Adequacy of Nutritional Support and Reasons for Underfeeding in Neurosurgical Intensive Care Unit Patients

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Purpose The purpose of the study was to identify the adequacy of enteral feeding, and the reason and prevalence of under-nutrition, and to determine the relationships between caloric intake and resulting nutritional parameters among neurosurgical intensive care unit (ICU) patients.

Methods The participants for this descriptive study were 47 neurosurgical ICU patients who had enteral feeding initiated after ICU admission. Data were collected from the initial day of enteral feeding for 7 days. Data related to enteral feeding, feeding interruptions or delay, prealbumin, and transferrin were collected.

Results The mean age of the participants was 56.62 years. Twenty-six patients did not receive their feeding formula more than once during 7 days, and 11 had interruptions more than 6 times. The mean number of feeding interruptions was 3.23 (SD = 4.47). On the average, only 76.44% of the estimated energy requirement was provided by enteral feeding to the patients. The frequency of underfeeding was 52.17% with respect to enteral feeding. The most frequent reason for the feeding interruption was observation before and after intubation and extubation, which was unavoidable. The next most common reason was gastrointestinal bleeding, mostly due to old clots or trace, followed by residual volume less than 100 mL. Changes in prealbumin and transferrin levels for 7 days between the underfed and adequately fed groups were not statistically significant.

Conclusion The management of enteral feeding by nurses was overprotective because of the unpredictable nature of ICU patients in terms of their underlying disease process. The management of feeding intolerance needs to be evidence-based and nurses must consistently follow the protocol that has been supported as a useful measure. [Asian Nursing Research 2010;4(2):102–110]

Key Words enteral feeding, intensive care unit, neurosurgical procedure, undernutrition

INTRODUCTION

Adequate and timely nutritional support is essential for the treatment of disease and is associated with a shorter stay in the intensive care unit (ICU) (Dénes, 2004; Robert, Kennerly, Keane, & George, 2003; Wu, Liu, Zheng, Quan, & Wu, 2005). Most ICU patients cannot eat orally for various reasons, such as
mechanical ventilation, sedation, or a decreased level of consciousness. For these patients, enteral feeding is the preferred method of nutritional support. In particular, early enteral feeding has been shown to decrease rates of infection, length of hospital stay, and medical costs among ICU patients (Debaveye & Berghe, 2006; Lewis, Egger, Sylvester, & Thomas, 2001; Marik & Zaloga, 2001).

Previous studies have demonstrated that many enterally-fed ICU patients often receive a much lower caloric intake than their daily requirement for various reasons (Elpern, Stut, Peterso, Gurk, & Skipper, 2004; McClave et al., 1999; Petros & Englemann, 2006; Reid, 2006; Wøien & Bjørk, 2006). Previous studies have also reported that patients received 51.6–64% of the goal energy intake because of elective discontinuation or delay (Elpern et al.; McClave et al., 1999). When administered feeding does not meet a patient’s daily caloric requirement (Higgins, Daly, Lipson, & Guo, 2006), underfeeding occurs. Underfeeding occurs more often than overfeeding in ICU patients who receive enteral feeding (Reid). Marshall and West (2006) stated that the practice habits of critical nurses as related to enteral feeding contribute to the underfeeding. Some of the reasons for feeding interruption or delay were avoidable (Elpern et al.; Marshall & West; McClave et al., 1999; Reid, 2006; Robert et al., 2003). Appropriate enteral feeding requires consideration for both the avoidable reasons and how often they hinder the feeding. However, little investigation has been conducted in the adequacy of nutritional intake, the frequency of underfeeding or overfeeding and the reasons for the cessation or delay of enteral feeding among Korean ICU patients.

