Assessment of Enteral Nutrition Delivery and Feasibility of Volume-Based Tube Feeding in the Critical Care Setting at OHSU

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Problem Statement

Despite the critical role of enteral nutrition (EN) in improving health outcomes in critically ill patients, underfeeding remains a persistent challenge in intensive care units (ICU) due to delayed EN initiation and frequent interruptions. These issues contribute to suboptimal nutritional intake and increased risk of malnutrition-related complications.

While volume-based tube feeding (VBTF) may offer a promising strategy to improve feeding adequacy by allowing flexibility and compensation for interruptions, the feasibility of this type of protocol in the trauma/surgery intensive care unit (TSICU) at OHSU remains unknown.

Project Goals

The goals of this project were to evaluate the feasibility of VBTF in the TSICU to improve EN delivery, assess the adequacy of current feeding practices, including how often patients meet prescribed nutrition goals, examine feeding initiation and progression timelines, and identify potential delays and interruptions in feeding that affect nutrition adequacy.

Project Introduction

The use of EN is essential for improving the outcomes of critically ill patients[1,2,3]. However, critically ill patients experience significant underfeeding due to numerous reasons including medically-related feeding interruptions[4,5,6]. Research shows inadequate nutrition during ICU admissions can put patients at risk for malnutrition and associated complications[5,7]. Volume-based tube feeding (VBTF) was developed as a promising alternative that allows for greater flexibility in delivering nutrition by prescribing a total daily volume vs. an hourly rate. The VBTF approach allows providers to adjust feeding rates dynamically, compensating for interruptions in feeding and ensuring that patients receive adequate nutrition[8]. Implementation of VBTF in the ICU can have significant implications for critically ill adult patients[9,10]. Improvements made to EN delivery through VBTF could lead to better overall health outcomes and reduce the incidence of malnutrition. These changes could improve the quality of life for patients both during and after their ICU stay[7,11]. Despite its potential benefits, VBTF remains underutilized in many clinical settings, including the ICU. The goal of this project was to examine feeding adequacy and the feasibility of a VBTF protocol in the ICU at OHSU.

Organization Overview

Oregon Health & Science University (OHSU) is an academic health center that includes a system of hospitals and clinics in Oregon and southwest Washington. OHSU has a total of 562 staffed beds available to its patients. OHSU has a total of 80 adult ICU beds, including 26 beds for the Cardiovascular ICU, 21 beds for the Trauma/General Surgery ICU, 17 beds for the Neurosurgical ICU, 16 beds for the medical ICU, and an opportunity to serve a virtual ICU in 7 hospitals across Oregon. This project worked primarily with the Trauma Surgical Intensive Care Unit (TSICU), located on 8C in the main hospital. This unit cares for patients who have life-threatening conditions that require intensive monitoring, such as gun violence, workplace injury, traumatic brain injuries, being severely injured due to falls, and other accidents. Many of the patients admitted to the TSICU require nutrition support as part of their care. Patients on nutrition support are followed by clinical

dietitians who specialize in the delivery of enteral and parenteral nutrition. The focus of this project was to assess the current adequacy of enteral nutrition support as well as the feasibility of improving the delivery of enteral nutrition support through VBTF. This project also examined feeding initiation and progression. This project provides valuable information on the current state of enteral feedings as well as recommendations to ensure critically ill patients receive optimal care and nutrition.

Background

Enteral nutrition (EN), commonly known as tube feeding, is a critical component in the management of critically ill patients. Incorporating EN into critical care not only fulfills metabolic demands but also significantly aids in patient recovery post-ICU. Malnutrition in the ICU poses substantial risks of morbidity and mortality[12,13]. Critical illness often leads to inflammation, increased catabolism, and muscle mass loss, contributing to malnutrition[4]. Early initiation is crucial to promote recovery and improve patient outcomes, especially in those who are hemodynamically stable[1,2,3]. Current literature indicates that early initiation of EN is associated with reduced complications from infectious diseases, improved nutrition delivery, and shorter length of stay (LOS) in both the ICU and hospital[5,7]. While additional safety precautions are essential when implementing an EN protocol for critically ill patients, the potential benefits of early EN initiation generally outweigh the risks of complications, such as aspiration, gastrointestinal intolerance, and hemodynamic instability[5].

There can be many barriers to delivering optimal nutrition in the ICU including physiological (such as poor appetite), functional (like dysphagia), psychological (including low mood), and feeding intterruptions[4]. Interruptions in EN are common in intensive care settings[5]. These interruptions can occur for various reasons, including anticipated procedures, physiotherapy, and routine nursing care, which can impede feeding interruptions and frequently hinder an ICU patient's ability to obtain adequate nutrition and achieve nutritional goals. The study found that at least three-fourths of ICU patients had observed and documented orders for interruption of EN. The causes for interruptions included ventilation dependency, tracheostomy, spontaneous breathing trials with a T-piece, and NPO orders before surgery[6]. Volume-based tube feeding (VBTF), as part of a multimodal approach to nutrition optimization, may be particularly beneficial for vulnerable patients at risk of hospital-acquired malnutrition who depend on EN[8], representing an alternative method of delivering EN. VBTF emphasizes providing a prescribed daily volume of feeding rather than a fixed hourly rate. VBTF allows for a total daily volume of EN to be administered over 24 hours, in contrast to traditional rate-based tube feeding (RBTF), which relies on a fixed hourly infusion rate. When implemented as part of a comprehensive nutrition optimization strategy, VBTF may help address the significant challenges associated with EN in the ICU, such as caloric deficits observed in critically ill patients[6].

