

Achieving Protein Targets in the ICU Using a Specialized High-Protein Enteral Formula: A Quality Improvement Project

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Bethany Hopkins, RD, MEd,¹ ; Sarah S. Cohen, PhD, MS²; Sarah R. Irvin, MS²; and Cathy Alberda, MSc, RD³

Abstract

Background: To meet protein needs in critical illness (CI), guidelines suggest ≥ 1.2 – 2.5 g protein/kg/d; however, most intensive care unit (ICU) patients receive ≤ 0.7 g/kg/d. Higher protein enteral nutrition (EN) formulas may be part of the solution to provide prescribed protein. Our objective was to demonstrate that an EN formula with 37% protein can deliver $\geq 80\%$ of prescribed protein, without overfeeding calories within the first 5 days of feeding and to describe ICU clinicians' experience. **Methods:** This quality improvement (QI) project included patients requiring exclusive EN for up to 5 days from 6 Canadian ICUs. Rationale for choosing formula included patient's BMI (kg/m^2), nutrition targets, daily protein and energy delivered feeding interruptions, and general tolerance. **Results:** Forty-four of 49 patients received the formula ≥ 2 days. Average protein prescribed was 137.5 g/d (82.5–200) or 1.9 g/kg/d (1.5–2.5). Average protein delivered was 116.9 g/d (33.5–180) or 1.6 g/kg/d (0.4–2.4). Seventy-five percent to 83% of patients received $\geq 80\%$ prescribed protein on days 2–5. Average energy prescribed was 1638.6 kcal/d (990–2500) or 17.8 kcal/kg (11–26). Average energy delivered was 1523.9 kcal/d (693.0–2557.5) or 17.3 kcal/kg/d (1.35–64.7). The formula was well tolerated with no gastrointestinal symptoms reported in 38 (86%) patients. The most common reasons to prescribe the formula were obesity and use of fat-based medications. **Conclusions:** We demonstrated in a QI study that a high-protein EN formula was tolerated in a small, heterogeneous group of ICU patients and effective in meeting protein targets without overfeeding. (*Nutr Clin Pract.* 2019;0:1–10)

Keywords

critical care; critical illness; enteral formulas; enteral nutrition; proteins; protein targets; quality improvement

Introduction

Critical illness can have a significant impact on protein needs.^{1–4} Providing adequate protein to critically ill patients may improve morbidity, mortality,^{2,5–7} and nitrogen accretion.⁸ In a recent analysis, Weijs and colleagues observed that reaching protein targets while avoiding overfeeding was associated with lower hospital mortality in a mixed medical-surgical intensive care unit (ICU).² A number of authors have suggested there may be subsets of critically ill patients who are particularly vulnerable to iatrogenic protein under nutrition, including the elderly or those with obesity, those with trauma or need for renal replacement therapy, and those considered at nutrition risk.^{3,6,8–10} To better understand the influence of delivering prescribed protein intakes on outcomes, Nicolo et al evaluated the impact of protein delivery on mortality and time to discharge alive (TDA) in critically ill patients.¹¹ In their study, from a large, multicenter observational database, Nicolo et al found that delivery of at least 80% of prescribed protein was associated with improved ICU survival and shorter TDA.¹¹ Findings

from this analysis have led some clinicians to consider provision of at least 80% of estimated protein needs as a quality metric for nutrition delivery in the ICU.

As the literature on protein in critical illness evolves, nutrition practice guidelines from a range of professional organizations and expert groups suggest acutely ill patients

From ¹Medical Affairs, Nestlé Health Science Canada, North York, Ontario, Canada; ²EpidStat Institute, Ann Arbor, Michigan, USA; and the ³Royal Alexandra Hospital, Alberta Health Services, Edmonton, Alberta, Canada.

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Corresponding Author:

Bethany Hopkins, RD, MEd, Medical Affairs, Nestlé Health Science Canada, 25 Sheppard Ave West, North York, ON, Canada M2N 6S8. Email: bethany.hopkins@ca.nestle.com

may require higher amounts of protein. Recommendations for protein requirements in current guidelines have shifted upward from a minimum of 1.2 g protein/kg/d to 2–2.5 g protein/kg/d for acutely ill patients.^{3,12-14} However, as evidenced in recent large-scale observational studies,^{15,16} current International Nutrition Survey (INS) data,⁴ and several high profile nutrition trials,¹⁷⁻¹⁹ most ICU patients receive 0.7 g protein/kg/d or less, which is well below current practice guidelines. These trials have demonstrated that achieving protein targets is more elusive than achieving energy targets in the ICU population.

