Nutrition status and functional prognosis among elderly patients with distal radius fracture: a retrospective cohort study

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Abstract

Background

Distal radius fractures (DRF) are common in the elderly and are typical of hand fractures during falls. Malnutrition has also been identified as a poor prognostic factor in elderly patients with fractures. However, the relationship between nutritional status and subsequent falls and functional prognosis in the elderly DRF is not clear. The aim of the present study was to investigate the association between nutritional status and functional prognosis in patients with elderly DRF.

Methods

Study participants included 229 outpatients who required surgical treatment with DRF. The patients' clinical information, including age, sex, body mass index, bone mineral density, Geriatric Nutritional Risk Index (GNRI), total number of drugs being treated with on admission, use of drugs for osteoporosis, comorbidity severity, Barthel Index(BI), presence of subsequent falls, fracture type, postoperative follow-up period, and Mayo wrist score was reviewed. The subjects were further divided into two groups according to their GNRI: the malnutrition group and the normal group. Propensity score matching was used to confirm the factor affecting BI and subsequent fall.

Results

Thirty-one patients (13.5%) were malnutrition before surgery for DRF. According to the multiple liner regression analysis, GNRI positively affected BI efficiency (β=0.392, 95% confidence interval, 0.001 to 0.351, p=0.039). Furthermore, on logistic regression analysis, subsequent fall was correlated with the serum albumin (odds ratio=0.033, 95% confidence interval,0.002 to 0.477, p=0.012).

Conclusion

Malnutrition impaired the improvement of the activity of daily living (ADL) and increased the incidence of subsequent fall. Improvement of nutritional status before DRF surgery may further improve ADL and prevent falls.

Background

Distal radius fracture (DRF) is the most common fragility fracture and is typically caused by a fall on an outstretched hand [1, 2]. There are two major age peaks for DRF: high energy injuries such as sports injuries in young people, and falls in older people [3]. As the life span of the general population increases, the incidence of DRF in the elderly is increasing [4]. In addition, elderly DRF patients are at high risk of subsequent falls [5, 6]. It has been reported that decreased activity due to pain after DRF and fear of falling may cause a decline in muscle strength and balance, which may be a risk of future falls [7, 8]. A large clinical cohort of individuals followed for 10 years showed that those with a DRF had 11% more fractures as compared to those without a prior fracture [9]. The association between DRF and subsequent fractures is independent of other osteoporosis risk factors. Non-modifiable factors such as age, sex, and prior fall history are well-established predictors of subsequent falls [10, 11].

More recently, sarcopenia has been reported as a new risk factor for DRF and other fractures. The association between sarcopenia and subsequent falls has also been observed previously, and treatment of sarcopenia leads to prevention of falls and fractures in the elderly. However, despite the association between sarcopenia and malnutrition, there are no reports on the association between nutritional status and subsequent falls after DRF.

The purpose of this study was therefore to investigate the relationship between nutritional status and functional prognosis after surgery in geriatric DRF.

Materials And Methods

Study design and participants

A retrospective study was conducted of 229 patients aged 65 years or older admitted to an acute care hospital with DRF between October 2014 and December 2018 who underwent surgery and were followed for at least 1 year after surgery. Patients were retrospectively identified via a search of the surgical database at our two affiliated hospitals. Demographic and postoperative clinical course information was extracted from each patient's electronic medical record. Patients with neurological/cognitive impairment, multiple fractures, death, and missing data were excluded. Ethical approval was obtained from each hospital board of ethics. Patient informed consent was not required due to the retrospective design of the study.

Surgical treatment and rehabilitation

All patients were treated with internal fixation using a volar locking plate (ACU-LOC plate, ACUMED, LLC., USA: 88 cases, Anatomic Volar Plate System. Depuy Synthes, Johnson- Johnson. Co., USA: 75 cases, Stellar2, HOYA Technosurgical Co., Japan: 42 cases, APUTUS 2.5, Medical engineering system Co., Japan: 24 cases). A standard volar approach was used to expose the fracture side. The surgical approach was to approach the fracture from the radial side of the flexor carpi radialis, and the quadrate pronator muscle was incised to reduce the fracture. If the fracture was unstable, it was reduced with Kirschner wire. Following the surgery, all patients were casted for 3–7 days depending on the stability of the fracture site. In postoperative rehabilitation, finger excursion training was started from the day after the operation. Automatic wrist joint training and wrist joint passive motion training with one-to-one guidance were started after cast removal.

