In Japan, the number of elderly living in nursing homes continues to increase with the progressive aging of its society. Malnutrition was detected in 20–30% of the aged in care health centers for the elderly and 33–73% in nursing-home-type units. The nursing care insurance system revision in 2005 introduced a payment for a nutritional care plan designed for undernourished subjects. Anemia, hypoalbuminemia and immunodeficiency are known to be indicators of malnutrition.

The incidence rate of anemia increased after the age of 65, and it reached 23% at the age of 85 and older. Anemia caused by a nutrient deficiency accounts for one-third
of all anemia cases. When the elderly suffers from anemia, there is a drop in physical activity and an increase in morbidity. Dementia often appears among the elderly with anemia. In this way, the onset of anemia reduces the quality of life (QOL) among the elderly. Anemia of the aged tends to have a slow progression and is easy to overlook because the symptoms are mild. And anemia can result from deficiency of dietary nutrients, there is deficiency diseases such as protein and iron, vitamins.

In this study, the prevalence rate of anemia and its relation to nutritional indices were examined for the elderly in the two nursing homes. We propose that the BMI is an appropriate nutritional index for the early implementation of nutritional therapy to prevent anemia.

SUBJECTS AND METHODS

Subjects

From 2002 to 2004, 197 residents were living in two nursing homes for the elderly with special care facilities in Okayama. The following subjects were excluded from the 197; 58 with incomplete data, 9 with tube feeding, 19 with any basal disease such as malignant tumors, infectious diseases, or renal failure, and 14 male subjects. This study involved on 97 female subjects with the average of age of 87 ranging from 62 to 101.

In the cases when it was impossible to measure the body height, it was estimated using the Chumlea knee height. The basal metabolic rate (BMR) of the subjects was calculated from a standard BMR per kg scale according to age and sex.

When conducting this research, the obligation to keep personal information confidential was rigidly observed for any personal information obtained through the survey. Informed consent was obtained from the subjects and none of the obtained results were utilized for anything other than the purpose of this study.

Examination of the peripheral blood and biochemical examinations of the serum

The SRL company was requested to measure the amount of hemoglobin (Hb), red blood cell count (RBC), hematocrit (Ht), mean cell volume (MCV), mean corpuscular hemoglobin concentration (MCHC), white blood cell count (WBC), number of platelets (Plt), total protein (TP), albumin (Alb), and total cholesterol (TC).

Classification of anemia

Anemia was determined by the amount of Hb of less than 11 g/dL according to Shirokura’s criteria. The types of anemia was classified as microcytic hypochromic anemia (MHA) for MCV < 80 fl and MCHC < 30%, as normocytic normochromic anemia (NNA) for MCV = 80–100 fl and MCHC = 31–35%, and as macrocytic normochromic anemia (MNA) for MCV > 100 fl and MCHC = 31–35%.

Data analysis

All analyses were performed using the procedures available in of the SPSS software. The significance of the differences was assessed using the t-test and Tukey HSD’s test. Correlations were assessed using Pearson’s correlation.

Ethical consideration

This study received approval of Mimasaka university Ethical Review Board.

RESULTS

1. Subject characteristics (Table 1)

Attributes are shown for all the 97 subjects, that consisted of 41 anemic subjects, and 56 non-anemic subjects. The calculated BMRs of the anemic subjects were significantly lower than those of the non-anemic subjects, which were mostly within normal limits. However, no difference was seen in the other attributes.

2. Peripheral blood examination and serum biochemical tests (Table 2)

The averages of all items for all subjects were within their standard ranges. Nutritional markers such as TP, Alb and TC were not different between the anemia and non-anemia groups. For the anemic subjects, only the Hb and WBC averages were lower than the standard range, while the Hb, RBC, Ht, MCHC, and WBC of the anemic subjects were significantly lower than those of the non-anemic subjects.

### Table 1 Physical characteristics of the subjects.

<table>
<thead>
<tr>
<th></th>
<th>Anemia (n = 41)</th>
<th>Non-Anemia (n = 56)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Height</strong> (cm)</td>
<td>145.1 ± 5.0</td>
<td>144.4 ± 4.7</td>
<td>n.s.</td>
</tr>
<tr>
<td><strong>Body Weight</strong> (kg)</td>
<td>39.4 ± 6.4</td>
<td>37.9 ± 6.3</td>
<td>n.s.</td>
</tr>
<tr>
<td><strong>BMI</strong> (kg/m²)</td>
<td>18.7 ± 2.9</td>
<td>18.1 ± 3.1</td>
<td>n.s.</td>
</tr>
<tr>
<td><strong>BMR</strong> (kcal/day)</td>
<td>861 ± 92.2</td>
<td>839 ± 91.9</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

* M ± SD, BMI = body weight (kg)/height (m²), BMR = basal metabolic rate.
3. The correlation between BMI, BMR, and blood examinations (Table 3)

The BMI was highly correlated to the BMR. The BMI and BMR did not correlate with the other examinations. The RBC positively correlated with the Hb and Ht, but negatively with the MCV and MCH.

4. The prevalence of anemia per quintile according to the BMI (Table 4, Fig. 1)

Anemia with an Hb less than 11 g/dL was observed in 41 people (42%). The BMR of Q5 was significantly higher than those of Q1 to Q4. The BMR of Q1 was significantly lower than those of Q2 to Q5. If body weight is low, the BMR becomes a low value, because the BMR was calculated from a standard BMR and body weight.