Commercially available enteral nutrition (EN) formulas with relatively low protein content have been implicated as contributing to inadequate protein intakes.^{20,21} To meet the protein needs of tube fed patients, clinicians frequently use EN formulas that contain 18%–25% calories from protein and may add additional protein through use of supplemental enteral modular protein products or parenteral nutrition (PN). However, as Heyland et al observed from their INS data, despite the availability, modular proteins are used infrequently and contribute very little to most patients' overall protein intake.⁴ A growing number of clinicians and medical nutrition experts recommend higher protein enteral formulas with lower nonprotein-calorie nitrogen (NPC:N) ratios as part of the solution to help meet the protein needs of critically ill patients.^{3,22,23}

Success of a tube feeding regimen and adequate delivery of protein and other nutrients may also depend on patient tolerance. Tube feeding intolerance (TFI) can manifest itself in a number of ways and is most often described by the presence of 1 or more upper or lower gastrointestinal (GI) symptoms including nausea, vomiting, reflux, bloating, diarrhea, or constipation.²⁴⁻²⁷ Intolerance and GI symptoms can have a significant impact on patients, caregivers, and healthcare resources and may lead to reduced volumes of feeding delivered and resultant undernutrition and underhydration.^{25,26,28} Incidence of TFI in the ICU has been reported to range from 30%–60% and has been associated with nutrition deficits and adverse clinical outcomes including mortality and increased length of ICU stay.²⁸⁻³¹

Despite the growing interest in protein delivery for acutely ill patients, little published evidence exists demonstrating that it is possible to meet prescribed protein targets enterally in this patient population. Clinicians may question if this lack of evidence is an indication that it is not feasible to deliver recommended protein doses using enteral nutrition therapy in the first week of critical illness.²¹ In 2016, a peptide-based EN formula containing 37% calories from whey protein (92 g/L) and a lower NPC:N ratio of 43:1 became commercially available in Canada. The purpose of this quality improvement (QI) study was 2-fold: (1) to improve protein provision in critically ill patients by demonstrating real-world experience that a specialized EN formula can deliver at least 80% of prescribed protein to

ICU patients without overfeeding calories within the first 5 days of feeding; and (2) to describe formula tolerance and clinicians' indications for use.

Methods

Background Focus Group

A focus group (FG) that included 6 registered dietitians (RDs) practicing in medical-surgical ICUs across 3 Canadian provinces was organized to examine nutrition practices in the ICU. Discussion topics included an examination of enablers and barriers to successful feeding in the ICU, strategies to enhance feeding success, and meeting protein targets of critically ill patients. There was agreement among participants that meeting protein needs is a challenge in the ICU and that certain subsets of patients posed a particular challenge, including those with obesity and those receiving lipid-based medications. These clinicians use a variety of enteral formulas, most often containing 25% of calories from protein, to which they added modular protein supplements. The group reported that modular protein is generally not well accepted by nursing staff because of the additional work required to administer the protein flushes. Despite efforts to provide prescribed protein, participants reported that protein targets are often not achieved. The FG validated what has been reported in the literature with respect to challenges in delivering prescribed protein in the ICU and ultimately led to the development of our QI study.

QI Project Design

This was a QI project implemented at 6 Canadian ICUs. Sites were included if they were identified internally by the nutrition team as having challenges with delivery of adequate protein and were willing to comply with the program. Sites were provided with a supply of EN formula and data collection forms. Protein delivery was compared with levels described in the current literature in which most ICU patients receive 0.7 g protein/kg/d or less.^{4,15-19} This study received ethics review by Western Institutional Review Board (Puyallup, WA, USA).

Setting and Nutrition Delivery

Six Canadian medical-surgical ICUs from academic-affiliated centers across 3 provinces participated. Units ranged in size from 14 to 42 beds. Critically ill patients receiving exclusive enteral nutrition and assessed to have higher protein needs were included in the QI project. Patients were initiated on the 37% protein formula at rates based on their clinical energy and protein assessment as per usual clinical practice. Guidelines were purposefully not provided for patient selection or nutrition prescription, given one of the intents of this project was to better

understand the types of patients clinicians would select to receive the 37% protein formula. The formula is a complete nutrition formula containing 1 kcal/mL, 37% protein (92 g/L), 31% carbohydrate, 32% fat (50% medium chain triglycerides [MCTs]; added eicosapentaenoic acid/docosahexaenoic acid), NPC:N ratio of 43:1, and osmolality of 345 mOsm/kg water (Peptamen Intense, Nestlé Health Science, Bridgewater, NJ, USA). Patients received the EN formula in accordance with local ICU-established EN initiation and advancement protocols. Modular protein supplements could be prescribed in addition to the formula, based on the RD's assessment of each patient's needs.

