Title
Enteral nutritional intake in adult korean intensivecare patients

Journal
American Journal of Critical Care, 22(2)

ISSN
1062-3264

Authors
Kim, Hyunjung
Stotts, Nancy A
Froelicher, Erika S
et al.

Publication Date
2013-03-01

DOI
10.4037/ajcc2013629

Peer reviewed

HHS Public Access

Author manuscript

Am J Crit Care. Author manuscript; available in PMC 2016 February 10.

Published in final edited form as:

Am J Crit Care. 2013 March ; 22(2): 126–135. doi:10.4037/ajcc2013629.

Enteral Nutritional Intake in Adult Korean Intensive Care Patients

Hyunjung Kim, RN, PhD,

Assistant professor, Division of Nursing, Hallym University, Chuncheon, Gangwon, South Korea

Nancy A. Stotts, RN, EdD,

Professor emeritus, Department of Physiological Nursing, University of California, San Francisco

Erika S. Froelicher, RN, PhD,

Professor emeritus, Department of Physiological Nursing and Department of Epidemiology and Biostatistics, University of California, San Francisco

Marguerite M. Engler, RN, PhD, and

Senior clinician, National Institute of Nursing Research, National Institutes of Health, Bethesda, Maryland

Carol Porter, RD, PhD

Clinical professor, Department of Pediatrics, University of California, San Francisco

Abstract

Background—Nutritional support is important for maximizing clinical outcomes in critically ill patients, but enteral nutritional intake is often inadequate.

Objectives—To assess the nutritional intake of energy and protein during the first 4 days after initiation of enteral feeding and to examine the relationship between intake and interruptions of enteral feeding in Korean patients in intensive care.

Methods—A cohort of 34 critically ill adults who had a primary medical diagnosis and received bolus enteral feeding were studied prospectively. Energy and protein requirements were determined by using the Harris-Benedict equation and the American Dietetic Association equation. Energy and protein intake prescribed and received and the reasons for and lengths of feeding interruptions were recorded for 4 consecutive days immediately after enteral feeding began.

Results—Although the differences between requirements and intakes of energy and protein decreased significantly, patients did not receive required energy and protein intake during the 4

Corresponding author: Nancy A. Stotts, RN, EdD, Professor Emeritus, University of California San Francisco, 2 Koret Way 631Y, San Francisco, CA 94143-0610, nancy.stotts@nursing.ucsf.edu.

FINANCIAL DISCLOSURES

This study was supported by the Alpha Eta Chapter Research Award of Sigma Theta Tau International Honor Society of Nursing, the University of California San Francisco Graduate Student Research Award, and the University of California San Francisco School of Nursing Century Club Award.

days of the study. Energy intake prescribed was consistently less than required on each of the 4 days. Enteral nutrition was withheld for a mean of 6 hours per patient for the 4 days. Prolonged feeding interruptions due to gastrointestinal intolerance ($r = -0.874$; $P < .001$) and procedures ($r = -0.839$; $P = .005$) were negatively associated with the percentage of prescribed energy received.

Conclusion—Enteral nutritional intake was insufficient in bolus-fed Korean intensive care patients because of prolonged feeding interruptions and underprescription of enteral nutrition. Feeding interruptions due to gastrointestinal intolerance and procedures were the main contributors to inadequate energy intake.

Nutritional support is vital care for critically ill patients. Appropriate nutritional support can enhance immunity and wound healing, prevent loss of and restore lean body mass, and decrease the risk for nosocomial infection and multiple organ failure.[1,2] Protein, an especially important nutrient, is required to maintain body structures, facilitate mobility, stimulate antimicrobial functions, and provide substrate for synthetic functions, including wound healing.[2,3]

Despite the importance of adequate nutritional intake, critically ill patients receiving enteral feedings often receive less nutritional intake than recommended.[4–6] Evidence[4,7–9] indicates that critically ill patients given enteral feedings have received mean energy intake ranging from 50% to 95% of requirements and protein intake from 38% to 82% of requirements.

Several factors affect the adequacy of enteral nutritional intake in intensive care unit (ICU) patients in the United States. Underprescription combined with insufficient delivery of prescribed nutrients results in inadequate nutritional intake.[10] Inappropriate stopping and delay in restarting enteral feedings cause a large volume of enteral formula to be wasted. Interruptions due to gastrointestinal intolerance of enteral feedings, displacement or obstruction of the feeding tube, airway management, diagnostic or therapeutic procedures, and routine nursing procedures result in marked underfeeding in ICU patients.[10–13] McClave et al[12] suggested that some interruptions of enteral feeding are avoidable and that preventing the interruptions will maximize delivery of nutrients.

Similarly, underfeeding in critically ill patients who recieve enteral feedings is a common problem in Korea.[14] According to estimates,[14–16] only 69% to 77% of the required energy and about 65% of the required protein are prescribed for enteral nutrition in critically ill patients. In addition, the amount of energy received is less than the amount prescribed. Few data are available on actual intake, but in 1 study[16] on enteral nutrition intake in critically ill patients, only 87% of the prescribed amount was delivered. Although data on actual prescribing patterns are limited, clinical experience indicates that the prescription of enteral feedings varies widely. This variation may be due to the lack of a standardized protocol for the prescription of enteral feeding. When Korean ICU patients are prescribed inadequate volumes of enteral formula, the result is insufficient nutritional intake. Incomplete delivery of prescribed enteral feedings may also contribute to underfeeding in this population.