Currently, there are multiple VBTF protocols available for reference and utilization. The protocols emphasize various aspects of feeding; the key components are enhanced protein delivery and meeting >80% caloric needs[14,15,16]. The flexibility of VBTF enables registered nurses (RNs) to adjust the hourly infusion rate to ensure the total prescribed volume is delivered, even in the event of feeding interruptions. The research shows a significant increase in delivered volume when adjusting for missed volume in ICU settings [5,10,17]. A quality improvement project compared EN delivery via RBF and VBF; in the VBF group, patients received at least 80% of the prescribed volume in a neuroscience ICU[8]. Another study found that EN volume

delivered at 92% in the VBTF group as compared to 67% in the RBF group[18]. Adaptability allows for "catch-up" on missed nutrition when interruptions occur for procedures[16]. When feeding cannot be administered for specific reasons, a catch-up phase can be implemented to meet energy needs, with at least one daily catch-up phase scheduled to calculate and adjust the volume of EN administered. This ensures that the 24-hour goal volume is achieved. Most importantly, the protocols allow for a catch-up of energy and protein needs[10,19]. Furthermore, most VBTF protocols include standardized guidelines for starting rates, titration, and catch-up calculations, alongside regular evaluations by RDs to ensure appropriateness and individualized adjustments. Safety measures, such as utilizing prokinetic agents, when necessary, are also included in these protocols[19].

The EN challenges associated with VBTF are like those encountered with traditional EN feeding protocols when used in the ICU. Common concerns include issues related to volume tolerance, underlying medical conditions, individual nutritional requirements, frequency and duration of necessary feeding interruptions, glycemic control considerations, GI function, and the type of feeding access (gastric vs. jejunal)[9,10]. A meta-analysis of sixteen studies has analyzed potential side effects and complications that can be attributed to VBTF[10]. The analysis observed potential risks for diarrhea, emesis, feeding intolerance, and gastric retention with VBTF protocols. However, those findings did not increase significantly compared to the adverse side effects observed in the RBTF group[10]. A UK study has also observed no significant differences in safety measures between VBF and RBF in medical ICUs. There were no differences in GI tolerance, such as vomiting, use of prokinetics, glycemic control, and insulin use[11]. These findings support the safety of VBTF in a critical care setting. Implementing VBTF protocols in clinical settings does present other challenges, including the need for staff education and training, adherence to protocols, effective documentation and monitoring systems, coordination of multidisciplinary efforts, and overcoming resistance to traditional practices[8]. When thorough education is provided and the protocol is implemented correctly, it can increase overall awareness of the importance of nutrition delivery to critically ill patients[8]. Moreover, various patient-specific factors can influence the effectiveness of VBTF protocols.

Enteral nutrition (EN) is crucial for improving health outcomes in critically ill patients. VBTF presents a potentially powerful strategy for preventing underfeeding, demonstrating safety and efficacy in tube feeding delivery [1,2,3]. However, the implementation of VBTF requires additional efforts, such as staff training and the creation of additional protocols. Therefore, it is essential to evaluate the current effectiveness of RBTF and the necessity of VBTF before its implementation.

Project Design and Methods

A prospective chart review was conducted to evaluate the current tube feeding practices, including feeding initiation rates and feeding adequacy, in the TSICU to determine if there is a need for a VBTF protocol. This project also assessed the feasibility of a VBTF protocol implementation in the TSICU. Data for this project was collected from January to April 2025 and included patients requiring enteral nutrition support to meet 100% of their nutritional needs. Data collection included the following information: clinical characteristics such as anthropometric measurements, information related to EN

and interruptions, dietitian nutrition prescriptions, information on medication related to nutrition, and possible TF intolerances. All data was collected and documented remotely through Epic Software via Citrix OHSU.

Patient Population

Patients admitted to the TSICU from January 15th, 2025 to April 5th, 2025 were screened for inclusion into this project. Patients were included if they were 18 years or older, receiving care in the TSICU exclusively, and receiving only EN. Exclusion criteria included patients younger than 18 years of age or receiving any oral diet (PO) or total parenteral nutrition (TPN). Patients who were on the unit for less than two days were also excluded. Data collection began as soon as EN was initiated and ended when the patient was discharged from the unit or EN was discontinued for any reason.

Clinical Data

Clinical data included patient demographics, admission details, anthropometrics, medications such as pressors and sedatives, use of mechanical ventilation, and nutrition-related data. Patient demographics included gender (male, female, or other), name, MRN, and age. Admission details included days when patients were admitted to the unit and discharged, reasons for discharge, reason for RD consultation once admitted to 8C, whether they had a diagnosis of malnutrition at admission, diagnosis at admission, and the unit name. Anthropometrics included weight (kg) and height (m). Medications included propofol, bowel medications, and pressors. Nutrition-related data included use of EN prior to admission, date and reason for nutrition consultation, and prior diagnosis of malnutrition.

LOS was calculated using Excel formulas - the date when patients were discharged from the unit minus the date when patients were admitted to the unit. Total days on a ventilator were calculated using Excel formulas - the date when ventilation was ceased minus the date when the ventilator was placed. Body mass index (BMI) was calculated using Excel formulas - weight (kg)/(height(m))2 (kg/ m2). Propofol was documented with the date of administration and volume provided during the day (mL). Calories from propofol were calculated using an Excel formula: volume (mL) * 1.1 kcal.