Outcome Measures

The primary outcome measure of the QI project was the adequate delivery of protein, defined as delivering at least 80% of prescribed daily protein within the first 5 days of enteral feeding. The secondary measures of the study were to evaluate caloric intake delivered compared with estimated needs, describe formula tolerance (reported presence of upper or lower GI symptoms, prevalence of elevated gastric residual volumes (GRVs) if measured in the site's ICU) and feeding interruptions (documented interruptions and reason if known), and to document clinician's indications for using the 37% protein formula.

Data Collection

Information collected on each patient included the RD's reason for choosing the 37% protein formula (diagnoses and/or RD's indication for use), body mass index (BMI; kg/m²), and nutrition targets (prescribed protein in g/kg/d and total g/d, prescribed energy in kcal/kg/d and total kcal/d, and prescribed formula rate/volume). Nutrition delivery was documented for each 24-hour period over a 5-day span and included formula volume, protein (formula ± modular protein supplements), and calories from nutrition, calories from fat-based medication, feeding interruptions and reasons for the interruptions, and open-ended notes on general tolerance.

Statistical Analysis

The proportion of daily protein needs met was calculated for each 24-hour period as daily protein intake/prescribed protein. When a range of protein prescription was recommended, the lower end of the provided range was used to calculate the proportion of daily intake. The proportion of energy needs achieved was calculated similarly for energy intake both with and without calories from fat-based medication. Patients were flagged (yes/no) as to whether they met 80% of daily protein and total energy needs on each study day. In addition, based on information from the original FG, daily protein intake/prescribed protein was assessed in 2 subgroups of patients: those with obesity (defined as a

Table 1. Patient Characteristics and Reasons for Selecting the High-Protein Enteral Formula.

Patients Included		
	Number of patients (any data)	Number of patients (≥2 days data)
Number of ICU sites	6	44
Patient characteristics		
BMI, kg/m ²		34.0 ± 8.8 [18–51.2 kg/m ²]
Fat-based medication (≥ 1 study day)		51% (N = 25)
Primary reason(s) for selecting 37% protein formula (≥ 1 reason provided for many patients)		
Reason	Number of patients (%)	
Obesity	28 (57)	
Fat-based medication	25 (51)	
Ratio of protein/energy	8 (16)	
High-protein needs	7 (14)	
Trauma/post-op	6 (12)	
Continuous renal replacement therapy	5 (10)	
Sepsis	5 (10)	

BMI, body mass index; ICU, intensive care unit.

BMI of 30 or greater per the ASPEN Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient¹²) and those receiving fat-based sedation. For all analyses, only patients with ≥2 days on study formula were included. Descriptive statistics including means, standard deviations, and ranges were calculated for protein prescription, energy prescription, protein intake, energy intake (with and without calories from fat-based medication), and BMI. Proportions of patients meeting 80% of protein and energy prescriptions on each study day were presented within strata of BMI (<30 kg/m² vs ≥30 kg/m²) and strata of fat-based medication use during the study period (yes/no). Tests of proportions were performed within each study day to account for different numbers of participants remaining in each stratum on each of the 5 study days. Open-ended responses for reason(s) for selecting the formula, reason(s) for feeding interruptions, and overall tolerance were grouped based on clinical information and presented as tabulations (N and %).

Results

Forty-nine patients were included across the 6 sites from July 2015 to January 2016. Of these, 44 patients received EN for ≥2 days and were included in the data analysis (Table 1). On days 3, 4, and 5 of the study, 42, 33, and

Table 2. Nutrition Prescription and Intake Over First 5 Study Days (n = 44).^{a,b}

Variable	Prescribed	Delivered	
Protein			
Protein, g/d	137.5 g/d ± 24.2 [82.5–200]	116.9 g/d ± 36.7 [33.5–188]	
Protein, g/kg/d	1.9 g/kg/d ± 0.28 [1.5–2.5]	1.6 g/kg/d ± 0.46 [0.4–2.4]	
		Delivered	
	Prescribed	Formula alone ^c	Formula + fat-based medication
Energy			
Energy, kcal/d	1638.6 kcal/d ± 317.2 [990–2500]	1230.93 kcal/d ± 431.5 [362.5–2142]	1523.9 kcal/d ± 403.6 [693.0–2557.5]
Energy, kcal/kg/d	17.8 kcal/kg/d ± 5.4 [11–26]	12.5 kcal/kg/d ± 4.7 [4.3–24.8]	17.3 kcal/kg/d ± 5.2 [8.7–27.8]

^aAmong patients who received formula for 2 or more days.

^bMean protein and energy prescribed; mean protein and energy delivery over the 5 study days, ± standard deviation [range].

^cEnergy delivered from formula alone includes all patients with 2+ days of feeding and is calculated using energy intake only from formula.

