

## ORIGINAL ARTICLE

# Correlation of Serum CAR with Postoperative Quality of Life and Hip Recovery in Elderly Patients with Intertrochanteric Fracture

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### SUMMARY

**Background:** Intertrochanteric fracture (ITF) is a common but devastating condition with high mortality in the elderly population. Early identification of high-risk patients to prevent poor prognosis is essential as treatment of postoperative adverse outcomes is complex. C-reactive protein (CRP)/albumin (ALB) ratio (CAR) is a predictor of prognosis in many diseases, but its correlation with postoperative prognosis in patients with ITF remains unclear.

**Methods:** One hundred and six elderly patients who underwent ITF surgery between May 2021 and May 2023 were retrospectively analyzed. Patients were evaluated based on postoperative Harris Score and SF-36 Score for good and poor recovery groups. CAR, ALB, and hemoglobin with statistically significant differences in univariate analysis were included in multifactorial logistic regression analysis to screen for independent influences. Predictive efficacy was analyzed using the ROC curve to obtain the area under the curve (AUC). Sample regression models were constructed to test whether there was a nonlinear relationship between ALB and CAR and the prognostic outcomes of patients with ITF. The correlation of ALB and CAR with Harris Score and SF-36 Score was analyzed by Pearson's correlation analysis.

**Results:** Elevated CAR (OR = 2.18,  $p = 0.00$ ) was an independent risk factor for poor recovery in patients with ITF, while ALB (OR = 0.90,  $p = 0.03$ ) was an independent protective factor against poor recovery. All CAR showed good predictive efficacy when the cutoff value took  $CAR > 1.79$ . In contrast, the predictive efficacy of ALB was low. Restricted cubic spline model and Pearson's correlation analysis showed a linear relationship between CAR, poor recovery in ITF patients, and a negative correlation with Harris Score and SF-36 Score.

**Conclusions:** Serum CAR is significantly associated with poor postoperative prognosis in elderly patients with ITF and may be an independent risk factor for postoperative quality of life and hip recovery.

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#### KEYWORDS

peripheral blood cell ratios, prognostic factors, decompensated cirrhosis, mortality

#### INTRODUCTION

Intertrochanteric fracture (ITF) is a form of femur fracture involving the lesser and greater trochanter. ITF occurs most often in the elderly with minor trauma such as falls. The 1-year postoperative mortality rate is 15.4% in elderly patients with ITF [1]. Surgery is the gold standard treatment for ITF. In elderly patients, however, degenerative body functions and hormonal insufficiency

result in a weakening of muscle protection functions and fragility of the hip. Elderly patients with ITF are at risk of postoperative fracture deformity healing or poor joint function recovery, which will reduce the effectiveness of the surgical treatment and negatively affect quality of life (QoL).

It has been found that inflammatory response and nutritional status have a significant impact on the prognostic outcomes of elderly patients with ITF after surgery, and the 1-year mortality rate of patients is associated with preoperative C-reactive protein (CRP) and albumin (ALB) levels [2]. CRP is involved in the body's immune response, and abnormally high levels are associated with trauma and inflammatory infections [3]. Many studies have reported a correlation between higher perioperative CRP levels and higher mortality in patients after hip fracture surgery [4,5]. However, some studies reported no such correlation [6,7]. There is no consensus on the correlation between CRP and ITF prognosis. ALB is a commonly used indicator for evaluating perioperative nutritional status. A decrease in its level may indicate poor nutrition, affect wound healing, increase the risk of postoperative complications such as incision, urinary and pulmonary infections, and affect the process of functional recovery [8]. CRP/ALB ratio (CAR) is an index that can comprehensively assess the patient's inflammatory and nutritional status, and has a reference value for the assessment of postoperative outcomes. Balta et al. concluded that CAR value can comprehensively reflect the patient's nutritional status and inflammatory response and can provide a reliable basis for the assessment of the condition and prognosis [9]. Capkin et al. confirmed that the  $CAR \geq 2.49$  has a predictive value for the death of elderly patients with hip fracture 1 year after surgery [10]. However, most of the current postoperative studies on elderly ITF patients focus on long-term outcomes, while relatively few studies have been conducted on postoperative short-term QoL and hip recovery.

In this study, we collected and analyzed the general clinical data and indicators of ITF patients for analysis to assess their efficacy in predicting postoperative QoL and poor hip recovery in ITF patients.

