

Positive Correlation Between Changes in Serum Albumin Levels and Breakfast Non-Protein Calorie/Nitrogen Ratio in Geriatric Patients

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Abstract

Background: Differences in nutrition intake by meal intake time of geriatric patients may affect albumin (Alb) synthesis ability.

Methods: We included 36 geriatric patients (81.7 ± 7.7 years; 20 males and 16 females) as subjects. We calculated their dietary patterns (DPs) by computing intake by breakfast, lunch, and dinner, as well as by nutrient, for a weight of 1 kg/day for 4 weeks after hospitalization. We confirmed the relationship between “DP with a positive correlation with breakfast protein” and the change rate of albumin (Alb-RC). Then, we performed linear regression analysis to explore factors influencing Alb-RC and compared non-protein calorie/nitrogen ratio (NPC/N) between the upper and lower Alb-RC groups.

Results: It was observed that Alb-RC was negatively correlated with “DP with a positive correlation with breakfast protein” ($B = -0.055$, $P = 0.038$) and positively correlated with breakfast NPC/N ($B = 0.043$, $P = 0.029$). Breakfast NPC/N tended to be higher in the upper group than in the lower group ($P = 0.058$).

Conclusion: The study revealed that there was a positive correlation between Alb-RC levels and breakfast NPC/N in geriatric patients at the care mix institution.

Keywords: Albumin; Energy intake; Hospitalization; Nutrients; Regression analysis

Manuscript submitted November 28, 2022, accepted January 27, 2023
Published online February 28, 2023

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doi: <https://doi.org/10.14740/jocmr4848>

Introduction

Serum albumin (Alb) level is widely used as an index to assess nutritional status [1-4]. To increase the intake of good protein or advantageously induce body protein synthesis, non-protein calorie/nitrogen ratio (NPC/N), which is the balance between energy and protein, is considered. NPC/N is an index demonstrating the amount of carbohydrate and lipid that should be consumed so that the consumed protein can be effectively utilized [5].

At small-scale, community-based hospitals providing care-mix medical care, geriatric patients who have completed acute treatment are continuously provided care. Hospital food is provided in controlled quantities and preparations, taking into account patients’ medical conditions as well as their masticatory and swallowing abilities. However, dietary intake may differ depending on patients’ appetites and preferences, and NPC/N may vary; therefore, it is necessary to clarify which type of meal should be consumed at which time of the day to provide nutritional support.

We have previously reported that the differences in intake by breakfast, lunch, and dinner, as well as by nutrient calculated from the nutrition of hospital food consumed by geriatric patients, may affect the Alb synthesis ability in the liver [6]. In addition, we have clarified that NPC/N in nutrition intake affects the selection of discharge destination [7].

In this study, we report the relationship between changes in Alb at discharge and admission, as well as NPC/N in nutrition intake that we examined.

Materials and Methods

Subjects

The target hospital was a small-scale (48-bed) hospital providing care-mix medical care in Nada Ward, Kobe, Hyogo.

The subjects were 36 geriatric patients (81.7 ± 7.7 years; 20 males and 16 females) admitted to the target hospital between January 1, 2017 and December 31, 2020, suffering from chronic diseases, receiving only oral nutritional support, and whose meal intake information 1 month after hospitalization

as well as blood test findings at admission and discharge were available. All of the subjects had chronic diseases such as diabetes and hypertension, but they were treated in an acute hospital and their medical conditions were stable at the time of this study.

No double-counting transpired. However, we excluded those who had severe restrictions on protein intake (≤ 45 g/day).

Methods

We conducted a retrospective medical-record review study. The survey items were as follows: basic attributes at admission, comorbidities, Barthel index, the length of hospitalization, the type of hospital food, blood biochemical data at admission and discharge, and the amount of leftovers from staple food and side dish of breakfast, lunch, and dinner for 4 weeks after admission.

We calculated the body mass index using height and weight and assigned a score to the comorbidities according to the Carlson comorbidity index [8].

Duration of hospitalization was the number of days from admission to discharge.

Alb level at discharge was divided by Alb level at admission to obtain the Alb rate of change (Alb-RC). Next, multivariate analysis was performed.

Dietary patterns (DPs) were extracted using principal component analysis. Energy intake (kcal/body weight (BW) kg/day), protein intake (g/BW kg/day), and non-protein energy intake (kcal/BW kg/day) obtained from breakfast, lunch, and dinner were calculated from dietary intake, and these nine variables were used.

