Original Research

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

Long Feng*, Wenji Chen*, Ping Ping*, Tao Ma*, Yang Li*, Longhe Xu, Zeguo Feng, Yali Zhao and Shihui Fu (iD)

Abstract

Objective: 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 $\leqslant$ 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

Correspondence to:
Longhe Xu
Department of Anesthesiology and Operation Center, The Third Medical Center of Chinese People's Liberation Army General Hospital, Beijing, China
longhexu@aliyun.com

Zeguo Feng
Department of Anesthesiology and Operation Center, The First Medical Center of Chinese People's Liberation Army General Hospital, Beijing, China
Beijing_301@sina.com

Yali Zhao
Central Laboratory, Hainan Hospital of Chinese People's Liberation Army General Hospital, Sanya, China
zhaoyl301@163.com

Shihui Fu
Department of Cardiology, Hainan Hospital of Chinese People's Liberation Army General Hospital, Sanya, China.
xiaoxiao0915@126.com

Long Feng
Department of Anesthesiology, Hainan Hospital of Chinese People's Liberation Army General Hospital, Sanya, China

Wenji Chen
Department of Rheumatology, Hainan Hospital of Chinese People's Liberation Army General Hospital, Sanya, China

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

Ping Ping
Main Station of Drug Instrument Supervision and Inspection, Joint Logistic Support Force of Chinese People's Liberation Army, Beijing, China

Tao Ma
Department of Anesthesiology, Chinese People's Liberation Army Rocket Force Characteristic Medical Center, Beijing, China

Yang Li
Department of Anesthesiology and Operation Center, The First Medical Center of Chinese People's Liberation Army General Hospital, Beijing, China

*Long Feng, Wenji Chen, Ping Ping, Tao Ma, and Yang Li are co-first authors.

nutritional supplementation during hospitalization.[9] Early nutritional intervention and effective malnutrition prevention can improve functional recovery following hip fracture in elderly populations.[9,10] Lu *et al*.[11] showed 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.[12] 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).[10] PNI was calculated using the following formula: $10 \times$ serum albumin (g/dl) $+ 0.005 \times$ total lymphocyte count (mm^3).[13] Patients were divided into one group with malnutrition (26 patients with PNI $\leqslant$ 38) and the other group without malnutrition (169 patients with PNI $>$ 38), respectively.[14]

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.[15–17]

