Caloric Intake in Medical ICU Patients*  
Consistency of Care With Guidelines and Relationship to Clinical Outcomes  
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Study objectives: To assess the consistency of caloric intake with American College of Chest Physicians (ACCP) recommendations for critically ill patients and to evaluate the relationship of caloric intake with clinical outcomes.  
Design: Prospective cohort study.  
Setting: Adult ICUs at two teaching hospitals.  
Participants: Patients with an ICU length of stay of at least 96 h.  
Measurements and results: On ICU admission, severity of illness (ie, simplified acute physiology score II) and markers of nutritional status (ie, serum albumin level and body mass index) were recorded. The route of feeding (ie, enteral or parenteral), actual caloric intake (ie, percentage of ACCP recommendations: 0 to 32% [tertile I]; 33 to 65% [tertile II]; ≥ 66% [tertile III]), and evidence of GI intolerance (ie, gastric aspirate levels, ≥ 100 mL) were recorded daily. The following outcomes were assessed: status on hospital discharge (alive vs dead); spontaneous ventilation before ICU discharge (yes vs no); and ICU discharge without developing nosocomial sepsis (yes vs no). The average caloric intake among 187 participants was 50.6% of the ACCP targets and was similar in both hospitals. Caloric intake was inversely related to the mean number of gastric aspirates > 100 mL/d (Spearman p = −0.04; p = 0.06), but not to severity of illness, nutritional status, or route of feeding. After accounting for the number of gastric aspirates ≥ 100 mL, severity of illness, nutritional status, and route of feeding, tertile II of caloric intake (vs tertile I) was associated with a significantly greater likelihood of achieving spontaneous ventilation prior to ICU discharge. Tertile III of caloric intake (vs tertile I) was associated with a significantly lower likelihood of both hospital discharge alive and spontaneous ventilation prior to ICU discharge.  
Conclusions: Study participants were underfed relative to ACCP targets. These targets, however, may overestimate needs, since moderate caloric intake (ie, 33 to 65% of ACCP targets; approximately 9 to 18 kcal/kg per day) was associated with better outcomes than higher levels of caloric intake.  

Key words: calories; clinical outcomes; critical illness; mechanical ventilation; medical ICU; nosocomial sepsis; nutrition

Malnutrition has been associated with poor outcomes among hospitalized patients, including prolonged mechanical ventilation, increased risk for infection, and higher mortality.1–6 Hypercatabolism associated with critical illness may further increase the risk of adverse outcomes among ICU patients who receive inadequate nutrition.7 However, providing enteral and parenteral nutritional support in this population may be difficult due to such factors as GI intolerance and fluid overload, respectively, and are associated with serious iatrogenic complications, including aspiration pneumonia and catheter-related infections.5–11 Concerns about the adverse effects of feeding and the paucity of evidence regarding its efficacy have led to substantial published debate and heterogeneous nutritional support practices among clinicians providing care to ICU patients.12–14 Thus, both patient factors that influence the ability to
provide nutrition and variations in the aggressiveness with which different ICU clinicians pursue feeding can lead to marked differences in the level of nutritional support achieved in individual patients.\textsuperscript{15–17}

Based on expert opinion and limited data from studies involving mostly surgical, burn, and head-injury patients, the American College of Chest Physicians (ACCP) in 1997 published guidelines\textsuperscript{18} for nutritional support, including empiric targets for daily caloric intake, to reduce practice variation among ICU physicians. No studies to date, however, have examined the degree to which the caloric intake in ICU patients meets these recommendations. Moreover, there are no published reports that validate the daily caloric intake targets set by these guidelines in critically ill medical patients.\textsuperscript{8} The main objectives of this study were as follows: (1) to assess the consistency of daily caloric intake with the ACCP guidelines; and (2) to evaluate the relationships of the caloric targets set by ACCP guidelines and clinical outcomes in medical ICU patients.

