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ICU and process related barriers to optimizing enteral nutrition in a tertiary medical intensive care unit

Michelle Kozeniecki, MS, RD, CNSC¹, Natalie McAndrew, MSN, RN, ACNS-BC, CCRN², and Jayshil Patel, MD³

¹Nutrition Services Department, Froedtert Hospital, Milwaukee, WI, USA

²Department of Nursing, Froedtert Hospital, Milwaukee, WI, USA

³Division of Pulmonary & Critical Care Medicine, Medical College of Wisconsin, Milwaukee, WI, USA

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 amongst critically ill MICU patients.

Methods—We performed a retrospective cohort quality improvement study of adult patients 18 years of age admitted to a tertiary MICU 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 a total of 344 days of EN were included in the study. EN was initiated at a median of 32 hours (IQR 18.5–75 hours) after ICU admission. Initiation and advancement of EN was identified as the most common reason for <90% prescribed intake. Top 5 interruption reasons were (1) extubation (2) fasting for bedside procedure (3) loss of enteral access and (4) gastric residual volume 0–499 mL and (5) radiology suite procedure

Conclusions—Sub-optimal 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 sub-optimal EN volume delivery. Variation in practice was also 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 amongst critically ill patients.

Keywords

enteral nutrition; critical illness; critical care; barriers; intensive care unit related barriers; process related barriers; medical intensive care unit

INTRODUCTION

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 admission¹. There is not a

universal definition of “adequate” EN, and thus an arbitrary value of greater than 90% of a calculated goal has been adopted². Despite this definition, nutrition research has consistently described the incomplete delivery of prescribed EN in the critically ill population^{3–6}.

Critical illness related increased resting 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 malnourished⁷. It has also been estimated that up to 69% of patients experience a decline in their nutritional status during hospitalization⁸. The detrimental effects of malnutrition include higher risk of infection, reduced wound healing, longer hospital stays, and increased morbidity and mortality⁹. 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. Barriers include patient-related factors, feeding method factors, and feeding process factors⁹. Kim et al demonstrated patient-related factors such as age, gender, nutritional status on admission, and feeding method factors such as type of formula and feeding tube location do not explain the inability to meet EN goals⁹. Feeding process factors such as initiating and advancing EN, however, may affect adequacy of EN delivery. The intensive care unit (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 GI 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 sensitive markers for feeding intolerance¹⁴. Additionally, EN is withheld in anticipation of bedside, operating room or radiology suite procedures, anticipated extubation, and hemodynamic instability; leading to inadequate EN delivery⁹. In fact, previous reports suggest EN is also withheld for up to 8 hours prior to scheduled tests or procedure and withheld overall on average for 7 hours per day in the ICU^{12,13,15,16}, resulting in a decrease in EN volume provided by 33% and 29%, respectively.

While it may be unrealistic to assume all ICU-related interruptions in EN (e.g. during endoscopy or percutaneous endoscopic gastrostomy) can be ameliorated, it is crucial to identify reversible ICU and process related barriers. The objective of this study is to identify barriers to achieve adequate EN (90% of prescribed EN) in a single tertiary center medical intensive care unit (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/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 nutrition services’ 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 the time period of October 1, 2013 through 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 two and six times daily¹⁷.

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 (RD) independently assesses the patient and places recommendations for nutrition support. RD coverage is provided by the equivalent to a 0.6 FTE, and all referrals are addressed within 24 hours, 7 days per week. Using a rate-based method, EN is initiated at a trophic rate, defined as 10–30 milliliters (mL) per hour and advanced to the target infusion rate within 24 hours. MICU nursing staff document EN volume provided in the electronic health record (EHR). The RD and nursing 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 XXXX institutional review board and 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 (e.g. 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 which 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 (using 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 those related 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 (a) anticipated extubation (b) bedside procedures (c) operating room procedure requiring mobilization (d) radiology suite procedure requiring mobilization (e) complications such as gastric residual volume 0–499 mL, gastric residual volume >500 mL, abdominal distention, vomiting, diarrhea, and reported hemodynamic instability (f) loss of enteral feeding access (g) patient refusal and (h) unknown reason.

Bedside procedures include central venous catheter placement, arterial catheter placement, lumbar puncture, chest tube thoracostomy, upper and lower gastrointestinal endoscopy, trans-esophageal 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 EHR 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 using both predictive equations and weight-based calculations (e.g. 25–30 kcal/kg), and adjustments were made as deemed clinically appropriate based on age, gender, body mass index (BMI), body composition, clinical status, and response to nutrition therapy.^{18,19} The EN product (range of 1–2 kcal per mL) was determined on an individual basis. For patients receiving continuous feeds, rate-based EN was prescribed over a 24-hour infusion schedule (e.g. 60 mL per hour for 24 hours, equaling a total daily volume of 1440 mL). If EN is interrupted for any period of time, 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 non-normal distribution using medians and interquartile ranges. Comparison of percentage EN received between days was made using 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 using Mann-Whitney test.

RESULTS

Between October 1 and 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 two 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 per hour for a total volume of 1440 mL per day (IQR 1080–1560). Patients achieved adequate intake (90% prescribed EN volume) 20% of the time (70 out 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 or more 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 and 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 percent EN volume provided between days 1 and 2 was statistically significant ($p<0.00001$). In comparing patients receiving and not receiving vasopressors, there was a statistically significant difference (median 7.8 % versus 10.3%; $p=0.028$) in the amount of EN received on day 1 between the two groups (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 five reasons and the median duration of each interruption were (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) gastric residual volume 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.