There are various methods to assess patients’ nutritional status such as physical and biochemical measurements. Physical measurements such as body weight, body mass index, or triceps skinfold thickness did not reflect undernutrition for 4 days, which is relatively short time period (Yang, Kwon, & Kim, 2001); rather, these data provide information on long-term nutritional deprivation. One of the most appropriate way to assess the adequacy of enteral feeding for a short period is measuring hepatic proteins (Beck & Rosenthal, 2002; Fuhrman, Charney, & Mueller, 2004; Higgins et al., 2006). There is some evidence that proteins with short half-lives, such as prealbumin and transferrin, are useful indicators of nutritional status for short periods (Lopez-Hellin, Baena-Fustegueras, Schwartz-Riera, & Garcia-Arumi, 2002; Nataloni et al., 1999; Raguso, Dupertuis, & Pichard, 2003; Sergi et al., 2006). In particular, Nataloni et al. reported that prealbumin is the most sensitive measure reflecting a person’s nutritional status. However, more recently the relationships between caloric intake and prealbumin and transferrin indicated that the values of these parameters for patients in a highly unstable state in terms of inflammation depend on the state of inflammation rather than the amount of caloric intake (Fuhrman et al.; Raguso et al.). Therefore, the relationships between the caloric intake and these parameters need to be investigated in either a controlled or homogenous state of inflammation.

In contrast with previous studies that focused on heterogeneous and mixed medical and surgical ICU patients, the individuals assessed for this study were neurosurgical ICU patients who were expected to have a relatively homogenous inflammation state because they had undergone the same surgical procedures without infection. The purposes of this study were three-fold: (a) to identify the adequacy of enteral feeding and the reasons for stopping or skipping enteral feeding, (b) to investigate the prevalence of under-nutrition among patients, and (c) to determine the relationships between caloric intake and the resulting nutritional parameters among patients.

METHOD

Study design
A prospective and descriptive study design was used to investigate the adequacy of enteral feeding and to evaluate the resulting changes in the nutritional indicators of the neurosurgical ICU patients.

Study participants
Participants were 52 neurosurgical ICU patients who had enteral feeding initiated after ICU admission.
Data were collected from the first day onward for 7 days because the mean length of ICU stay was about 7 days, and the half lives of prealbumin and transferrin were also shorter than 7 days. Data for patients who were discharged from the ICU or died before the end of the 7 days were excluded from analyses.

After collecting data from 52 neurosurgical ICU patients, data for the 47 patients were included for the final analysis due to missing data and early dropout. Mean turnover days of the ICU patients were 5–7 days. Three out of the five early drop-out patients started oral feeding before completion of the study; one patient expired before the end of the 7 days; one patient transferred to general ward before the second data collection.

Hepatic proteins with short half-lives were found to be related to the inflammation state (Kim, Choi, & Ham, 2009). Therefore, only neurosurgical ICU patients who were recovering from surgery without suspected infection as determined by physicians were included in the study, in order to render the inflammation variable homogenous.

Procedure and measures
This study was approved by the hospital’s human subjects review board. Data were collected in a surgical ICU of a tertiary teaching hospital. Data related to patient characteristics, enteral feeding, and feeding interruptions or delay (with reasons for the interruption or delay of feeding) were collected from the patient’s records prospectively.

All patients in the ICU received enteral feeding by intermittent administration methods, and the prescribed formula divided into three or four administrations per day was given to patients. Some patients had interruptions or delay of enteral feeding due to medical, surgical or procedural reasons. The total volume of formula received in the previous day was abstracted from the patient’s records every day. Prescribed and provided enteral caloric intakes were recorded and compared with estimated daily requirements.

To measure the prealbumin and transferrin level, blood samples were taken from the subjects on the first day of enteral feeding and on the seventh day of feeding.

Before analysis, the estimated energy requirement was calculated using the recommended 25 kcal/kg/day rule (Cerra et al., 1997; Reid, 2007). The information provided by the manufacturers was used to calculate the energy of each formula. Underfeeding and overfeeding were defined as total energy intake <80% and >110% of the estimated requirement, respectively. The range between 80% and 110% of the energy intake was deemed to be an adequate energy intake based on information from previous studies (Reid, 2006, 2007).

Data analysis
Data were analyzed using SPSS 15.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to delineate the general patient characteristics, caloric intake, and the frequency and reasons for feeding interruptions. Student t test was performed to compare changes in nutritional indicators for 7 days between the underfed and adequately fed groups. To examine the relationships between prealbumin and transferrin and C-reactive protein (CRP), Pearson’s correlation was performed.

