Abstract: This cross-sectional study investigated the relationship between Oral Assessment Guide (OAG) scores and malnutrition in newly hospitalized patients. A total of 880 hospitalized adults were enrolled. Hypoalbuminemia was defined as serum albumin less than 3.5 g/dL. Patients with hypoalbuminemia were older (P < 0.001), had a higher prevalence of respiratory diseases (P < 0.01), a higher prevalence of digestive diseases (P < 0.01), a lower prevalence of oral feeding (P < 0.001), a lower body mass index (P < 0.001), and higher OAG scores (P < 0.001) than those without hypoalbuminemia. Multivariate logistic regression analyses showed that the prevalence of hypoalbuminemia was significantly related to age (odds ratio [OR] = 1.05, P < 0.001), absence of oral feeding (OR = 2.72, P < 0.001), presence of digestive diseases (OR = 2.53, P < 0.01), presence of digestive diseases (OR = 1.64, P < 0.01), and OAG scores (OR = 1.14, P < 0.01). Regarding OAG scores, the OR of hypoalbuminemia was greater in patients with disorders (scores 2 or 3) of swallowing (vs. score 1, OR = 1.51, P < 0.05) and saliva (vs. score 1, OR = 1.51, P < 0.05). There appears to be a positive association between OAG scores and hypoalbuminemia in hospitalized patients.

Keywords: cross-sectional study, hospitalized patients, hypoalbuminemia, oral health

Introduction

Hypoalbuminemia, defined as a serum albumin concentration <3.5 g/dL, is regarded as an indicator of poor nutritional status [1]. A previous clinical study revealed that hypoalbuminemia was associated with 30-day all-cause mortality in acutely admitted medical patients [2]. Another study reported that patients with hypoalbuminemia had a higher risk for surgical site infection, pneumonia, extended length of hospital stay, and readmission after total joint arthroplasty than patients with normal albumin concentrations [3]. Furthermore, it was demonstrated that hypoalbuminemia is a predictor of postoperative complications (death, unplanned intubation, being on a ventilator >48 h, sepsis, and blood transfusion), and increased length of hospital stay in patients with hip fractures [4]. These observations indicated that hypoalbuminemia is an important clinical target for the suppression of risk for adverse clinical outcomes during hospitalization.

Hypoalbuminemia is associated with low protein intake [5] and several different diseases, including hepatic and kidney diseases [6]. Studies have suggested that chewing function has an impact on an individual’s nutritional status [7,8], and poor oral health may also be associated with hypoalbuminemia. In fact, a clinical study showed that a significant negative correlation existed between periodontal health and serum albumin concentrations in chronic obstructive pulmonary disease patients [9]. However, further research investigating the relationship between oral health status and hypoalbuminemia in hospitalized patients is required.

The Oral Assessment Guide (OAG) is a communication tool that is used to share information about oral health status in hospitalized patients [10-12]. At Asahi University Hospital, newly hospitalized patients receive oral examinations from dental hygienists using OAG. Investigating how OAG scores correlate with hypoalbuminemia is expected to improve the understanding of whether or not it is appropriate for dentists and dental hygienists to care for hospitalized patients. In the present study, it was hypothesized that the risk of hypoalbuminemia may be associated with OAG scores in newly hospitalized patients. Therefore, the purpose of the present cross-sectional study was to investigate the relationship between OAG scores and hypoalbuminemia in newly hospitalized adults.

Materials and Methods

Study population

A total of 962 hospitalized patients (median age: 76 years) who underwent oral examination were recruited from November 2017 to February 2018 at Asahi University Hospital in Gifu, Japan. Since the present study involved completing a survey, sample size calculations were not performed. Eighty-two patients with missing data were excluded. Accordingly, data from 880 patients were included in the final analyses. The present study was conducted in accord with the Declaration of Helsinki, and the study protocol was approved by the Ethics Committee of Asahi University (No. 29025). All participants provided written informed consent prior to enrollment in the study.