Enteral Nutrition Data

The use of EN was documented daily using data from flowsheets and chart notes from dietitians and other providers. Patients' recommended EN nutrition prescription, including estimated calories (kcal), and estimated protein needs (g), were obtained from dietitian chart notes, while EN infusion rate, reason for EN interruptions and medication administration were obtained from other chart notes. Detailed EN data was collected including: the EN access site, type of EN formula, rate of initiation, daily volume of EN received, protein modular administration, date of achievement of goal EN rate and number days at EN goal rate, and all changes to EN formula type and administration. For patients who were on the unit for seven or more days, recalculated calories and protein estimates were documented. For protein modulars, the number of packets administered per day was documented, and protein and calorie content were calculated using 60 kcal and 15 gm protein per packet. Data collection was discontinued once a patient transitioned to a different unit or facility, initiated PO intake, or experienced other circumstances that made EN data irrelevant or impossible.

The day difference between when a patient was admitted to the TSICU and the date when EN was initiated was calculated using an Excel formula: date of EN consult - date of TSICU admission (d). The rate of initiation and volume received in the first four days was documented. Average calories and protein received from EN, propofol, and protein

modulars were calculated and translated into percent needs met based on nutritional needs calculated by the dietitians. Once patients reached a desired goal infusion rate, the average calories and protein received from EN, propofol, and protein modulars were calculated and translated into percent needs met.

Enteral Nutrition Interruptions

Once a patient reached the goal EN rate, interruptions to their EN were documented. Interruptions were any event that resulted in the temporary discontinuation of EN infusion. The reasons for interruptions were determined by looking at flowsheets. If information could not be found in the flowsheet, provider and dietitian notes were examined as well as order history and procedure notes. The reason for each interruption was noted as well as the length of the interruption and the volume of EN that was missed. If multiple interruptions occurred in a day, the total hours of interruption were calculated.

Statistical Analysis

The findings were analyzed using statistical software, StataNOW 19 BE, to evaluate proportions and trends. Mean and standard deviations were calculated using STATA for each variable.

Project Outcomes

A total of 186 patients were screened for this project and 54 patients were included in the analysis (Figure 1). Patients were excluded due to PO intake being initiated, failure to initiate EN or EN infusion for less than two days, being younger than 18 years of age, and one patient was excluded due to restricted access on their electronic medical record.

Patient Demographics

The average age at admission was 54.9 years (±19.7 years), with most patients being male (77.8%, n = 42), followed by female (20.4%, n = 11), and one non-binary patient (1.9%). The average LOS was 10.1 days (±6.4 days), and the mean BMI was 28.2 kg/m² (±6.1 kg/m²). Only 20.4% (n = 11) of patients received EN prior to admission, while 79.6% (n = 43) did not. The average number of ventilator days was 6.1 days (±5.76 days) (Table 1).