## MATERIALS AND METHODS

### Clinical sample collection

A total of 106 patients with ITF who underwent surgical treatment in The First Hospital of Lanzhou University from May 2021 to May 2023 were retrospectively collected and divided into the group with good recovery (Harris Score  $\geq 70$  points; SF-36 Score  $\geq 70$  points) and poor recovery group (Harris Score  $< 70$  points; SF-36 Score  $< 70$  points).

**Inclusion criteria:** 1) all ITF patients were diagnosed with ITF by physical examination and imaging (X-ray and CT); 2) all had been treated with closed reduction fixation and intramedullary nail; 3) all underwent sur-

gery within 48 h of the fracture; 4) ITF was caused by low-energy violence and unilateral; 5) the medical records and follow-up data were complete and the informed consent was signed; 6) all the patients were above 65 years of age.

**Exclusion criteria:** 1) patients with previous or pathological fractures, fractures secondary to osteoarticular tuberculosis/bone tumor, or cardiac, hepatic, or renal complications; 2) patients suffering from blood disorders, coagulation disorders, immune system disorders, or contraindications to surgery; 3) patients with other fractures; 4) patients undergoing other surgeries within the last six months; and 5) patients suffering from consciousness, communication, or mental disorders.

### Postoperative joint function and QoL

Six months after surgery, all patients were assessed for joint function and QoL. The Harris Score was a quantitative measure of postoperative joint function in all patients. The Harris Score consists of 12 entries, including pain, function, activity, deformity, and muscle strength, with a total score of 0 - 100, with higher scores indicating better joint function. A score of  $\geq 70$  is classified as excellent or good recovery, and  $< 70$  is classified as poor recovery [11].

The SF-36 scale assessed the QoL of all patients after surgery. The SF-36 scale consists of 36 entries, with 8 different dimensions for physical functioning (PF), role limitations due to physical health, body pain, general health, vitality, social functioning, role limitations due to emotional problems, and mental health. Each dimension of the SF-36 scale was scored using a transformed score, i.e., score = (actual score - theoretical minimum score)/(theoretical maximum score - theoretical minimum score), and the total score = the sum of scores for each dimension/8. The total score was 0 - 100, with higher scores indicating a better QoL [12].

### General information

By reviewing the hospital's electronic medical record system, information on patients' gender, age, time from fracture to surgery, comorbid underlying diseases (hypertension, diabetes mellitus, coronary artery disease), surgical modality (intramedullary fixation, total hip arthroplasty), surgical time, osteoporosis comorbidities, history of smoking, history of drinking, and fracture site were compiled and recorded. In addition, the fracture type (A1, A2, A3) was classified according to the AO/OTA classification [13].

### Laboratory indicators

After admission, 5 mL of venous blood was collected from all patients in the morning, and serum was collected by centrifugation (3,500 r/minute, 10 minutes). Hemoglobin (HGB), white blood cells, platelets, red blood cells, lymphocyte count, CRP and ALB levels were measured by a fully automated biochemical analyzer (Mindray, Shenzhen, China, model: 7500), and CAR was calculated. ALB, aspartate aminotransferase, ala-

Table 1. Comparison of the general clinical characteristics of the two groups of patients.