Oral examination

Six dental hygienists evaluated OAG scores of the study participants within a few days after hospitalization. The dental hygienists had ≥3 years of experience. OAG is a multi-variable scale that consists of eight items: voice, swallowing, lips, tongue, saliva, oral mucosa, gingiva, and teeth [10-13]. Each item has three progressive descriptors that are scored from one (healthy) to three (severe alteration; Table 1). The final score represents the sum of the individual scores and ranges from 8 to 24 with higher scores indicating worse oral conditions. To check the intra- and inter-examiner agreement, OAG scores were recorded and the examination was repeated within a 2-week interval in 10 photographs of hospitalized patients. The kappa coefficients for intra- and inter-examiner and intra-class correlation coefficients were >0.8.

Medical examination

Body weight and height were measured using a body composition meter (Tanita, Tokyo, Japan), and the body mass index (BMI) was calculated for each participant. Venous fasting blood samples were collected and the serum albumin concentration was determined using an automatic analyzer (Cobas C 702, Roche Diagnostics, Tokyo, Japan). Measurements of serum albumin concentrations were performed during the same period as the oral examinations.
Continuous variables were expressed as the median (first quartile, third quartile).

Table 2
Characteristics of patients with and without hypoalbuminemia

| Variable                      | All (n = 880) | Without hypoalbuminemia (n = 572) | With hypoalbuminemia (n = 308) | P value\* |
|-------------------------------|--------------|-----------------------------------|-------------------------------|-----------|
| Gender*                       | 448/432 (49%)| 290/282 (49%)                     | 158/150 (49%)                 | 0.865     |
| Age                           | 76 (65, 83)  | 73 (60, 81)                       | 81 (73, 87)                   | <0.001    |
| BMI kg/m²                     | 22.2 (19.4, 24.8) | 22.5 (20.0, 25.1) | 21.4 (18.6, 24.0) | <0.001    |
| Oral feeding\*                | 735/145 (16%)| 514/58 (10%)                      | 221/87 (28%)                  | <0.001    |
| Major diagnosis at the time of admission |                   |                                    |                               |           |
| Respiratory diseases\*        | 44/836 (5%)  | 19/553 (3%)                       | 25/283 (9%)                   | 0.002     |
| Surgical diseases\*           | 248/632 (39%)| 172/400 (43%)                     | 76/232 (33%)                  | 0.099     |
| Cardiovascular diseases\*     | 55/825 (7%)  | 29/543 (5%)                       | 26/282 (9%)                   | 0.057     |
| Digestive diseases\*          | 172/708 (24%)| 93/479 (19%)                      | 79/229 (34%)                  | 0.001     |
| Urologic diseases\*           | 36/844 (4%)  | 20/552 (4%)                       | 16/292 (5%)                   | 0.284     |
| OAG score                     | 9 (8, 10)    | 10 (8, 10)                        | 10 (8, 11)                    | <0.001    |
| OAG times\*                   |               |                                   |                               |           |
| Voice                         | 731/149 (17%)| 505/67 (12%)                      | 226/87 (27%)                  | <0.001    |
| Swallowing                    | 814/66 (8%)  | 554/18 (3%)                       | 260/48 (16%)                  | <0.001    |
| Lips                          | 790/90 (10%) | 534/38 (7%)                       | 256/52 (17%)                  | <0.001    |
| Tongue                        | 607/273 (31%)| 417/155 (27%)                     | 190/118 (38%)                 | <0.001    |
| Saliva                        | 756/130 (15%)| 521/51 (9%)                       | 229/79 (26%)                  | <0.001    |
| Oral mucosa                   | 855/25 (3%)  | 563/9 (2%)                        | 292/16 (5%)                   | 0.003     |
| Gingiva                       | 732/148 (17%)| 490/82 (14%)                      | 242/66 (21%)                  | 0.014     |
| Teeth                         | 494/386 (44%)| 345/227 (40%)                     | 149/159 (52%)                 | 0.003     |