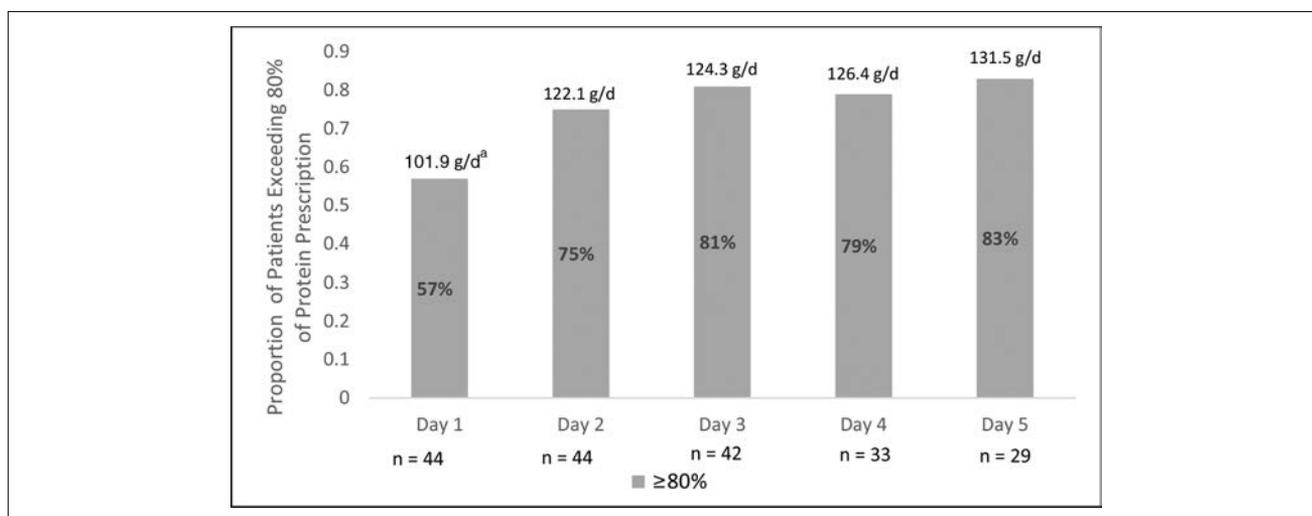


Figure 1. Proportion of patients meeting ≥80% daily protein prescription. Tests of proportions were performed within each study day to account for different patient numbers per study day. ^aAverage total g protein delivered per day in subjects who received formula on 2+ days.

29 patients, respectively, remained on the 37% protein EN formula. The primary reason for discontinuing the 37% protein EN before the end of the 5-day collection period was extubation with subsequent transition to oral intake (N = 7/15, 47%). Other reported reasons included change in feeding formula (N = 2/15, 13%; discontinuation of fat-based medication [N = 1], fluid restriction and changed to a 2-kcal/mL formula [N = 1]), loss/removal of enteral feeding access (N = 2/15, 13%), death (N = 1/15, 7% [reasons unrelated to nutrition]), and no reason (N = 3/15, 20%).

Mean BMI was 34.0 ± 8.8 kg/m² with 61% (N = 30) of patients reported as obese (BMI ≥ 30 kg/m²). Approximately half of the patients received fat-based medication on 1 or more study days (N = 25, 51%) (Table 1). The primary reasons for prescribing the 37% protein formula were obesity (N = 28, 57%) and receiving fat-based medication

(N = 25, 51%). Table 1 summarizes patient characteristics as primary indications for formula use.

Protein

The average protein prescription was 137.5 g/d ± 24.2 (82.5–200) and 1.9 g/kg/d ± 0.28 (1.5–2.5). Protein was dosed according to actual body weight (ABW) in patients with BMI <25 kg/m² and ideal body weight (IBW) when BMI ≥30 kg/m². For patients with BMIs between 25 and 29.9 kg/m², prescriptions varied with use of both IBW and ABW to dose protein. The average protein intake across all 5 days was 116.9 g/d ± 36.7 (33.5–188) or 1.6 g/kg/d ± 0.46 (0.4–2.4) (Table 2). Average protein delivered on each of the 5 study days is reported in Figure 1. On days 2–5, 75%–83% of patients received at least 80% of the protein prescribed

Table 3. Proportion of Patients Meeting $\geq 80\%$ of Daily Protein Over First 5 Study Days by Strata of Obesity and Fat-Based Medication Use.