5. The prevalence of anemia types in the 5 BMI quintiles (Table 4)

The prevalence of anemia was not different among the quintiles from Q1 to Q5. When the quintiles were classified into Q1–3 and Q4–5, the prevalence of anemia was significantly lower in Q4–5 (28%) than in Q1–3 (52%). The boundary between Q3 and Q4 was a BMI of 19.5. The prevalence of anemia was not different between the groups above 18.5 and less than 18.5. A low weight is often defined as a BMI less than 18.5, which was not the appropriate marker for the detection of anemia in this study as shown in Fig. 1.

NNA was observed in 26 people (27%), MNA was found in 15 people (15%) and MHA and macrocytic hyperchromic anemia were not found. MNA was observed in 1 person (3%) in Q4–5, which was less frequent than the 24% of Q1–3.

**DISCUSSION**

Anemia was observed in 41 (42%) of the 97 senile women without serious basal diseases in the two nursing homes evaluated in this study. The average BMI of this study was 18.7 (Table 1) that was lower than 22.3 of the elderly living in private homes based on the 2002 Japan national nutrition survey. The Hb, RBC and Ht of 11.3 ± 1.4 g/dL, 36.2 ± 4.9 million/μL and 34.9 ± 4.1%, respectively, in this study (Table 2), were lower by about 14% than the survey results of 12.6 ± 1.2 g/dL, 41.0 ± 4.0 million/μL and 40.8 ± 3.7%. Our subjects had more numerous anemic people. In contrast, the nutritional mark-
In this study, the prevalence rate of MNA was 24% in the subjects with a BMI less than 19.5 (Q1 to Q3), and higher than the 3% for the subjects with a BMI of 19.5 or higher (Table 4). The prevalence of anemia was not different between the groups above 18.5 and less than 18.5 in this study. MNA is induced by a deficiency in folic acid, vitamins B12 or B6, and Joosten et al. reported that a low serum vitamin B12 concentration was found in 6% and 5%, low folate in 5% and 19%, and low vitamin B6 in 9% and 51% of healthy elderly subjects and elderly hospitalized patients, respectively. Folic acid deficient anemia was found in 17% of elderly anemia patients, and the incidence of a folate deficiency increased from day 1 to day 360 in recently institutionalized elderly people without evidence of functional deterioration. We surveyed nutrient

ers, such as TP, Alb and TC, were not as low suggesting a low protein nutritional status. The anemia RBC negatively correlated with the MCV and MCH (Table 3).

Total anemia was observed in 42% of the patients in this study, while NNA was in 27%, MNA was in 15%, and HMA was 0% in the patients. Saito reported that anemia was observed in 50% of general hospital inpatients who were 60 years of age or older (190 patients). Anemia in senile inpatients from general hospitals was mainly due to inflammation, gastrointestinal bleeding due to malignant tumors, etc. Abe et al. reported that anemia was detected in 28% of the elderly living in retirement homes (100 senior citizens aged 80 years and over). It is known that RBC, Hb, and Ht drop in conjunction with aging, and the prevalence of anemia increases as people age.

Table 4  Prevalence of anemias classified by quintile of the BMI.

<table>
<thead>
<tr>
<th>quintile</th>
<th>BMI</th>
<th>number</th>
<th>non-anemia</th>
<th>anemia</th>
<th>anemia types</th>
<th>NNA</th>
<th>MNA</th>
<th>MHA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1-3</td>
<td>19.5&gt;</td>
<td>58</td>
<td>28 (48) a</td>
<td>30 (52) a</td>
<td>16 (28) b</td>
<td>14 (24) b</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Q4-5</td>
<td>19.5≤</td>
<td>39</td>
<td>28 (72) a</td>
<td>11 (28) a</td>
<td>10 (26) b</td>
<td>1 (3) b</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Q1-5</td>
<td>97</td>
<td>56 (58)</td>
<td>41 (42)</td>
<td>26 (27)</td>
<td>15 (15)</td>
<td>0 (0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MHA = microcytic hypochromic anemia. NNA = normocytic normochromic anemia.
MNA = macrocytic normochromic anemia.
a: Anemia was less prevalent in Q4 to Q5 than Q1 to Q3 (p < 0.05).
b: MNA was less prevalent in Q4 to Q5 than Q1 to Q3 (p < 0.05), whereas NNA showed no difference.
intakes of the elderly with anemia by weighing the amount of the waste plate\(^3\). There were a lot of leftovers of the vegetable and the amount of waste plate, the intakes of energy and protein of the subjects with MNA showed the lowest values. And the folic acid intake of the MNA increased significantly than the NNA.

Based on these findings, it appears that MNA is an anemia that facility residents with a lower BMI are prone to develop, and it could be prevented by improving the nutritional status, particularly with the supplementation of folic acid, vitamin B12 and B6. A BMI of less than 19.5 was thus found to be a useful criterion for the early prediction of MNA. BMI is a useful nutritional index for predicting anemia in elderly women in nursing homes. We recommend a BMI of 19.5 as a surrogate border marker for the early implementation of supplemental nutrition therapy in order to prevent MNA.

Acknowledgements

We thank Masayuki Takeshima, Okayama Saiseikai General Hospital, and Junko Tsunesada, Ikoinkooka Nursing Home, for their excellent clerical support in this research.

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