Characteristics	Good recovery (n = 72)	Poor recovery (n = 34)	p-value
Age (year)	71.59 ± 2.25	72.72 ± 4.37	0.08
Gender (male)	32 (44.44%)	16 (47.06%)	0.8
Time from fracture to surgery (hour)	3.71 ± 2.54	4.48 ± 1.79	0.12
Hypertension	26 (36.11%)	11 (32.35%)	0.7
Diabetes	21 (29.17%)	8 (23.53%)	0.54
Coronary heart disease	25 (34.72%)	12 (35.29%)	0.95
History of smoking	42 (58.33%)	19 (55.88%)	0.81
History of drinking	48 (66.67%)	22 (64.71%)	0.84
<b>Surgical time</b>			
< 3 hours	48 (66.67%)	20 (58.82%)	0.43
≥ 3 hours	24 (33.33%)	14 (41.18%)	
<b>Surgical modality</b>			
intramedullary fixation	45 (62.50%)	21 (61.76%)	0.94
THA	27 (37.50%)	13 (38.24%)	
<b>Osteoporosis comorbidity</b>			
Yes	51 (70.83%)	22 (64.71%)	0.52
No	21 (29.17%)	12 (35.29%)	
<b>Fractured side</b>			
Left	34 (47.22%)	15 (44.12%)	0.76
Right	38 (52.78%)	19 (55.88%)	
<b>AO classification of fracture</b>			
A1	20 (27.78%)	9 (26.47%)	0.91
A2	38 (52.78%)	21 (61.76%)	
A3	14 (19.44%)	7 (20.59%)	
HGB (g/L)	115.80 ± 8.21	111.50 ± 10.50	0.02
WBC (× 10 <sup>9</sup> /L)	6.32 ± 2.34	6.61 ± 1.41	0.51
PLT (× 10 <sup>9</sup> /L)	106.88 ± 10.43	107.06 ± 11.05	0.93
RBC (× 10 <sup>12</sup> /L)	3.79 ± 0.41	3.95 ± 0.79	0.17
Ly (× 10 <sup>9</sup> /L)	2.19 ± 0.45	2.17 ± 0.61	0.85
ALB (g/L)	36.08 ± 5.33	33.57 ± 4.46	0.02
