aspen | LEADING THE SCIENCE AND PRACTICE OF CLINICAL NUTRITION
American Society for Parenteral and Enteral Nutrition

Nutrition in Clinical Practice
Volume 31 Number 1
February 2016 80–85

DOI: 10.1177/0884533615611845
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Process-Related Barriers to Optimizing Enteral Nutrition in a Tertiary Medical Intensive Care Unit

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Abstract

Purpose: Enteral nutrition (EN) is the preferred route of nutrient delivery in critically ill patients. Research has consistently described an incomplete delivery of EN in critically ill patients. The purpose of this study was to investigate barriers to reach and maintain >90% prescribed EN among critically ill medical intensive care unit (ICU) patients. *Methods:* We performed a retrospective cohort quality improvement study of patients ≥18 years of age admitted to a tertiary medical ICU and referred for EN from October 1–December 31, 2013. We excluded patients who received intermittent or bolus feeding. Demographic, clinical, and nutrition data were collected. Potential barriers to EN were categorized a priori. *Results:* Seventy-eight patients receiving 344 days of EN were included in the study. EN was initiated at a median of 32 hours (interquartile range, 18.5–75 hours) after ICU admission. Initiation and advancement of EN was identified as the most common reason for <90% prescribed intake. The top 5 interruption reasons were extubation, fasting for bedside procedure, loss of enteral access, gastric residual volume (0–499 mL), and radiology suite procedure. *Conclusions:* Suboptimal EN volume delivery continues to be an issue in critically ill patients. Our study identified initiation and advancement of EN as the most common reason for suboptimal EN volume delivery. Variation in practice was noted within several categories, and multiple reversible barriers to optimal EN delivery were identified. These data can serve as the impetus to modify practice models and workflow to optimize EN delivery among critically ill patients. (*Nutr Clin Pract*. 2016;31:80-85)

Keywords

enteral nutrition; critical illness; critical care; intensive care unit; process assessment; nutritional support

The provision of enteral nutrition (EN) is recommended for critically ill patients who are unable to maintain volitional intake. The 2009 Society of Critical Care Medicine guidelines recommend initiating EN within 48 hours of intensive care unit (ICU) admission.[1] There is not a universal definition of "adequate" EN; thus, an arbitrary value >90% of a calculated goal has been adopted.[2] Despite this definition, nutrition research has consistently described the incomplete delivery of prescribed EN in the critically ill population.[3-6] Critical illness–related energy expenditure and incomplete delivery of EN promotes malnutrition. In fact, research has found that 38% of critically ill patients are either moderately or severely malnourished.[7] It has also been estimated that up to 69% of patients experience a decline in their nutrition status during hospitalization.[8] The detrimental effects of malnutrition include higher risk of infection, reduced wound healing, longer hospital stays, and increased morbidity and mortality.[9] Ensuring adequate EN to a critically ill patient blunts the catabolic response, maintains mucosal integrity to prevent bacterial translocation, and mitigates the downstream consequence of multiple organ dysfunction.[10,11]

There are many barriers leading to EN cessation: patient-related factors, feeding method factors, and feeding process factors.[9] Kim et al demonstrated that patient-related factors (eg, age, sex, nutrition status on admission) and feeding method factors (eg, type of formula, feeding tube location) do not explain the inability to meet EN goals.[9] Feeding process factors such as initiating and advancing EN, however, may affect adequacy of EN delivery. The ICU setting also poses additional, unique barriers that may interfere with EN delivery. For example, EN is frequently withheld due to (real or perceived) critical illness–related gastrointestinal feeding intolerance.[12,13] Markers of feeding intolerance include absent bowel sounds, absent bowel movement, abdominal distention, and high gastric residual volume (GRV). Unfortunately, none of these are

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Financial disclosure: This publication was supported by the National Center for Research Resources and the National Center for Advancing Translational Sciences, National Institutes of Health, through grant 8UL1TR000055. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the National Institutes of Health.

This article originally appeared online on October 15, 2015.

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sensitive markers for feeding intolerance.[14] Additionally, EN is withheld in anticipation of procedures (bedside, operating room, or radiology suite), anticipated extubation, and hemodynamic instability, leading to inadequate EN delivery.[9] In fact, previous reports suggest that EN is also withheld for up to 8 hours prior to scheduled tests or procedures and withheld overall on average for 7 hours per day in the ICU, [12,13,15,16] resulting in a decrease in EN volume by 33% and 29%, respectively.