Studies of critically ill patients in the United States have addressed enteral nutritional intake and interruptions in enteral feedings, but the actual relationship between intake and interruptions has not been evaluated. Likewise, few data on enteral nutritional intake in

Korean ICU patients are available. The reasons for feeding interruptions that can affect insufficient delivery of enteral nutrition in Korean ICU patients were addressed in only 1 study.[15] Evaluating the enteral nutritional intake and determining the reasons for interruptions in enteral feeding are essential for developing an evidence-based protocol for enteral nutritional care in ICUs in Korea.

The purpose of the prospective, cohort study reported here was to evaluate the trends in the amount of energy and protein prescribed and received during the first 4 days after initiation of enteral feeding in Korean medical ICU patients. The relationship between length of interruptions in enteral feeding and energy received was also investigated. The specific aims of the study were to determine the following: Does energy intake prescribed and received meet energy requirements on each day? Does protein prescribed and received meet protein requirements on each day? What is the relationship between total duration of interruption of enteral nutrition and mean energy received for the entire 4 days? What is the relationship between duration of interruption and the reason for the interruption and the energy received on the day feeding was interrupted?

Methods

In this prospective cohort study, the adequacy of energy and protein intake prescribed and received during the first 4 days after start of enteral feeding in Korean patients in a medical ICU was examined. Data were collected from July 2010 to September 2010.

Setting and Sample

Patients were recruited from the ICU (18 beds) of a tertiary care hospital in Daejeon, Korea. The sample consisted of adult medical ICU patients (>18 years old) who were prescribed enteral feeding and required enteral tube feeding for at least 4 days. Patients were excluded if they were receiving parenteral or oral feeding as the main energy source or had a surgical intervention at the time of enrollment. The 4-day study period was chosen because enteral nutrition is usually stabilized within 4 days after the start of feeding and should be provided adequately within 3 days for clinical outcomes such as a shorter period of mechanical ventilation and lower mortality.[17–20]

Variables and Measures

Required energy was defined as energy requirements in calories calculated by using the Harris-Benedict equation with a stress factor (1.0–1.6).[21] A conservative approach was used to calculate requirements; specifically, the lowest factor was used to calculate the stress factor when a range of values existed. Ideal body weight used to calculate adjusted body weight was determined from the mean height and weight charts for Korean men and women at different ages.[22] Adjusted body weight with a 50% correction factor[23] was used for patients who were obese (body mass index ≥ 25)[24] to reduce overestimation. Required energy was calculated at enrollment on the basis of information in patients' medical records.

Required protein was defined as protein requirements in grams calculated by using the American Dietetic Association equation.[21] The lowest value of medical conditions was used as a conservation approach. Metabolically active weight was used for obese patients.[25]

Prescribed amounts of energy and protein were defined as a physician's order for calories and protein to be infused each day. Data on the prescribed amounts were collected daily from patients' medical records.

Received amounts of energy and protein were calculated by multiplying the volume of enteral formula received by the calorie and protein contents of the formula.[26] Data on the received amounts were collected daily from patients' medical records.

Interruption time of enteral feeding was defined as the number of minutes when a patient should be fed but was not receiving feeding because of gastrointestinal intolerance, gastrointestinal hemorrhage, a problem with the feeding tube, procedures, routine nursing care, airway management, or other reasons. The expectation was that enteral feeding prescribed was infused in 30 minutes at 8 AM, 12 noon, and 6 PM. If enteral feeding was stopped during the infusion of formula or feeding was not restarted at the time scheduled, the bedside nurse recorded the reason for withholding of enteral nutrition and the times the feeding was stopped and restarted by using a standardized recording sheet.

Demographic and Clinical Characteristics

Data were collected on each patient's age, sex, diagnosis, mechanical ventilation, body weight, and serum levels of albumin and C-reactive protein by review of medical records. Supine knee height was measured by using a knee-height caliper at enrollment to estimate height.[27] Body mass index was calculated and categorized by using the criteria for Asians.[24] Scores on the Acute Physiology and Chronic Health Evaluation II[28] were obtained by one of the researchers (H.K.) at enrollment.

Enteral Feeding Characteristics

Characteristics of enteral feeding obtained from each patient's medical records at the time of enrollment included the interval from ICU admission to initiation of enteral feeding and location and size of the enteral feeding tube. Information on gastric residual volume (GRV; volume of gastric contents aspirated from the feeding tube by a nurse immediately before each feeding), diarrhea (>3 liquid stools per day[12]), and vomiting was obtained daily from the medical records. High GRV (≥50 mL), diarrhea, and vomiting were used as indications of gastrointestinal intolerance of enteral feedings.[29] Use of pro-kinetics and antibiotics that can influence the motility of the gastrointestinal tract was also recorded daily.[30]

Procedures

After approval by the appropriate institutional review boards, medical ICU patients were screened on the basis of their medical records. The study was explained to those patients who met the inclusion criteria, and written informed consent was obtained from each patient or the patient's legal surrogate.

According to the nursing protocol of the ICU, enteral feedings were administered intermittently via the gravity method. Usually, a total of 3 bottles, 1 bottle each at 8 AM, 12 noon, and 6 PM, were administered over a 30-minute period with the head of the bed elevated 30° to 45°. Enteral feeding was prescribed by a patient's physician on the previous day or early morning of the day that feeding started; prescription was not incorporated into the unit protocol. No specific protocol was followed for stopping and restarting enteral feeding.