RESULTS
General characteristics
Sample characteristics are depicted in Table 1. The mean age of the subjects was 56.62 years. Thirty subjects (63.8%) had undergone craniotomy surgery due to spontaneous brain hemorrhage, 21 (44.7%) received all prescribed feeding formulas without any stops or delays, 26 (55.3%) did not receive their feeding formula more than once during the 7 days, and 11 (23.4%) had interruptions more than 6 times during the study period. The mean number of feeding interruptions was 3.23 (SD = 4.47).

Estimated energy requirements and provided caloric intakes
The enteral feeding calories actually provided to the patient were less than the estimated average daily caloric requirements (1,551.38 kcal, Table 2). The calories actually provided were 1,186.69 kcal for
Nutritional Support and Underfeeding in ICU Patients

Table 1
Patient Characteristics (N = 47)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Category</th>
<th>n (%)</th>
<th>M (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>26 (55.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>21 (44.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Spontaneous brain hemorrhage</td>
<td>30 (63.8)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Traumatic brain hemorrhage</td>
<td>14 (29.8)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Brain tumor</td>
<td>2 (4.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spinal cord injury</td>
<td>1 (2.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of feeding interruptions</td>
<td></td>
<td></td>
<td>3.23 (4.47)</td>
<td>0–16</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>21 (44.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1–5</td>
<td>15 (31.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6–10</td>
<td>6 (12.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11–16</td>
<td>5 (10.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td>56.62 (16.37)</td>
<td>16–38</td>
</tr>
<tr>
<td>CRPa</td>
<td></td>
<td></td>
<td>7.86 (5.46)</td>
<td>1.20–23.04</td>
</tr>
</tbody>
</table>

Note. CRP = C-reactive protein. a n = 31 due to missing values.

Table 2
Caloric Intake Actually Provided Compared With Estimated Requirements (N = 47)

<table>
<thead>
<tr>
<th>Energy</th>
<th>Estimated requirement</th>
<th>Provided enteral energy</th>
<th>Total administration (enteral + TPN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M (SD)</td>
<td>1,551.38 (278.51)</td>
<td>1,186.69 (253.98)</td>
<td>1,211.33 (243.07)</td>
</tr>
<tr>
<td>Range</td>
<td>867.50–2,212.50</td>
<td>464.29–1,687.50</td>
<td>285.71–1,500.00</td>
</tr>
</tbody>
</table>

Note. TPN = total parenteral nutrition.

enteral feeding alone and 1,211.33 kcal for that including additional parenteral nutrition; the former representing only 76.49% of the estimated energy requirement, that is, less than their adequate daily energy intake.

Frequency of underfeeding and overfeeding
The frequencies of underfeeding and overfeeding are given in Tables 3 and 4. The frequencies of underfeeding and overfeeding were 37.2% and 10.7% with respect to total energy intake, and 52.17% and 6.52% with respect to enteral feeding, respectively. Only 52.1% and 41.30% of subjects were provided an adequate daily energy amount with respect to total energy intake and enteral feeding, respectively.

Reasons for feeding interruption
The most frequent reason for the feeding interruption was related to intubation/extubation (Table 5). Patients did not receive formula more than once for the preparation of intubation and extubation, and observation for the risk of aspiration after extubation. The next most common reason was related to gastrointestinal bleeding. None of these cases showed active bleeding signs; most had a small amount of old blood, old clots, or brownish-colored gastric contents when nurses aspirated the syringe. All patients whose feeding was interrupted due to an increased residual volume had a residual volume of less than 100 mL. Major and minor surgery were other reasons for stopping enteral feeding in patients.
Differences in short-term nutritional indicators by total caloric intake

The change in nutritional indicators for 7 days in the underfed group was compared with indicators of the group in which the enteral nutrition intake was >80% of the estimated daily caloric requirement (Table 6). The decrease in the prealbumin level in the underfed group was much greater than the prealbumin level.
of the adequately-fed group, but the difference was not statistically significant. Transferrin was increased in both the underfed and adequately fed groups on the seventh day. The increment for the adequately fed group was greater than that of the underfed group, but this difference was not statistically significant.