**Materials and Methods**

**Study Design**

This was a prospective cohort study conducted from February 1999 to October 2000. Patients were recruited from the medical ICUs at the following two teaching hospitals serving different patient populations: a tertiary care referral center (Johns Hopkins Hospital); and a community-based medical center (St. Agnes HealthCare). Recruitment began at Johns Hopkins Hospital in February 1999 and was expanded to St. Agnes HealthCare in February 2000 to allow comparisons of nutritional support practices between these teaching institutions.

**Study Population**

Adult medical patients (ie, those ≥ 18 years of age) who had been admitted to the two ICUs were screened for eligibility. The intent of this study was to compare nutritional support practices with the ACCP guidelines. Therefore, inclusion in the study was restricted to patients for whom these guidelines were written (ie, adults with an ICU length of stay ≥ 96 h).\textsuperscript{19} Patients were excluded for the following reasons: (1) they had been admitted to the ICU for preoperative or postoperative care (ie, surgical patients), or following trauma or burns; (2) they had been able to eat by mouth within 96 h of ICU admission; (3) they had been transferred from other hospitals or ICUs; or (4) the patient had a “do-not-resuscitate” order in place within the 96 h of ICU admission. Physicians with training in critical care medicine served as attending physicians for all patients who had been admitted to the ICUs at these institutions. There were no protocols in place with which to direct the nutritional support of patients who were unable to eat by mouth, so all decisions regarding feeding (eg, enteral or parenteral nutrition, rate of feeding, or the use of pro-motility agents) were made at the discretion of patients’ attending physicians. Standard enteral and parenteral formulas were used during the study period (ie, none of the formulas were enriched with immunonutrients\textsuperscript{20}). The requirement for obtaining informed consent in this observational study was waived by the institutional review boards at both institutions.

**Definitions of Variables**

**Outcome Variables:** For analyses examining consistency of care with ACCP guidelines for nutritional support, the outcome variable was the mean caloric intake in the ICU relative to guideline recommendations. To calculate the daily caloric intake, the caloric content of enteral and parenteral nutritional formulations that were provided each day were recorded, starting at ICU admission and proceeding until (1) patients began eating by mouth, (2) a do-not-resuscitate order was written, or (3) ICU discharge, whichever occurred first. Each day’s enteral and/or parenteral caloric intake was divided by target values set by the ACCP guidelines (25 kcal/kg or 27.5 kcal/kg during systemic inflammatory response syndrome [SIRS]\textsuperscript{20}). Each day, SIRS was recorded as being present if two or more of the following criteria were observed: (1) temperature > 38°C or < 36°C; (2) heart rate > 90 beats/min; (3) respiratory rate > 20 breaths/min; and (4) leukocytosis (ie, > 12,000 cells/mL), leukopenia (ie, < 4,000 cells/mL), or > 10% bands. This definition of SIRS follows the ACCP/Society of Critical Care Medicine Consensus Conference recommendations,\textsuperscript{20} with the exception that hypocapnia (ie, PaCO\textsubscript{2} < 32 mm Hg) was omitted since patients did not have an arterial blood gas measurements made each ICU day. The formula for calculating the mean caloric intake was as follows:

\[
\text{Mean % recommended caloric intake} = \frac{\sum (\text{each day’s caloric intake/ACCP target each day})}{\text{Number of ICU days}}
\]

To describe each participant’s pattern of caloric intake as a function of ICU length of stay, the cumulative average caloric intake was calculated for each ICU day (ie, average caloric intake from first ICU day through each of the subsequent ICU days).