Data Analysis

All data were analyzed by using SPSS software, version 15.0 for Windows (IBM SPSS). A 2-tailed *P* less than .05 was set as the level of significance, except for the post hoc test, in which α was preset at *P* less than .01. Descriptive statistics were used to examine the characteristics of patients. A 2-way repeated-measures analysis of variance was used to determine the difference between prescription, intake, and requirement on each of the 4 days. If the magnitude of the difference varied significantly from one day to another, post hoc tests were conducted to identify which days significantly differed from each other. A Pearson product moment correlation was calculated to determine the relationship between the duration of interruption and energy received. The nQuery Advisor software (Statistical Solutions) was used to calculate the sample size for the 2-way repeated-measures analysis of variance. The estimated sample size was 28 ($\alpha = 0.05$; $\beta = 0.20$; effect size = 0.106). In order to allow for potential attrition, the goal was a sample of at least 34 patients.

Results

Sample Characteristics

A total of 45 patients were enrolled in the study. Of these, 11 (24%) were withdrawn because they stopped receiving enteral feeding within 4 days. Reasons for stopping feeding were change to parenteral nutrition (5 patients), change to oral feeding (3 patients), transferred out of the unit (2 patients), and died (1 patient).

Thus, 34 patients completed the entire study. The mean age was 70.8 years; half of the subjects were men. A total of 15 patients (44%) were treated with mechanical ventilation. The mean score on the Acute Physiology and Chronic Health Evaluation II was 13.0 (SD, 6.1). All patients were fed through a nasogastric tube.

Most patients had a major diagnosis of neurological or respiratory disease (Table 1). Mean serum levels were 3.3 (SD, 0.8) g/dL for albumin and 6.1 (SD, 7.1) mg/dL for C-reactive protein (to convert milligrams per deciliter to nanomoles per liter, multiply by 95.24). According to Asian standards for body mass index, 11 patients were mildly obese, 7 were overweight, 13 had normal weight, and 3 were underweight. Enteral nutrition was started a mean of 5.3 (SD, 6.8) days after admission to the ICU.

Energy Intake and Prescription

A 2-way repeated-measures analysis of variance indicated that energy received via enteral feeding differed significantly from the energy required ($F_{1,33} = 27.14$; $P < .001$). Energy received was consistently less than energy required for each of the 4 study days (Figure 1). The difference between amounts of energy required and amounts received was significant depending on time ($F_{3,99} = 28.16$; $P < .001$). In post hoc tests, the difference between energy required and energy received on day 1 (555 kcal) was significantly larger ($P < .001$) than the differences on days 2 (287 kcal), 3 (171 kcal), and 4 (174 kcal). The difference on day 2 was significantly larger (P = .003) than the difference on day 3 but not different (P = .02) from the value on day 4. The difference on day 3 did not differ significantly from the difference on day 4 (P =.93).

Energy requirements were also consistently greater than prescribed ($F_{1,33}$ = 12.27; P = .001; Figure 1). The difference between energy required and energy prescribed differed significantly for each of the 4 days ($F_{3,99}$ = 44.12; P < .001). The difference on day 1 (−362 kcal) differed significantly (P < .001) from the differences on days 2 (−189 kcal), 3 (−95 kcal), and 4 (−68 kcal), with the magnitude of the difference decreasing over time. The difference on day 2 was significantly larger than the differences on days 3 and 4 (P = .001).

Protein Intake and Prescription

Patients received significantly less protein than their requirement during the study period ($F_{1,33}$ =21.44; P <.001; Figure 2). The difference in amounts received and required differed significantly different depending on time ($F_{3,99}$ = 31.56; P < .001). The difference on day 1 (−25.4 g) was significantly larger (P < .001) than the differences on days 2 (−12.1 g), 3 (−6.3 g), and 4 (−6.8 g). The difference on day 2 was significantly larger than that on day 3 (P = .002); the difference on day 4 did not differ significantly from the differences on days 2 (P = .01) and 3 (P = .81).

There was a significant interaction between protein required and prescribed, and time ($F_{3,99}$ = 40.57; P < .001). The negative gap (protein prescribed lower than required) on day 1 drastically decreased on day 2 and then became positive (protein prescribed higher than required) on days 3 and 4 (Figure 2).

Relationship of Feeding Interruptions to Energy Intake

Enteral feeding was withheld 54 times in 24 patients (79%) in the first 4 days after the start of enteral nutrition. The mean length of time that enteral feeding was withheld during the 4 days was 360 minutes per patient. Total duration of interruption had a strong negative correlation with mean percentage of prescribed energy received for 4 days (r = −0.822; P < .001); patients who had more prolonged feeding interruption received less prescribed energy.

The reasons for interruptions of enteral feeding are presented in Table 2. The most frequent and longest feeding interruptions were due to gastrointestinal intolerance, accounting for 28% of the incidence and 29.5% of the total time that enteral feeding was withheld (the total interruption time). The duration of interruption due to gastrointestinal intolerance had a strong negative correlation with percentage of prescribed energy received (r = −0.874; P < .001). Gastrointestinal problems, including gastrointestinal intolerance and bleeding, accounted for almost 50% of the total interruption time.

The second most frequent category of interruptions was routine nursing care; 22% of the feedings were withheld. However, routine nursing care accounted for only 1.4% of the total interruption time and was not related to energy intake.

The next most common reason that feedings were withheld (19% incidence) was related to procedures and accounted for 17.5% of the total interruption time. The interruption time caused by procedures had a strong negative correlation with energy intake ($r = -0.839$; $P < .001$). Although interruptions for airway management accounted for 22.4% of the interruption time, they were less frequent than the 3 most frequent reasons for interruptions and had no relationship with energy intake.