While it may be unrealistic to assume that all ICU-related interruptions in EN can be ameliorated (eg, during endoscopy or percutaneous endoscopic gastrostomy), it is crucial to identify reversible ICU- and process-related barriers. The objective of this study is to identify barriers to adequate EN (≥90% of prescribed EN) in a single tertiary center medical ICU (MICU). We hypothesized that ICU-related and feeding process interruptions in EN are the largest barriers to achieving adequate EN. We aimed to identify barriers by conducting a retrospective chart review of consecutive critically ill patients meeting criteria for EN.

Methods

Study Population and Setting

We conducted a retrospective quality improvement study to determine barriers to EN using the Nutrition Services Department database of consecutive patients referred for EN in the MICU of a major academic medical center in the Midwest. The database includes a list of all MICU patients referred for EN support. We collected data on consecutive patients ≥18 years old receiving EN in a tertiary MICU between October 1–December 31, 2013. We excluded patients who received intermittent or bolus feeding, defined as gravity-, pump-, or syringe-assisted feedings delivered over 15–45 minutes with a frequency between 2–6 times daily.[17]

At our institution, MICU patients unable to maintain volitional intake are started on EN within 48 hours of MICU admission. Orogastric feeding tubes are primarily used for intubated patients, whereas nasogastric or nasojejunal feeding tubes are used for spontaneously breathing patients. A licensed independent practitioner places a referral to nutrition services. A registered dietitian independently assesses the patient and places recommendations for nutrition support. Registered dietitian coverage is provided by a 0.6 full-time equivalent, and all referrals are addressed within 24 hours, 7 days per week. With a rate-based method, EN is initiated at a trophic rate, defined as 10–30 mL/h and advanced to the target infusion rate within 24 hours. MICU nursing staff document EN volume provided in the electronic health record. The registered dietitian and nursing staff record all EN interruptions. EN is held for GRV ≥500 mL, and motility agents are provided on a case-by-case basis as deemed appropriate by the MICU provider. The study was approved by the Medical College of Wisconsin institutional review board, and it met all national guidelines for protection of human subjects.

Definition of Variables

We collected 22 variables, including demographic, clinical, and nutrition data (Tables 1 and 2). Nutrition data (eg, indication for EN, daily prescribed EN volume, and daily EN volume received) were collected for up to 6 days, as this is the mean duration of EN for an MICU patient at our institution.

Target EN volume is defined as the total daily volume that meets 100% of the patient's estimated energy needs. Prescribed EN volume is the total daily volume prescribed by the provider. Since our institution prescribes 100% of estimated energy needs (per a rate-based method), these terms are used synonymously.

Potential barriers to EN were identified a priori and included those related to the feeding process and to interruptions in EN. The feeding process barriers include initiation of EN at a low rate and incremental advancement of EN rate within the recommended 24–48 hours. Defined interruptions include those related to anticipated extubation, bedside procedures, operating room procedure requiring mobilization, radiology suite procedure requiring mobilization, complications (eg, GRV of 0–499 mL, GRV >500 mL, abdominal distention, vomiting, diarrhea, and reported hemodynamic instability), loss of enteral feeding access, patient refusal, and unknown reason.

Bedside procedures include central venous catheter placement, arterial catheter placement, lumbar puncture, chest tube thoracostomy, upper and lower gastrointestinal endoscopy, transesophageal echocardiography, percutaneous gastrostomy tube insertion, percutaneous tracheostomy, surgical wound debridement, and diagnostic and/or therapeutic bronchoscopy, thoracentesis, and paracentesis.

Prior to data collection, all members of the study team reviewed the data collection tool and were provided education on retrieving relevant information from the electronic health record to ensure uniformity in data collection. All data were independently collected by members of the study team and subsequently verified by the lead and senior authors.

Processes of Care

Patients received an EN referral if they were unable to maintain volitional intake due to mechanical ventilation, altered mental status, anorexia, or dysphagia. Patients who are chronically dependent on tube feeding received EN referrals as well.

No consensus currently exists on which of the predictive equations should be used for critically ill patients, as prediction accuracy differs among the available equations. Energy needs were therefore estimated through predictive equations and weight-based calculations (eg, 25–30 kcal/kg), and adjustments were made as deemed clinically appropriate based on age, sex, body mass index, body composition, clinical status, and response to nutrition therapy.[18,19] The EN product (range, 1–2 kcal/mL) was determined on an individual basis. For patients receiving continuous feeds, rate-based EN was prescribed over a 24-hour infusion schedule (eg, 60 mL/h for 24 hours, equaling

a total daily volume of 1440 mL). If EN is interrupted for any period, the EN rate is not increased to "make up" for the volume lost. Regardless of the method used to estimate needs or the EN product used, an interruption of 3 hours, for example, would result in a loss of 12.5% of daily EN volume.