DISCUSSION

Sub-optimal EN volume delivery continues to be an issue in critically ill patients. Data from our single center tertiary MICU study demonstrated that patients receive 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 suggests those on vasopressors received a significantly less percentage of prescribed EN on day 1 as compared to those not receiving vasopressors. We speculate 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, trans-esophageal echocardiography, and surgical intervention for debridement of wounds or fixation of orthopedic fractures²¹. In fact, frequent use of invasive procedures and devices have been found to be responsible for 35–70% of the total time EN is temporarily stopped^{5,16}. De Jonghe and colleagues demonstrated diagnostic procedures were accountable for an additional 567 ± 338 mL of wasted daily EN¹⁵. Studies have found EN was held for unaccountable reasons such as 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 amongst critically ill patients.

The optimal calorie and protein intake required to improve patient outcomes remain unknown, especially when considering the severity of critical illness and co-morbid conditions. Adequate feeding to meet estimated calorie and protein needs becomes more important as risk increases²². McClave and colleagues define high nutrition risk by disease severity (reflecting inflammation), pre-existing deterioration of nutritional status (reduced nutrient intake prior to admission, BMI, and/or weight loss prior to admission), and anticipated prolonged length of stay in the ICU²³.

Irrespective of desired calorie level (i.e. trophic versus permissive underfeeding versus full feeding), our data reinforces the need for an ICU EN protocol, which 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 and calculates daily EN volume requirement and divides it by 20 rather than 24 hours to establish a higher hourly infusion rate¹². Lichtenberg and colleagues demonstrated that implementation of this strategy resulted in patients receiving >110% of estimated needs on 58% of EN days¹². Other investigators have implemented a volume-based feeding protocol in which EN is prescribed in mL per day, and after an EN interruption, the rate is increased to “make-up” for lost infusion time^{24,25}. In one such study, Taylor and colleagues demonstrated a volume-based strategy led to an increase in EN volume and calories delivered (rate based, $63\% \pm 20\%$; volume-based, $89\% \pm 9\%$; $P < .0001$) 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 CPG-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, optimization of volume intake, time to initiation of nutrition therapy, the number of days with nutrition therapy, and report better outcomes related to feeding optimization³⁰.

Limitations

There were several limitations to our study. First, the retrospective nature of our study forced us to rely on using pre-existing documentation to identify volume of EN provided as well as barriers to EN administration. We acknowledge 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 identification of potentially reversible procedural policy where EN interruption may not be needed. Third, we were not able to determine why barriers exist. We speculate barriers exist because of variability in clinical practice amongst MICU providers. Methods such as surveys and direct provider interviews will be used to qualify our speculation. We believe 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, limiting external validity. The barriers identified in our medical ICU population may be different than barriers in a surgical ICU. Lastly, ours was a quality improvement study to determine barriers. Thus, we did not measure outcomes and therefore cannot comment on implications of sub-optimal 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, such as impact on length of intensive care unit stay and morbidities such as the development of malnutrition and new infections.

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Abbreviations

EHR	electronic health record
EN	enteral nutrition
GRV	gastric residual volume
BMI	body mass index

ICU	intensive care unit
MICU	medical intensive care unit
mL	milliliter

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Figure 1.
Daily EN Volume: Prescribed vs. Received

Table 1

Baseline Patient Characteristics

Characteristic	Value
Gender, No. (%)	
Male	32 (41)
Female	46 (59)
Charlson's co-morbidity index, median (IQR)	3 (2–4)
Admission diagnosis, No. (%)	
Severe Sepsis	28 (36)
Respiratory Failure	36 (46)
Neurological Failure	7 (9)
Cardiac Failure	2 (3)
Other	5 (6)
Age, mean years ($\pm$ SD)	61.8 ($\pm$ 15.6)
Body mass index, median kg/m ² (IQR)	28 (23–32)
Location of feeding tube, No. (%)	
Gastric	70 (90)
Small Bowel	8 (10)
Time to initiation of EN, median hours (IQR)	32 (18.5–72)
Vasopressor use with EN, No (%)	42 (54)

EN=enteral nutrition, IQR=interquartile range

Table 2

EN Indication and Daily EN Volume Prescribed vs Received

Characteristic	Value
Indication for EN, No. (%)	
Mechanical ventilation	59 (76)
Acute illness [*]	10 (13)
Chronic tube feeding	9 (12)
Daily EN volume <i>prescribed</i> , median mL (IQR)	1440 (1080–1560)
% Prescribed EN <i>received</i> by day, median (IQR)	
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)

^{*} Altered mental status, poor oral intake, dysphagia

EN=enteral nutrition, IQR=interquartile range

Table 3

Percentage prescribed EN received on day 1 between those receiving and not receiving vasopressors

% Prescribed EN volume received on day 1		
Vasopressors (n=42), median % (IQR)	No vasopressors (n=36), median % (IQR)	P-value
7.8 (5.6–11.2)	10.3 (7.2–19.0)	0.028

EN=enteral nutrition, IQR=interquartile range

Table 4

Reason and Length of EN Interruptions

Reason for Interruption (n)	EN Interrupted median hour (IQR)	% EN Lost* median % (IQR)
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

* Daily % of prescribed EN volume not provided as a result of EN interruption

EN=enteral nutrition, IQR=interquartile range