Problems related to the enteral feeding tube led to the fewest and shortest feeding interruptions, and this short interruption time was positively and significantly related to energy intake ($r = 0.968$; $P = .03$). The "other" category, which included hemodynamic shock in 1 patient and lapse in nursing care, also led to a low incidence of feeding interruptions.

Discussion

For critically ill patients who cannot tolerate an oral diet, enteral nutrition is a suitable alternative because of its more favorable effects compared with the effects of fasting or parenteral nutrition.[31–33] However, insufficient enteral intake is a weakness of enteral feeding in critically ill patients.[7,13,15] Our results confirm that Korean critically ill patients do not receive their required energy and protein with enteral nutrition. To our knowledge, our study is the first to show the trend in prescribed energy and protein amounts for enteral nutrition with the amounts actually received by focusing on the relationship with time. Also, we addressed the reasons for interruptions in enteral feeding that are associated with enteral intake.

Our patients received less energy and protein intake than required for 4 days after the start of enteral nutrition. The insufficient nutritional intake we observed is consistent with the findings of previous studies.[10,11,13,15,18,32] This finding indicates that more aggressive nutritional interventions and monitoring are required for critically ill patients.

Umali et al[19] found significant differences between requirements and actual intake of energy and protein during 3 days after patients' admission to an ICU. Petros and Engelmann,[18] Singer et al,[34] and De Beaux et al[35] reported an increasing trend in daily intake during the early phase of an ICU stay (from day 1 to day 4 or 6). This trend is a usual one in enteral feeding: a lower level of intake that increases with time. However, calculating the mean value for several days leads to a loss in important data by collapsing the data across time. The acute starvation that occurs cannot be recognized or addressed when mean values are presented. Therefore, attention to the difference across the days is important to identify the adequacy on each day and to focus the nutritional intervention on the day of inadequate intake. Our results indicate that the difference between requirements and actual intake is significantly associated with time. In our patients, the difference significantly decreased over time but leveled out on the fourth day.

Our comparison of requirements, prescription, and actual intake in terms of energy and protein suggests that the combination of underprescription and underdelivery contributed to inadequate intake of energy and protein. Although the amount of the daily prescription of energy and protein increased with time, the prescription for energy did not meet patients' requirements during the study period. This trend is consistent with findings reported in previous studies.[10,11] The American Society of Parenteral and Enteral Nutrition[20] recommends a gradual increase in bolus enteral feeding: starting with a small amount of 120 mL given 3 to 8 times per day and increasing the amount by 60 to 120 mL every 8 to 12 hours, as tolerated, reaching the goal volume 48 to 72 hours after the start of feeding. Although underprescription may be beneficial for tolerability for early enteral feeding in critically ill patients, in our study the amount of energy prescribed did not reach patients' requirements even after 72 hours of feeding. Enteral feeding was underprescribed, and the enteral feeding prescribed was even underdelivered, although we had no specific protocol in the ICU of slowly increasing volume as indicated by a patient's tolerance. Therefore, underprescription obviously contributed significantly to insufficient intake.

A possible explanation for underprescription is the complex process for prescribing nutritional support. Health care providers must consider a patient's nutritional requirements, physiological conditions, and anticipated potential problems with enteral nutrition on the basis of the providers' awareness and knowledge of nutritional support.[10] Despite the importance of enteral nutritional support in critically ill patients, enteral nutrition is typically a lower priority than interventions for hemodynamic, neurological, or respiratory problems. The low technology associated with enteral feeding may contribute to its low priority. Furthermore, no registered dietician is responsible for ICU patients in Korean hospitals, a characteristic that contributes to the lack of awareness of the unique nutritional needs of patients and the importance of enteral nutritional support for critically ill patients.

Nutritional support is challenging for ICU health care providers. Determining nutrient requirements for critically ill patients is difficult because the requirements are calculated on the basis of age, weight, height, sex, stress level, severity of disease, and/or metabolic needs.[21] The Harris-Benedict equation with a stress factor and the American Dietetic Association equation that we used, which are relatively simple formulas and are used in many clinical institutions,[36–38] may be better assessments of energy and protein requirements. If the equations result in overestimation of a patient's' needs, however, the patient may not actually be underfed. The method we used to prevent overestimation was use of the lowest stress factors and adjusted body weight when we calculated the requirements conservatively. However, in Korean ICUs, many health care providers do not use a specific formula for prescribing enteral feedings, and this situation may contribute to the inadequate prescription of enteral nutrition. One strategy to raise health care providers' awareness and knowledge of enteral nutritional support in critically ill patients is to provide education. A standardized enteral feeding prescription, including an accurate estimation of nutrient requirements and consideration of anticipated problems, may guide appropriate prescription of enteral nutrition for critically ill patients.

In our study, protein prescription was variable, with smaller amounts early on and larger amounts on days 3 and 4, although the amount of protein received was less than that required for each of the 4 days. In addition, differences in energy and protein between prescription and actual intake during 4 days were significant. These findings suggest that insufficient delivery of what was prescribed also contributed to insufficient intake of energy and protein required. Long interruptions in enteral feeding were the likely explanation for the insufficient delivery of enteral formula. If a feeding was interrupted for a long time, the interruption might be not compensated for on the day feeding was interrupted, and that lack of compensation would affect the insufficient intake. The duration of interruptions in feeding was significantly negatively associated with energy intake in our study.

