Malnutrition is a significant factor in the development of pressure ulcers and many studies have shown that early nutritional assessment is essential for preventing pressure ulcers. Many nutritional guidelines for preventing pressure ulcers have been published because ulcers tend to develop in patients with malnutrition despite intensive care. However, few reports have recommended levels of energy intake needed to heal pressure ulcers. The present study investigated the total nutritional intake of patients with pressure ulcers to determine the level of energy intake needed to heal pressure ulcers.

Methods
Forty patients with pressure ulcers at Nagasaki Medical Center (Nagasaki, Japan) were treated from August 2007 through February 2008. Of these patients, 21 whose wounds improved or healed (improvement group) and 19 whose wounds became worse or did not improve were eligible for this retrospective study. Pressure ulcers in patients who received more than 30 kcal/kg per day improved or healed, while those of patients who received less than 20 kcal/kg per day worsened or failed to improve. Furthermore, intake of 30 kcal/kg per day enabled serum albumin levels to improve. Energy intake of 30 kcal/kg per day is comparable to the predicted total energy expenditure and is thought to be essential for improving pressure ulcers in bedridden patients.
19 whose wounds became worse or did not improve (worse/unimproved group) were eligible for this retrospective study. Primary diseases are shown in Figure 1. In both groups, malignant neoplasms were the most common primary disease.

Patients in the improvement group ranged in age from 22 to 94 years (mean age, 67.4 ± 16.4 years), and patients in worse/unimproved group ranged in age from 51 to 92 years (mean age, 71.7 ± 10.9 years). Pressure ulcer locations are shown in Figure 2. Pressure ulcers developing over the sacrum accounted for about half of all ulcers in both groups. The severity of the pressure ulcers at discovery is shown in Figure 3. The severity of the pressure ulcers was similar in both groups, in that only Stage I and Stage II ulcers were discovered; this finding indicates that these pressure ulcers were discovered within the early stage. Eight of 21 patients (38%) in the improvement group and 5 of 19 (26%) presented with a Stage I pressure ulcer. Differences in wound severity may account for bias in the study. However, changes in the wounds were investigated (improvement or worsening), and it was assumed that the influence of the primary wound state had little effect on the reported results. Regardless of stage, pressure ulcers usually will improve when they are treated with proper wound bed preparation, use of extra-soft mattresses, and proper alimentation. All patients in this study underwent desirable wound treatment and were placed on either a low-air loss mattress or an extra-soft mattress. Despite these curative efforts, worsened or unimproved pressure ulcers were still seen mainly as a result of insufficient nutritional support.

Height, body weight, body mass index (BMI), and serum albumin level before the pressure ulcer developed in patients in the improvement group and in the worse/unimproved group are shown in Table 1. There were no significant differences in these variables between the improvement group and the worse/unimproved group.
To evaluate ulcer changes, all patients were observed each week at least 1 month from the time the pressure ulcer was discovered. Patients who were discharged before the pressure ulcer healed and either died at home or in hospice within 1 month were excluded from the study. The size, depth, increase in granulation, amount of exudate and necrotic tissue, and development of wound infection were recorded each week. Then, each wound was judged to be either in the healing phase, worsening phase, or the unimproved phase. During the study, all wounds were treated with the usual methods of wound bed preparation including debridement, exudate management, bacterial imbalance resolution, and moist wound dressings; low-air loss mattresses or extra-soft mattresses were supplied to all patients. The total daily energy intake, including that through normal feeding, oral supplementation, tube-feeding, and intravenous alimentation were determined and investigated. The nutritional intake was measured on the day the pressure ulcer was discovered and 2 weeks before and 2 and 4 weeks after discovery.

We investigated several problems when patients developed pressure ulcers including: 1) whether wound healing is affected by total energy intake, and 2) if so, how many calories are required for wound healing?

Statistical analysis was performed using Student’s t-tests.

Ethical considerations. The study’s procedures were in accordance with the ethical standards of the Nagasaki Medical Center’s institutional committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 1983.

Results

Changes in total energy intake in patients of both groups are shown in Figure 4. The mean total energy intake per kilogram of body weight in the improvement group was higher than that in the worse/unimproved group. Total energy intake in the improvement group was always greater than 30 kcal/kg body weight (kcal/kg), whereas in the worse/unimproved group, energy intake was not greater than 20 kcal/kg throughout the observation period. There was a significant difference between the groups in total energy intake at each time point during the 6 weeks (P < 0.01).

Changes in daily protein intake for patients in both groups are shown in Figure 5. The mean daily protein intake in the improvement group was higher than that in the worse/unimproved group. Protein intake in the improvement group was always greater than 45 g, whereas that in the worse/unimproved group was about 20 g.