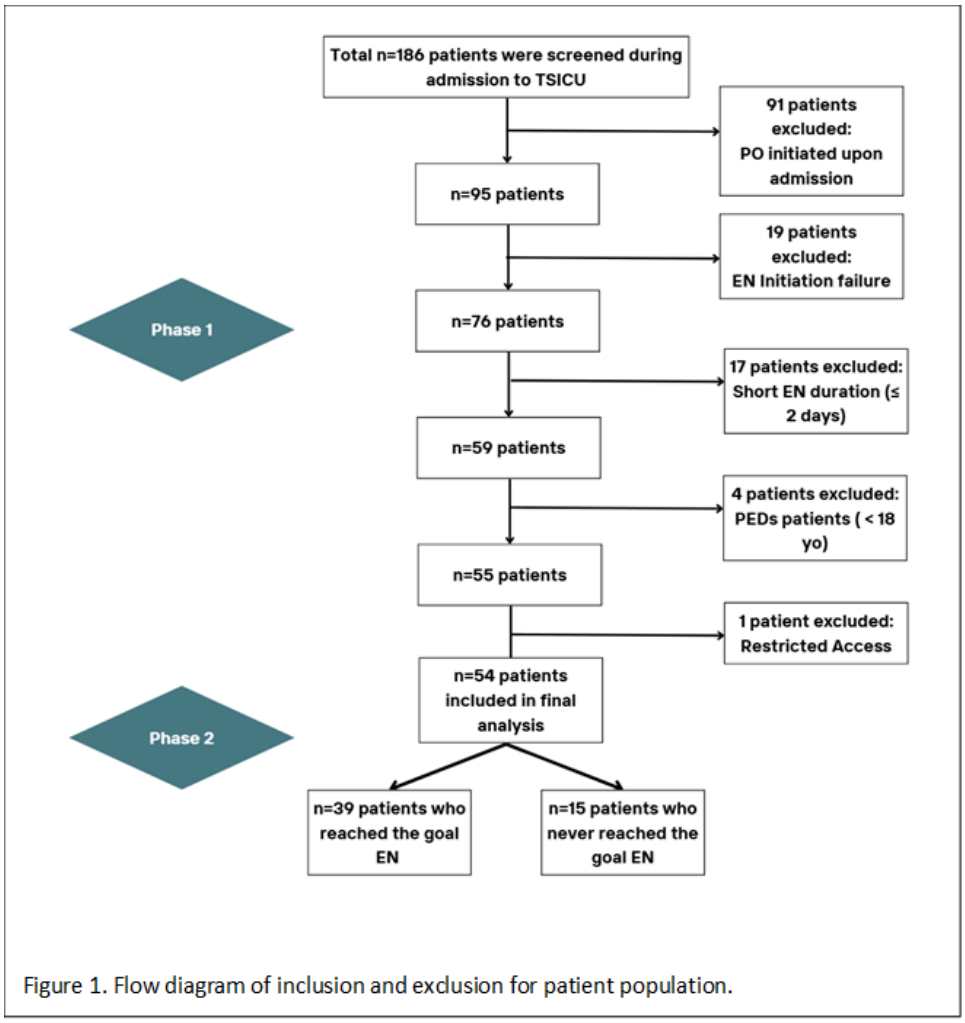


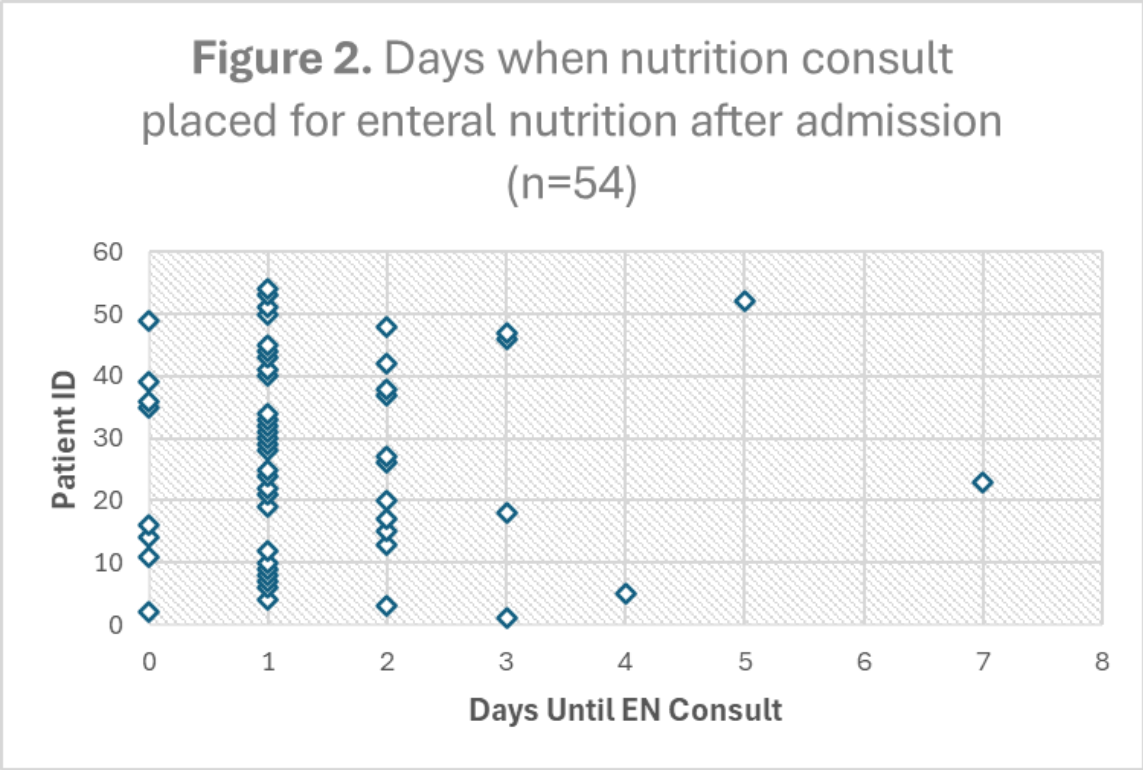
Figure 1. Flow diagram of inclusion and exclusion for patient population.

Table 1. Patient clinical characteristics (n=54)

Characteristic		**Mean (±SD)**
Age (years)		54.9 (±19.7)
BMI (kg/m²)		28.2 (±6.1)
Ventilator Days		6.1 (±5.76)
Length of Stay (days)		10.1 (±6.4)
		n (%)
Gender		
	Female	11 (20.4%)
	Male	42 (77.8%)
	Non-binary	1 (1.9%)
EN Prior to Admission		
	Yes	11 (20.4%)
	No	43 (79.6%)

Early Enteral Nutrition Delivery

Once a patient was admitted to the unit, the average time from admission to a nutrition consult for EN was 1.4 days (Figure 2). However, some consults were placed on the date of admission, in other cases, EN consults for the dietitian were placed on the 7th day of admission.

