Nutrition Support in the Intensive Care Unit

Adequacy, Timeliness, and Outcomes

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Nutrition support is commonly used as supportive care in critically ill patients, either to treat existing malnutrition or to prevent development of nutritional deficiencies. Critical care nurses are important in this supportive therapy because they administer nutritional formulas to critically ill patients. A number of clinical trials indicated the benefits of providing nutrition support, particularly enteral feedings, to critically ill patients. Important outcomes such as rates of infection, lengths of stay, and costs can be decreased by the early initiation of enteral feedings. Despite knowledge of these benefits, the actual nutrition support received by patients in the intensive care unit (ICU) is not always optimal for various reasons. Overfeeding by any route of nutrition support can be detrimental, and inadequate provision of nutrition support or underfeeding, which is more common in tube-fed patients, can also be harmful (Table 1). Additionally, because provision of nutrition support is not without risks, it is important to use nutrition support in the appropriate patients and under the appropriate conditions (Table 2).

Gastrointestinal complications (eg, constipation, diarrhea) are common in critically ill patients. To prevent these complications and other adverse outcomes associated with nutrition support, critical care nurses need to be aware of the potential for complications and take steps to minimize or prevent them. This article provides an overview of the importance of nutrition support in critically ill patients and discusses the potential for complications associated with this therapy.

Authors

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impaired gastric emptying and diarrhea) and the requirement to stop feedings before procedures and surgery are the major factors impeding adequate delivery of enteral feedings. Therefore, clinicians often implement protocols for critically ill patients to improve the adequacy and timeliness of nutrition support.

All members of the multidisciplinary team contribute to adequate and timely provision of nutrition support, but the skill and experience of critical care nurses in caring for critically ill patients is pivotal to the success of nutrition support. Because nutrition support can affect important outcomes, we undertook a retrospective review of medical records of 50 patients in the ICU to determine the adequacy and timeliness of nutrition support provided, the influence of these factors on outcomes, and areas in need of improvement.

**Methods**

Baylor University Medical Center is a 1000-bed tertiary care hospital in Dallas, Tex, that has medical, surgical, trauma, and coronary ICUs. Study patients were obtained from a list of all ICU admissions from January through February 2000. Data were collected on the first 50 patients on the list that met the inclusion criteria. The following inclusion criteria were used: stay in the ICU of 3 days or more, received nutrition support while in the ICU, and no do-not-resuscitate order at the time of admission. The data were collected retrospectively from the medical record. Permission to review and collect data for publication was obtained from Baylor Medical Center’s institutional review board. Table 3 outlines the information retrieved from each patient’s medical record.

SPSS, version 9.0 (SPSS Inc, Chicago, Ill) was used for statistical analyses. The Pearson product moment correlation was used to determine correlations between variables studied and outcomes such as length of stay in the ICU, survival, and days of mechanical ventilation. A t test was used to evaluate differences in length of stay in the ICU between patients fed early versus those fed late, and to evaluate for differences in age, score on the Acute Physiology and Chronic Health Evaluation (APACHE) II, and energy intake per kilogram between the early feeding and late feeding groups.
Results
Characteristics of Patients

Table 4 contains the data for characteristics of patients. Malnutrition at admission was determined by considering the underlying disease process, the presence of marked recent unintentional weight loss (defined as 4.5 kg [10 lb] in the past 2 months), low body mass index (<19; calculated as weight in kilograms divided by the square of height in meters), recent oral intake, and presence of gastrointestinal signs and symptoms such as vomiting, dysphagia, and diarrhea before admission. A large percentage of patients had chronic diseases, such as diabetes, chronic obstructive pulmonary disease, and cardiovascular disease, in addition to their acute illness leading to admission to the ICU. The APACHE II score reflects severity of illness in this group of patients and was calculated by using data from the first 24 hours in the ICU. The APACHE II score correlated positively with age ($r = 0.44, P = .001$), days receiving mechanical ventilation ($r = 0.35, P = .013$), and presence of chronic disease ($r = 0.41, P = .003$). Figure 1 provides information on length of stay in the ICU, number of days receiving mechanical ventilation and nutrition support, and the ICU day that nutrition support was started. Seventy-two percent of the patients survived (discharged from the hospital either to home or another institution). Survival did not correlate significantly with most variables studied, including age, body mass index, presence of chronic disease, length of stay in the ICU, and adequacy of nutritional support. A trend of association was apparent between survival and both APACHE II score ($r = -0.23, P = .12$) and malnutrition at admission ($r = -0.24, P = .09$).