### Table 1. Age, height, body weight, BMI, and serum albumin of patients with pressure ulcers.

<table>
<thead>
<tr>
<th></th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Body weight (kg)</th>
<th>BMI (kg/m²)</th>
<th>Serum albumin (g/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement</td>
<td>67.4 ± 16.4</td>
<td>155.8 ± 9.7</td>
<td>45.7 ± 10.3</td>
<td>18.7 ± 3.3</td>
<td>2.8 ± 0.6</td>
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<tr>
<td>(n = 21)</td>
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<tr>
<td>Worse/unimproved</td>
<td>71.7 ± 10.9</td>
<td>157.8 ± 12.5</td>
<td>48.1 ± 8.9</td>
<td>19.9 ± 3.2</td>
<td>3.0 ± 0.9</td>
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<tr>
<td>(n = 19)</td>
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Figure 4. Changes in total daily energy intake.

Figure 5. Changes in total daily protein intake.
throughout the observation period. There was a significant difference between the groups in daily protein intake at each time point during the 6 weeks \((P < 0.01)\).

Changes in serum albumin levels are shown in Figure 6. Mean serum albumin levels of the worse/unimproved group decreased throughout the observation period, whereas those in the improvement group increased after pressure ulcers developed. The mean serum albumin levels in the improvement group was significantly higher than that in the worse/unimproved group 4 weeks after the wound developed \((P < 0.05)\), although the initial serum albumin level in the improvement group was lower than that in the worse/unimproved group. Changes in hemoglobin levels are shown in Figure 7. Mean hemoglobin levels of the worse/unimproved group decreased throughout the observation period, whereas those in the improvement group were almost stable at 10 g/dL.

**Discussion**

Pressure ulcers and malnutrition have a strong correlation. Many clinical studies of malnutrition and pressure ulcers have been performed. These studies have shown that a relevancy of an increase in pressure ulcers and the presence of malnutrition or a decreased intake of energy are related. The European Pressure Ulcer Advisory Panel (EPUAP) issued clinical nutritional guidelines for preventing pressure ulcers in 2004, which recommended that a patient requires a minimum of 30 kcal/kg to 35 kcal/kg per day to prevent pressure ulcer development. All of the patients in the present study had a BMI of 18.5 kg/m² to 20 kg/m², indicating they were underweight or chronically malnourished (Table 1). The EPUAP nutritional guidelines also suggest that a similar strategy of nutritional intervention should be considered for the treatment of patients who have established pressure ulcers. However, few reports have indicated recommended intake levels to heal pressure ulcers.

An insufficient dietary intake impairs wound healing, because a poor nutritional status decreases collagen synthesis, skin elasticity, antibiotic levels, general cellular turnover, and the ability to fight infection. Accordingly, the EPUAP nutritional guidelines recommend that patients with pressure ulcers require 30 to 35 kcal/kg for wounds to heal. The results of the present study show that the total energy intake in patients whose pressure ulcers improved was greater than 30 kcal/kg per day, whereas energy intake in patients whose ulcers worsened or did not improve was not more than 20 kcal/kg per day. These results were unexpected, because we believed that extra calories were required to heal pressure ulcers. The EPUAP nutritional guidelines were intended mainly to prevent pressure ulcers from developing, meaning that some of the targeted patients are ambulatory. Conversely, all of the patients in the present study were bedridden and had energy requirements that were thought to be lower than those of nonbedridden patients. Energy intake of 30 kcal/kg per day is comparable to the predicted total energy expenditure \((1.2 \times \text{basal energy expenditure})\) and is thought to be sufficient for bedridden patients. As proof, intake of 30 kcal/kg per day facilitates an increase in serum albumin levels, which would also encourage wound healing.

The present study revealed that the mean energy intake in the worse/improved group was less than 20 kcal/kg per day, which suggests that wounds cannot be...
expected to improve in patients whose energy intake is 20 kcal/kg or less per day. This result indicates that improving wounds is almost impossible in patients whose feeding is interrupted because of some disorder of digestion or absorption including nausea, vomiting, unpleasantness of tube placement, and repeated pneumonia caused by bronchial reflex despite tube feeding. These unpleasant disturbances are likely to occur in patients with malignant neoplasms especially in the terminal stage. This notion is supported by the primary disease being a malignant neoplasm in 13 of 19 patients (68%) whose pressure ulcers did not improve, but in only 6 of 21 patients (26%) whose pressure ulcers did improve.

Nutritional support with more than 30 kcal/kg per day for patients with pressure ulcers should encourage wound healing and increase serum albumin levels.

Conclusion
The use of nutritional guidelines in pressure ulcer care has been recommended since malnutrition is a significant factor in both the development and healing of pressure ulcers. However, these guidelines were mainly intended to prevent formation of pressure ulcers. To encourage wound healing, total energy intake of 30 kcal/kg per day is essential for bedridden patients with pressure ulcers.

References