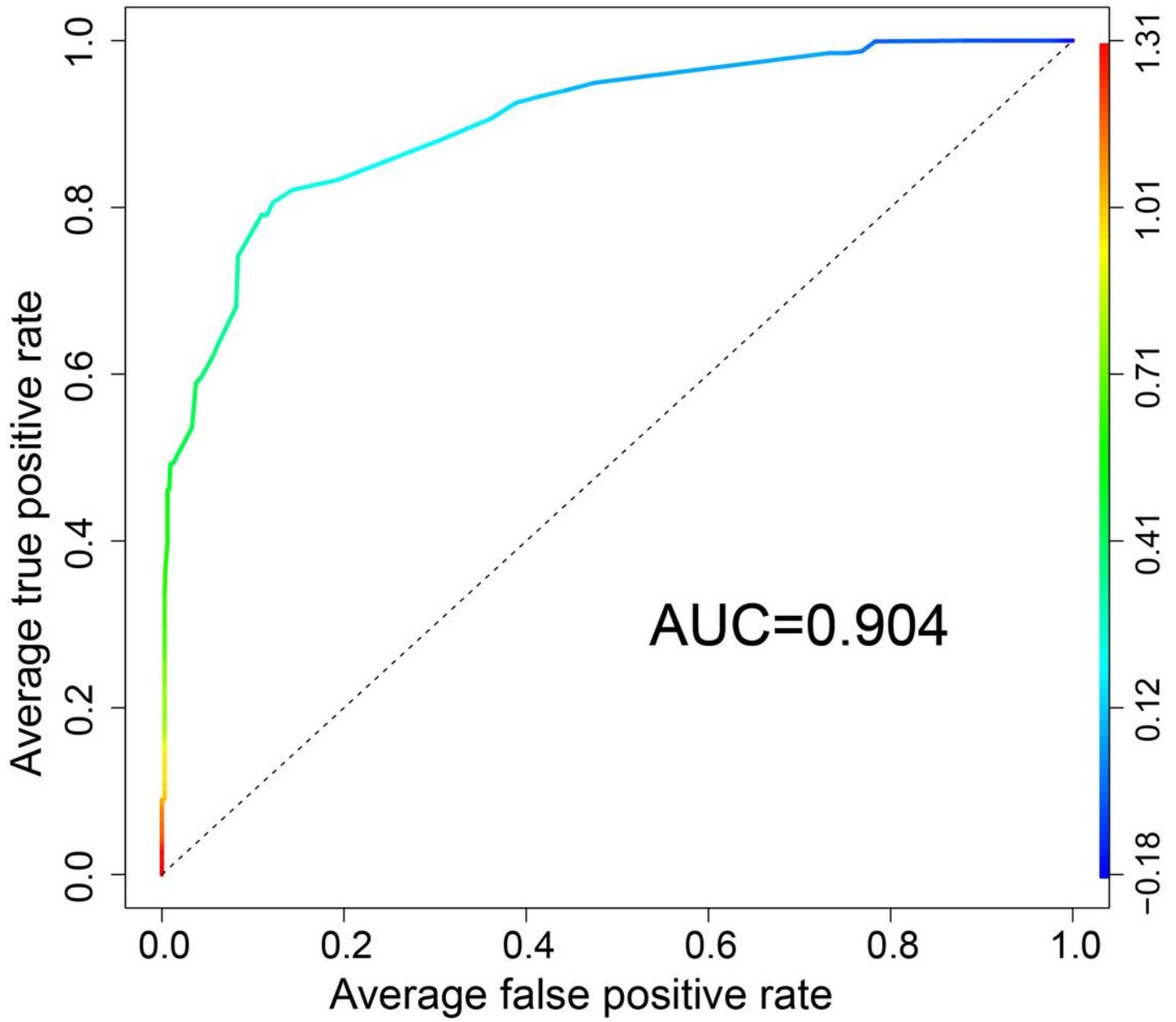


Figure 5

ROC curves for validating the discrimination power of the nomogram