The patient’s status on hospital discharge (ie, alive vs dead) served as the primary clinical outcome of interest in analyses examining the relationship between caloric intake and outcomes. Three participants (1.6%) were discharged from the hospital to hospice care and were considered to be dead on hospital discharge in the analyses. The following two secondary clinical outcomes also were assessed on ICU discharge: (1) spontaneous ventilation at ICU discharge (yes vs no); and (2) ICU discharge without developing nosocomial sepsis (yes vs no). *Spontaneous ventilation* was defined as being able to breathe unassisted for ≥ 48 consecutive hours (ie, extubated, or breathing with T-piece, tracheostomy-collar, or continuous positive airway pressure of ≤ 5 cm H\textsubscript{2}O with pressure support of 0 cm H\textsubscript{2}O). *Nosocomial sepsis* was defined using published criteria (ie, the presence of SIRS and either positive microbiology cultures and/or clinical signs of infection) ≥ 48 h after ICU admission.\textsuperscript{20} Patients who died prior to ICU discharge were considered in the analysis as not achieving either the primary or secondary clinical outcomes.

**Independent Variables:** On ICU admission, age, markers of nutritional status (ie, serum albumin level and body mass index),\textsuperscript{21,22} and severity of illness (simplified acute physiology score [SAPS]-II)\textsuperscript{23} were recorded. The route of nutritional support (ie, enteral, parenteral, or both) was recorded daily. For patients who were being fed via the enteral route, it was standard practice at participating ICUs to employ nasogastric tube feeds rather than postpyloric tube feeds. Gastrostomy tubes were reserved typically for patients discharged to chronic ventilator units (five study participants). However, data regarding the precise route of...
ental feeding was not collected during this study. To assess GI intolerance during enteral feeding, the number of gastric aspirates $\geq 100 \text{ mL}$ (a threshold commonly used to limit enteral feeding in participating ICUs) documented by nurses on patients’ ICU flowsheets was recorded.

Statistical Analysis

Means (SDs), medians (interquartile range [25th to 75th percentiles]), and proportions were calculated for descriptive analyses. Kruskall-Wallis, $\chi^2$ tests, or Spearman correlation coefficients were employed in bivariate analyses. The following three logistic regression models were constructed to assess the relationship of caloric intake with clinical outcomes: status on hospital discharge (alive vs dead [model 1]), spontaneous ventilation before ICU discharge (yes vs no [model 2]), and ICU discharge without developing nosocomial sepsis (yes vs no [model 3]). Multivariable models were used to adjust for serum albumin level, body mass index, SAPS II score, route of feeding, and number of gastric aspirates $\geq 100 \text{ mL}$. Age was not included as an independent variable in multivariable analyses since it is part of the SAPS II score.

Patients were significantly more likely to be discharged alive from St. Agnes HealthCare (78.3%) than from Johns Hopkins Hospital (46.1%; $p < 0.001$). To account for possible correlation of outcomes among patients to whom care was provided within each ICU, Huber24 and White25 estimators of variance were calculated. In secondary analyses, we also examined separately in multivariable models the relationship of caloric intake with outcomes within subgroups of patients according to SAPS II score, albumin level, body mass index, mean number of gastric aspirates $\geq 100 \text{ mL}$, and route of feeding (see the categories of independent variables described below). Model instability due to the small number of patients enrolled in the study at St. Agnes HealthCare precluded multivariable analyses limited to this ICU.

The results were similar whether independent variables were modeled as continuous or categoric variables, so the results of analyses using categoric variables are presented to facilitate interpretation. Dummy variables for caloric intake (tertile I, 0 to 32% of ACCP guidelines [reference group]; tertile II, 33 to 65% of ACCP guidelines; and tertile III, $\geq 66\%$ of ACCP guidelines) were employed. For other continuous independent variables (ie, SAPS II score, serum albumin level, body mass index, and number of gastric aspirates $\geq 100 \text{ mL}$ each day), categories were based on the distribution in the study population (ie, less than or equal to the median vs more than the median). The route of feeding was entered as a categoric variable (enteral feeding only vs any parenteral feeding).