Route of Nutrition Support

The percentages of patients fed enterally, parenterally, or via both routes were 70%, 12%, and 18%, respectively. Of the patients fed via the enteral route, 93% received gastric feedings and 7% received small-bowel feedings. The patients given total parenteral nutrition did meet the medical center’s standard criteria for parenteral nutrition (presence of...
bowel obstruction, ileus, inflammatory bowel disease, short-bowel syndrome, pancreatitis, fistula, abscess, hematopoietic stem cell transplant, or failure to tolerate small-bowel enteral feedings); therefore, no inappropriate use of total parenteral nutrition occurred in this group of patients. Compared with patients fed via the enteral route only, a larger percentage of patients who received total parenteral nutrition (either alone or in combination with enteral feedings) received adequate calories and protein (Figure 2). Provision of calories and protein was considered adequate if 85% or more of nutrient needs were met.

**Timeliness of Initiation of Nutrition Support and Intervention by a Dietitian**

Nutrition support was initiated in 68% of patients by the end of the third day of ICU stay and in 86% of patients by the fifth ICU day. Figure 3 displays the mean length of stay in the ICU for patients who were started on nutrition support in 3 days or less and patients started on nutrition support more than 3 days after admission to the ICU. Selected characteristics of these 2 groups of patients were compared (Figure 4). The groups had similar ages (mean 60.5 vs 51.6 years) and APACHE II scores (mean 21.9 vs 20.9), and the energy intake per kilogram of body weight was equivalent in the 2 groups (mean 86 vs 89.5 kJ/kg). ICU day of initial nutrition assessment or intervention by a registered dietitian was also studied. The dietitian assessed 66% of the patients within the first 3 days of their ICU stay. Intervention by a registered dietitian within the first 3 days resulted in a trend toward a shorter ICU stay ($r = -0.23, P = .10$). The ICU day that nutrition support was initiated did not correlate with the number of days patients required mechanical ventilation ($r = -0.07, P = .63$).

**Adequacy of Nutrition Support**

Table 5 provides information on the nutrient intake received by the patients in the ICU. Advancement of feedings was slow; only 28% of patients were receiving 83.68 to 146.44 kJ/kg (20-35 kcal/kg) by the third day of nutrition support. When the relationship between adequacy of calories and length of stay in the ICU was evaluated, the length of stay in the ICU was shorter for patients who had sufficient energy intake, defined as within the range of 83.68 to 146.44 kJ/kg ($r = -0.28, P < .05$). A nonsignificant positive correlation was found between the percentage of energy needs met and the number of days of mechanical ventilation ($r = 0.19, P = .19$). A statistically significant positive correlation was found on nutrition support in 3 days or less and patients started on nutrition support more than 3 days after admission to the ICU.
between the percentage of protein needs met and the number of days of mechanical ventilation ($r = 0.28$, $P < .05$).

Gastrointestinal Complications

Table 6 lists the gastrointestinal complications present in this group of ICU patients. The most common gastrointestinal complications were high gastric residual volumes and diarrhea. The medical center did not have an accepted residual volume when this study was done. Therefore, physicians would specify the acceptable residual volume for each patient, often a very low volume, a practice that led to missed enteral feedings. Diarrhea was the second most common gastrointestinal complication and was noted as a complication if a patient had 3 or more loose stools per day. Enteral feedings were also often stopped or slowed because of diarrhea. The occurrence of gastrointestinal complications correlated positively with a longer stay in the ICU ($r = 0.44$, $P < .011$). Mean APACHE II scores were 21.4 for patients with and 22.2 for patients without gastrointestinal complications.

Discussion

Nutrition support is generally accepted as an important supportive therapy for critically ill patients. In our study, feeding critically ill patients adequately and in a timely manner, especially via the enteral route, was a challenge. Limitations of this study include the retrospective collection of data, lack of randomization, and small sample size. However, the study provided information that will facilitate quality improvement in the delivery of nutrition support to critically ill patients at the medical center.