Measurements

Information collected for all patients included age, sex, body mass index (BMI), total number of drugs administered on admission, number and type of potentially inappropriate medications (PIMs) on admission, bone mineral density (as a percentage of the mean values for young adults), fracture type, comorbidity severity (Charlson Comorbidity Index), nutritional status (Geriatric Nutritional Risk Index: GNRI), wrist function criteria (Mayo wrist score), Barthel Index (BI), presence of subsequent falls, and follow up periods after surgery.

Osteoporosis was defined as a T-score ≤-2.5 SD in the lumber vertebrae (L2-4). AO classification was used to describe the DRF type. This system is commonly used in the radiographic classification of DRF and includes three types: A, B, and C. A is an extra-articular fracture, B is an intra-articular fracture, and C is an intra-articular complete fracture.

Comorbidity was assessed using the Charlson Comorbidity Index (CCI) [12]. The CCI is an indicator of multidisease comorbidities and includes diabetes with chronic complications, heart failure, kidney disease, liver disease, chronic lung disease, dementia, hemiplegia or paraplegia, malignancy, and AIDS/HIV. The Index uses a weighted score for each comorbidity, with higher numbers indicating a greater number of comorbidities and greater risk of mortality.

GNRI was calculated by the formula proposed by Bouillanne et al [13]:

$14.89 \times$ serum albumin (g/dl) + {41.7 x (Current/Ideal body weight)}.

In addition, those with GNRI less than 92 were defined as the malnutrition group, and those with GNRI more than 92 were defined as the normal group with mild or no risk of malnutrition.

Activities of daily living (ADL) were evaluated by BI. The BI is an assessment of 10 items: eating, moving, dressing, toilet movement, bathing, walking, going up and down stairs, changing clothes, defecation, and urination. Each item is scored as 0: unable to complete; 1: needs help; or 2: independent, and the total score is multiplied by 20, for a maximum score of 100. ADL was assessed before surgery and at the final follow-up. BI efficacy was defined as BI at the end of follow-up minus preoperative BI. The Mayo wrist score was used for wrist function evaluation. The scale includes scores for pain, functional status, range of motion, and grip strength, with a total score of 0 to 100. The higher the score, the better the function.

Subsequent falls were defined as falls caused by carelessness and did not include falls caused by traffic accidents, brain injuries, or diseases such as epilepsy.

Outcomes

The primary outcome was BI gain, which was defined as the difference in the total BI at one year after surgery from that on admission. The secondary outcome was subsequent falls during follow up periods.

Statistical analysis

The subjects were divided into two groups: the malnutrition group and the normal group. The unpaired t-test, Mann-Whitney's U-test, and $\chi 2$ test were used for comparison between the two groups, depending on variables and normality. Spearman's rank correlation was used for univariate analysis of BI at final evaluation. Logistic regression analysis was also performed to determine whether the dependent variable was the presence or absence of a subsequent fall. As the number in the malnutrition group was small, the number of variables included in the logistic model had to be reduced. Propensity scores were calculated by logistic regression analysis including age, sex, comorbidity index, number of drugs, and fracture type as explanatory variables. All analysis was carried out using IBM SPSS Statics version 25 (IBM Corporation; Armonk, NY, USA). A P-value less than 0.05 was considered significant. This research has been approved by the IRB of the authors' affiliated institution.

Results

During the study period, a total of 229 patients were eligible for participation. Patient characteristics are shown in Table 1. Thirty-one patients (37.2%) were in the malnutrition group. The malnutrition group had a lower BMI, serum albumin, and BI score ($p < 0.001$), and a higher subsequent fall and CCI ($p < 0.001$, $p = 0.006$, respectively) than the normal group. Postoperative complications of DRF are shown in Table 2. In the malnutrition group, the rates of extensor pollicis longus (EPL) rupture, screw loosening, compression, and neuropathy were significantly higher than in the normal group. The Spearman's rank correlation results are shown in Table 3. GNRI was correlated with BMI, serum albumin, subsequent fall, BI at admission, and BI gain. BI gain was correlated with GNRI, serum albumin, and CCI, but not age or Mayo wrist score.