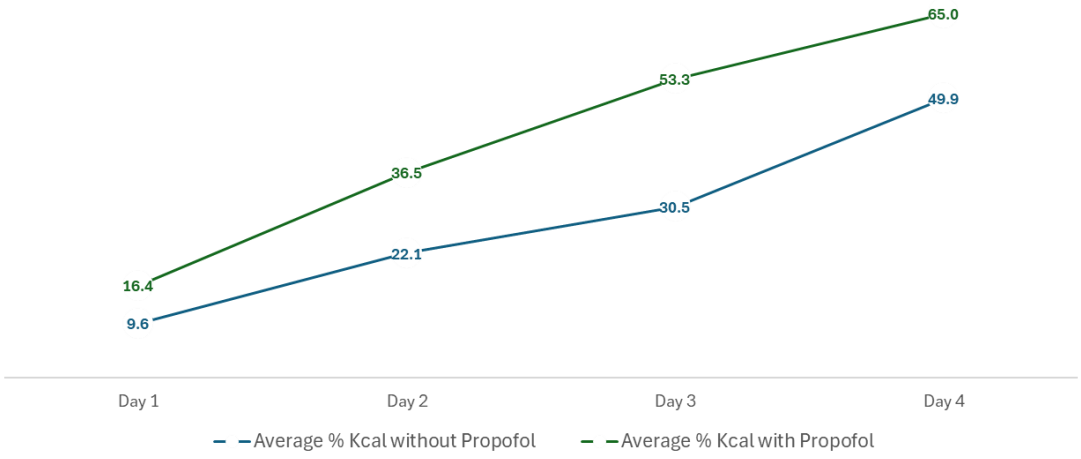


Over the first four days of admission, the progression of EN was tracked for all patients, even those who did not reach their goal EN rate. The amount of propofol administered was also calculated during this time for all patients. Average percentages of kcal and protein goals met, with and without propofol, and total formula volumes received were recorded and calculated (Table 2). Calories, protein and EN volume received all increased over the first four days of admission. Between Day 1 and Day 2, there was an increase in nutritional needs met with the average percent of calories met increasing by 12.1%, without propofol, and 20.1%, with propofol. The average protein goal met increased by 21.8%. Between Day 2 and Day 3, the average percent of calories met increased by 8.4% and 16.8% (with propofol), and the average protein goal met increased by 23.9%. Between Day 3 and Day 4, the average percent of calories met without propofol increased the most by 19.4%, and the average protein goal met increased by 15.2%. On average, the highest percent of estimated calorie goal met during the first four days of admission was 65% on Day 4, with the highest percent of protein goal met reaching 74.3% on Day 4.

Table 2. Enteral nutrition progression during the first four days of admission to the TSICU (n=54)				
Day	**% Kcal Goal Met (w/o Propofol)**	**% Kcal Goal Met (w/ Propofol)**	**% Protein Goal Met**	**EN Volume Received (mL)**
	(Mean ± SD)			
1	9.6 (±20.2)	16.4 (±21.6)	13.4 (±27.3)	79.9 (±179.8)
2	22.1 (±31.9)	36.5 (±30.9)	35.2 (±37.4)	236.8 (±306.7)
3	30.5 (±35.2)	53.3 (±39.5)	59.1 (±43.8)	488.6 (±447.3)
4	49.9 (±37.7)	65.0 (±35.9)	74.3 (±41.9)	570.8 (±457.0)

In the span of the first four days of admission, patients steadily received more calories each day. However, patients received fewer calories with EN alone as compared to receiving propofol and EN (Figure 3). On Day 1, patients met an average of 9.6% of their estimated caloric needs without propofol and 16.4% when propofol calories were included. By Day 4, these values increased to 49.9% and 65.0%, respectively. Propofol contributed a meaningful proportion of total caloric intake across all days, particularly in the early phase of nutrition delivery when EN volumes were titrating upwards.

FIGURE 3. AVERAGE % KCAL MET WITH OR WITHOUT PROPOFOL DURING FIRST 4 DAYS OF ADMISSION (N=54)

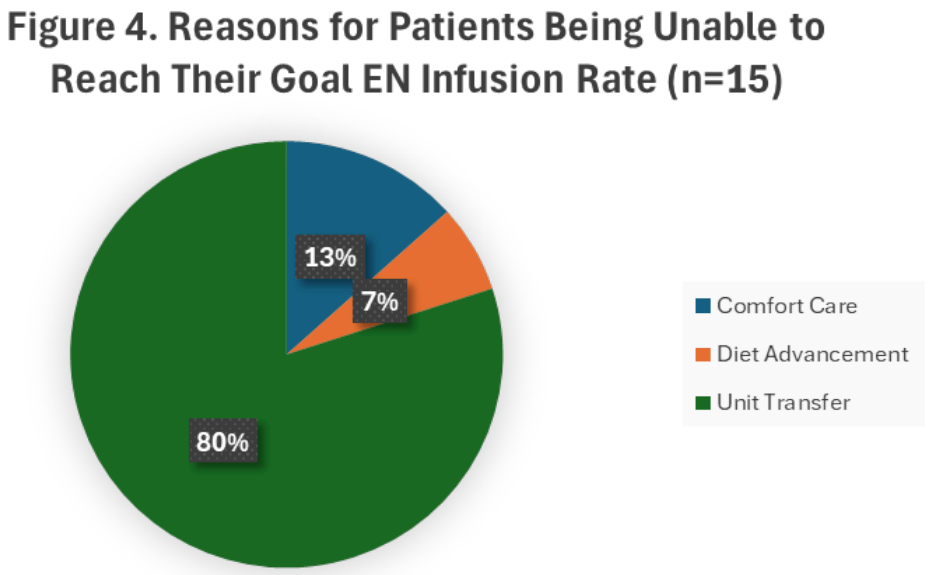


Among patients who received propofol (n = 54), both the volume administered and the caloric contribution from propofol varied over the first four days of admission (Table 3). The highest average volume was administered on Day 2 (227.0 mL ± 182.2 mL), followed by Day 4 (195.1 mL ± 179.1 mL), Day 3 (182.2 mL ± 179.3 mL), and Day 1 (107.9 mL ± 101.9 mL). The average percentage of total calories provided by propofol peaked on Day 2 at 170.1 kcal (± 202.2), before decreasing to 122.0 kcal (± 182.1) on Day 3 and 108.9 kcal (± 176.3) on Day 4. On Day 1, propofol contributed an average of 92.9% (± 110.5) of daily caloric needs.