Of note, our results indicate the specific reasons for feeding interruption are significantly associated with enteral intake. The percentage of prescribed energy received was significantly correlated with the total time that enteral feeding was withheld due to gastrointestinal intolerance of enteral formula. Gastrointestinal intolerance was the most common reason for interruptions in feedings and resulted in the longest total interruption time; these findings are consistent with those of previous studies.[12,29] However, our results differ somewhat from those of other studies in which gastrointestinal intolerance accounted for only 9% of total interruption events[6] and 13.3% of the total interruption time.[11]

In our study, enteral nutrition was withheld when GRVs were greater than 50 mL, consistent with cutoff points of 60 to 100 mL in previous studies[15,39] with intermittent feeding. In contrast, in studies[6,11] with continuous feeding, the cutoff points were to 200 to 300 mL. The discrepancy in the cutoff points may be explained by the findings[40,41] that continuous feeding is associated with higher GRVs and less intestinal peristalsis than is intermittent feeding. Even so, the low cutoff point of 50-mL GRVs in our study might have contributed to frequent and unnecessary feeding interruptions. The result suggests that the cutoff point in this ICU needs to be improved. Although prokinetics that can reduce GRVs were administrated for 119 of 136 feeding days (88.3%) in our study, gastrointestinal intolerance was the most common reason for feeding interruptions. We found no statistically significant relationship between the number of pro-kinetics administered and GRVs (data not presented).

However, GRV may be not useful for monitoring gastrointestinal intolerance of enteral nutrition. Although scores on the Acute Physiology and Chronic Health Evaluation II did not differ between patients with and without gastrointestinal intolerance in our study, more severely ill patients might have more gastrointestinal intolerance than do patients with less severe disease.[29] The use of GRV as an indicator of gastrointestinal intolerance may lead to unnecessary interruption of enteral feeding.[7,11] Therefore, determination of reliable markers for intolerance of enteral nutrition in critically ill patients is important.

Energy intake was also negatively associated with the total time that feeding was withheld to prepare for diagnostic or therapeutic procedures. This finding is consistent with the results of other studies in which procedures were the most common reason for feeding interruption, affecting 52% of patients[13] and accounting for the longest feeding interruption, which was 35% of the total interruption time.[12,42] In clinical settings, patients who are scheduled for many procedures usually receive nothing by mouth after midnight. McClave et al[12] suggested that enteral nutrition can be provided up to 4 hours before a procedure without a risk of aspiration. These recommendations, however, have not been tested. Furthermore, if a procedure is rescheduled for the next day, fasting time is prolonged more than 24 hours. In our study, a tracheostomy was scheduled for airway management in 4 patients (data not presented). Among those 4 patients, 2 had the tracheostomy rescheduled for the next day; that is, they fasted unnecessarily because the procedure was delayed. Evaluation of the variances in patients' care that cause delay of scheduled procedures may provide valuable insight into the scheduling of these procedures.

Routine nursing care often requires that patients be supine, increasing the risk for aspiration and necessitating interruption of enteral feeding. Nursing care was the second most frequent reason for interruption of enteral nutrition, although enteral nutrition was withheld for only a short time (range, 1–30 minutes). Importantly, feeding interruptions for short times to accommodate nursing care were compensated for, so the interruptions did not significantly affect energy intake. feeding time could be flexible to compensate for the delayed delivery because enteral nutrition is provided as an intermittent bolus in the ICU at Konyang University Hospital. Routine nursing care is usually scheduled to avoid disrupting the feeding schedule. Intermittent feeding has the drawback of a high risk for aspiration,[43] but one of its strengths is that some interruptions can be compensated for. Furthermore, feeding overnight can be avoided and the required nutrient intake can be met in a manner consistent with a usual eating schedule.[39] Therefore, intermittent feeding with a flexible feeding schedule may be beneficial for adequate delivery of enteral nutrition.

Problems with feeding tubes were a major reason for interruption in some studies.[11,13] In our study, 4 patients who removed their feeding tubes experienced withholding of feeding for a short time (range, 10–50 minutes). The time required to reinsert the feeding tube was relatively short because placement of the reinserted tube was confirmed by auscultation rather than by obtaining a radiograph, a change that may have contributed to the short interruption time. The amounts of feeding formula undelivered because of interruptions were administered after the tubes were reinserted. However, compared with radiographic verification of tube placement, verification via auscultation can have complications, such as the increased risk for incorrect tube placement or aspiration. Research is needed to determine the advantages of the methods used to confirm the tube placement.

Insufficient intake due to frequent interruptions in enteral nutrition can be avoided. Well-defined feeding protocols to prevent and compensate for unnecessary interruptions might improve the delivery of enteral feedings. Protocols need to address management of gastrointestinal intolerance, decisions to withhold or advance enteral feeding, and adjustment of feeding rates to reach the desired goal.

Our study has several limitations. First, we assessed a small number of patients who received gastric feeding through large-bore feeding tubes in a single ICU in a single university teaching hospital. Although our results may be not generalized to diverse populations of ICU patients, our findings most likely are representative of patients in Korean ICUs, because this feeding method is commonly used in those ICUs. Second, energy and protein requirements were not considered on a day-to-day basis during the study period, because they were calculated once at enrollment. However, the requirements might not have changed significantly during the study period, because the parameters used to calculate the requirements do not markedly change during a short period of 4 days. Finally, the number and duration of interruptions in enteral feedings might have been underrecorded, because the data were recorded by bedside nurses. However, underrecording was minimized by verifying the data with the bedside nurses who cared for the patients.