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 $\pm$ 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).
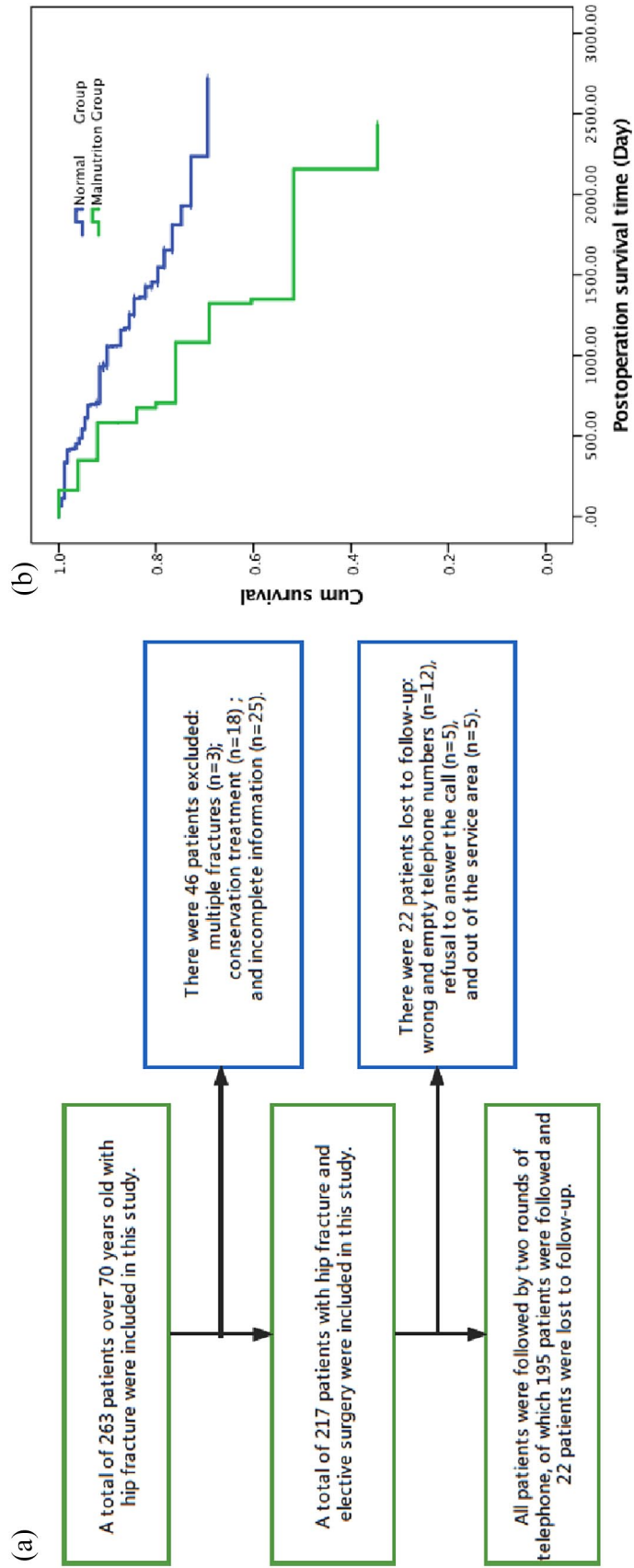
Figure 1. (a) Patient number and exclusion criteria in this study. (b) Survival curves of patients with and without malnutrition.

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/m²)[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)

Table 1. (Continued)

Characteristics	Total (*n* = 195)	With malnutrition (*n* = 26)	Without malnutrition (*n* = 169)	*p*
Transfusion, *n* (%)	29 (14.9)	4 (15.4)	25 (14.8)	1.000
Hospital costs (RMB)[a]	65,076 (55,470, 78,146)	63,239 (55,404, 82,496)	65,336 (55,524, 77,293)	0.823
Albumin (g/l)[a]	36.9 (34.4, 39.5)	31.6 (30.4, 32.7)	37.6 (35.2, 39.8)	<0.001
Hemoglobin (g/l)[a]	115 (102, 128)	103 (86, 115)	117 (104, 128)	<0.001
ESR (109/l)[a]	32 (20, 50)	42 (34, 65)	30 (20, 50)	0.002
PH[a]	7.41 (7.39, 7.43)	7.44 (7.41, 7.45)	7.41 (7.39, 7.43)	<0.001
PO_2[a]	72.9 (66.2, 82.9)	69.2 (62.0, 74.5)	73.4 (67.1, 83.7)	0.062
PCO_2[a]	39.7 (36.1, 42.4)	38.7 (33.7, 41.4)	39.7 (36.8, 42.8)	0.048
EF (%)[a]	60 (60, 61)	60 (60, 61)	60 (60, 61)	0.513
mFI[a]	0.09 (0.00, 0.27)	0.09 (0.00, 0.29)	0.09 (0.00, 0.27)	0.706
PNI[a]	43.5 (40.7, 46.3)	36.5 (35.1, 37.5)	44.2 (42.3, 46.7)	<0.001
Mortality, *n* (%)	42 (21.5)	10 (38.5)	32 (18.9)	0.024

ASA, American Society of Anesthesiologists; BMI, body mass index; EF, ejection fraction; ESR, erythrocyte sedimentation rate; mFI, modified frailty index; PH, potential of hydrogen; PNI, prognostic nutritional index; PCO_2, partial pressure of carbon dioxide; PO_2, partial pressure of oxygen.
[a]Median (interquartile range).

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,

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

which could also lead to 1-year mortality rates of up to 50–70% after hip fracture.[29,30] In addition, Bell *et al.*[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.[32]

Typically, food intake is reduced in elderly individuals, leading to prevalent malnutrition.[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.[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.[35] 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 anesthesiology 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

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.