Continuous variables were expressed as the median (first quartile, third quartile). *Chi-squared test or Mann-Whitney U test; \*male/female (percentage of females); \*presence/absence (percentage of absence), \*presence/absence (percentage of presence), \*normal/abnormal (percentage of abnormal). BMI, body mass index; OAG, Oral Assessment Guide

Other variables
Information on the patient’s age, sex, presence or absence of oral feeding, and major diagnosis at the time of admission (respiratory disease, surgical disease, cardiovascular disease, digestive disease, urologic disease, or other) was obtained from electronic health records.

Statistical analysis
Patients with a serum albumin concentration <3.5 g/dL were defined as having hypoalbuminemia [1-4]. Significant differences in selected characteristics between study participants with and without hypoalbuminemia were assessed using chi-squared tests and Mann-Whitney U tests. Regarding the major diagnosis at the time of admission, the category “other” was not included in the analysis. Univariate and multivariate logistic regression analyses with a stepwise method were performed with the presence or absence of hypoalbuminemia as the dependent variable. In this stepwise method, variables with P < 0.10 were removed from the model and variables with P < 0.05 were added to the model. Independent variables were selected for the univariate model when the P value was <0.05. In addition, in the logistic analysis, each item of OAG (i.e., voice, swallowing, lips, tongue, saliva, oral mucosa, gingiva, and teeth) was categorized as normal (score of 1) or disordered (score of 2 or 3). All data were analyzed using SPSS statistics version 24 (IBM Japan, Tokyo, Japan). All P values were considered statistically significant at <0.05.

Results
The overall prevalence of hypoalbuminemia was 15%. OAG scores ranged between 8 and 22 (median 9). Patients with hypoalbuminemia were significantly more likely to be older, have a lower BMI, lower prevalence of oral feeding, higher prevalence of respiratory diseases, higher prevalence of digestive diseases, and higher OAG score (P < 0.01 for all; Table 2). Patients with hypoalbuminemia also had a higher prevalence of abnormal oral conditions related to voice, swallowing, lips, tongue, saliva, oral mucosa, gingiva, and teeth than those without hypoalbuminemia (P < 0.05 for all).

In the univariate logistic regression, the odds ratio (OR) of hypoalbuminemia was associated with age (OR, 1.05, P < 0.001), BMI (OR, 0.92, P < 0.001), absence of oral feeding (OR, 3.49, P < 0.001), presence of respiratory diseases (OR, 2.57, P < 0.01), presence of digestive diseases (OR, 1.78, P = 0.001), and OAG score (OR, 1.35, P < 0.01; Table 3). The OR of hypoalbuminemia was also associated with abnormalities related to the voice (OR, 2.20, P < 0.001), swallowing (OR, 4.35, P < 0.001), lips (OR, 2.73, P < 0.001), tongue (OR, 1.65, P < 0.01), saliva (OR, 4.77, P < 0.001), oral mucosa (OR, 2.60, P < 0.001), gingiva (OR, 1.65, P < 0.01), and teeth (OR, 1.46, P = 0.001).

In the multivariate logistic regression, the OR of hypoalbuminemia was associated with age (OR, 1.05, P < 0.001), absence of oral feeding (OR, 2.72, P < 0.001), presence of respiratory diseases (OR, 2.53, P < 0.01), presence of digestive diseases (OR, 1.64, P < 0.01), and OAG score (OR, 1.14, P < 0.01) after adjusting for age, BMI, absence of oral feeding, presence of respiratory diseases, presence of digestive diseases, and OAG score (Table 4). The OR of hypoalbuminemia was also associated with age (OR, 1.04, P < 0.01), absence of oral feeding (OR, 2.48, P < 0.01), presence of respiratory disease (OR, 2.55, P < 0.01), presence of digestive disease (OR, 1.67, P < 0.01), and disorders related to swallowing (OR, 1.83, P < 0.05) and saliva (OR, 1.51, P < 0.05) after adjusting for age,
Table 3  Factors associated with hypoalbuminemia in univariate logistic regression analysis