Table 3. Propofol administration and calorie provision from propofol during the first four days of admission in the TSICU (n=54)

Day	Average mLs of propofol received	Average kcal from propofol received per day
	Mean (± SD)	
1	107.9 (± 101.9)	92.9 (± 110.5)
2	227.0 (± 182.2)	170.1 (± 202.2)
3	182.2 (± 179.3)	122.0 (± 182.1)
4	195.1 (± 179.1)	108.9 (± 176.3)

Fifteen patients never reached their goal EN rate due to several factors (Figure 4). The majority of these patients (80%) were transferred to a different unit for further medical care. Thirteen percent (13%) were transitioned to comfort care or were at the end of life. Lastly, 7% of patients were advanced to an oral diet.



Enteral Nutrition Delivery After Goal rate Achieved

Among patients who reached their goal EN rate (n = 39), the average number of days required to meet their goal rate was 5.4 days ± 2.8 days, with a range of 2 to 13 days (Table 4). After reaching their goal rate, patients spent an average of 70.4% (± 29.8%) of their days at or above 90% of their daily EN goal volume. On average, patients met 91.9% (± 23.3%) of their estimated caloric needs, not including propofol, and 95.4% (± 22.3%) of their estimated caloric needs when propofol was included.

The protein goals were met through EN as well as protein modulars. On average, patients met 104.7% (± 21.2%) of their estimated protein goals with EN and modular supplements. Protein content from modulars contributed 41.3 g (± 4.2 g)

per day on average and accounted for 35.9% (± 5.7%) of total estimated protein needs. However, documentation of the protein modulars was inconsistent. Due to gaps in the documentation of protein modulars, it was assumed that all prescribed modulars were given. However, this assumption might lead to inaccuracies, potentially underestimating the actual amount of protein received by a patient throughout their day.

Table 4. Enteral nutrition provisions in patients who reached their goal enteral nutrition infusion rate (n = 39)

Characteristic	Mean (±SD)
Days to Reach Goal Rate	5.4 ± 2.8 (min: 2, max: 13)
% of Days at Goal After Reaching Goal	70.4 ± 29.8
% Kcal Goal Met (without propofol)	91.9 ± 23.3
% Kcal Goal Met (with propofol)	95.4 ± 22.3
% Protein Goal Met	104.7 ± 21.2
Protein from Modulars per Day (g)	41.3 ± 4.2 g
% of Protein Goal Met by Modulars per Day	35.9 ± 5.7

Enteral Delivery Interruptions

In patients who reached their goal EN rate, interruptions to EN delivery were documented after they reached their goal rate. The reason for and length of each interruption was collected. Many of these interruptions were medically necessary (Figure 5). Procedure-related interruptions were the most common, contributing to 28% of all cases. Those procedures could include major or minor surgeries involving NPO status and GI rest, such as tracheostomy, craniotomy, laparotomy, percutaneous endoscopic gastrostomy (PEG), hip replacement, and more. Side effects were the second most common reason for interruptions, encompassing 16% of interruptions. Side effects would include abdominal cramping, nausea, vomiting, and stomach distension. In these instances, EN would be re-adjusted to run at a lower rate until tolerance was established. Other reasons (e.g, formula spilled, barium swallow study, establishing clearance after procedures, and status NPO) contributed to 15% of interruptions. Imaging, such as CT, MRI, and bronchoscopy, contributed to 13% of interruptions. The rest of the reasons for interruptions encompassed feeding tube being dislodged or pulled, patients being extubated or intubated, and in certain instances, EN would not be restarted immediately after the procedure leading to a loss of feeding volume. Lastly, 10% of the interruptions in feeding were not documented by medical staff. On average, 4.3 hours ± 5.6 hours were lost due to interruptions resulting in an average of 149.6 mL ± 196.5 mL of formula missed per day (Table 5).

FIGURE 5. REASONS FOR ENTERAL NUTRITION INTERRUPTIONS IN PATIENTS WHO REACHED THEIR GOAL ENTERAL NUTRITION INFUSION RATE (N=39)