**Correlations between prealbumin, transferrin and C-reactive protein (CRP)**

Additional analysis was performed to identify relationships between prealbumin, transferrin and CRP in ICU patients (Table 7). There were significant negative correlations between CRP and the differences from the first day of feeding to the seventh day of feeding in prealbumin and transferrin. The strength of the relationships were moderate (−.447 to −.551).

**DISCUSSION**

This study was conducted to evaluate the adequacy of caloric intake among ICU neurosurgical patients. Previous studies have shown that most ICU patients receive their nutrition through enteral feeding, but adequate nutritional support for these patients was not an easy goal to achieve (Reid, 2006; Roberts et al., 2003). In the present study, underfeeding was a more common phenomenon than overfeeding and occurred in 52.2% of subjects with respect to enteral energy intake. The actual intake of enteral calories was also lower than the minimum of optimal intake, as suggested in a previous study (Reid, 2007). This pattern of results was similar with other previous studies (Park, Lee, & Lim, 2001; Reid, 2006; Roberts et al.). Park et al. reported that subjects received only 69.7% of required daily calories on average for 29 days of follow-up and that 44.6% of subjects had attained their required energy intake after 3 days from the beginning of feeding.

The main reason for the underfeeding was underprescription by physicians compared to the required amount, which was attributed to concern for potential complications related to enteral nutrition, such as increased risk of aspiration pneumonia, high residual volume, or diarrhea.

Another reason for the underfeeding was the frequent elective disruptions of feeding due to intolerance of enteral feeding, as reported in other previous studies (Elpern et al., 2004; Marshall & West, 2006; Petros & Engelmann, 2006; Roberts et al., 2003). The numbers of feeding and total caloric intake were related to residual volume, nausea, vomiting, GI bleeding, diarrhea, abdominal distension, minor surgery or airway management (Park et al., 2001). These results were similar to those reported in another study which suggested the same factors as the causes of

<table>
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<th>Table 6</th>
<th>Differences in Short-term Nutritional Indicators by Total Caloric Intake</th>
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<tbody>
<tr>
<td>Total energy intake</td>
<td>n (%)</td>
</tr>
<tr>
<td>Prealbumin &lt; 80</td>
<td>21 (48.8)</td>
</tr>
<tr>
<td>≥ 80</td>
<td>22 (51.2)</td>
</tr>
<tr>
<td>Transferrin &lt; 80</td>
<td>21 (47.7)</td>
</tr>
<tr>
<td>≥ 80</td>
<td>23 (52.3)</td>
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</table>

*a n = 43 for prealbumin and 44 for transferrin due to missing values.

| Table 7 | Correlations Among Prealbumin, Transferrin and C-Reactive Protein (n = 31)
<table>
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<tbody>
<tr>
<td>CRP r (p)</td>
<td>Differences in prealbumin between 1st and 7th days</td>
</tr>
<tr>
<td></td>
<td>Differences in transferrin between 1st and 7th days</td>
</tr>
</tbody>
</table>

Note. CRP = C-reactive protein. *n = 31 due to missing values.
feeding interruption (Petros & Engelmann), but the relative contribution of the factors to the interruption were slightly different to those of the present study.

Approximately 55% of the patients in our study had feeding interruptions more than once during the study period. The practice of nurses as it relates to enteral feeding, such as the measurement of gastric residual volume (GRV), might contribute greatly to patient underfeeding in the ICU. McClave et al. (1999) reported that 66% of feeding interruptions were inappropriate and avoidable. The reasons could be categorized into respiratory procedures, intolerance, minor or major surgery, and others. Similar reasons were found in the present study. All the subjects in the present study were fed intragastrically via a nasogastric tube. There was not a single rule consistently enforced by the ICU nurses to stop or delay feeding in cases of GRV. The decision to stop and delay feeding greatly depended on the judgment of the individual nurse and physician. In eight cases, subjects were not provided their formula because of a large amount of GRV; in six of these cases the GRV was less than 60 mL and in two cases the residual volume was 100 mL. Based on the trend of previous studies that allowed gradually increased cut-off values of GRV, sometimes up to 200–400 mL (McClave et al., 2005; Reid, 2006), nurses and physicians in the current ICU had excessively strict rules for GRV and this practice needs to be improved. In the case of GI bleeding, even though active bleeding was not indicated in any case, enteral feeding was interrupted in all cases. This practice also needs to be changed based on literature evidence. According to McClave et al. (1999), there is no risk for potential aspiration by endoscopic procedures or brief surgery when enteral feeding is stopped 4 hours prior to the procedures. In this study, feeding was stopped most frequently because of the pre- and post-management of intubation/extubation. Therefore, valid, evidence-based, and safe practice guidelines need to be developed in such situations.