There was no published literature about the potential effect sizes related to various levels of caloric intake on hospital mortality in medical ICU patients, so sample size requirements were estimated using the number of events necessary to avoid overfitting multivariable regression models.26 Analyses of pilot data suggested a 50% hospital mortality rate among patients with an ICU length of stay of $\geq 96 \text{ h}$, indicating that 180 patients (90 deaths) would be sufficient for conducting the multivariate analyses specified in this study. The calibration of multivariable models was assessed using the Hosmer-Lemeshow goodness-of-fit test.27 A two-tailed p value of $< 0.05$ defined statistical significance for all analyses. All computations were performed using a statistical software package (STATATA, version 7; StataCorp; College Station, TX).25

Results

Patient Characteristics

Of the 1,539 admissions to the two ICUs during the study period (Johns Hopkins Hospital, 1,195 admissions; St. Agnes HealthCare, 344 admissions), 187 patients (Johns Hopkins Hospital, 141 patients; St. Agnes HealthCare, 46 patients) met the eligibility criteria and were enrolled in the study. The reasons for study exclusion were as follows: ICU length of stay $< 96 \text{ h}$ (1,029 patients); transfer from other hospitals or ICUs (216 patients); able to eat by mouth within 96 h of ICU admission (60 patients); do-not-resuscitate order within 96 h of ICU admission (19 patients); previous participant (7 patients); surgical, or burn or trauma patient (3 patients); and missed/unknown eligibility (18 patients). The median age of study participants was 54.7 years (interquartile range, 42.4 to 70.1 years). Nearly all patients had respiratory failure in the ICU, with 94.1% receiving mechanical ventilation during their ICU stay. About half of the participants (50.3%) had been admitted to the ICU from the emergency department, with the remainder having been admitted from other inpatient units (Table 1). Compared to

| Table 1—Patient Characteristics* |
|--------------------------|-----------------|-----------------|-----------------|------|
| Characteristics          | Johns Hopkins   | St. Agnes       | Combined        | p Value |
| Source, %                 | (n = 141)       | (n = 46)        | (n = 187)       |       |
| ED                        | 50.4            | 50.0            | 50.3            |       |
| Inpatient floor           | 49.6            | 50.0            | 49.7            | < 0.0001 |
| Age, yr                   | 48.8 (39.0–64.3)| 68.2 (54.9–74.9)| 54.7 (43.4–70.1)|       |
| SAPS II                   | 51 (41–62)      | 47.5 (40–62)    | 50 (41–62)      |       |
| Received PPV, %           | 92.2            | 100.0           | 94.1            |       |
| Albumin                   | 2.6 (2.2–3.1)   | 3.9 (2.6–4.0)   | 2.7 (2.3–3.6)   | < 0.0001 |
| BMI                       | 24.3 (19.3–30.4)| 26.3 (20.2–30.3)| 25.0 (19.7–30.4)|       |

*Values given as median (interquartile range), unless otherwise indicated. ED = emergency department; PPV = positive-pressure ventilation; BMI = body mass index.
patients from Johns Hopkins Hospital, patients from St. Agnes were older and had higher serum albumin levels.

**Consistency of Caloric Intake With ACCP Guidelines**

Feeding began a median of 2 days (interquartile range, 1 to 2 days) after ICU admission. There was no caloric intake on 22.0% of 2,208 ICU days, with 2 participants (1.1%) receiving no nutritional support during their ICU stay. The cumulative average caloric intake among participants increased over the first several ICU days to a median of 50.6% of ACCP guideline recommendations (interquartile range, 31.6 to 68.7%) [Fig 1 and Table 2]. By the time of ICU discharge, 49 patients (26.2%), 88 patients (47.0%), and 50 patients (26.7%), respectively, had achieved tertiles I, II, and III of caloric intake. Nutritional support was provided most commonly via the enteral route, with 129 patients (69.7%) having been fed exclusively with enteral tube feeds, 36 patients (19.5%) having been fed via the enteral and parenteral routes, and 20 patients (10.8%) having been fed via the parenteral route exclusively. Significantly fewer patients were fed via the parenteral route at St. Agnes HealthCare than at Johns Hopkins Hospital (2.2% vs 39.0%, respectively; p < 0.001).