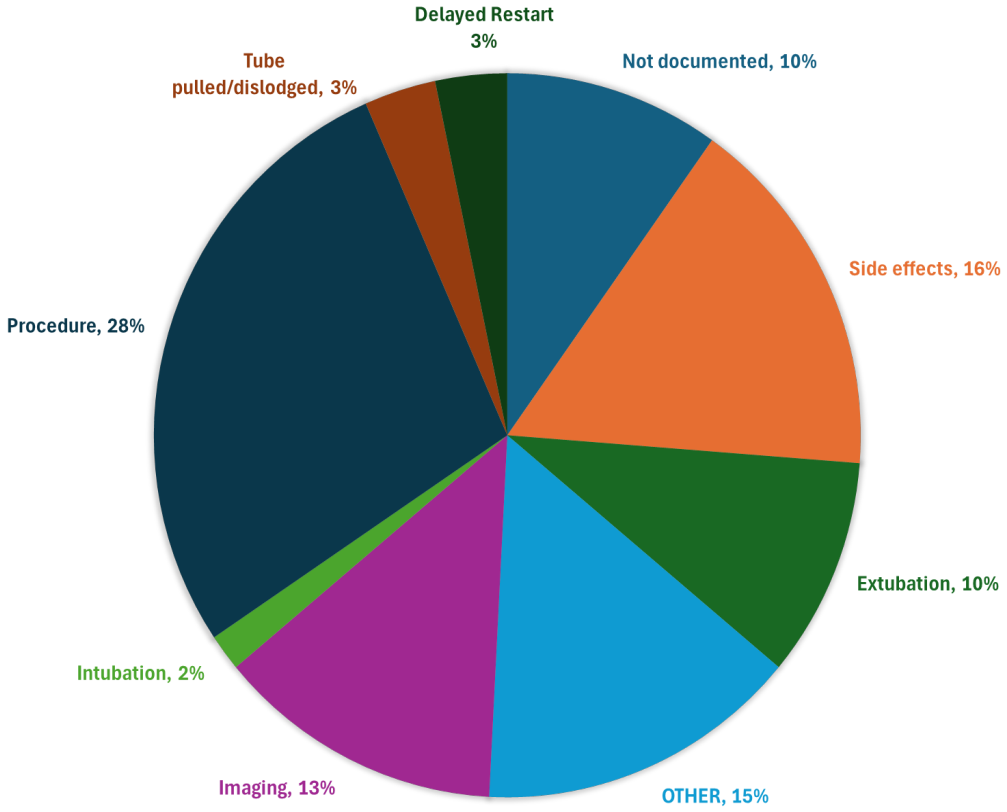


Table 5. Feeding interruptions in patients who reached their goal enteral nutrition infusion rate (n = 39)

	Mean (±SD)
Hours of Feeding Lost per Day	4.3 ± 5.6
Volume of Feeding Missed per Day (mL)	149.6 ± 196.5

Summary of Written Deliverable

The written deliverable of this project was a QI report that summarizes the data collected on the feasibility of VBTF in the TSICU, adequacy of current feeding practices, feeding initiation and progression timelines, and frequency of enteral feeding interruptions. Based on the results of this QI project, the following three key recommendations have been identified and addressed in the final deliverable.

Key Recommendation #1: Increase nutrition delivery in the first four days of admission by implementing a feeding protocol that can be initiated by medical providers.

Rationale: EN should be initiated within 24 to 48 hours of admission to optimize nutritional intake and improve clinical outcomes [1,20]. Particularly, early initiation benefits GI microflora. EN should reach the goal, preferably, within 48-72 hours of admission [1]. The goal EN is referred to as 100% of needs met. Yet, McClave et al. suggests reaching a goal of >80% within the time frame to achieve similar results. In this project, EN intake was mostly initiated within an optimal timeframe, but initiation was slow over the first four days of admission. On average, patients received only 9% of their estimated energy needs on Day 1, and by Day 4, EN alone met approximately 50% of estimated energy needs, still below the recommended 80%. Even with the presence of propofol, patients did not reach the desired goal of >80% energy needs. However, the average percent of protein needs almost met the desired >80%, peaking at 72.8% on Day 4. Dietitians play a key role in the timely initiation of EN and in this project, dietitian consults were received on average 33 hours after admission, but some consults took up to seven days. Feeding protocols can allow for early delivery of EN until a dietitian can complete a full assessment and determine a nutrition prescription based on the patient's unique needs. Similar protocols are used in hospital units with higher acuity, such as the burn unit and the NICU[21,22]. In protocols found in the NICU, providers have detailed information on when to initiate EN, what to give, what rates and advancements can be accomplished, fluid adjustments, and what nutrition labs to monitor[22]. In this project, there were only four instances when a provider or medical team initiated a tube feeding for a newly admitted patient. Utilizing feeding protocols to facilitate early EN initiation could improve health outcomes by allowing them to meet their nutritional goals in a timely manner.

Key Recommendation #2: Ensure optimal delivery of enteral prescription by implementing a volume-based tube feeding protocol.

Rationale: While patients did receive a high percent of their prescribed energy and protein needs through EN, interruptions were common and resulted in the loss of EN delivery. Forty-six percent (46%) of patients who reached their goal rate had at least one interruption. On average, patients lost 4.3 hours of feeding and 150 mL of EN due to procedures, side effects, imaging, or delayed restarts. It is feasible to recover this volume of EN through a VBTF protocol. A VBTF protocol would allow for the recovery of lost EN through adjusting pump rates. Such protocols are being successfully used in burn units to 'catch up' on volume, and implementation of VBTF protocols can enhance recovery and improve clinical outcomes[21,23]. Typical VBTF protocols include calculations for volume lost and make-up volume for pump adjustment. The implementation of a VBTF protocol would require support from nursing staff as well as comprehensive education on its use for the entire care team.

Key Recommendation #3: Encourage all providers on the unit to fully document any changes happening to EN daily, and improve consistency of modular administration by encouraging providers to document in the flowsheet.

Rationale: Interruptions in EN (e.g., paused feeds or rate changes) were often not documented or explained. The medical care team typically used flowsheets to report any changes to EN delivery. However, not all changes were

reported in the flowsheets. This inconsistency in documentation may be attributed to a lack of time, limited staff, and differences in training. Documentation for protein modulars faced a similar challenge. Protein modulars were inconsistently recorded on the flowsheet, sometimes hidden in "Other" fields, or omitted entirely. Unclear records of the delivery of EN or modulars might impair dietitians' ability to adjust prescriptions and monitor nutrition status during follow-up assessments. To improve documentation, all members of the medical care team should be educated on the importance of nutrition support as well as the need for accurate documentation related to any alterations in EN delivery such as interruptions and lost volume. In the case of protein modulars, changes in the electronic medical record could be investigated such as having a designated row in the flowsheet for modulars or adding modulars to the medication administration record. Implementing these changes could improve communication across the care team and support more precise and effective nutrition assessments. Furthermore, gaps in data could limit the accuracy and effectiveness of future QI projects.