Conclusion

Our study is the first one in both the United States and Korea to show the trend of enteral nutritional intake by considering the interaction with time in critically ill adults. Our findings indicate that critically ill patients receive inadequate enteral nutrition during their ICU hospitalizations. Insufficient prescription and incomplete delivery of enteral feeding caused by frequent interruptions in feedings are the reasons for insufficient energy and protein intake. Prolonged interruptions due to gastrointestinal intolerance or to diagnostic or therapeutic procedures contributed mainly to the amount of nutritional intake.

The awareness and knowledge of health care providers about nutritional therapy in critical care must be increased to improve nutritional support of critically ill patients. Continued education and training in nutritional support should be integrated into the mandatory critical care program for health care providers. Uncertainties about the levels of GRVs that trigger aspiration, reliable indicators of gastrointestinal intolerance, acceptable lengths of time that patients can be supine without aspiration during enteral feeding, and minimal fasting time in preparation for procedures need to be investigated, and the findings should be incorporated into enteral feeding protocols for critically ill patients. Future study is warranted to develop, implement, and test standardized enteral feeding protocols that can prevent and compensate for unnecessary feeding interruptions.

Acknowledgments

This research was performed at Konyang University Hospital, Daejeon, Korea. We thank the nursing staff of the medical ICU at Konyang University Hospital for their assistance and support.

References

1. Day L, Stotts NA, Frankfurt A, et al. Gastric versus duodenal feeding in patients with neurological disease: a pilot study. J Neurosci Nurs. 2001; 33(3):148–160. [PubMed: 11413660]
2. Parrish CR, McCray SF. Nutrition support for the mechanically ventilated patient. Crit Care Nurse. 2003; 23(1):77–80. [PubMed: 12640963]
3. Stipanuk, MH. Biochemical, Physiological, and Molecular Aspects of Human Nutrition. 2. St Louis, MO: Saunders Elsevier; 2006.
4. Desachy A, Clavel M, Vuagnat A, Normand S, Gissort V, Francois B. Initial efficacy and tolerability of early enteral nutrition with immediate or gradual introduction in intubated patients. Intensive Care Med. 2008; 34(6):1054–1059. [PubMed: 18210092]
5. Krishnan JA, Parce PB, Martinez A, Diette GB, Brower RG. Caloric intake in medical ICU patients: consistency of care with guidelines and relationship to clinical outcomes. Chest. 2003; 124(1):297–305. [PubMed: 12853537]
6. Rice TW, Swope T, Bozeman S, Wheeler AP. Variation in enteral nutrition delivery in mechanically ventilated patients. Nutrition. 2005; 21(7–8):786–792. [PubMed: 15975485]
7. Reid C. Frequency of under- and overfeeding in mechanically ventilated ICU patients: causes and possible consequences. J Hum Nutr Diet. 2006; 19(1):13–22. [PubMed: 16448470]
8. Rubinson L, Diette GB, Song X, Brower RG, Krishnan JA. Low caloric intake is associated with nosocomial bloodstream infections in patients in the medical intensive care unit. Crit Care Med. 2004; 32(2):350–357. [PubMed: 14758147]

9. Taylor SJ, Fettes SB, Jewkes C, Nelson R. Prospective, randomized, controlled trial to determine the effect of early enhanced enteral nutrition on clinical outcome in mechanically ventilated patients suffering head injury. Crit Care Med. 1999; 27:2525–2531. [PubMed: 10579275]
10. De Jonghe B, Appere-De-Vechi C, Fournier M, et al. A prospective survey of nutritional support practices in intensive care unit patients: what is prescribed? what is delivered? Crit Care Med. 2001; 29(1):8–12. [PubMed: 11176150]
11. O'Meara D, Mireles-Cabodevila E, Frame F, et al. Evaluation of delivery of enteral nutrition in critically ill patients receiving mechanical ventilation. Am J Crit Care. 2008; 17(1):53–61. [PubMed: 18158390]
12. McClave SA, Sexton LK, Spain DA, et al. Enteral tube feeding in the intensive care unit: factors impeding adequate delivery. Crit Care Med. 1999; 27(7):1252–1256. [PubMed: 10446815]
13. O'Leary-Kelley CM, Puntillo KA, Barr J, Stotts N, Douglas MK. Nutritional adequacy in patients receiving mechanical ventilation who are fed enterally. Am J Crit Care. 2005; 14(3):222–231. [PubMed: 15840896]
14. Kim H, Choi SH, Ham YJ. Nutritional status and indicators of intensive care unit patients on enteral feeding. J Korean Acad Fundam Nurs. 2009; 16(1):21–29.
15. Kim H, Shin JA, Shin JY, Cho OM. Adequacy of nutritional support and reasons for underfeeding in neurosurgical intensive care unit patients. Asian Nurs Res. 2010; 4(2):102–110.
16. Park EK, Lee JA, Lim HS. Degree of enteral tube feeding in the intensive care unit and change in nutritional status. J Korean Diet Assoc. 2001; 7(3):217–226.
17. Cerra FB, Benitez MR, Blackburn GL. Applied nutrition in ICU patients: a consensus statement of the American College of Chest Physicians. Chest. 1997; 111:769–778. [PubMed: 9118718]
18. Petros S, Engelmann N. Enteral nutrition delivery and energy expenditure in medical intensive care patients. Clin Nutr. 2006; 25:51–59. [PubMed: 16216393]
19. Umali MN, Llido LO, Francisco EM, et al. Recommended and actual calorie intake of intensive care unit patients in a private tertiary care hospital in the Philippines. Nutrition. 2006; 22:345–349. [PubMed: 16472978]
20. ASPEN. Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: Society of Critical Care (SCCM) and American Society of Parenteral and Enteral Nutrition (ASPEN). JPEN J Parenter Enteral Nutr. 2009; 33:277–316. [PubMed: 19398613]
21. American Dietetic Association. Manual of Clinical Dietetics. 6. Chicago, IL: American Dietetic Association; 2000.
22. Ministry for Health, Welfare, and Family Affairs. The Distribution of Height and Weight. Seoul, Korea: Ministry for Health, Welfare, and Family Affairs; 2001. National health and nutrition survey.
23. Amato P, Keating KP, Quercia RA, Karbonic J. Formulaic methods of estimating caloric requirements in mechanically ventilated obese patients: a reappraisal. Nutr Clin Pract. 1995; 10(6): 229–232. [PubMed: 8700053]
24. Choo V. WHO reassesses appropriate body-mass index for Asian populations. Lancet. 2002; 360:235. [PubMed: 12133671]
25. Fuhrman PM. When is it appropriate to use adjusted body weight for estimating energy requirements? Support Line. 2003; 25(3):26.
26. Binnekade JM, Tepaske R, Bruynzeel P, Mathus-Vliegen EMH, de Haan RJ. Daily enteral feeding practice on the ICU: attainment of goals and interfering factors. Crit Care. 2005; 9:R218–R225. [PubMed: 15987393]
27. Hwang IC, Kim KK, Kang HC, Kang DR. Validity of stature-predicted equations using knee height for elderly and mobility impaired persons in Koreans. Epidemiol Health. 2009; 31:1–6.
28. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med. 1985; 13(10):818–829. [PubMed: 3928249]
29. Roberts SR, Kennerly DA, Keane D, George C. Nutrition support in the intensive care unit: adequacy, timeliness, and outcomes. Crit Care Nurse. 2003; 23(6):49–57. [PubMed: 14692172]

