Preoperative malnutrition as an independent risk factor for the postoperative mortality in elderly Chinese individuals undergoing hip surgery: a single-center observational study

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Abstract
Objectives: Malnutrition is prevalent in elderly with hip fracture and higher than in community-dwelling older adults. Scarce studies have examined the association between preoperative malnutrition and postoperative mortality in elderly Chinese individuals with hip fracture. This study was designed to explore the effect of preoperative malnutrition on the postoperative long-term mortality in elderly Chinese individuals undergoing hip surgery.

Methods: As a single-center observational study, this study included 263 consecutive patients above 70 years old with hip fracture and elective surgery. Preoperative nutritional status was evaluated by prognostic nutritional index (PNI). Patients were divided into one group with malnutrition (26 patients with PNI ≤ 38) and the other group without malnutrition (169 patients with PNI > 38), respectively.

Results: The overall malnutrition rate was 13.3% (26 patients). The postoperative long-term mortality rates of patients with and without malnutrition had statistically significant difference [10 patients (38.5%) and 32 patients (18.9%), p < 0.05]. Cox regression analysis showed that malnutrition (hazard ratio: 0.269, 95% confidence interval: 0.085–0.859, p < 0.05) and partial pressure of carbon dioxide (hazard ratio: 0.873, 95% confidence interval: 0.790–0.964, p < 0.05) were independent risk factors for the postoperative long-term mortality.

Conclusion: This study demonstrated that preoperative malnutrition was an independent risk factor for the postoperative long-term mortality and resulted in a more than 2.5-fold increase of the postoperative long-term mortality in elderly Chinese individuals undergoing hip surgery.

Keywords: Chinese elderly, hip fracture, malnutrition, mortality

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Introduction
Studies predict that greater than 3.9 million fractures will occur annually by 2050.1 Hip fractures represent a significant health risk for elderly populations because the prevalence of fractures increases notably with age.2,3 High residual disability, morbidity, and mortality rates will lead to considerable health and economic consequences for patients and families worldwide.3,4 Malnutrition is prevalent in elderly patients with hip fracture and higher than in community-dwelling elderly adults.5 Elderly patients with hip fracture present an inadequate nutrient intake for their requirements, which causes the deterioration in their already compromised nutritional status.2 A great number of studies indicated that the association between malnutrition and function increased health care spending, induced comorbidity and rehospitalization, and caused high mortality rate.6–8 The guidelines of the European Society of Parenteral and Enteral Nutrition recommend that all elderly patients with hip fracture should receive...
nutritional supplementation during hospitalization. Early nutritional intervention and effective malnutrition prevention can improve functional recovery following hip fracture in elderly populations. shows that decreased serum albumin level and total lymphocyte count were important risk factors for predicting 1-year mortality in elderly patients with fracture. However, scarce studies have been performed to examine the association between preoperative malnutrition and postoperative mortality in elderly Chinese individuals with hip fracture. Therefore, this study was designed to explore the effect of preoperative malnutrition on the postoperative long-term mortality in elderly Chinese individuals undergoing hip surgery.

Methods
This study included 263 consecutive patients above 70 years old with hip fracture and elective surgery in Hainan Hospital of Chinese People’s Liberation Army General Hospital from 1 January 2012 to 31 December 2018. It was a single-center observational study. Exclusion criteria for this study were multiple fractures, conservation treatment, and incomplete information (Figure 1(a)). Preoperative nutritional status was evaluated by prognostic nutritional index (PNI). PNI was calculated using the following formula: \( 10 \times \text{serum albumin (g/dl)} + 0.005 \times \text{total lymphocyte count (mm}^3) \). Patients were divided into one group with malnutrition (26 patients with PNI \( \leq 38 \)) and the other group without malnutrition (169 patients with PNI > 38), respectively.

All data included demographic characteristics, comorbidities (including hypertension, diabetes, coronary artery disease, arrhythmia, cerebral infarction, deep vein thrombosis, Parkinson’s disease, anemia, pulmonary disease, osteoporosis, and operation history), type of operation, type of anesthesia, American Society of Anesthesiologists classification, injury to operation time, inhospital to operation time, operation time, inhospital time, blood loss, transfusion, hospital costs, albumin, hemoglobin, erythrocyte sedimentation rate (ESR), blood-gas analysis, and ejection fraction. Anemia was defined as hemoglobin below 120 g/dl in males and 110 g/dl in females. Modified frailty index was calculated based on medical history and physical examination, with increasing scores indicating higher levels of frailty.