Day	N (%) Meeting $\geq 80\%$ Daily Protein Prescription					<i>P</i> ^b
	BMI <30 kg/m ² (N = 16) ^a	BMI ≥ 30 kg/m ² (N = 28) ^a	<i>P</i> ^b	Fat-based medication used (N = 24) ^a	No Fat-based medication (N = 20) ^a	
Day 1	9 (56%)	16 (57%)	0.94	12 (50%)	13 (65%)	0.33
Day 2	13 (81%)	20 (71%)	0.47	18 (75%)	15 (75%)	1.00
Day 3	12 (75%)	23 (85%)	0.43	20 (83%)	15 (79%)	0.75
Day 4	10 (91%)	17 (74%)	0.27	16 (80%)	11 (79%)	0.94
Day 5	8 (89%)	16 (80%)	0.56	14 (82%)	10 (83%)	0.95

BMI, body mass index.

^aOn days 3, 4, and 5; 42, 33, and 29 patients, respectively, remained on the 37% protein enteral nutrition formula.

^bTests of proportions were performed within each study day to account for different patient numbers per study day.

enterally. On day 1, feedings were initiated at varying times throughout the day, with 57% of patients receiving at least 80% of their prescribed protein (Figure 1).

Protein Delivery in Patients With Obesity and Fat-Based Medication

Subgroup analysis revealed on days 2–5, 75%–91% of patients with a BMI <30 kg/m² received at least 80% of prescribed protein. In comparison, 71%–85% of patients with a BMI ≥ 30 kg/m² received at least 80% of prescribed protein (no significant difference, Table 3). On days 2–5, 75%–83% of patients on fat-based medication received at least 80% of prescribed protein. There were no significant differences in protein delivery between patients that did and did not receive fat-based medication (Table 3).

Modular Protein Supplements

Modular protein was used in addition to the EN formula in 7/44 (16%) patients. The protein delivery data for these patients is included in the overall results reported above (Figure 1). In patients who did not receive any additional modular protein (37/44 or 84%), 76%–88% of patients received at least 80% of their prescribed protein on days 2–5 on formula alone.

Energy

The average daily energy prescription was 1638.6 kcal \pm 317.2 (990–2500) or 17.8 kcal/kg \pm 5.4 (11–26). The average energy intake across all days (including calories from fat-based medication) was 1523.9 kcal/d \pm 403.6 (693.0–2557.5) or 17.3 kcal/kg/d (± 5.2 , 8.7–27.8). On days 2–5, 72%–83% of patients received at least 80% of prescribed energy (Figure 2).

Feeding Interruptions and Tolerance

Feeding interruptions were reported on 62/192 feeding days. More than 1 interruption and >1 reason may have been recorded for an interruption day; for instance, 1 interruption day for 1 patient indicated feedings held for a test, restarted, then held for reinsertion of the enteral access device. The primary reason for feeding interruptions was fasting for tests or procedures (N = 34/62, 55%). Table 4 summarizes the reason for interruptions by category.

Of the 44 patients who received study formula for ≥ 2 days, 38 (86%) reported that the study formula was well tolerated with no GI symptoms reported. Of the other 6 patients, 5 reported bowel symptoms possibly related to tolerance (loose stools [N = 3/44, 7%], no bowel movement [N = 2/44, 4.5%]), and 1 (N = 1/44, 2%) had tolerance listed as “fair” with the RD reporting that withdrawal of care was being considered.

Discussion

Protein Delivery

In this QI project, we demonstrated that it is possible to achieve the recommended 80% of protein targets enterally during the first 5 days of feeding in the ICU. Data from recent large-scale observational studies,^{15,16} current INS findings,⁴ and several high-profile nutrition trials^{17–19} indicate that most ICU patients receive 0.7 g protein/kg/d or less, which is well below current guidelines that suggest protein dosing in the range of ≥ 1.2 –2.5 g/kg/d.^{3,12–14} Alberda et al¹⁵ and Heyland et al⁴ reported mean protein intakes of 47 and 52 g/d in over 6500 ICU patients from their analysis of surveys of actual clinical practice in 2007 and 2014, respectively. Despite increased attention to protein in the past decade of ICU literature, minimal improvements in protein intake were noted over the 7 years between these INS surveys. It is also noteworthy that the results from