30. Pachorek, RE.; Chan, J. Gastrointestinal motility. In: Anderson, PO.; Knoben, JE.; Troutman, WG., editors. Handbook of Clinical Drug Data. 10. New York, NY: McGraw-Hill; 2002. p. 563-574.
31. Rayes N, Hansen S, Seehofer D. Early enteral supply of fiber and lactobacilli versus conventional nutrition: a controlled trial in patients with major abdominal surgery. Nutrition. 2002; 18:609–615. [PubMed: 12093440]
32. Dvir D, Cohen J, Singer P. Computerized energy balance and complications in critically ill patients: an observational study. Clin Nutr. 2006; 25(1):37–44. [PubMed: 16321459]
33. Hill D, Kearney P, Magnuson B, et al. Effects of route and timing of nutrition support in critically ill patients [AGA abstract 346]. Gastroenterology. 2002; 122(suppl 4):A38.
34. Singer P, Berger MM, Van den Berghe G, et al. ESPEN. ESPEN guidelines on parenteral nutrition: intensive care. Clin Nutr. 2009; 28(4):387–400. [PubMed: 19505748]
35. De Beaux I, Champman M, Fraser R, et al. Enteral nutrition in the critically ill: a prospective survey in an Australian intensive care unit. Anaesth Intensive Care. 2001; 29(6):619–622. [PubMed: 11771607]
36. Ishibashi N, Plank LD, Sando K, Hill GL. Optimal protein requirements during the first 2 weeks after the onset of critical illness. Crit Care Med. 1998; 26(9):1529–1535. [PubMed: 9751589]
37. MacDonald A, Hildebrandt L. Comparison of formulaic equations to determine energy expenditure in the critically ill patients. Nutrition. 2003; 19:233–239. [PubMed: 12620525]
38. Scheinkestel CD, Kar L, Marshall K, et al. Prospective randomized trial to assess caloric and protein needs of critically ill anuric, ventilated patients requiring continuous renal replacement therapy. Nutrition. 2003; 19:909–916. [PubMed: 14624937]
39. Chen YC, Chou SS, Lin LH, Wu LF. The effect of intermittent nasogastric feeding on preventing aspiration pneumonia in ventilated critically ill patients. J Nurs Res. 2006; 14(3):167–180. [PubMed: 16967399]
40. Steevens EC, Lipscomb AF, Pool GV, Sacks G. Comparison of continuous vs intermittent nasogastric enteral feeding in trauma patients: perceptions and practice. Nutr Clin Pract. 2002; 17(2):118–122. [PubMed: 16214974]
41. Chao YC. Factors predisposing the development of gastrointestinal intolerances in ICU patients starting enteral nutrition and corresponding management. Nurs Res. 1998; 6(6):461–474.
42. Elpern EH, Stutz L, Peterson S, Gurka DP, Skipper A. Outcomes associated with enteral tube feedings in a medical intensive care unit. Am J Crit Care. 2004; 13(3):221–227. [PubMed: 15149056]
43. Singh N, Gupta D, Aggarwal AN, Agarwal R, Jindal SK. An assessment of nutritional support to critically ill patients and its correlation with outcomes in a respiratory intensive care unit. Respir Care. 2009; 54(12):1688–1696. [PubMed: 19961635]