Route of Administration

At Baylor Medical Center, enteral feeding is used more often than is total parenteral nutrition. Enteral feeding is generally the preferred route of nutrition support because it is less expensive, preserves gut function, and has fewer infectious complications.
Most patients in our study receiving enteral feedings were fed intragastrically. Debate is ongoing over whether gastric feedings or small-bowel feedings are best. Studies comparing gastric and small-bowel feedings for aspiration risk have yielded conflicting results, but in most, patients usually received more adequate nutrition support when fed into the small bowel. Heyland et al recently reported that transpyloric enteral feedings led to significantly less gastroesophageal regurgitation and showed a trend toward less microaspiration than did gastric enteral feedings. That study also indicated that the farther the tip of the feeding tube is located in the distal part of the small bowel, the less likely it is that regurgitation will occur. Heyland et al concluded that feeding beyond the ligament of Trietz may prevent aspiration and related pulmonary infections. In our study, we did not examine the difference in frequency of aspiration or pneumonia in gastric versus duodenal feedings because such a small percentage of the patients receiving enteral feedings were fed into the small intestine. Critical care nurses can decrease aspiration risk in patients fed intragastrically by ensuring that the head of the bed is elevated 30° to 45° and requesting use of a prokinetic agent or placement of a small-bowel feeding tube in patients with persistent high residual volumes.

### Table 5 Adequacy of nutrition support provided in the intensive care unit

<table>
<thead>
<tr>
<th>Adequacy</th>
<th>Energy intake, kJ/kg</th>
<th>Protein, g/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrition support</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>87.0</td>
<td>0.88</td>
</tr>
<tr>
<td>SD</td>
<td>38.5</td>
<td>0.40</td>
</tr>
<tr>
<td>Range</td>
<td>20.9-230.1</td>
<td>0.1-2.0</td>
</tr>
<tr>
<td>Percentage of needs met</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>77.4</td>
<td>58.2</td>
</tr>
<tr>
<td>SD</td>
<td>27.1</td>
<td>24.8</td>
</tr>
<tr>
<td>Range</td>
<td>20-157</td>
<td>6-100</td>
</tr>
<tr>
<td>Percentage of patients fed ≥85% of needs (N = 50)</td>
<td>40</td>
<td>20</td>
</tr>
</tbody>
</table>

### Table 6 Gastrointestinal complications in patients receiving nutrition support in the intensive care unit

<table>
<thead>
<tr>
<th>Complication</th>
<th>% of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>High residual volume</td>
<td>38</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>28</td>
</tr>
<tr>
<td>Constipation</td>
<td>24</td>
</tr>
<tr>
<td>Emesis</td>
<td>14</td>
</tr>
<tr>
<td>Ileus</td>
<td>0.04</td>
</tr>
<tr>
<td>Gastrointestinal bleeding</td>
<td>0.02</td>
</tr>
</tbody>
</table>

### Table 7 Characteristics of 4 studies of early enteral feedings

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Protocol</th>
<th>Population of patients</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marik and Zalogal</td>
<td>2001</td>
<td>Meta-analysis of 15 randomized trials comparing early with delayed enteral feeding</td>
<td>Patients hospitalized after surgery, trauma, head injuries, and burns (N=753)</td>
<td>Starting enteral feeding earlier resulted in lower infection rate and shorter hospital stay</td>
</tr>
<tr>
<td>Lewis et al</td>
<td>2001</td>
<td>Meta-analysis of 11 randomized trials comparing early enteral feeding with no oral intake</td>
<td>Elective gastrointestinal surgical patients (N=837)</td>
<td>Group in which enteral feeding was started earlier had lower infection rate and shorter hospital stay</td>
</tr>
<tr>
<td>Minard et al</td>
<td>1998</td>
<td>Randomized trial of early vs delayed enteral feeding with an immune-enhancing formula</td>
<td>Patients with severe closed-head injury (N=30)</td>
<td>No difference was detected between the groups for length of stay or infection</td>
</tr>
<tr>
<td>Ibrahim et al</td>
<td>2002</td>
<td>Randomized trial of early vs late enteral feeding with a standard polymeric formula</td>
<td>Patients receiving mechanical ventilation in medical intensive care unit (N=150)</td>
<td>Group in which enteral feeding was started earlier had increased infections and longer stays</td>
</tr>
</tbody>
</table>
whereas in the smaller studies, early enteral feeding did not appear to be advantageous compared with late enteral feeding. Although early versus delayed feedings were examined in all studies, different populations of patients were included, and the feeding tubes were located in different sites. These differences may explain the variations in the results. Additionally, in the study by Ibrahim et al, who found that patients fed early had more infections and longer stays, the patients all received gastric feedings and target nutrition goals were not met in either the control or treatment group. These factors may have affected the results. Even though more infections occurred in the group fed early, Ibrahim et al did not find any difference in mortality between the group fed early and the group fed late. We also found that survival rates were unaffected by the nutrition support provided. However, patients who received nutrition support within the first 3 days of ICU admission had significantly shorter stays.