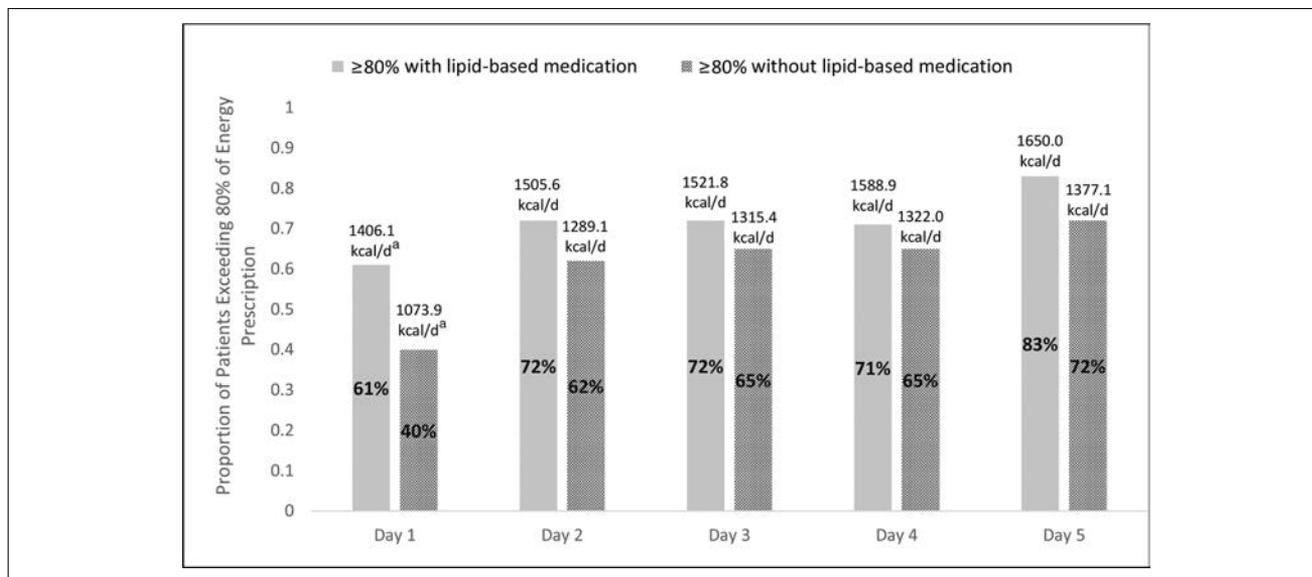


Figure 2. Proportion of patients meeting $\geq 80\%$ daily energy prescription. ^aAverage total energy and g protein delivered per day in subjects who received formula on 2+ days.

Table 4. Reasons for Feeding Interruptions Over First 5 Study Days by Category.^a

Reason	N (% out of 62) ^b
Fasting for procedures	34 (55)
Inotrope/vasopressor requirement/ subject deemed unstable	8 (13)
Trial oral/transition to oral	6 (10)
No enteral access available/enteral access lost, displaced or malfunctioning	3 (5)
Gastrointestinal intolerance	4 (6)
Reason not known/other	11 (18)

^a62 feeding interruption days in total.

^bPatients may have had >1 reason for a given interruption, so N and % sum to greater than the total.

the INS include protein delivery from all sources (EN/PN), whereas this project did not include patients receiving PN. In a single-center study with 886 patients, 27% of whom were receiving parenteral nutrition, Weijs et al achieved a higher protein delivery with an average protein intake of 76 g/d or 1.02 g/kg/d.³² In a recent multicenter RCT, a higher-protein EN formula delivered 1.54 g/kg IBW/d in 22 critically ill patients.³³ We demonstrated an average enteral protein intake of 116.9 g/d or 1.6 g/kg/d. To our knowledge, this is the first published data to demonstrate these levels of protein delivery via exclusive enteral nutrition in real world practice. In Taylor et al's UK audit of protein intakes, enteral feeding formulas with an NPC:N ratio of >100:1 failed to meet protein requirements in the majority of critically ill patients.²³ In addition, it has

been noted that despite the availability of modular protein supplements, these products contribute minimally to most patients' overall protein intake.⁴ In our project, the majority of patients (84%) did not receive any additional protein supplements. As this was a QI project and we did not control for patient selection, severity of illness, feeding protocols, or other institutional and practice variables, we are unable to comment on whether the particular case mix, institutional culture, or other environmental factors in these Canadian centers acted as enablers to achieving protein intakes. However, 2 abstracts presented at the American Association of Parenteral and Enteral Nutrition Annual Nutrition Science and Practice conference in 2015 and 2017, respectively, demonstrate findings consistent with our study, using the same enteral formula. The first, a prospective observational pilot study of 16 obese adult medical-surgical ICU patients showed an average protein intake of 118 g/d.²² The second, a retrospective study in adult ICU patients with neurological diagnoses receiving intravenous fat-based sedation, demonstrated an average protein intake of 98 g/d in 20 patients receiving the 37% protein EN.³⁴ Taken together, these findings increase our confidence that use of this formula will help clinicians achieve their protein targets.