Statistical Analysis

We used descriptive statistics to describe variables associated with barriers to enteral feeding. We used percentages to describe the distribution of categorical variables. Similarly, we used means and standard deviations to describe continuous variables with a normal distribution. We described continuous variables with a nonnormal distribution using medians and interquartile ranges (IQRs). Comparison of percentage EN received between days was made through Wilcoxon signed-rank test and paired *t* test. Comparison of percentage EN received on day 1 between those receiving and not receiving vasopressors was made through Mann-Whitney test.

Results

Between October 1–December 31, 2013, we identified 81 MICU patients referred for EN support. We excluded 3 patients because they received intermittent or bolus feeding. Seventy-eight patients who received a total of 344 days of EN were included in the study.

Demographic, Clinical, and Nutrition Data

Demographic data and clinical characteristics are presented in Table 1. Thirty-two patients (41%) were male. The mean age was 61.8 years. The 2 most common admission diagnoses were respiratory failure (n = 36) and severe sepsis (n = 28). The most common indication for EN was inability to maintain volitional intake due to mechanical ventilation (59 of 78 patients). Nutrition data are presented in Table 2.

Adequacy of EN Intake

All patients included in the study were prescribed a continuous rate-based EN regimen, based on a 24-hour infusion schedule. All patients were prescribed an EN volume that would meet 100% of their estimated energy needs. The median rate prescribed was 60 mL/h for a total volume of 1440 mL/d (IQR, 1080–1560). Patients achieved adequate intake (≥90% prescribed EN volume) 20% of the time (70 of 344 days) with an overall mean intake of 51% of the prescribed volume. Median daily EN volume received, as compared with prescribed EN volume, is presented in Figure 1.

Feeding Processes

Forty-nine patients (63%) received EN within 48 hours. The median time to EN initiation was 32 hours (IQR, 18.5–75 hours) after ICU admission. All patients received EN for ≥2 days. Initiation and advancement of EN was the most commonly identified reason for <90% of prescribed enteral intake (121 of 344 days), with the majority of occurrences on days 1–2 of EN. On EN day 1, patients received a median of 8% of prescribed EN volume, and no patients achieved adequate intake. On EN day 2, patients received a median of 58% of prescribed EN volume, and 13 patients (17%) achieved adequate intake. The difference in percentage EN volume provided between days 1–2 was statistically

Table 1. Baseline Patient Characteristics.[a]

Characteristic	Value
Sex	
Male	32 (41)
Female	46 (59)
Charlson's comorbidity index	3 (2–4)
Admission diagnosis	
Severe sepsis	28 (36)
Respiratory failure	36 (46)
Neurologic failure	7 (9)
Cardiac failure	2 (3)
Other	5 (6)
Age, y	61.8 ± 15.6
Body mass index, kg/m^2	28 (23–32)
Location of feeding tube	
Gastric	70 (90)
Small bowel	8 (10)
Time to initiation of EN, h	32 (18.5–72)
Vasopressor use with EN	42 (54)

EN, enteral nutrition.
[a]Values presented as No. (%), median (interquartile range), or mean ± SD.

Table 2. EN Indication and Daily EN Volume Prescribed vs Received.[a]

Characteristic	Value
Indication for EN	
Mechanical ventilation	59 (76)
Acute illness[b]	10 (13)
Chronic tube feeding	9 (12)
Daily EN volume prescribed, mL	1440 (1080–1560)
Prescribed EN received by day, %	
Day 1 (n = 78)	8 (5–12)
Day 2 (n = 78)	58 (34–77)
Day 3 (n = 67)	56 (33–79)
Day 4 (n = 51)	63 (31–90)
Day 5 (n = 40)	69 (39–94)
Day 6 (n = 30)	59 (30–88)

EN, enteral nutrition.
[a]Values presented as No. (%) or median (interquartile range).
[b]Altered mental status, poor oral intake, dysphagia.

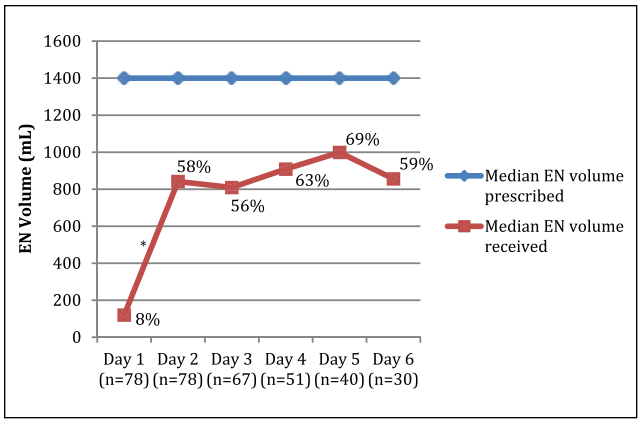

Figure 1. Daily enteral nutrition (EN) volume: prescribed vs received. *$P < .00001$.