Overall, the evidence suggests that early enteral feeding is beneficial to critically ill patients. Further study is warranted to determine if only certain types of critically ill patients benefit or if outcomes differ between early intestinal and early gastric enteral feeding. In our study, early intervention (within the first 3 days) by a dietitian was associated with a shorter stay in the ICU, suggesting that more “nutritional attention” is important. Perhaps patients assessed earlier by a dietitian are more likely than patients assessed later either to already be receiving nutrition support or to receive more adequate nutrition support, because of the dietitian’s recommendations and interaction with the other members of the healthcare team. At Baylor Medical Center, critical care nurses and dietitians converse often about patients’ nutritional status, needs, and tolerance. This exchange of information provides a valuable contribution to the dietitian’s nutrition assessment and monitoring of nutrition support. Additionally, critical care nurses can communicate with physicians to facilitate early initiation of enteral feeding and intervention by a dietitian in critically ill patients, a step that in turn may improve patients’ outcomes.

Adequacy of Nutrition Support
Several investigators have studied practices related to enteral feeding in the ICU and found that inadequate nutrition support is common. Goals for critically ill patients are commonly set at 104.6 to 146.44 kJ/kg body weight for energy intake and 1.2 to 2.0 g/kg body weight for protein intake. Underfeeding may reduce function of skeletal muscle, preservation of the integrity of the gastrointestinal tract, and maintenance of immunity and the stress response to injury. In our study, provision of adequate energy intake correlated with a shorter stay in the ICU. In our study, as in other studies, difficulty providing sufficient nutrition support was related to a number of factors: gastrointestinal dysfunction, procedures and surgeries that require patients to fast, tube displacement, and routine nursing procedures. McClave et al found that 66% of cessations of enteral feeding were avoidable and provided many suggestions for improving delivery of such feedings. These suggestions include, in many patients, continuing enteral feedings as late as up to 4 hours before surgical or endoscopic procedures without increasing risk for aspiration or endangering the quality of the view at the time of the procedure.

Additionally, cessation of enteral feedings for nursing care or because of inappropriate low residual volumes could be eliminated with the implementation of standing orders and infusion protocols. Evaluation of the adequacy of nutrition support and reasons impeding adequate delivery should be investigated at individual facilities. Critical care nurses can collaborate with other members of the healthcare team to develop protocols and changes in policies that will promote more adequate provision of nutrition support.

Gastrointestinal Dysfunction
Impaired gastrointestinal function is relatively common in critically ill patients. High gastric residual volume and diarrhea were the most prevalent gastrointestinal disturbances in our patients, and gastrointestinal dysfunction was associated with a longer stay in the ICU. Mentec et al reported a 32% occurrence of increased residual volume, which compares well with our result of 38%. These investigators also reported that upper digestive intolerance was associated with a longer ICU stay, as well as a higher incidence of nosocomial pneumonia and increased mortality.

Patients who are more critically ill may have more gastrointestinal dysfunction and remain in the ICU longer than those who are less ill. However, the similarity of APACHE II scores for patients with and without gastrointestinal complications in our study does not support this theory.
Another possibility is that gastrointestinal dysfunction leads to inadequate nutrition support and that this situation results in a longer stay in the ICU. Other investigators17,18,30 have reported on the relationship between gastrointestinal dysfunction and inadequate nutrition support.

We also found that most of our patients were underfed. This underfeeding may be related to the high percentage of patients receiving gastric feedings and the concomitant cessation of feedings because residual volume exceeded the cap set by the physician. In our study, residual volumes were often set very low (≤ 100 mL). A residual volume of less than 150 to 200 mL is considered safe by most clinicians. Gastric residual volumes are monitored to reduce the risk of aspiration in patients fed intragastrically. Table 8 summarizes selected studies19,31,32 related to enteral feeding and residual volume.