| Variable                  | Crude odds ratio | 95% confidence interval | P value |
|---------------------------|-----------------|-------------------------|---------|
| Gender                    | 0.98            | 0.78-1.27               | 0.86    |
| Age                       | 1.05            | 1.04-1.07               | <0.001  |
| BMI, kg/m²                | 0.92            | 0.89-0.96               | <0.001  |
| Absence of oral feeding   | 3.49            | 2.42-5.04               | <0.001  |
| Presence of respiratory diseases | 2.57   | 1.39-4.75              | 0.003   |
| Presence of surgical disease | 0.76   | 0.56-1.04              | 0.090   |
| Presence of cardiovascular diseases | 1.73  | 0.99-2.99              | 0.051   |
| Presence of digestive disease | 1.78  | 1.27-2.49             | 0.001   |
| Presence of urologic disease | 1.51   | 0.77-2.96             | 0.228   |
| OAG score                 | 1.35            | 1.24-1.46               | <0.001  |
| OAG itemsd                |                 |                        |         |
| Voice                     | 2.20            | 1.64-2.95               | <0.001  |
| Swallowing                | 4.35            | 2.64-7.17               | <0.001  |
| Lips                      | 2.73            | 1.79-4.16               | <0.001  |
| Tongue                    | 1.65            | 1.25-2.17               | <0.001  |
| Saliva                    | 4.77            | 2.69-8.46               | <0.001  |
| Oral mucosa               | 2.60            | 1.95-3.48               | <0.001  |
| Gingiva                   | 1.65            | 1.16-2.35               | 0.006   |
| Teeth                     | 1.46            | 1.16-1.84               | 0.001   |

Table 4 Factors associated with hypoalbuminemia in a stepwise multivariate logistic regression analysis of OAG scores

| Variable                  | Adjusted odds ratioa | 95% confidence interval | P value |
|---------------------------|----------------------|-------------------------|---------|
| Age                       | 1.05                 | 1.03-1.06               | <0.001  |
| Absence of oral feeding   | 2.72                 | 1.79-4.14               | <0.001  |
| Presence of respiratory diseases | 2.53   | 1.29-4.97           | 0.007   |
| Presence of digestive disease | 1.64  | 1.13-2.39           | 0.007   |
| OAG score                 | 1.14                 | 1.04-1.23               | 0.004   |

Table 5 Factors associated with hypoalbuminemia in a stepwise multivariate logistic regression analysis of OAG items

| Variable                  | Adjusted odds ratioa | 95% confidence interval | P value |
|---------------------------|----------------------|-------------------------|---------|
| Age                       | 1.04                 | 1.03-1.06               | <0.001  |
| Absence of oral feeding   | 2.48                 | 1.60-3.86               | <0.001  |
| Presence of respiratory diseases | 2.55   | 1.29-5.03          | 0.007   |
| Presence of digestive disease | 1.67  | 1.15-2.43           | 0.007   |
| Swallowing                | 1.83                 | 1.64-3.21               | 0.036   |
| Saliva                    | 1.51                 | 1.09-2.99               | 0.019   |

BMI, absence of oral feeding, presence of respiratory diseases, presence of digestive diseases, and OAG items (voice, swallowing, lips, tongue, saliva, oral mucosa, gingiva, teeth). *presence/absence (reference was presence), *presence/absence (reference was absence), *male/female (reference was male), *presence/absence (reference was normal). OAG, Oral Assessment Guide

Discussion

OAG is an established method for assessing oral health [10-13]. The present study revealed that patients with hypoalbuminemia had higher OAG scores than those without hypoalbuminemia. Multivariate logistic regression showed that the risk of hypoalbuminemia was higher in patients with higher OAG scores. These results indicated that hypoalbuminemia is positively associated with poor oral health in hospitalized patients. Previous studies have shown a significant association between oral health and nutritional status in people living at home and receiving home care services [14] and in those living in nursing homes [15]. This previous study and the present study both support the concept that oral health is an important indicator of risk of malnutrition in home health care.