Table 3. Percentage Prescribed Enteral Nutrition Received on Day 1 Between Those Receiving and Not Receiving Vasopressors.[a]

Vasopressors (n = 42)	No Vasopressors (n = 36)	*P* Value
7.8 (5.6–11.2)	10.3 (7.2–19.0)	.028

[a]Values presented as median (interquartile range).

significant ($P < .00001$). In comparing patients receiving and not receiving vasopressors, there was a statistically significant difference (median, 7.8% vs 10.3%; $P = .028$) in the amount of EN received on day 1 (Table 3).

EN Interruptions

Interruptions in EN occurred on 49% of days (168 of 344 days). A total of 198 interruptions were identified. Between days 2–6, EN was held on average 4.8 hours per day. For 59 interruptions, no indication was specified (n = 59; median, 5 hours; IQR, 3–7.5 hours). For the remaining interruptions, the top 5 reasons and median durations of interruption were as follows:

(1) anticipated extubation (n = 56; median, 3 hours; IQR, 1–8 hours),
(2) fasting for bedside procedure (n = 24; median, 7 hours; IQR, 4.5–13.25 hours),
(3) loss of enteral access (n = 16; median, 6.5 hours; IQR, 3.75–12.5 hours),
(4) GRV 0–499 mL (n = 13; median, 6 hours; IQR, 3–9 hours), and
(5) radiology suite procedure (n = 12; median, 6 hours; IQR, 3–12 hours).

All interruptions are presented in Table 4.

Table 4. Reason and Length of EN Interruptions.[a]

Reason for Interruption	n	EN Interrupted, h	EN Lost, %[b]
Unknown reason	59	5 (3–7.5)	20 (13–31)
Anticipated extubation	56	3 (1–8)	13 (4–33)
Bedside procedure	24	7 (4.5–13.25)	29 (19–55)
Loss of enteral access	16	6.5 (3.75–12.5)	27 (16–52)
Gastric volume, 0–499 mL	13	6 (3–9)	25 (13–38)
Radiology suite procedure	12	6 (3–12)	25 (13–50)
Hemodynamic instability	4	6 (4.75–9.5)	25 (20–40)
Patient refusal	4	6 (5–10)	25 (21–42)
Abdominal distention	3	8 (5.5–16)	33 (23–67)
Vomiting	3	5 (4–9.5)	21 (17–40)
Gastric volume >500 mL	2	18.5	77
Operating room procedure	2	12.5	52

EN, enteral nutrition.
[a]Values presented as median (interquartile range).
[b]Daily percentage of prescribed EN volume not provided as a result of EN interruption.

Discussion

Suboptimal EN volume delivery continues to be an issue in critically ill patients. Data from our single-center tertiary MICU study demonstrated that patients received 51% of their prescribed EN volume. Initiation and advancement of EN was identified as the most common reason for inadequate EN volume delivery. Our center initiates EN at a trophic rate with gradual advancement. This process may explain our finding; however, our data also suggest that those on vasopressors received a significantly lesser percentage of prescribed EN on day 1 as compared with those not receiving vasopressors. We speculate that providers may be more reluctant to advance EN in patients on vasopressor support. EN was held on average 4.8 hours per day between days 2–6. EN was frequently held in anticipation of extubation and bedside and radiology suite procedures, resulting in a daily EN loss of 13%–29% of the prescribed EN volume. We were unable to identify a reason why adequate EN was not provided on 59 EN days. Variation in practice was also noted within several categories, and multiple reversible ICU-related barriers to optimal delivery of EN were identified.

Multiple studies have described similar barriers in achieving adequate EN delivery.[3,5,9,15,16,20,21] Procedures most often leading to EN interruption include endoscopy, percutaneous gastrostomy tube placement, bronchoscopy, tracheostomy placement, transesophageal echocardiography, and surgical intervention for debridement of wounds or fixation of orthopedic fractures.[21] In

fact, frequent use of invasive procedures and devices has been found to be responsible for 35%–70% of the total time that EN is temporarily stopped.[5,16] De Jonghe and colleagues demonstrated that diagnostic procedures were accountable for an additional 567 ± 338 mL of wasted daily EN.[15] Studies have found that EN was held for unaccountable reasons (eg, high bilirubin) or, worse, reasons for which no explanation was found.[5,21]

Our reported ICU-related barriers are similar to those described in other studies; however, our study also demonstrates a process-related barrier, as advancement of EN rate (even at EN day 2) was insufficient in achieving optimal EN delivery. Thus, our data can serve as the impetus to modify practice models and workflow to optimize the process of EN delivery among critically ill patients.