The primary endpoint of this study was survival status and time from discharge to follow-up. Follow-up of the patient’s survival status was performed by two rounds of telephone. Patients or their immediate family members were called by telephone. The second follow-up was primarily for patients who did not answer the phone at first and those with wrong and empty telephone numbers, refusal to answer the call, and out of the service area. The deadline for follow-up was 8 August 2020, and the mean follow-up was 1339 ± 610 days.

Statistical analysis
Data were described using means and standard deviations (continuous variables with normal distributions), medians and interquartile ranges (continuous variables with skewed distributions), and numbers and percentages (categorical variables). Characteristic comparison between groups was performed using Student’s t tests for continuous variables with normal distributions, Mann–Whitney U tests for continuous variables with skewed distributions, and chi-square tests for categorical variables. Cox regression was applied to detect risk factors independently affecting the postoperative long-term mortality. Hazard ratio was displayed with 95% confidence interval. A two-tailed \( p < 0.05 \) was regarded as statistically significant. All data were analyzed using the Statistical Package for Social Sciences (SPSS) version 19.0 (SPSS Inc., Chicago, IL, USA).

Results
All patients had a median age of 78, ranging from 70 to 90 years. The total number of deaths was 42 (21.5%), and the number of survivors was 153 (78.5%). The overall malnutrition rate was 13.3% (26 patients). The postoperative long-term mortality rates of patients with and without malnutrition had statistically significant difference [10 patients (38.5%) and 32 patients (18.9%), \( p < 0.05 \)]. Proportion of anemia, general anesthesia, general + regional anesthesia, and levels of albumin, hemoglobin, ESR, potential of hydrogen (PH), and partial pressure of carbon dioxide (PCO\(_2\)) had statistically significant difference between patients with and without malnutrition (\( p < 0.05 \) for all). Proportion of hypertension, blood loss, and partial pressure of oxygen (PO\(_2\)) had moderate difference between patients with and without malnutrition (Table 1).
Figure 1. (a) Patient number and exclusion criteria in this study. (b) Survival curves of patients with and without malnutrition.
Table 1. Characteristics of patients with and without malnutrition.