Of the OAG items, swallowing disorder was associated with hypoalbuminemia. This result is consistent with a previous study suggesting that swallowing disorder was associated with the incidence of malnutrition in elderly people receiving home care [16]. Poor swallowing function leads to insufficient food intake, and such a condition would contribute to the development of malnutrition, including hypoalbuminemia. In these observations, saliva disorder was also associated with hypoalbuminemia. The function of saliva includes formation of a food bolus conducive to swallowing [17]. Saliva disorder can block the formation of the food bolus and may result in malnutrition through suppression of swallowing.

However, gum disorder was not associated with hypoalbuminemia. This result differed from previous studies [18,19], indicating a positive association between poor periodontal health and the serum albumin level. Regarding OAG scores, while gum disorder was diagnosed as the presence of gingival inflammation (redness and bleeding), periodontal tissue destruction (attachment loss and alveolar bone loss) was not considered. The effects of periodontal health on serum albumin levels may reflect the severity of periodontal tissue destruction rather than the presence of gingival inflammation [20].

Aging [21] and absence of oral feeding [22] are accepted as risk factors for malnutrition. These observations also showed that the risk of hypoalbuminemia was associated with aging and the absence of oral feeding. On the other hand, there was no association between BMI and the risk of hypoalbuminemia. In the present study, the prevalence of patients with BMI ≥25 (23.6%) was greater than those with BMI <18.5 (17.5%; data not shown). The association between BMI and the risk of hypoalbuminemia might not have reached the level of significance since the current study participants had more cases of obesity than being underweight.

In this study, OAG scores of all participants were evaluated within a few days of hospitalization. This was done to avoid the effects of medical treatments on OAG scores as much as possible. In addition, the serum
albumin levels of all patients at Asahi University Hospital were measured at the time of hospitalization. Since the circulating half-life of serum albumin is about 3 weeks, it is suggested that the time-lag between OAG score evaluation and serum albumin level measurement had little effect on the present results.

It has been reported that the prevalence of hypoalbuminemia in hospitalized patients was 16.3% in Korea [23] and 29% in Israel [1]. In this study, the prevalence of hypoalbuminemia was 35%. In Japan, the role of the hospital is defined and Asahi University Hospital is an acute care hospital. Therefore, the prevalence of hypoalbuminemia in the present study may be relatively high. In addition, the OAG scores in these observations ranged from 8 to 22. These values were similar to a previous report showing a range of OAG scores in hospitalized patients of 8 to 20 [24].

Hypoalbuminemia is associated with adverse clinical outcomes during hospitalization [1-4]. Therefore, improvement of hypoalbuminemia is effective in preventing adverse clinical outcomes during hospitalization. In these observations, OAG scores were significantly correlated with the risk of hypoalbuminemia. In Japanese hospitals there is a system in which dental hygienists and nurses check the OAG score regularly. On the other hand, dentists can perform visiting medical treatment depending on the request from a hospital. Cooperation between dentists and dental hygienists/nurses using OAG as a communication tool would be beneficial to reduce adverse clinical outcomes during hospitalization.

This study has some limitations. First, information on sociological factors was not collected, which may have an influence on serum albumin levels [25]. Second, the current study design was cross-sectional, so causal relationships remain unclear; longitudinal studies are needed to further elucidate the connections between OAG score and hypoalbuminemia.

In conclusion, there appears to be a positive association between OAG scores and hypoalbuminemia in hospitalized patients. Among the OAG items, hypoalbuminemia was especially associated with swallowing and salivary disorders.

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Conflict of interest

None declared.

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