The optimal calorie and protein intake required to improve patient outcomes remain unknown, especially in consideration of the severity of critical illness and comorbid conditions. Adequate feeding to meet estimated calorie and protein needs becomes more important as risk increases.[22] McClave and colleagues define high nutrition risk by disease severity (reflecting inflammation), preexisting deterioration of nutrition status (reduced nutrient intake prior to admission, body mass index, and/or weight loss prior to admission), and anticipated prolonged length of stay in the ICU.[23]

Irrespective of desired calorie level (ie, trophic vs permissive underfeeding vs full feeding), our data reinforce the need for an ICU EN protocol that can ensure the delivery of prescribed EN volume by ameliorating much of the guesswork currently associated with variable ICU EN practices. Several institutions have implemented nutrition protocols designed to optimize EN intake by compensating for EN interruption time.[12,24,25] One such strategy anticipates EN interruptions, calculates daily EN volume requirement, and divides it by 20 hours, rather than 24 hours, to establish a higher hourly infusion rate.[12] Lichtenberg and colleagues demonstrated that implementation of this strategy resulted in patients receiving >110% of estimated needs on 58% of EN days.[12] Other investigators have implemented a volume-based feeding protocol in which EN is prescribed in milliliters per day, and after an EN interruption, the rate is increased to "make up" for lost infusion time.[24,25] In 1 such study, Taylor and colleagues demonstrated that a volume-based strategy led to an increase in EN volume and calories delivered (rate based, 63% ± 20%; volume-based, 89% ± 9%; $P < .0001$) without an increase in complications, such as elevated GRV, emesis, aspiration, or pneumonia.[24,25] Development of protocols and guidelines within the context of multidisciplinary identification of barriers and process deficiencies may increase the likelihood of success.[26,27]

Regardless of strategy, ICU EN feeding protocols help to promote compliance with clinical practice guidelines–directed nutrition practices and lead to optimization of nutrition therapy as a whole.[28,29] A review of 19 studies demonstrated that protocol implementation has a positive impact on the number of patients receiving nutrition therapy, the optimization of volume intake, the time to initiation of nutrition therapy, and the number of days with nutrition therapy and yields better reported outcomes related to feeding optimization.[30]

Limitations

There were several limitations to our study. First, the retrospective nature of our study forced us to rely on using preexisting documentation to identify volume of EN provided as well as barriers to EN administration. We acknowledge that there may be unmeasured barriers to enteral feeding. Second, we were not able to determine exactly which procedures commonly served as barriers to optimizing EN delivery. This has implications for identifying potentially reversible procedural policy where EN interruption may not be needed. Third, we were not able to determine why barriers exist. We speculate that barriers exist because of variability in clinical practice among MICU providers. Methods such as surveys and direct provider interviews will be used to qualify our speculation. We believe that it is prudent to first identify the reasons behind the barriers, and methods such as surveys and direct provider interviews will assist in identifying these reasons. Fourth, ours was a single-center study, thereby limiting external validity. The barriers identified in our MICU population may be different from barriers in a surgical ICU. Last, this was a quality improvement study to determine barriers. We did not measure outcomes and cannot comment on the implications of suboptimal EN.

Conclusion

This study highlights the need for institution-specific investigation and mitigation of process-related barriers to achieving adequate delivery of prescribed EN. Additionally, research is needed to identify clinically meaningful outcomes associated with feeding strategy, including impact on length of ICU stay and morbidities such as the development of malnutrition and new infections.

Acknowledgments

We acknowledge the following individuals for their contributions to this project: Therese Cole, RN; Sylvia Dabrowski, MSN, RN; Jennifer Harrison, BSN, RN; and Kaylen Moore, BSN, RN, CCRN.

Statement of Authorship

M. Kozeniecki, N. McAndrew, and J. J. Patel contributed to conception/design of the research and contributed to acquisition of the data. M. Kozeniecki and J. J. Patel contributed to the analysis or interpretation of the data and drafted the manuscript. All authors critically revised the manuscript, read and approved the final manuscript, and agree to be fully accountable for ensuring the integrity and accuracy of the work.

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