Gastric aspirates ≥ 100 mL occurred on 176 of 1,355 days (13.0%) of enteral feeding. During days with one or more gastric aspirates ≥ 100 mL, the median level of enteral nutrition was 52% (range, 0 to 198%) of the ACCP recommendations for daily caloric intake. The median enteral caloric intake on days with no gastric aspirates ≥ 100 mL was 62% (range, 0 to 227%). The number of gastric residuals ≥ 100 mL for each participant (average over all days) was weakly and inversely related to mean caloric intake (Spearman ρ = −0.04; p = 0.06). Mean caloric intake was not associated with route of feeding (enteral only, 52.0% of ACCP-recommended calories; enteral and parenteral, 51.0% of ACCP-recommended calories; parenteral only, 46.5% of ACCP-recommended calories; p = 0.67 [Kruskall-Wallis test]). The mean caloric intake also was not associated with SAPS II (Spearman ρ = 0.02; p = 0.78) or markers of nutritional status on ICU admission (ie, serum albumin level: Spearman ρ = −0.02; p = 0.77; body mass index: Spearman ρ = −0.07; p = 0.36).

**Figure 1.** The cumulative average caloric intake since ICU admission for each of 187 participants (ε) is shown. For example, a participant’s cumulative average caloric intake for ICU day 5 is the mean for days 1 to 5. Similarly, a participant’s cumulative average caloric intake for ICU day 10 is the mean caloric intake for ICU days 1 to 10. The last cumulative average caloric intake for each participant thus represents the average caloric intake from nutritional support over all ICU days for that participant. The mean caloric intake for each ICU day (ε) for all participants in the ICU is also shown. The horizontal line at caloric intake represents 100% of the target caloric intake recommended by ACCP guidelines.
Table 2—Caloric Intake*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Johns Hopkins (n = 141)</th>
<th>St. Agnes (n = 46)</th>
<th>Combined (n = 187)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to initiation of feeding, d</td>
<td>2 (1–2)</td>
<td>2 (1–2)</td>
<td>2 (1–2)</td>
<td></td>
</tr>
<tr>
<td>Recommended caloric intake for all ICU days, %</td>
<td>50.6 (31.8–70.2)</td>
<td>50.7 (29.2–63.9)</td>
<td>50.6 (31.6–68.7)</td>
<td></td>
</tr>
<tr>
<td>Received any parenteral feeding</td>
<td>55 (39.0)</td>
<td>1 (2.2)</td>
<td>56 (30.0)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Parenteral feeding, % of ICU days for each patient</td>
<td>0.0 (0–43.5)</td>
<td>0.0 (0–0)</td>
<td>0 (0–20.0)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Gastric residuals per day, No.</td>
<td>0 (0–0.38)</td>
<td>0 (0–0.17)</td>
<td>0 (0–0.28)</td>
<td></td>
</tr>
</tbody>
</table>

*Values given as median (interquartile range) or No. (%), unless otherwise indicated.

**Relationship of Caloric Intake to Clinical Outcomes**

**Bivariate Analyses:** There were 101 participants (54.0%) who were alive at hospital discharge (Fig 2, top). Compared to tertile I of caloric intake, tertile II was associated with a significantly higher likelihood of hospital discharge alive (odds ratio [OR], 1.22; 95% confidence interval [CI], 1.15 to 1.29), whereas tertile III was associated with a significantly lower likelihood of hospital discharge alive (OR, 0.83; 95% CI, 0.77 to 0.90) and tertile III (OR, 0.46; 95% CI, 0.28 to 0.75) were associated with a significantly lower likelihood of being discharged alive. In patients with SAPS II of > 50, however, both tertile II (OR, 0.83; 95% CI, 0.77 to 0.90) and tertile III (OR, 0.46; 95% CI, 0.28 to 0.75) were associated with a significantly lower likelihood of being discharged alive.