Table 1
Patients characteristics

	All(n = 229)	GNRI ≥ 92 (n = 198)	GNRI < 92 (n = 31)	p-value
Age (yr)	72.0 ± 8.1	76.1 ± 8.4	73.5 ± 8.1	0.770 1)
Sex, female	198(86.5)	168(84.8)	30(96.8)	0.194 2)
Fracture type				0.903 2)
AO type A	13 (5.6)	11 (5.5)	2 (6.5)	
type B	82 (35.8)	70 (35.4)	12 (38.7)	
type C	134(58.5)	117 (59.1)	17 (54.8)	
BMI (kg/m2)	21.9 ± 3.9	22.8 ± 3.7	18.6 ± 2.6	< 0.001 1)
Serum albumin (g/dl)	4.08 ± 0.38	4.18 ± 0.28	3.47 ± 0.37	< 0.001 1)
BMD (g/cm^2)	0.881 ± 0.143	0.885 ± 0.144	0.860 ± 0.136	0.364 1)
CCI	1 (0–2)	1 (0–2)	1 (0–2)	0.006 2)
Total number of drugs administered on admission	4 (0–14)	4(0–8)	5(0–14)	0.274 1)
Use of drugs for osteoporosis, N (%)	36 (15.7)	32 (16.2)	4 (12.9)	0.794 2)
Days between onset and operation	4.81 ± 1.6	4.42 ± 2.1	5.18 ± 2.1	0.655 1)
BI score				
Admission	77.2 ± 7.0	78.4 ± 6.3	69.8 ± 7.01	< 0.001 1)
One year after surgery	86.4 ± 8.9	88.2 ± 7.8	75.2 ± 7.4	< 0.001 1)
BI gain	9.2 ± 5.6	9.8 ± 5.6	5.3 ± 2.9	< 0.001 1)
Mayo wrist score				
One year after surgery	84.2 ± 6.6	84.3 ± 6.6	83.7 ± 6.8	0.645 1)
Fall during follow up periods, N (%)	21 (9.2)	9 (4.5)	12 (38.7)	< 0.001 2)

Value are presented as mean ± standard, deviation or number(%) or median(interquartile range).

GNRI: Geriatric Nutritional Risk Indexes, BMI: Body Mass Index, CCI: Charlson Comorbidity Index,

BI: Barthel index, 1) Student t-test, 2) Chi-squared test.

Table 2
Postoperative complications of DRF

Complications	All(n = 229)	GNRI ≥ 92 (n = 198)	GNRI < 92 (n = 31)	p-value
				0.024 1)
EPL rupture	3(1.3)	2(1.0)	1(3.2)	
Screw loosening	1(0.4)	0(0)	1(3.2)	
Compression	9(3.9)	6(3.0)	3(9.7)	
Neuropathy	3(1.3)	3(1.5)	0(0)	
Value are presented as number (%), GNRI: Geriatric Nutritional Risk Indexes,				
1) Chi-squared test.				

Table 3
Spearman rank correlation coefficients among the factors

	Age	BMI	GNRI	Serum albumin	Total number of drugs on admission	CCI	BI at admission	BI gain	Mayo score	Fall during follow up periods
Age	1	0.000	-0.107	-0.191**	0.276	0.090	-0.126	-0.089	-0.124	0.169*
BMI	0.000	1	0.835**	0.193**	0.036	0.033	0.163*	0.033	0.002	-0.115
GNRI	-0.107	0.835**	1	0.701**	-0.083	-0.083	0.378**	0.206**	0.087	-0.353**
Serum albumin	-0.191**	0.193**	0.701**	1	-0.194**	-0.191**	0.462**	0.324**	0.152**	-0.482**
Total number of drugs on admission	0.276	0.036	-0.083	-0.194**	1	0.303**	-0.177**	-0.053	-0.161*	0.058
CCI	0.090	0.033	-0.083	-0.191**	0.303**	1	-0.208**	-0.180**	-0.070	0.145*
BI at admission	-0.126	0.163*	0.378**	0.462**	-0.177**	-0.208**	1	-0.006	0.039	-0.285**
BI gain	-0.089	0.033	0.206**	0.324**	-0.053	-0.180**	-0.006	1	0.055	-0.105
Mayo score	-0.124	0.002	0.087	0.152**	-0.161*	-0.070	0.039	0.055	1	-0.101
Fall during follow up periods	0.169*	-0.115	-0.353**	-0.482**	0.058	0.145*	-0.285**	-0.105	-0.101	1
BMI: Body Mass Index, GNRI: Geriatric Nutritional Risk Indexes, CCI: Charlson Comorbidity Index, BI: Barthel index, *p < 0.05, **p < 0.01										

The results of the multiple linear regression analysis for BI gain after propensity score matching for GNRI are shown in Table 4. Propensity scores were calculated by logistic regression analysis including age, sex, CCI, number of drugs, and fracture type as explanatory variables. GNRI positively affected the BI gain (β = 0.392, 95% confidence interval: 0.001 to 0.351, p = 0.039).