When calculating the nine variables, we calculated each nutrition intake for 4 weeks after hospitalization and the mean intake by nutrient per day based on the survey results of the amount of leftover food by staple food and side dish of each individual subject as well as the nutrient described in the menu table. There were several types of hospital food available, including the normal diet, whole porridge diet, diabetic diet, dyslipidemia diet, liver diet, heart/hypertensive diet, and kidney disease diet.

In addition, NPC/N was calculated by $(\text{energy(kcal)} - \text{protein(g)} \times 4(\text{kcal})) / (\text{protein}/6.25)$, standardized, and used.

Furthermore, Alb-RC was arranged in ascending order, and NPC/N by breakfast, lunch, and dinner were compared between the lower 12 subjects (lower group) and upper 12 subjects (upper group).

Ethical considerations

This study was approved by the Research Ethics Committee of Mukogawa Women's University and Junior College on March 15, 2019 (approval No. 18-85), and was conducted according to the principles of the Declaration of Helsinki. We obtained the subjects' informed consent, with the assurance that they would remain anonymous and could withdraw from the study anytime.

Statistical analysis

Factor loading for the food groups representing the principal components was set at ≥ 0.50 , and three principal components were extracted.

Next, two multiple regression analyses were performed. In model 1, with Alb-RC as the objective variable, gender and the three principal components were input as the explanatory variables. In model 2 (stepwise method), with Alb-RC as the objective variable, gender, breakfast energy intake, protein intake, and NPC/N were input as the explanatory variables.

Statistical Analysis System (SAS) version 9.4 (SAS Institute Inc., Cary, NC, USA) was used for analysis, and the criterion for statistical significance was less than 5%.

Results

Subjects' demographics

As shown in Table 1, the most common reasons for admission were chronic heart failure, bronchial pneumonia, chronic obstructive pulmonary disease, and type 2 diabetes; however, these conditions had been treated in the acute care hospital, and thus, there were no clinical issues requiring active intervention (Table 1).

There was no difference between Alb at admission and discharge, and mean Alb-RC was 0.98 ± 0.13 (Table 1, Fig. 1).

Mean energy intake was 29.8 ± 6.5 kcal/BW kg/day, mean protein intake was 1.17 ± 0.28 g/BW kg/day, and there was no excessive or insufficient nutrition intake, as instructed by attending physicians (Table 1).

Daily mean NPC/N was 136 ± 22 , breakfast NPC/N was 167 ± 37 , lunch NPC/N was 140 ± 30 , and dinner NPC/N was 130 ± 30 (Table 1).

Multivariate analysis results

Principal component analysis

The first principal component was "DP without characterized factors", and its contribution rate was 79.0%. The second principal component was "DP characterized by a positive correlation with breakfast energy (0.551) and non-protein energy intake (0.607)", and its contribution rate was 9.8%. The third principal component was "DP characterized by a positive correlation with breakfast protein (0.760)", and its contribution rate was 7.3%. The cumulative contribution rate of the three principal components was 96.1% (Table 2).

Multiple regression analysis

1) Model 1

The third principal component was a significant negative de-

Table 1. Demographics (n = 36)

	At admission	At discharge	P-value
Number of patients (male/female)	36 (20/16)		
Age (years)	81.7 ± 7.7		
Duration of hospitalization (days)	74.0 ± 43.7		
Charlson co-morbidity index (score)	2.5 ± 1.2		
BI (score)	50.8 ± 41.6		
Body mass index (kg/m ²)	19.9 ± 3.2	19.9 ± 3.0	0.953
Alb (g/dL)	3.5 ± 0.4	3.4 ± 0.4	0.227
25-75%	3.3 - 3.7	3.3 - 3.7	
TC (mg/dL)	173 ± 38	175 ± 35	0.635
25-75%	145 - 195	147 - 198	
TLC (/mm ³)	1,422 ± 471	1,588 ± 536	0.133
25-75%	1,129 - 1,718	1,278 - 1,817	
CRP (mg/dL)	0.29 ± 0.42	0.4 ± 0.52	0.283
25-75%	0.03 - 0.33	0.07 - 0.52	
AST (IU/L)	22 ± 8	21 ± 6	0.128
25-75%	16 - 25	18 - 23	
ALT (IU/L)	17 ± 9	16 ± 10	0.801
25-75%	12 - 19	10 - 19	
Nutrition intake			
Energy intake (kcal/BW kg/day)	29.8 ± 6.5		
Breakfast	9.5 ± 2.4		
Lunch	10.3 ± 2.4		
Dinner	10.0 ± 2.4		
Protein intake (g/BW kg/day)	1.17 ± 0.28		
Breakfast	0.32 ± 0.08		
Lunch	0.42 ± 0.12		
Dinner	0.43 ± 0.11		
NPC/N mean	136 ± 22		
Breakfast	167 ± 37		
Lunch	140 ± 30		
Dinner	130 ± 30		