According to Lukan et al,31 monitoring residual volume to prevent aspiration is not useful. The other studies19,32 provide evidence for the use of prokinetic agents for improving tolerance of gastric feedings. Although gastric feedings are easily initiated, appropriate practices and interventions should be implemented to avoid interruption of enteral feeding. Once gastric enteral feedings have not been successful because of high residual volume, despite addition of a prokinetic agent or change in formula type or rate, placement of a small-bowel feeding tube is indicated.

Diarrhea, another common gastrointestinal complication in patients receiving enteral feedings, is sometimes related to the enteral feeding. However, diarrhea usually has multiple causes, including medications, enteric pathogens, hypoalbuminemia, underlying disease, inflammatory syndromes, and sepsis. Bowling33 reported that diarrhea is more prevalent with gastric enteral feedings than with small-bowel feedings. The proposed mechanism is that large volumes of formula infused intragastrically can lead to secretion of water, sodium, and chloride from the colon, which may diminish its absorptive ability.33

Determination of the cause of diarrhea can assist in optimizing treatment. Nurses can facilitate this process by consulting with pharmacists, dietitians, and physicians to determine if a medication is the culprit or if changes in formula or infusion rate would be helpful. Additionally, cessation of the enteral feeding is not recommended as the initial treatment, and critical care protocols should be implemented to improve delivery of nutrition support.

### Table 8
<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Protocol</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lukan et al31</td>
<td>2002</td>
<td>Investigation of the validity of residual volume as a marker for aspiration risk in critically ill patients (N = 28)</td>
<td>Residual volumes of 400 mL or less were not valid markers for aspiration risk; authors recommended focus on prevention of aspiration instead</td>
</tr>
<tr>
<td>Jooste et al17</td>
<td>1999</td>
<td>Prospective, cross-over trial to assess the effect of metaclopramide on gastric motility in critically ill patients (N = 10)</td>
<td>Use of metaclopramide rather than isotonic sodium chloride solution resulted in significant increase in gastric emptying; metaclopramide is a useful prokinetic agent in critically ill patients</td>
</tr>
<tr>
<td>Pinilla et al19</td>
<td>2001</td>
<td>Prospective, randomized trial comparing 2 different residual volume caps (150 mL with optional prokinetic agent vs 250 mL with mandatory prokinetic agent) (N = 96)</td>
<td>The group receiving a mandatory prokinetic agent (with a residual volume cap of 250 mL) had significantly less high gastric residual volume, reached the energy goal faster, and received more energy content than did the group receiving the optional prokinetic agent</td>
</tr>
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</table>

### Table 9
<table>
<thead>
<tr>
<th>Protocols and education implemented to improve delivery of nutrition support</th>
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<tr>
<td>Education provided to registered nurses regarding appropriate enteral feeding practices through in-service trainings, mini posters, and information submitted to the nurses’ monthly newsletter</td>
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<tr>
<td>Intervention and assessment of patients by a registered dietitian within 48 hours of admission to the intensive care unit</td>
</tr>
<tr>
<td>Revision of policies, procedures, and feeding protocols related to delivery of nutrition support and feeding practices of nurses, including the establishment of a standard residual volume cap of 150 mL or more for gastric feedings and standard advance orders for all tube feedings</td>
</tr>
<tr>
<td>Initiation of a protocol for bedside placement of small-bowel feeding tubes in patients in the intensive care unit, to assist in eliminating cessation of feedings due to high residual volumes associated with gastric feedings</td>
</tr>
<tr>
<td>Addition of banana flakes to formula for control of diarrhea in tube-fed patients</td>
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</table>
nurses may need to advocate for patients by discouraging this practice. Other interventions nurses can suggest the team consider while determining the cause of diarrhea include adding fiber or banana flakes to the formula and changing to a peptide-based formula.

**Conclusion**

Our findings suggest that length of stay in the ICU most likely has an inverse relationship with adequacy of nutrition support, ICU day when nutrition support is started, gastrointestinal dysfunction, and ICU day when the dietitian intervenes. Our results provide multiple opportunities for implementation of quality improvement measures by the healthcare team to enhance the provision of nutrition support to critically ill patients. Additionally, critical care nurses are crucial to the success of nutrition support, especially in the administration of enteral feedings. At our institution, we have implemented protocols and educational sessions to optimize delivery of nutrition support (Table 9).

**References**