Yang Li: Data curation; Methodology.

Longhe Xu: Data curation; Methodology; Supervision; Writing – review & editing.

Zeguo Feng: Data curation; Methodology; Supervision; Writing – review & editing.

Yali Zhao: Conceptualization; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Writing – review & editing.

Shihui Fu: Conceptualization; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Validation; Visualization; Writing – review & editing.

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.

Conflict of interest statement

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ORCID iD

Shihui Fu 🆔 https://orcid.org/0000-0001-6707 -9049

References

1. Magaziner J, Chiles N and Orwig D. Recovery after hip fracture: interventions and their timing to address deficits and desired outcomes – evidence from the Baltimore Hip Studies. *Nestle Nutr Inst Workshop Ser* 2015; 83: 71–81.

2. Gullberg B, Johnell O and Kanis JA. World-wide projections for hip fracture. *Osteoporos Int* 1997; 7: 407–413.

3. Mizrahi EH, Arad M, Fleissig Y, *et al.* Gender differences in functional outcome of elderly hip fracture patients. *Geriatr Gerontol Int* 2014; 14: 845–850.

4. Zuckerman JD. Hip fracture. *N Engl J Med* 1996; 334: 1519–1525.

5. Leggo M, Banks M, Isenring E, *et al.* A quality improvement nutrition screening and intervention program available to home and community care eligible clients. *Nutr Diet* 2008; 65: 162–167.

6. Karampampa K, Ahlbom A, Michalsson K, *et al.* Declining incidence trends for hip fractures have not been accompanied by improvements in lifetime risk or post-fracture survival – a nationwide study of the Swedish population 60 years and older. *Bone* 2015; 78: 55–61.

7. Hinton PS, Rector RS, Linden MA, *et al.* Weight-loss-associated changes in bone mineral density and bone turnover after partial weight regain with or without aerobic exercise in obese women. *Eur J Clin Nutr* 2012; 66: 606–612.

8. Li HJ, Cheng HS, Liang J, *et al.* Functional recovery of older people with hip fracture: does malnutrition make a difference? *J Adv Nurs* 2013; 69: 1691–1703.

9. Volkert D, Berner YN, Berry E, *et al.* ESPEN guidelines on enteral nutrition: geriatrics. *Clin Nutr* 2006; 25: 330–360.

10. Feng L, Fu S, Yao Y, *et al.* Age, Prognostic Nutritional Index, and Charlson Comorbidity Index were independent risk factors for postoperative long-term mortality in Chinese geriatric patients who sustain hip fracture. *J Am Med Dir Assoc* 2021; 22: 2602–2603.

11. Lu J, Chen YY, Zhang L, *et al.* Laboratory nutritional parameters predict one-year mortality in elderly patients with intertrochanteric fracture. *Asia Pac J Clin Nutr* 2016; 25: 457–463.

12. Ren H, Wu L, Hu W, *et al.* Prognostic value of the c-reactive protein/Prognostic Nutritional Index ratio after hip fracture surgery in the elderly population. *Oncotarget* 2017; 8: 61365–61372.

13. Buzby GP, Mullen JL, Matthews DC, *et al.* Prognostic Nutritional Index in gastrointestinal surgery. *Am J Surg* 1980; 139: 160–167.

14. Sze S, Zhang J, Pellicori P, *et al.* Prognostic value of simple frailty and malnutrition screening tools in patients with acute heart failure due to left ventricular systolic dysfunction. *Clin Res Cardiol* 2017; 106: 533–541.

15. Rockwood K, Andrew M and Mitnitski A. A comparison of two approaches to measuring frailty in elderly people. *J Gerontol A Biol Sci Med Sci* 2007; 62: 738–743.

16. Mitnitski AB, Mogilner AJ and Rockwood K. Accumulation of deficits as a proxy measure of aging. *Scientific World Journal* 2001; 1: 323–336.