**Multivariable Analyses:** The results were similar to those found in bivariate analyses with the exception that the likelihood of hospital discharge alive was no longer significantly different between tertiles II and I of caloric intake (OR, 1.18; 95% CI, 0.90 to 1.56) [Fig 2]. The results of subgroup analyses were similar to the findings among all participants, except for status on hospital discharge for subgroups defined by the median SAPS II (ie, score ≤ 50 and score > 50). In patients with SAPS II of ≤ 50, caloric intake was not significantly associated with the likelihood of hospital discharge alive (tertile II vs tertile I: OR, 1.67; 95% CI, 0.94 to 2.95; tertile III vs tertile I: OR, 0.98; 95% CI, 0.61 to 1.56). In patients with SAPS II of > 50, however, both tertile II (OR, 0.83; 95% CI, 0.77 to 0.90) and tertile III (OR, 0.46; 95% CI, 0.28 to 0.75) were associated with a significantly lower likelihood of being discharged alive.

**Discussion**

In this study of critically ill medical patients with an ICU length of stay of at least 96 h, caloric intake increased during the initial few days after ICU admission, but the cumulative average reached only about half of what is recommended by the ACCP guidelines. Similar levels of nutritional support relative to the ACCP guidelines occurred in both the tertiary care medical ICU patients (Johns Hopkins Hospital) and the community-based medical ICU patients (St. AgnesHealth). Compared to the lowest tertile of caloric intake (ie, 0 to 32% of ACCP recommendations), the mid-tertile (ie, 33 to 65%) was associated with a significantly greater likelihood of achieving spontaneous ventilation prior to ICU discharge. However, the highest tertile of caloric intake (ie, ≥ 66%) was associated with a significantly lower likelihood of hospital discharge alive and spontaneous ventilation prior to ICU discharge.

The levels of caloric intake that were observed in this study are consistent with those of previous reports of underfeeding in surgical or mixed medical-surgical ICUs. In the current study, there was a wide range of daily caloric intake (0 to 227%) even in the absence of gastric aspirates ≥ 100 mL, and the mean number of gastric aspirates ≥ 100 mL was only weakly related to mean caloric intake. Also, overall caloric intake was not associated with markers of nutritional status or severity of illness on ICU admission. As with the results of previous studies, these data strongly suggest that differences in caloric intake achieved among individual participants in this study were poorly explained by patient-related factors.

Although the prescribed volumes of nutritional formulas were not recorded in this study, the results of previous investigations suggest that physicians’ nutritional support practices vary and contribute to substantial levels of underfeeding. For example, a study of European Society of Intensive Care Medicine members found that, even in the absence of
Figure 2. Top, A: ORs and 95% CIs for hospital discharge alive in patients with tertiles II and III of caloric intake. Hosmer-Lemeshow test statistic for multivariable model, $p = 0.76$. Middle, B: ORs and 95% CIs for spontaneous ventilation prior to ICU discharge in patients with tertiles II and III of caloric intake. Hosmer-Lemeshow test statistic for multivariable model, $p = 0.77$. Bottom, C: ORs and 95% CIs for ICU discharge without sepsis in patients with tertiles II and III of caloric intake. Hosmer-Lemeshow test statistic for multivariable model, $p = 0.23$. An OR of $> 1.0$ indicates a greater likelihood of outcome compared to tertile I. An OR of $< 1.0$ indicates a lower likelihood of outcome compared to tertile I. * = adjusted for SAPS II score, serum albumin level, body mass index, gastric residuals, and route of feeding in a multivariable logistic regression model (see “Materials and Methods” section for details).
contraindications, 45% of physicians started nutritional support within 24 h of ICU admission, 47% started nutritional support between 24 and 48 h after ICU admission, 8% started nutritional support after \( \geq 48 \) h after ICU admission. The initial prescribed volume of nutritional formulas varied fourfold (500 to 2,000 mL) in this study. The type of nutritional formulation used, the type and size of feeding tubes, and the indications for parenteral feeding also varied. These observations are consistent with a study that found marked differences in the aggressiveness of feeding protocols employed in different ICUs and studies linking underfeeding to conservative physician-prescribing patterns, particularly delays in restarting nutritional support after diagnostic or therapeutic procedures.