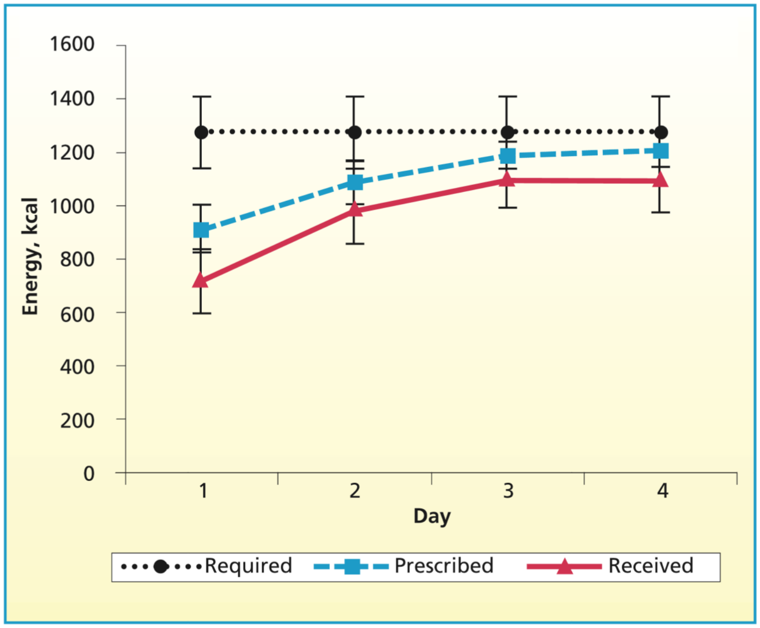

Figure 1.
Mean energy required, prescribed, and received enterally, by day (N = 34).

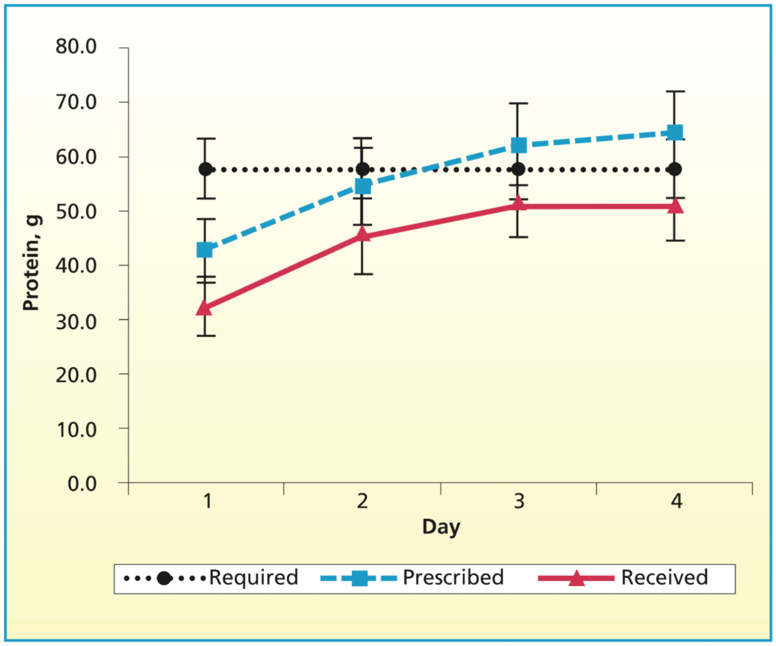

Figure 2.
Mean protein required, prescribed, and received enterally, by day (N = 34).

Table 1

Demographic and clinical characteristics of the participants (N = 34)

Characteristic	Value
Age, mean (SD), y	70.8 (14.8)
Sex (male/female), No.	17/17
Primary diagnosis, % (No.)	
Neurological	47 (16)
Respiratory	29 (10)
Sepsis	15 (5)
Gastrointestinal	6 (2)
Renal	3 (1)
Mechanical ventilation, % (No.)	44 (15)
APACHE II score, mean (SD)	13.0 (6.1)
Albumin, mean (SD), g/dL	3.3 (0.8)
C-reactive protein,[a] mean (SD), mg/dL	6.1 (7.1)
Body mass index[b] category, % (No.)	
Underweight	9 (3)
Healthy weight	38 (13)
Overweight	21 (7)
Mild obese	32 (11)
Nasogastric feeding tube, % (No.)	100 (34)
Nasogastic feeding tube size, %	
16F/18F	50/50
Days from admission to intensive care unit to start of enteral feeding, mean (SD)	5.3 (6.8)

Abbreviation: APACHE II, Acute Physiology and Chronic Health Evaluation II.

[a]To convert to nanomoles per liter, multiply by 95.24.

[b]Calculated as weight in kilograms divided by height in meters squared.

Table 2

Reasons for and duration of interruptions in enteral feeding

Reasons	No. of patients affected	No. of interruptions	% of total interruption time	r[a]
Gastrointestinal intolerance[b]	9	15	29.5	−0.874[c]
Routine nursing care[d]	12	12	1.4	0.506
Procedure[e]	9	10	17.5	−0.839[c]
Airway management[f]	4	6	22.4	−0.006
Gastrointestinal bleeding	3	5	18.9	−0.252
Feeding tube problem[g]	4	4	1.2	0.968[h]
Other[i]	2	2	9.1	—

[a]Relationship between the interruption time that feedings were withheld for each reason and percentage of prescribed energy received with enteral nutrition.

[b]High gastric residual volumes, diarrhea, and vomiting.

[c]$P < .01$.

[d]Skin care, changing of bed linens, position changes, and incontinence care.

[e]Diagnostic or therapeutic procedures and radiology.

[f]Tracheostomy.

[g]Absence of the feeding tube.

[h]$P < .05$.

[i]Hemodynamic shock, lapse in nursing care.