Data are expressed as mean ± standard deviation. Paired *t*-test. The main diseases for admission included chronic heart failure, bronchial pneumonia, chronic obstructive pulmonary disease, and type 2 diabetes; however, these conditions had been treated in the acute care hospital, and thus, patients' condition became stable. BI: Barthel index; Alb: serum albumin; TC: total cholesterol; TLC: total lymphocyte count; CRP: C-reactive protein; AST: aspartate aminotransferase; ALT: alanine aminotransferase; NPC/N: non-protein calorie/nitrogen ratio.

terminant factor for Alb-RC (B = -0.055, P = 0.038, Table 3).

2) Model 2

Breakfast NPC/N was a significant positive determinant factor for Alb-RC (B = 0.043, P = 0.029, Table 3).

Comparison of Alb-RC between the two groups: upper group vs. lower group

Alb-RC was 1.11 ± 0.09 for the upper group and 0.85 ± 0.08

for the lower group, and there was a significant difference (P < 0.001). Breakfast NPC/N was 0.54 ± 1.23 for the upper group and -0.35 ± 0.91 for the lower group, and it was higher in the upper group than in the lower group (P = 0.058), but no difference was observed in lunch and dinner NPC/N. A choice of bread or porridge was given for breakfast, and individuals choosing porridge tended to be more in the upper group than in the lower group (P = 0.069, Table 4).

Discussion

This study aimed to explore nutritional factors affecting

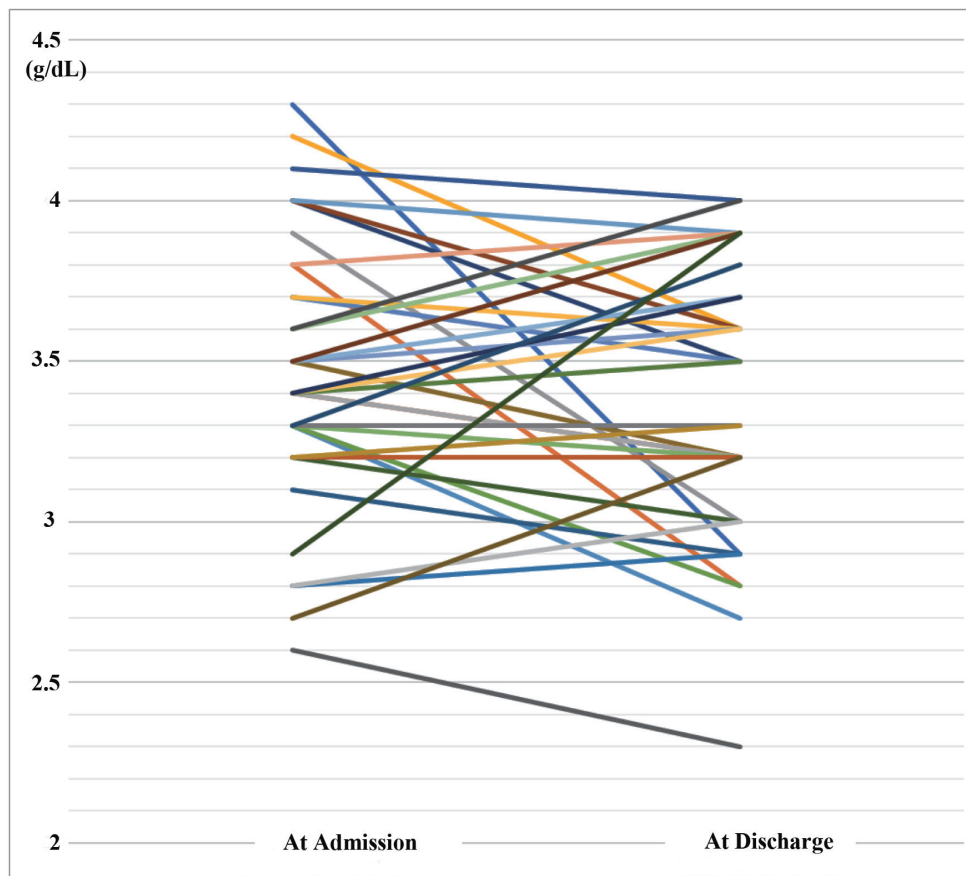


Figure 1. Changes in serum albumin levels at admission and discharge.