AST (U/L)	42.97 ± 5.04	45.03 ± 6.11	0.07
ALT (U/L)	46.33 ± 5.04	46.18 ± 6.12	0.89
Cr (μmol/L)	46.55 ± 6.17	46.12 ± 5.82	0.73
CAR	2.02 ± 0.89	2.75 ± 1.05	0

Data were expressed as mean ± standard deviation or number of cases (%). Student's *t*-test was used for continuous variables and chi-squared test for qualitative data.  $p < 0.05$  indicated statistical difference.

THA total hip arthroplasty, HGB hemoglobin, WBC white blood cell, PLT platelet, RBC red blood cell, Ly lymphocyte count, ALB serum albumin, AST aspartate transaminase, ALT alanine aminotransferase, Cr creatinine, CAR C-reactive protein-albumin ratio.

nine aminotransferase, and creatinine were measured by enzyme immunoassay using a Beckman AU5800 instrument (Elabscience, Wuhan, China).

#### Statistical analyses

SPSS 26.0 was used for statistical analysis. Measures were tested for normality, and those that met the normal distribution were expressed as mean ± standard deviation, and Student's *t*-test was used for comparison be-

**Table 2. Multifactorial logistic regression modelling to analyze risk factors affecting postoperative quality of life and hip recovery in ITF patients.**

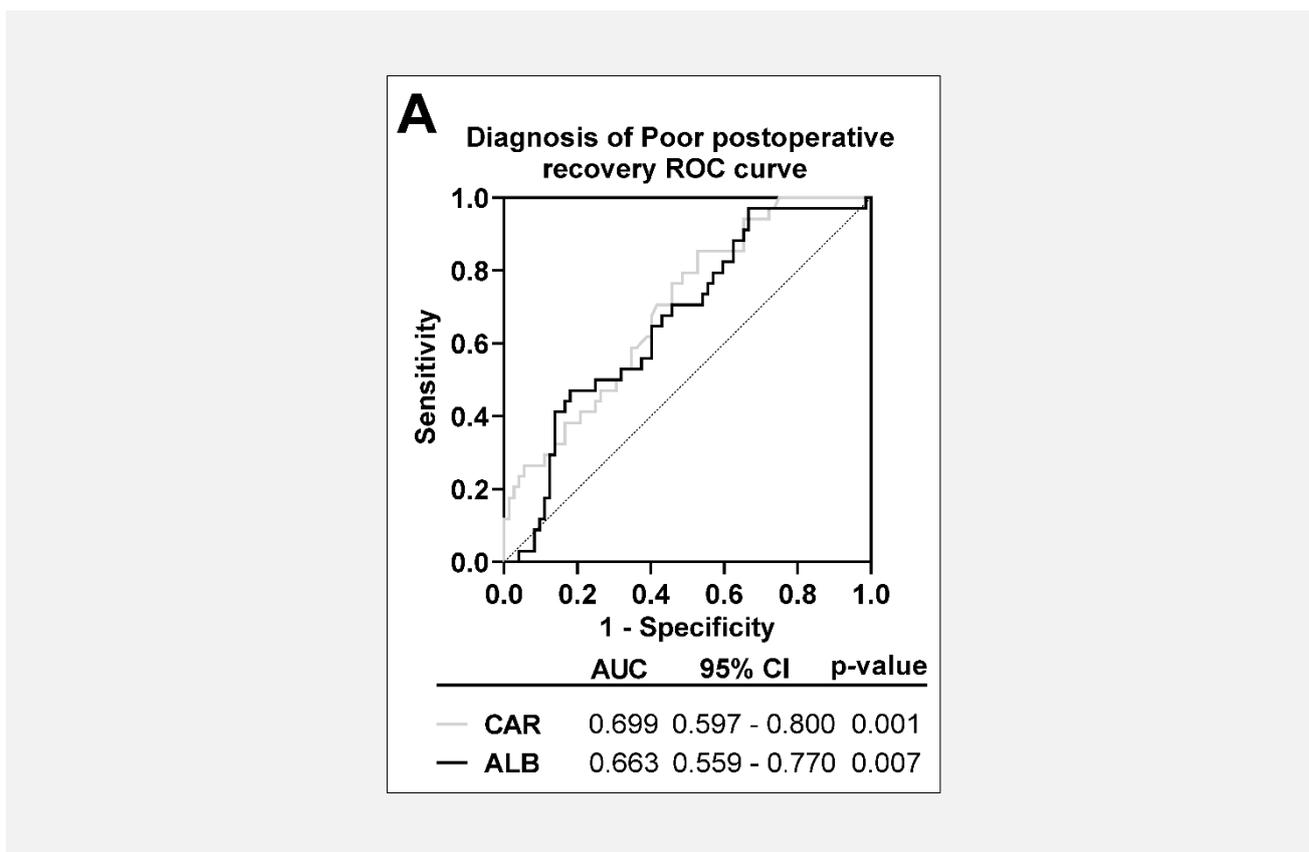
Indices	OR	95% CI	p-value
HGB	0.95	0.91 - 1.00	0.07
ALB	0.9	0.82 - 0.99	0.03
CAR	2.18	1.35 - 3.35	0