Based on the Nicolo et al observation that delivery of at least 80% of prescribed protein was associated with improved clinical outcomes,¹¹ we used this metric as our primary QI outcome. In our study, on average, patients were prescribed 133.7 g of protein/d or 1.9 g/kg/d, and 73%–85% of patients received at least 80% of the protein prescribed enterally on days 2–5. These results are in contrast to Heyland et al 2014 INS of 187 ICUs which found on average patients were prescribed 94 g protein/d or approximately

1.3 g/kg/d, and only 16.1% of patients received >80% of prescribed protein amounts.⁴ Although the protein targets in our study were higher (1.9 g/kg/d vs 1.2 g/kg/d or 1.5 g/kg/d), our findings are similar to 2 recent publications which both demonstrated that reaching protein targets is feasible.^{32,33} In the first study, at a single center, the researchers aimed to deliver 1.2 g protein/kg/d; on average, 86% of protein targets were met.³² The second study, a small multicenter RCT, aimed to deliver 1.5 g protein/kg/d and achieved 74.7% of protein targets on days 1–3 and over 100% on days 4–10 using a 32% protein enteral formula.³³ Although our study was a multicenter project across 6 ICUs, these Canadian centers may be similar to other centers where nutrition is a strong focus. Nonetheless, we have demonstrated that meeting 80% of prescribed protein targets is an achievable goal.

Energy Delivery

The concept of hypocaloric, high-protein feeding as a nutrition strategy in the ICU has been garnering attention in recent years,^{3,21} in part owing to the work of Rugeles et al, who demonstrated that use of a 1.7 g/kg and 15 kcal/kg/d nutrition regime reduced severity of illness and hyperglycemia compared with a standard nutrition intervention with 25 kcal/kg/d and 20% protein calories.³⁵ The European Society of Intensive Care Medicine's *Early Enteral Nutrition Practice Guidelines* recommend clinicians should not aim to cover full energy targets in early days of ICU admission and acknowledge hypocaloric feeding appears safe, whereas provision of excess energy may be harmful.³⁶ Similar recommendations with respect to energy delivery are found in the recent consensus recommendations from the International Protein Summit (IPS), where provision of 80%–90% of energy requirements is recommended, as long as protein is dosed in the range of 1.2–2.5 g/kg/d. To help achieve this energy/protein balance, the IPS group goes on to recommend availability of high-protein, low-calorie enteral products in the ICU.³ In our study, the average energy prescription was 1638.6 kcal/d or 17.8 kcal/kg. The average energy intake was 1523.9 kcal/d or 17.3 kcal/kg/d. On days 2–5, 72%–83% of patients received at least 80% of prescribed energy. Importantly, this energy intake was delivered while providing 1.6 g/kg/d protein, which may represent an attractive strategy for clinicians looking to deliver adequate protein without overfeeding calories in critically ill patients.

Feeding Interruptions and Intolerance

Interruptions in enteral feeding occur frequently in the ICU and interfere with the delivery of prescribed nutrition.^{37,38} Common reasons for interruptions include cessation of EN for tests and procedures, technical issues with enteral access, and TFI. In a recent single-center retrospective study of 100

enterally fed patients, the median duration of interruptions was 5.5 hours and resulted in an average calorie deficit of 11.5%.³⁸ Stewart cites similar statistics with mean time of interruptions per patient >5 hours.³⁷ In our project, feeding interruptions were reported on almost 1/3 of feeding days. By far, the most common cited reason for interruptions were tests and procedures (55%), with GI intolerance contributing to 6% of reported interruptions (Table 3). Data on duration of the interruptions were reported on >25% of interruption days, which makes it difficult to draw any conclusions regarding the effect of interruptions on adequacy of EN delivered. However, despite that interruptions did occur, the majority of patients received $\geq 80\%$ of their protein targets.

Previous research has attempted to capture the prevalence of TFI in the ICU and its association to adequate feeding delivery.^{28,30,31} TFI is directly linked with decreased nutrition adequacy when compared with feeding-tolerant patients.^{28,31} A systematic review and meta-analysis of TFI was conducted in 2014,³⁰ in which the definition of TFI was classified into 3 main categories: (1) large GRVs, (2) presence of GI symptoms, or (3) inadequate delivery of EN. Since the publication of this 2014 review, and as reflected in current practice guidelines,¹² the practice of monitoring GRVs has been abandoned or modified in many centers. Acceptable GRV thresholds have been increased, which would be expected to contribute to improved EN delivery. In our project, GRVs were not routinely measured at all sites; in 2 sites that measured GRV feedings were withheld when GRVs exceeded 250–300 mL. Of the 44 patients studied, there were records of 3 patients with high GRVs that interrupted EN delivery (6.8%).