Table 2. Dietary Pattern (n = 36)

Nutrient intake ratio	Dietary pattern		
	First factor	Second factor	Third factor
Breakfast			
Energy intake	0.317	0.551 ^a	0.134
Protein intake	0.285	-0.016	0.760 ^a
Non-protein energy intake	0.305	0.607 ^a	0.032
Lunch			
Energy intake	0.359	-0.075	-0.241
Protein intake	0.328	-0.395	0.217
Non-protein energy intake	0.351	0.000	-0.334
Dinner			
Energy intake	0.357	-0.128	-0.236
Protein intake	0.337	-0.381	0.174
Non-protein energy intake	0.351	-0.071	-0.316
Variance explained by each factor (eigenvalue)	2.666	0.940	0.809
Proportion of variance (%)	79.0	9.8	7.3
Cumulative proportion (%)	79.0	88.8	96.1

^a|load| > 0.500 were considered as an important factor (in module).

Table 3. Examination of Factors for Change Rate of Albumin (n = 36)

	Regression of coefficient	Standard error	t value	P-value
Model 1				
Sex	0.078	0.042	1.846	0.075
First factor	0.002	0.008	0.255	0.801
Second factor	0.008	0.022	0.354	0.726
Third factor	-0.055	0.025	-2.164	0.038*
Model 2 ^a				
Breakfast NPC/N	0.043	0.019	2.282	0.029*

*P < 0.05, n = 36. Multiple regression analysis. ^aStepwise method. NPC/N: non-protein calorie/nitrogen ratio.

changes in Alb at discharge and admission in geriatric patients admitted to a local small-scale hospital providing care-mix medical care.

Regarding the methods, the nine variables of energy intake (kcal/BW kg/day), protein intake (g/BW kg/day), and non-protein energy intake (kcal/BW kg/day) collected from the hospital food intake status survey of each individual patient were calculated by breakfast, lunch, and dinner, as well as by nutrient, and three DPs were calculated using principal component analysis method. Next, linear regression analysis was performed with Alb-RC as the objective variable and gender and three principal components as the explanatory variables. The result showed that the third principal component was negatively correlated. The third principal component had “a positive correlation with breakfast protein intake”. By focusing on NPC/N, linear regression analysis (stepwise method) was performed with Alb-RC as the objective variable and gender, breakfast energy intake (kcal/BW kg/day), protein intake (g/BW kg/day), and NPC/N as the explanatory variables. Breakfast NPC/N was positively correlated with Alb-RC. Furthermore, to verify the validity of breakfast NPC/N, the upper and lower Alb-RC groups were compared. Breakfast NPC/N tended to be higher in the upper group than in the lower group. NPC/N indicates the ratio of non-protein energy intake (energy from carbohydrates and lipids) per gram of nitrogen contained in protein [6]. Therefore, higher amounts of energy were derived from carbohydrates and lipids in the upper Alb-RC group.

NPC/N is an index that determines whether administered amino acids are effectively synthesized into proteins [6]. It is also an index applicable to hospital food ingested orally. In this study, NPC/N might be dispersed due to the bias in the in-

take of staple food and side dishes of each individual patient or the difference in staple food selection. Initially, hospital food is managed by nutrition and NPC/N contributing to improvement based on medical conditions. However, when dietary intake differs depending on patients' appetites and preferences, NPC/N may vary. Among them, at the target hospital, the side dish for breakfast is fixed, such as vegetable dishes, fruits, and milk, but the staple food is either bread or porridge. As protein and carbohydrate levels differ in bread and porridge, breakfast NPC/N varies depending on which of them is chosen. NPC/N is higher with porridge than with bread. Breakfast contents were confirmed between the upper and lower groups, and it was found that individuals choosing porridge tended to be more in the upper Alb-RC group (six out of 12 subjects) than in the lower group (one out of 12 subjects) (P = 0.069). Based on these observations, it was thought that an enough amount of non-protein energy may be necessary at breakfast. In other words, to improve Alb metabolism, it might be useful to increase the ratio of carbohydrates as much as possible and to increase non-protein energy intake at breakfast after taking required nutrition into account. In addition, there was no difference in lunch and dinner NPC/N. This is because, in principle, there was no choice for the staple food of lunch and dinner, which was unified as rice or porridge.