HGB hemoglobin, ALB serum albumin, CAR C-reactive protein-albumin ratio, OR odds ratio, CI confidence interval.  $p < 0.05$ .

**Table 3. Predictive value of ALB and CAR for postoperative quality of life and hip recovery in patients with ITF.**

Indices	Cutoff	Youden index	Sensitivity (%)	Specificity (%)
ALB (g/L)	39.43	0.3	97.06	33.33
CAR	1.79	0.33	85.29	47.22

ALB serum albumin, CAR C-reactive protein-albumin ratio.



**Figure 1. ROC curves to assess the predictive efficacy of CAR and ALB for poor recovery in ITF patients.  $p < 0.05$ .**

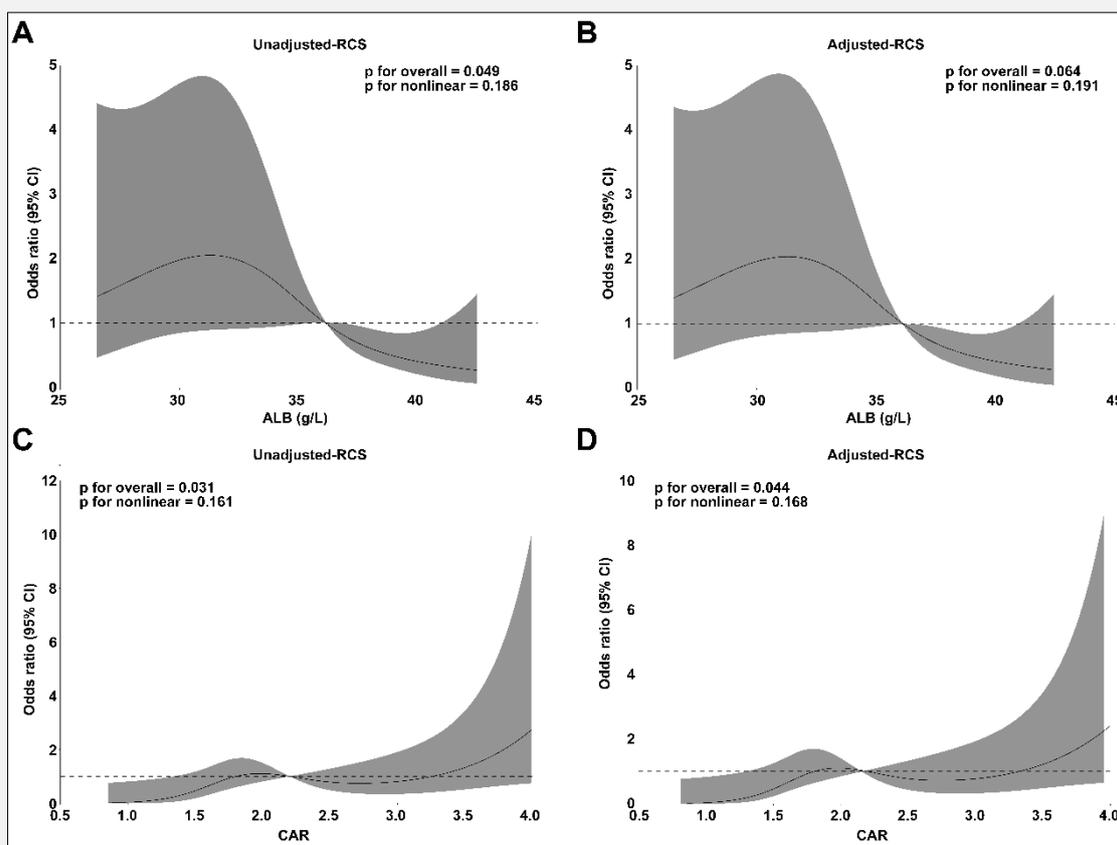


Figure 2. Restricted cubic spline model describing the risk of poor recovery for CAR and ALB in ITF patients.  $p < 0.05$ .

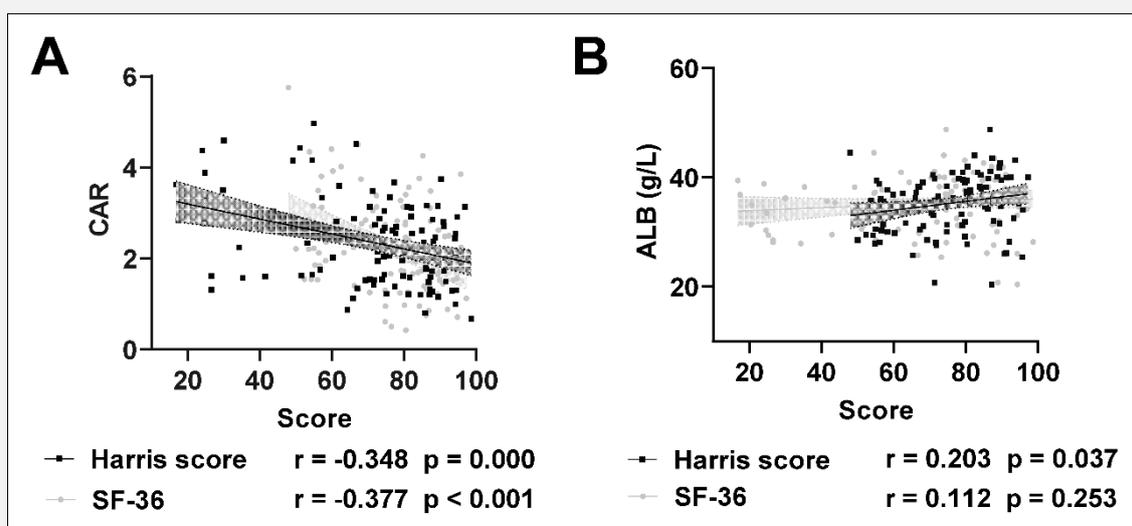


Figure 3. Pearson's analysis of the correlation between CAR and ALB with postoperative QoL and hip recovery.  $p < 0.05$ .

tween two groups. Non-normal distribution was expressed as median and interquartile spacing  $M$  ( $Q_{25} \sim Q_{75}$ ), and comparisons between groups were made using Wilcoxon signed rank sum test. The chi-squared test was performed for count data. Independent variables with statistically significant differences in univariate analysis were included in multifactorial logistic regression analyses to screen for independent influences. Predictive efficacy was analyzed using receiver operating characteristic (ROC) curve analysis to obtain area under the curve (AUC), confidence intervals, sensitivity, specificity, and cutoff values. A spline regression model was constructed to examine whether there was a nonlinear relationship between ALB and CAR and the prognostic outcomes of ITF patients. The correlation between ALB and CAR and Harris Score and SF-36 Score was analyzed by Pearson's correlation coefficient.  $p < 0.05$  was considered significant.