Although TFI is inconsistently defined, Blaser et al's meta-analysis concluded that 38.3% of enterally fed ICU patients were feeding intolerant.³⁰ In a different retrospective analysis of feeding intolerance in 21 countries, a 30.5% incidence of feeding intolerance was demonstrated,³¹ whereas a recent single-center retrospective study found a 36% incidence in the ICU.²⁸ In our study, 6% of patients had reported GI concerns that caused an interruption in EN, and when asked about overall tolerance, RDs reported that 86% of patients tolerated the EN formula. The lower incidence of TFI reported in our study could be attributable to factors such as patient characteristics, severity of illness, and use of practices and protocols within the 6 participating ICUs that we are unable to account for, given the nature of our study and the variables we collected. Another aspect, which may be important to consider with respect to TFI, is the actual EN formula being delivered. In addition to factors such as rate of formula delivery, there may be characteristics of the formula and its constituent ingredients that contribute to feeding tolerance. In this project, the protein in the formula is hydrolyzed 100% whey and the fat blend contains 50% MCT. Whey protein has been called a

“fast protein” and remains soluble in an acidic environment such as the stomach.^{39,40} One of the benefits of whey’s rapid digestion kinetics may be to facilitate gastric emptying and promote upper GI tolerance in critically ill patients who have disordered motility.^{41,42} MCTs have unique digestive, absorptive, and metabolic properties as compared with conventional long-chain triglycerides that may play a role in facilitating digestion and absorption of fat and providing a ready substrate for energy.^{24,43,44}

Indications for Formula Use

By asking front-line RDs to trial the product at their own discretion in heterogeneous ICUs across the country, we were able to gain insight into patient selection for the product in authentic practice settings. There were a number of reported indications for selecting the 37% protein formula, with obesity and use of fat-based medications clearly positioned as the primary reasons. This outcome was not surprising given emerging practice guidelines and insights obtained in our earlier FG. The nutrition needs of the obese ICU patient were first brought to widespread attention with the publication of the 2009 ASPEN/Society of Critical Care Medicine critical care nutrition guidelines,⁴⁵ which had an influence on practice across Canadian ICUs. Meeting higher protein targets while avoiding possible dangers of overfeeding have presented a challenge for clinicians using traditional EN formulas. In addition, use of short-acting fat-based sedation as a concurrent treatment in the ICU provides what has been described as “occult” calories that RDs should account for when considering their patient’s overall energy intakes.^{46,47} The energy provided from such non-nutrition sources can pose a challenge to providing adequate protein without excess caloric intake from all sources. In our project, we demonstrated that use of the 37% protein formula was able to deliver $\geq 80\%$ of prescribed protein in the majority of patients without overfeeding calories, including subgroups of patients who were obese or receiving fat-based sedation (Table 2). These results are consistent with findings from McClave et al²² and Wieser et al³⁴ who studied use of this same formula in critically ill obese patients and those receiving intravenous fat-based sedation, respectively.

Limitations

We acknowledge that our project has limitations. This was a QI project, and as such, was not intended to test a hypothesis or control for differences in patients or site characteristics. When designing the study, we were interested in understanding the clinicians’ reported indications for choosing the high-protein formula. Patient characteristics such as severity of illness and reason for ICU admission were not captured and limit the generalizability of this study. However, the project was able to show that a simple change

in practice, using a new formula, enabled clinicians to better care for their patients by helping deliver protein dose targets in this small heterogeneous group of ICU patients. This QI study was designed to demonstrate that it is possible to achieve protein targets using the EN route in critically ill patients compared with historical data from the literature and large international audits of nutrition practice. We did not address appropriate protein dosing, which is a subject of considerable interest in the medical nutrition community that requires further study to explore the impact of protein delivery on outcomes that matter to patients, health care providers, and the larger healthcare system. As noted by Kuchnia et al, notwithstanding the validity of current protein dosing recommendations, providing adequate protein is problematic for many clinicians.⁴⁸

Conclusion and Implications

Observational studies and early prospective trials on protein provision for ICU patients point to the importance of protein intakes in the early stages of ICU admission. Future research is turning attention to appropriate protein dosing and adequacy of protein intake, with energy intake secondary—this is one of the most pressing questions in the ICU nutrition literature and may affect not only morbidity and mortality but also preservation of lean muscle mass and long-term quality of life for patients. We demonstrated in a QI study that a high-protein EN formula was well tolerated in a small heterogeneous group of ICU patients and was effective in meeting prescribed protein targets without overfeeding.

Statement of Authorship

B. Hopkins contributed to the conception and design of the research; S. R. Irvin and S. S. Cohen contributed to the acquisition and analysis of the data; B. Hopkins and C. Alberda contributed to the interpretation of the data; and B. Hopkins and C. Alberda drafted the manuscript. All authors critically revised the manuscript, agree to be fully accountable for ensuring the integrity and accuracy of the work, and read and approved the final manuscript.

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