| Characteristics                                      | Total (n = 195) | With malnutrition (n = 26) | Without malnutrition (n = 169) | p   |
|------------------------------------------------------|-----------------|---------------------------|--------------------------------|-----|
| Age (years)\(^a\)                                    | 78 [74.82]      | 78 [76.81]                | 78 [74.83]                     | 0.752 |
| Males, n [%]                                         | 51 [21.2]       | 9 [34.6]                  | 42 [24.9]                      | 0.300 |
| BMI (kg/m\(^2\)\(^a\))                              | 23.0 [20.3, 25.9]| 22.6 [20.1, 27.2]         | 23.1 [20.3, 25.9]              | 0.861 |
| Comorbidities, n [%]                                 |                 |                           |                                |     |
| Hypertension                                         | 96 [49.2]       | 9 [34.6]                  | 87 [51.5]                      | 0.109 |
| Diabetes                                             | 49 [25.1]       | 7 [26.9]                  | 42 [24.9]                      | 0.821 |
| Coronary artery disease                              | 36 [18.5]       | 4 [15.4]                  | 32 [18.9]                      | 0.791 |
| Arrhythmia                                           | 41 [21.0]       | 7 [26.9]                  | 34 [20.1]                      | 0.428 |
| Cerebral infarction                                  | 37 [19.0]       | 7 [26.9]                  | 30 [17.8]                      | 0.267 |
| Deep vein thrombosis                                 | 13 [6.7]        | 2 [7.7]                   | 11 [6.5]                       | 0.686 |
| Parkinsons disease                                   | 3 [1.5]         | 0 [0.0]                   | 3 [1.8]                        | 1.000 |
| Anemia                                               | 82 [42.1]       | 18 [69.2]                 | 64 [37.9]                      | 0.003 |
| Pulmonary disease                                    | 22 [11.3]       | 4 [15.4]                  | 18 [10.7]                      | 0.504 |
| Osteoporosis                                         | 2 [1.0]         | 0 [0.0]                   | 2 [1.2]                        | 1.000 |
| Operation history, n [%]                             | 15 [7.7]        | 3 [11.5]                  | 12 [7.1]                       | 0.428 |
| Type of operation, n [%]                             |                 |                           |                                |     |
| Hip replacement                                      | 22 [11.3]       | 1 [3.8]                   | 21 [12.4]                      | 0.319 |
| Femoral head replacement                             | 72 [36.9]       | 10 [38.5]                 | 62 [36.7]                      | 0.861 |
| Bone nail                                            | 100 [51.3]      | 15 [57.7]                 | 85 [50.3]                      | 0.482 |
| Type of anesthesia, n [%]                            |                 |                           |                                |     |
| General anesthesia                                   | 40 [20.5]       | 11 [42.3]                 | 29 [17.2]                      | 0.003 |
| Epidural anesthesia                                  | 14 [7.2]        | 2 [7.7]                   | 12 [7.1]                       | 1.000 |
| Regional anesthesia                                  | 111 [56.9]      | 13 [50.0]                 | 98 [58.0]                      | 0.444 |
| General + regional anesthesia                        | 29 [14.9]       | 0 [0.0]                   | 29 [17.2]                      | 0.017 |
| ASA classification\(^a\)                             | 3 [2.3]         | 3 [2.3]                   | 3 [2.3]                        | 0.771 |
| Injury to operation time (day)\(^a\)                | 8.5 [6.0, 12.0]  | 9.0 [5.5, 12.0]           | 8.0 [6.0, 12.0]                | 0.950 |
| Inhospital to operation time (day)\(^a\)            | 6.0 [4.0, 9.0]  | 6.0 [4.0, 9.0]            | 6.0 [4.0, 9.0]                 | 0.950 |
| Operation time (min)\(^a\)                          | 86 [67, 117]    | 80 [58, 118]              | 88 [68, 118]                   | 0.417 |
| Inhospital time (day)\(^a\)                         | 15 [12, 20]     | 15 [11, 20]               | 16 [13, 20]                    | 0.559 |
| Blood loss (ml)\(^a\)                               | 200 [100, 300]  | 150 [50, 300]             | 200 [150, 300]                 | 0.111 |

(Continued)
As shown in Table 2, Cox regression analysis showed that malnutrition (hazard ratio: 0.269, 95% confidence interval: 0.085–0.859, \( p < 0.05 \)) and PCO\(_2\) (hazard ratio: 0.873, 95% confidence interval: 0.790–0.964, \( p < 0.05 \)) were independent risk factors for the postoperative long-term mortality. Age, gender, hypertension, anemia, general anesthesia, general + regional anesthesia, blood loss, and levels of ESR, PH, PO\(_2\), and PCO\(_2\) had no significant associations with the postoperative long-term mortality (\( p > 0.05 \) for all).

Survival curves of patients with and without malnutrition are shown in Figure 1(b).

**Discussion**

This study indicated that the postoperative long-term mortality had obviously significant difference between patients with and without malnutrition, and PNI was an independent risk factor for the postoperative long-term mortality in elderly Chinese individuals undergoing hip surgery. Lu et al.\(^{11}\) and Symeonidis and Clark\(^{18}\) also showed that serum albumin levels and total lymphocyte count represented independent prognostic factors in patients with hip fracture. PNI aims to assess nutritional status of surgical patients.\(^{19}\) However, previous study\(^{17}\) did not indicate that PNI is correlated with 1-year survival in elderly patients after hip fracture surgery. It may be related to the study sample size of 80 cases and the mortality of 1 year after operation. The sample size of this study was twice that of its sample size, and the average follow-up time was 1339 ± 610 days. Recent studies also showed that patients with femoral fracture needed nutritional evaluation and nutritional intervention, and PNI at admission may be a good nutritional evaluation index.\(^{20}\) Furthermore, studies using other tools such as Mini-Nutritional Assessment (MNA) and Modified Vulnerability Index also proved that malnutrition in elderly patients with hip fracture was closely related to their mortality.\(^{21–23}\)