## RESULTS

### General Clinical Characteristics

All enrolled patients underwent examinations such as imaging tests (X-ray and CT) and were divided into a good recovery group ( $n = 72$ ) and a poor recovery group ( $n = 34$ ) based on the Harris and SF-36 Scores. The probability of poor recovery among ITF patients was 32.08%. The clinicopathological characteristics of all subjects are shown in Table 1. There was no significant difference in age between the two groups ( $p > 0.05$ ). Patients in the good recovery group ranged in age from 69 - 73 with a mean age of  $(71.59 \pm 2.25)$  years. Patients in the poor recovery group aged 68 - 77 with a mean age of  $(72.72 \pm 4.37)$  years. No significant differences were found between the two groups in terms of surgical time, past medical history, surgical modality, and routine blood tests (AST, ALT, WBC, etc.) ( $p > 0.05$ ). Notably, CAR values were significantly higher in the poor recovery group than in the good recovery group, while HGB and ALB levels were significantly lower than in the good recovery group ( $p < 0.05$ ).

### Multifactorial logistic regression analyses of independent factors influencing poor recovery in ITF patients

A multifactorial logistic regression model was established using the factors analyzed with differences in Table 1 ( $p < 0.05$ ) as independent variables, whereas CAR, HGB, and ALB as dependent variables. Elevated CAR (OR = 2.18,  $p = 0.00$ ) was an independent risk factor for poor recovery in patients with ITF, while ALB (OR = 0.90,  $p = 0.03$ ) was an independent protective factor for poor recovery. HGB (OR = 0.95,  $p = 0.07$ ) was not an independent influence on poor recovery in patients (Table 2).

### ROC curve results of CAR and ALB in predicting poor recovery of ITF patients

To further explore the predictive efficacy of CAR and ALB for poor recovery of ITF patients, ROC curves were plotted with poor recovery group as positive sample and good recovery group as negative sample. Both CAR showed good predictive efficacy. The AUC of CAR was 0.699 (95% CI = 0.597 - 0.800,  $p = 0.001$ ), the sensitivity to predict poor recovery of ITF patients was 85.29%, and the specificity was 47.22% when the cutoff value was taken as  $CAR > 1.79$ . The predictive efficacy of ALB was relatively weak. The AUC of ALB was 0.663 (95% CI = 0.597 - 0.800,  $p = 0.007$ ), the sensitivity of poor recovery was 97.06% and the specificity was 33.33% when the cutoff value was taken to be  $ALB < 39.43$  g/L (Table 3, Figure 1).

### Correlation analysis of CAR and ALB with postoperative QoL and hip recovery outcomes of ITF patients

A restricted cubic spline model was used to describe the risk of poor recovery in patients. After adjusting for the confounder HGB, there was a linear relationship between CAR ( $p_{\text{for nonlinear}} = 0.168$ ) and ALB ( $p_{\text{for nonlinear}} = 0.191$ ) and poor recovery in ITF patients. Notably, CAR ( $p_{\text{for overall}} = 0.044$ ) correlated with poor recovery in ITF patients, whereas ALB ( $p_{\text{for overall}} = 0.064$ ) did not correlate with poor recovery. Pearson's correlation was used to further analyze the correlation of CAR and ALB with postoperative QoL and hip recovery. There was a negative correlation between patient CAR and Harris Score ( $r = -0.348$ ,  $p = 0.000$ ) and SF-36 Score ( $r = -0.377$ ,  $p < 0.01$ ), a positive correlation between ALB and Harris Score ( $r = 0.203$ ,  $p = 0.037$ ), and no correlation between ALB and SF-36 Score ( $r = 0.112$ ,  $p = 0.253$ ) (Figures 2, 3).

## DISCUSSION

Most clinical practice assessment of postoperative prognosis for ITF is based on imaging techniques, which, while highly accurate, can be detected after poor prognosis has already occurred, preventing clinical interventions. Therefore, it would be helpful to find independent influencing factors with good predictive efficacy. In this study, both CAR and ALB had predictive efficacy for poor recovery in ITF patients. After adjusting for the confounding factor HGB, CAR was negatively correlated with Harris Score and SF-36 Score, and ALB was positively correlated with Harris Score but not with SF-36 Score. These results suggest that CAR may be an independent risk factor in ITF and a useful biomarker for surgical prognosis.