Several studies have examined the benefit of nutrition in critical illness, particularly in surgical, burn, or trauma patients, and have focused on comparing various feeding strategies (e.g., early vs late feeding, “immunonutrition” vs “standard” formulations, and enteral vs parenteral feeding). Two reviews, however, have concluded that there are insufficient data from methodologically sound studies to permit firm recommendations about the nutritional support of critically ill patients, particularly medical ICU patients. To our knowledge, this is the first study to examine the relationship between the level of caloric intake and clinical outcomes in critically ill medical patients. After accounting for measures of nutritional status, severity of illness, enteral or parenteral route of feeding, and GI intolerance, modest levels of caloric intake (i.e., 33 to 65% of ACCP guidelines) appeared to be most beneficial, whereas even higher levels (i.e., \( \geq 66\% \) of ACCP guidelines) were associated with significantly higher morbidity and mortality. These data suggest a therapeutic window, above which exist no additional benefit and, potentially, worse outcomes.

In the subgroup of patients with higher severity of illness on ICU admission (i.e., SAPS II, \( > 50 \)), caloric intake of \( > 33\% \) of ACCP recommendations was associated with lower rates of hospital discharge alive. The results of some previous studies also have suggested that nutritional support may be deleterious in the most severely ill patients. For example, data from the Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments found that patients with acute respiratory failure or multiorgan failure with sepsis were less likely to survive if they received nutritional support. In a randomized clinical trial of medical ICU patients requiring mechanical ventilation, infectious complications (e.g., aspiration pneumonia) and length of stay were reduced with delayed feeding. Other studies also have reported that hyperglycemia increases the risk of adverse outcomes in critically ill patients, including bloodstream infections, renal failure, prolonged hospital lengths of stay, and mortality. These observations suggest that iatrogenic complications of feeding (e.g., aspiration and hyperglycemia) may have attenuated the potential benefits of more aggressive nutritional support (i.e., caloric intake closer to ACCP recommendations). In many respects, the demonstration of a therapeutic window associated with nutritional support may help to reconcile conflicting views in the literature regarding the benefits of this supportive therapy. Moreover, the documentation of unfavorable effects of low and high levels of daily caloric intake on needs for mechanical ventilation and survival underscores the importance of attentiveness to individualized nutritional assessment and supplementation, and efforts to minimize the complications associated with this therapy in critically ill patient populations.

Findings from the current investigation should be interpreted with some caution. Although analyses accounted for severity of illness, route of feeding, markers of nutritional status, and GI intolerance, the results may have been confounded by unmeasured patient factors that determined levels of caloric intake and outcomes (confounded by indication). However, the results of previous studies have indicated that the levels of nutritional support achieved in critically patients are, in large part, determined by variable physician propensities to feed (practice variation) rather than on patient characteristics. While nutritional support practices and clinical outcomes were evaluated both in a tertiary care and a community-based ICU, the results may not necessarily generalize to other medical ICU patient populations. Also, it is possible that other constituents of nutritional formulas (i.e., protein, minerals, vitamins, and other essential nutrients) also contributed to observed differences in clinical outcomes among patients with varying levels of caloric intake.

In conclusion, medical ICU patients were inadequately fed in comparison to goals set by ACCP guidelines. However, the relationships between caloric intake and clinical outcomes measured in this study suggest that daily ACCP caloric targets may overestimate needs since caloric intake that is \( > 65\% \) of recommendations (approximately 18 kcal/kg/d) was associated with excess morbidity and mortality. In addition, the most severely ill patients appeared to be the least likely to benefit from nutritional support. A randomized clinical trial that includes a supportive care protocol to manage serum glucose and minimize risk of other iatrogenic complications of feeding (e.g., aspiration pneumonia) is needed to rigorously
assess the efficacy and safety of nutritional support in critically ill medical patients. Until then, these data suggest that clinicians should moderate levels of nutritional support in this population.

ACKNOWLEDGMENT: We thank Dr. E. Haponik for his thoughtful comments on a previous draft of this report.

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