Malnutrition is a risk factor for the poor postoperative outcome.\(^{24,25}\) However, malnutrition is acknowledged as underrecognized and undertreated in health care.\(^{26}\) One study found that more than half of the patients with hip fracture had a poor nutritional status.\(^{27,28}\) Previous studies showed that malnutrition was associated with an increased mortality rate of inhospital patients,
which could also lead to 1-year mortality rates of up to 50–70% after hip fracture.\textsuperscript{29,30} In addition, Bell \textit{et al}.\textsuperscript{31} indicated that malnutrition was an independent predictor of 1-year mortality in a representative sample of inpatients with hip fracture. There was significant difference in the postoperative long-term mortality rates of patients with and without malnutrition in this study. Therefore, it should be prioritized for clinical doctors to perform effective strategies in identifying and treating malnutrition in patients with hip fracture.\textsuperscript{32}

Typically, food intake is reduced in elderly individuals, leading to prevalent malnutrition.\textsuperscript{33} It is well known that calorie and protein deficits can contribute to the pathophysiology of fracture. The specific mechanism may be connected with reduced muscle mass and bone mineral, which reduces the resistance of bones to trauma and increases the risk of fracture.\textsuperscript{34} A systematic review recommended that oral supplements with protein, vitamins, and minerals before or soon after surgery may prevent potential complications after hip fracture in elderly people but may not affect long-term mortality.\textsuperscript{15} Furthermore, an evidence-based study indicated that hip fracture was a complex syndrome representing the culmination of susceptibility to fracture combined with a heightened injurious fall risk. Nutrition problems may be one of the most important factors for the prevention of hip fracture.

This study had some limitations. First, this study did not take weight loss, psychological factors, physical activity, and calcium and vitamin D supplementation of patients into consideration. These factors may have certain effects on postoperative mortality and need to be observed through further study in elderly Chinese individuals undergoing hip surgery. Second, this study had no enough data to support the assessment of MNA and Global Leadership Initiative on Malnutrition (GLIM) and the analyses of anaesthesiology management. Our results will be more comprehensive and credible if they could be used to assess nutritional and perioperative status. Third, this study lacked a calculation (power analysis) and justification of sample size.

**Conclusion**

This study demonstrated that preoperative malnutrition was an independent risk factor for the postoperative long-term mortality and resulted in a more than 2.5-fold increase in the postoperative long-term mortality in elderly Chinese individuals undergoing hip surgery. All these underlined in

### Table 2. Multivariate Cox regression analysis.

| Characteristics                          | Hazard ratio | 95% confidence interval | p    |
|------------------------------------------|--------------|-------------------------|------|
| Malnutrition                             | 0.269        | 0.085–0.859             | 0.027 |
| Age                                      | 1.068        | 0.970–1.176             | 0.178 |
| Gender                                   | 0.785        | 0.284–2.166             | 0.640 |
| Hypertension                             | 1.165        | 0.482–2.814             | 0.735 |
| Anemia                                   | 1.211        | 0.487–3.014             | 0.680 |
| General anesthesia                       | 0.688        | 0.182–2.602             | 0.582 |
| General + regional anesthesia            | 0.823        | 0.159–4.268             | 0.817 |
| Blood loss                               | 0.999        | 0.998–1.001             | 0.575 |
| Erythrocyte sedimentation rate           | 1.002        | 0.978–1.026             | 0.879 |
| Potential of hydrogen                    | 0.001        | 0.000–21.654            | 0.177 |
| Partial pressure of oxygen               | 0.994        | 0.972–1.017             | 0.606 |
| Partial pressure of carbon dioxide       | 0.873        | 0.790–0.964             | 0.007 |
such patients that preoperative nutritional status significantly affects long-term prognosis, making nutritional supplement essential in clinical practice.

**Ethics approval and consent to participate**
This study was conducted in accordance with the Declaration of Helsinki and approved by the Medical Ethics Committee of Chinese People’s Liberation Army General Hospital (301HNFY41). All participants provided written informed consent before participating in the study.

**Consent for publication**
Not applicable.

**Author contributions**
- **Long Feng**: Data curation; Formal analysis; Software; Visualization; Writing – original draft.
- **Wenji Chen**: Investigation; Methodology; Project administration; Resources.
- **Ping Ping**: Conceptualization; Methodology; Resources; Software; Validation; Visualization.
- **Tao Ma**: Data curation; Methodology.
- **Longhe Xu**: Data curation; Methodology; Supervision; Writing – review & editing.
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**Availability of data and materials**
The data sets used and/or analyzed during the current study are not publicity available. All data are available from the corresponding author upon reasonable request.

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