The inadequacy of nutritional support was not reflected by the change in nutritional indicators for the short time period in the present study. That is, the nutritional indicators did not show significant differences between the underfed and adequately fed groups. The prealbumin level in the adequately fed patients was increased after 7 days, but the values in the underfed patients decreased during the 7 feeding days. The difference was not statistically significant and the different trends need to be reinvestigated with a bigger sample size. Transferrin did not differ significantly between the two groups either. The evidence remains contradictory regarding the appropriateness of hepatic protein as an indicator of nutritional assessment in ICU patients.

Prealbumin and retinol binding proteins are the most sensitive indicators for the adequacy of nutrients provided in ICU patients (Raguso et al., 2003). The correlation coefficients between fat-free mass and these visceral proteins are greater than moderate among elderly (Sergi et al., 2006). Prealbumin has also been reported as one of the sensitive measures reflecting nutritional status and suggested as a selective measure for early assessment and intervention of head injury patients (Nataloni et al., 1999).

Emerging evidence, however, has suggested not only that prealbumin is a sensitive indicator of nutritional status, but also that it is affected by stress response and inflammation (Lopez-Hellin et al., 2002). Serum hepatic proteins are a useful index for the severity of disease and indicators of inflammation processed that precipitate nutrient exhaustion (Fuhrman et al., 2004). Positive relationships have been reported between the prealbumin level and the period of mechanical ventilation and weaning period (Higgins et al., 2006). In another study, prealbumin was not a sensitive indicator for nutritional status and prognosis in ICU patients (Lim et al., 2005).

Raguso et al. (2003) suggested that hepatic protein could be a good indicator to assess a patient’s nutritional status, when inflammatory parameters are stable. In this study, the authors looked at the relationship between nutritional indicators and caloric intake in head surgery patients who were presumed to be homogenous in terms of inflammatory parameters. However, the inflammatory parameters were not controlled directly. Further investigation is required regarding the suitability of hepatic protein as a proper indicator for nutritional assessment among
ICU patients who do not have a prominent or mild inflammatory response after controlling for inflammatory parameters.

**CONCLUSION**

According to results from the present study, most neurosurgical ICU patients were underfed because of the unpredictable nature of their condition in terms of the underlying disease process as suggested by McClave et al. (1999). In addition to this insufficient caloric intake, a discrepancy arose between the provided and required amounts, although enteral feeding did demonstrate considerable benefits for ICU patients. ICU nurses should endeavor to increase the amount of enteral feeding. Most of all, the management of feeding intolerance needs to be firmly evidence-based and nurses need to strictly and consistently follow the protocol which has been provided as a useful measure. Nurses must appropriately manage the cases of avoidable stopping or skipping of enteral feedings.

Although head surgery patients for the analysis of nutritional indicators were assumed to be homogeneous in terms of inflammatory response and surgical stress level, nutritional indicators, including prealbumin, were not significantly different between the underfed and adequately fed groups. Seven days may not have been sufficient to reflect a change in prealbumin by nutritional status or the sample size may have been too small to detect a significant difference. Another limitation was that inflammatory parameters were not controlled when comparing hepatic proteins between the underfed and adequately fed groups. We suggest that future studies control more strictly the effect of inflammation and stress on hepatic proteins in order to investigate the relationship between nutritional indicators and provided caloric intake. Another study limitation was the small sample size. The minimum sample size for t test to compare the mean scores of changes for 7 days in prealbumin and transferrin was 63 patients to achieve a statistical power of 80% at a significance level of .05 and with a medium effect size (Polit & Beck, 2004).

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**REFERENCES**