The SF-36 is a comprehensive health assessment. It is widely recognized for its reliability and validity in measuring QoL. The SF-36 measures a wide variety of aspects of health status and is widely used to measure QoL for patients with rheumatic diseases and evaluate

medication efficacy [14]. The Harris Score is a reliable and validated tool for hip pathologies, used as a self-perception tool [15]. A study conducted by Hoeksma et al. demonstrated the high sensitivity and specificity of the Harris Score in patients with osteoarthritis [16]. The Harris Score demonstrates high sensitivity in assessing gait, pain, and functional speed compared to other self-report tools.

Serum ALB level is often used to assess the preoperative and postoperative nutrition of perioperative patients. Malnutrition significantly contributes to incision infections, extended hospital stays, and increased mortality in postoperative hip fracture patients. Malnutrition of patients can not only lead to delayed bone healing, surgical site infection, and impaired functional recovery, but also affect the recovery of limb function to the level before fracture [17]. Reports on the relationship between postoperative recovery and CRP levels in hip fractures are controversial. Beloosesky et al. concluded that there was no association between preoperative and postoperative CRP levels and 6-month mortality in elderly patients undergoing hip fracture surgery [18]. The same opinion was reached in a retrospective study by Niessen et al. [6]. Whereas, there is also a considerable number of studies suggesting that elevated CRP is an independent risk factor for postoperative mortality in elderly patients with hip fracture. High preoperative CRP levels have a significant impact on mortality in elderly patients with hip fracture after surgery or femoral neck fracture [19,20]. In our study, we detected a good predictive efficacy of preoperative CAR in patients associated with poor prognosis at 6 months postoperatively in ITF patients. As a risk factor for predicting surgical prognosis in patients with ITF, CAR values have several advantages as well. CRP and ALB values can be easily obtained by laboratory tests during the re-diagnosis process. Furthermore, CRP and ALB values can be obtained earlier in the diagnostic process to help identify the patient earlier.

In this study, ALB was found to be an independent risk factor for poor recovery in ITF patients, with good predictive efficacy, and positively correlated with Harris scores in ITF patients. ALB is a major protein in human plasma and is involved in the transport of nutrients required for bone formation, such as amino acids, calcium, and phosphorus [21]. ITF patients with low levels of ALB experience slow bone healing at the fracture end and poor bone matrix construction, which affects joint function recovery [22]. An abnormally low ALB level indicates that the body's immunity is declining, making it more susceptible to external pathogenic bacteria at this time and triggering postoperative wound infections, pneumonia, and urinary tract infections, which in turn slows down the quality of the fracture recovery and increases the risk of poor prognosis. ALB is involved in maintaining the stability of plasma colloid osmotic pressure. When the level of ALB is reduced, the postoperative edema is aggravated, which promotes the slow recovery of blood supply at the fracture end and

increases the possibility of poor prognosis [23]. However, it was evident in our study that CAR had a significantly better predictive ability than ALB for poor recovery in ITF patients, with a stronger correlation with postoperative QoL and hip function recovery. Therefore, the use of CAR is a more comprehensive predictor of postoperative QoL and hip function recovery than ALB alone.

Some limitations are associated with this study, such as limited sample size and follow-up period. Additionally, only one instrument was used to assess QoL and hip recovery, which may need to be expanded in future studies to be most accurate. Another limitation of this study is the lack of sample size and insufficient quality, resulting in the inability to perform further complex statistical analyses, including the development of predictive models.

## CONCLUSION

In conclusion, preoperative CAR is significantly associated with poor postoperative prognosis in elderly patients with ITF. Thus, it may be an independent risk factor for postoperative QoL and hip recovery. Since early screening of patients at high risk for possible poor postoperative outcome is essential to improve surgical prognosis, the preoperative CAR may serve as a valuable biomarker of clinical outcome in elderly patients undergoing surgery for ITF.

### Data Availability:

Data is available from the corresponding author on request.

### Ethics Statement:

The present study was approved by the Ethics Committee of The First Hospital of Lanzhou University (No. 202101LZ-21) and written informed consent was provided by all patients prior to the study start. All procedures were performed in accordance with the ethical standards of the Institutional Review Board and The Declaration of Helsinki, and its later amendments or comparable ethical standards.

### Declaration of Interest:

The authors have no conflicts of interest to declare.

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