Table 4
Liner regression analysis for BI efficiency

Variables	β	95% confidence interval		p-value
		Lower	Upper	
PS	-0.175	-22.050	2.982	0.133
GNRI	0.392	0.010	0.351	0.039
Serum albumin	0.103	-2.921	5.107	0.588
PS (log-transformed propensity score) was calculated from log transformation of the propensity score for age, sex, Charlson comorbidity index, number of drugs, and fracture type.				
GNRI: Geriatric Nutritional Risk Indexes				

The results of the logistic regression analysis are shown in Table 5. The incidence of a subsequent fall was correlated with serum albumin (odds ratio 0.033, 95% confidence interval: 0.002 to 0.477, $p = 0.012$). Propensity scores were calculated by logistic regression analysis including age, sex, CCI, number of drugs, and fracture type as explanatory variables.

Table 5
Logistic regression analysis for subsequent fall

Variables	Odds ratio	95% confidence interval		p-value
		Lower	Upper	
PS	18.987	0.018	19590.442	0.406
GNRI	1.033	0.926	1.153	0.559
Serum albumin	0.033	0.002	0.477	0.012
PS (log-transformed propensity score) was calculated from log transformation of the propensity score for age, sex, Charlson comorbidity index, number of drugs, and fracture type.				
GNRI: Geriatric Nutritional Risk Indexes				

Discussion

The results of this retrospective cohort study revealed two facts concerning nutrition status in patients with DRF. First, this study suggested malnutrition as a risk factor for reduced ADL in older patients after DRF. Second, low serum albumin may increase the risk of a subsequent fall after DRF. This study supports the hypothesis that improvement in nutritional status reduces the risk of decreased ADL for older patients after DRF. To our knowledge, this is the first study to show the impact of nutrition status on ADL in patients with DRF.

First, we found that malnutrition may lower the ADL of older patients after DRF. There are several reports on the relationship between nutritional status and ADL, and poor nutritional status is associated with lower ADL [14, 15, 16]. Osta et al. reported that malnutrition was associated with lower education levels and older age, length of hospital stay, complications, multidrug use, and decreased ADL [15]. The prevalence of malnutrition in the elderly was reported by Osta et al. to be 13.5% and by Krichamoothy et al. to be 17.9% [15, 16]. Our study similarly found that 13.5% of elderly DRF patients had malnutrition. Assessment of nutritional status after DRF may improve ADL by improving nutritional status

Second, low serum albumin may increase the risk of a subsequent fall after DRF. In a previous study on fall risk, Mazur et al. reported that age ≥ 76 years, BMI < 23.5, Mini-Mental State Examination < 20, BI < 65, hemoglobin < 7.69 mmol/L, serum protein < 70 g/L, albumin < 32 g/L, and calcium level < 2.27 mmol/L were risk factors for falls in hospitalized elderly patients [17]. Galet et al. reported that the rate of readmission hospitalizations among fallers increased from 15.6–17.4% between 2010 and 2014, suggesting that social support and a fall prevention program are required [18]. In this study, GNRI, serum album, BI at admission, and CCI were determined to be factors related to subsequent falls. Furthermore, a logistic regression analysis using propensity score matching for the probability of subsequent falls showed that serum albumin had an influence on the probability of falling again. Hypoalbuminemia may be associated with falls because it leads to insufficient muscle synthesis and decreases in skeletal muscle, resulting in decreased balance and gait ability.

These results suggest the necessity of introducing nutritional assessment and a fall prevention program in elderly DRF patients.

This study has a few limitations. First, the assessment of muscle strength, gait function, and balance in patients with DRF was inadequate. In the future, it is necessary to examine the risk of falling by evaluating walking function and balance. Secondly, the verification of the life situation and the history of falling was insufficient. It is necessary to verify the relation of ADL with life and falling history.

Conclusion

This study showed that malnutrition is related to the ability to resume ADL in elderly patients with DRF, and low serum albumin may increase the risk of subsequent fall after DRF. Nutrition assessment and fall prevention programs may be of great benefit to older patients with DRF.

Abbreviations

BI
Barthel Index
BMI
Body Mass Index
CCI
Charlson Comorbidity Index
DRF
Distal Radius Fracture
GNRI
Geriatric Nutritional Risk Indexes
PS
log-transformed propensity score

Declarations

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Conflict of interest and sources of funding

None declared.

Authors' contributions

All authors helped with date collection and contributed to the writing and critical revisions for intellectual content and final approval of the article.

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Availability of data and materials

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

Ethics approval and consent to participate

The study protocol was reviewed and approval by the Committee on Ethics and the institutional review board of Nihon University Hospital and Osumi Hospital. Because this study was retrospective, the requirement for informed consent was not deemed necessary.

Consent for publication

Not applicable.

Competing interests

All authors declare that they have no competing interests.

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