17. Fu S, Hu J, Chen X, *et al.* Mutant single nucleotide polymorphism rs189037 in ataxia-telangiectasia mutated gene is significantly associated with ventricular wall thickness and human lifespan. *Front Cardiovasc Med* 2021; 8: 658908.

18. Symeonidis PD and Clark D. Assessment of malnutrition in hip fracture patients: effects on surgical delay, hospital stay and mortality. *Acta Orthop Belg* 2006; 72: 420–427.

19. Fu S, Yao Y, Lv F, *et al.* Associations of immunological factors with metabolic syndrome and its characteristic elements in Chinese centenarians. *J Transl Med* 2018; 16: 315.

20. He M, Fan Q, Zhu Y, *et al.* The need for nutritional assessment and interventions based on the Prognostic Nutritional Index for patients with femoral fractures: a retrospective study. *Perioper Med* 2021; 10: 61.

21. van Wissen J, van Stijn MF, Doodeman HJ, *et al.* Mini nutritional assessment and mortality after hip fracture surgery in the elderly. *J Nutr Health Aging* 2016; 20: 964–968.

22. Wilson JM, Boissonneault AR, Schwartz AM, *et al.* Frailty and malnutrition are associated with inpatient postoperative complications and mortality in hip fracture patients. *J Orthop Trauma* 2019; 33: 143–148.

23. Feng L, Chu Z, Quan X, *et al.* Malnutrition is positively associated with cognitive decline in centenarians and oldest-old adults: a cross-sectional study. *EClinicalMedicine* 2022; 47: 101336.

24. Frost SA, Nguyen ND, Black DA, *et al.* Risk factors for in-hospital post-hip fracture mortality. *Bone* 2011; 49: 553–558.

25. Norring-Agerskov D, Laulund AS, Lauritzen JB, *et al.* Meta-analysis of risk factors for mortality in patients with hip fracture. *Dan Med J* 2013; 60: A4675.

26. Zhang Y, Fu S, Wang J, *et al.* Association between Geriatric Nutrition Risk Index and low muscle mass in Chinese elderly people. *Eur J Clin Nutr* 2019; 73: 917–923.

27. Nuotio M, Tuominen P and Luukkaala T. Association of nutritional status as measured by

the Mini-Nutritional Assessment Short Form with changes in mobility, institutionalization and death after hip fracture. *Eur J Clin Nutr* 2016; 70: 393–398.

28. Goisser S, Schrader E, Singler K, *et al.* Malnutrition according to Mini Nutritional Assessment is associated with severe functional impairment in geriatric patients before and up to 6 months after hip fracture. *J Am Med Dir Assoc* 2015; 16: 661–667.

29. Miyanishi K, Jingushi S and Torisu T. Mortality after hip fracture in Japan: the role of nutritional status. *J Orthop Surg* 2010; 18: 265–270.

30. O'Daly BJ, Walsh JC, Quinlan JF, *et al.* Serum albumin and total lymphocyte count as predictors of outcome in hip fractures. *Clin Nutr* 2010; 29: 89–93.

31. Bell JJ, Pulle RC, Crouch AM, *et al.* Impact of malnutrition on 12-month mortality following acute hip fracture. *ANZ J Surg* 2016; 86: 157–161.

32. Malafarina V, Reginster JY, Cabrerizo S, *et al.* Nutritional status and nutritional treatment are related to outcomes and mortality in older adults with hip fracture. *Nutrients* 2018; 10: 555.

33. Fu S, Ping P, Li Y, *et al.* Centenarian longevity had inverse relationships with nutritional status and abdominal obesity and positive relationships with sex hormones and bone turnover in the oldest females. *J Transl Med* 2021; 19: 436.

34. Huang Z, Himes JH and McGovem PG. Nutrition and subsequent hip fracture risk among a national cohort of white women. *Am J Epidemiol* 1996; 144: 124–134.

35. Avenell A, Smith TO, Curtain JP, *et al.* Nutritional supplementation for hip fracture aftercare in older people. *Cochrane Database Syst Rev* 2016; 11: CD001880.

Visit SAGE journals online
journals.sagepub.com/home/taj

§SAGE journals