Chrononutrition has shown that the regulation of the body clock, which forms a rhythm of approximately 24 h a day, is important for maintaining health [9, 10]. Light is the most crucial factor in resetting (synchronizing) the subtle deviation in the biological clock among cells, but eating is a stronger factor than light [11]. Breakfast normalizes the liver clock, but late-night supper disrupts the liver clock. When the same high-

Table 4. Comparison Between the Upper Group and the Lower Group of Change Rate of Albumin (n = 24)

	Lower group	Upper group	P value
Number of patients (male/female)	12 (8/4)	12 (5/7)	0.414
Age (years)	83 ± 4.5	79.6 ± 10.1	0.296
At discharge Alb/at admission Alb	0.85 ± 0.08	1.11 ± 0.09	< 0.001
Breakfast NPC/N	-0.35 ± 0.91	0.54 ± 1.23	0.058
Breakfast (bread/porridge) ^a	11/1	6/6	0.069

Data are expressed as mean ± standard deviation. Mann-Whitney U test. ^aFisher's exact test. Alb: serum albumin; NPC/N: non-protein calorie/nitrogen ratio.

carbohydrate food is consumed at breakfast and dinner, differences have been shown in pathways related to glycolysis and the tricarboxylic acid (TCA) cycle, which are close to glucose metabolism [12-14].

Furthermore, it has been elucidated by animal experiments that the metabolism of nutrients changes as per time zone [15-17]. In addition, the metabolic dynamics in the blood during breakfast and dinner were comprehensively compared using human metabolome. The results showed that the metabolic activities of the energy generation system and biocomponent synthesis system are enhanced during breakfast than dinner by focusing on glycolysis, TCA cycle, and amino acid metabolism [18]. From the perspective of chrononutrition, it is important to prioritize and consume food ingredients that move the body clock in the morning, and carbohydrates are useful for promoting the metabolism of sugar that is easily expended in the morning.

Alb is a protein produced only in the liver. It is used as one of the indices to assess disease severity and the quality of nutritional status [19-24]. The liver has a large reserve capacity and is resistant to aging. However, it is a well-known fact that, with aging, liver weight and volume decrease, hepatocytes count and blood flow decrease, and its metabolic function declines. Therefore, glucose tolerance deteriorates with age, and protein and lipid metabolism are also impacted considerably [25-27].

On the other hand, liver glycogen is essential for the liver to maintain its metabolic function. As liver glycogen is expended even during sleep, it is necessary to rapidly increase it through breakfast. In geriatric patients, in addition to the physiological aging of the liver, pathological aging may also reduce its function. Therefore, rapid glycogen synthesis is necessary at breakfast following fasting after dinner. Thus, it is believed that the active intake of carbohydrates that is easily expended at breakfast may promote sugar metabolism and contribute to the recovery of liver function.

In this study, we investigated the relationship between Alb-RC and breakfast NPC/N in geriatric patients. Current findings and discussions support, the usefulness of increasing the ratio of carbohydrate intake, non-protein energy intake, and NPC/N at breakfast. Therefore, it is recommended for older adults to support their dietary needs by increasing non-protein energy intake at breakfast within the appropriate range to improve their Alb.

Limitations of the study

The limitations of this study are that it is a retrospective study rather than an intervention study, the subjects are limited, and the number of cases is small as geriatric patients admitted to a local small-scale hospital were targeted. Therefore, it is undeniable that there are limitations in the interpretation of results. We used a stepwise method in this study because of the small sample size; however, it would be preferable to increase the number of subjects and analyze using a non-stepwise method to compare outcomes with other studies with similar objectives. The authors understand that the results should not be generalized because of the insufficient sample size. Nevertheless, we believe that it is worth reporting that the current result provides a good opportunity to begin verifying this issue

through a future larger study.

Conclusions

It was shown that differences in breakfast NPC/N in nutrition intake observed in geriatric patients may affect the improvement of Alb at discharge. It may be useful to increase breakfast NPC/N within the acceptable range.

Acknowledgments

We would like to express our deep gratitude to the patients admitted to Nakai Hospital who provided their consent to participate in this study.

Financial Disclosure

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Conflict of Interest

None to declare.

Informed Consent

This study was a retrospective study. We asked on the message board if we could use their data anonymously in our hospital. We have obtained informed consents for publication from all participants.

Author Contributions

Yasuko Fukuda: all processes including data collection, analysis, paper writing and so on. Mikako Ochi and Ryoko Kanazawa were responsible for medical chart survey. Hiromu Nakajima, Keisuke Fukuo and Masanobu Nakai: final proof-reading of the manuscript.

Data Availability

Any inquiries regarding supporting data availability of this study should be directed to the corresponding author.

Abbreviations

Alb: albumin; DP: dietary pattern; Alb-RC: change rate of albumin; NPC/N: non-protein calorie/nitrogen ratio; BW: body weight

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