Conclusion

This project addressed a critical aspect of TSICU care, looking at early and adequate EN. This project highlights challenges in EN delivery in the TSICU, including delays in initiation and frequent feeding interruptions. Despite efforts to meet nutritional goals, some patients failed to reach optimal intake, often due to modifiable barriers. The findings support the need for implementation of a feeding protocol for EN initiation and a VBTF protocol for maximizing EN delivery once patients have reached their goal EN rate. Initiating feeds earlier through a provider-driven protocol can reduce delays and improve intake during the critical first few days. Implementing a VBTF protocol may help recover missed nutrition due to medically necessary interruptions. Furthermore, improvements in documentation of EN and modular delivery could lead to more accurate and timely adjustments to feeding prescriptions. Standardizing documentation practices could also enhance communication across the interdisciplinary team. These efforts could support improved patient outcomes and overall care quality in the intensive care setting.

Strengths and Limitations

The study had multiple strengths including a large sample size and detailed data collection. Nutritional intake was tracked daily over the patients' LOS, observing EN progression and potential barriers in early nutrition. The study had an adequate sample size of 54 patients, which allowed for effective assessment of trends in EN delivery and feeding adequacy. With a focus on providing early and adequate nutrition to critically ill TSICU patients, the project ensures our findings are relevant to current feeding practices. Additionally, our detailed daily data collection throughout the entire length of stay provided a comprehensive view of feeding practices. The QI report approach allowed us to make practical, protocol-based recommendations aimed at improving enteral nutrition delivery at OHSU TSICU.

In terms of limitations, the population included in this report represents only the TSICU and practices may differ in other units. This was a single-site study conducted at OHSU, Floor 8C, which means the findings might not be easily generalized to other settings. Incomplete or inconsistent documentation could have reduced the overall data accuracy, possibly affecting our findings and conclusion. Also, the assumption that all prescribed modulars were administered

introduced potential inaccuracies and could weaken conclusions about protein goal achievement. Factors such as sedation levels, GI tolerance, or nursing staffing levels could influence feeding initiation and feeding practices and were not thoroughly controlled in this report.

Future Directions

When considering future directions, research could be conducted on the implementation of feeding protocols, such as a Provider-Initiated Feeding protocol and/or VBTF protocol, and the adequacy of EN delivery in the ICU. With the initiation of any protocol, education materials and staff education would be needed to train medical professionals on how to utilize a protocol. To further improve EN delivery, staff education sessions could be conducted to highlight the importance of timely enteral nutrition initiation, volume recovery, and maintaining consistent documentation.

The impact of adequate EN delivery as well as initiation rates on patient outcomes, such as malnutrition and LOS, could also be investigated. Future QI projects could explore patient outcomes, particularly observing how new nutrition practices might affect ICU LOS, infection rates, and mortality. These initiatives would provide further guidance to RDs on the best feeding practices for patients receiving care at OHSU.

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Evidence Table

Citation	Year	1st Author Name	Population	Methods	Results/Conclusion	Relevant to Study Information
L. Douglas Smith, Hoy H, Whitmore S. Increasing the Volume of Delivered Enteral Feeds Using a Volume-Based Feeding Protocol in a Neuroscience Intensive Care Unit. Critical care nurse. 2024;44(3):54-64. doi:https://doi.org/10.4037/ccn2024622	2024	L. Douglas Smith Jr	40 patients in the neuroscience ICU (19 in the RBF group & 21 in the VBF group) with a total of 241 EF days.	Conducted in an 8-bed neuroscience ICU at a 741-bed tertiary care hospital. The first 12 wks involved collecting electronic data on patients in the RBF group, followed by the implementation of the VBF protocol and another 12 wks of data collection. The VBF protocol was developed by a multidisciplinary team. Staff received educational sessions to ensure competency with the new protocol.	After implementing the VBF protocol, the percentage of delivered EF volume significantly increased. The percentage of days patients received at least 80% of the prescribed volume also improved. Staff reported a heightened emphasis on nutrition delivery and a greater agreement that nutrition is a priority in critical care.	The VBF protocol was developed and implemented by a multidisciplinary team with the overall objective that it can fit within the unit's established workflow. Successful adaptation of a new protocol required a thorough front-end education to ensure staff competency with its use. Participants (medical staff) completed an online knowledge assessment, verifying obtained knowledge. After the implementation of VBF protocol, the % of delivered EN was significantly increased, and patients received at least 80% of the prescribed volume. This project was accomplished with success, allowing for its expansion to different ICU units. Yet, there were some concerns about gastric residuals, gastric intolerances, and relatively moderate, maximum volume (75 mL/hr).
Prest PJ, Justice J, Bell N, McCarroll R,	2019	Phillip J. Prest	A retrospectiv	RDs screened pts via subjective	The post-PEP uP group met or exceeded energy goals	This study emphasized a retrospective review of patients' charts. The study employed the strategy of comparing two groups of

Watson CM. A Volume-Based Feeding Protocol Improves Nutrient Delivery and Glycemic Control in a Surgical Trauma Intensive Care Unit. Journal of Parenteral and Enteral Nutrition. Published online September 16, 2019. doi:https://doi.org/10.1002/jpen.1712			e review of patient data from an 18-bed Surgical Trauma Intensive Care Unit (STICU) at a Level I Trauma Center. A total of 1,088 charts were reviewed; Pre-PEP uP group: (n = 197) and Post-PEP uP group:(n = 295)	global assessment tool for malnutrition assessment. Energy and protein needs were calculated based on established guidelines. The PEP uP protocol involved prescribing enteral feeds with specific formulations, starting at a low rate and increasing to goal rates based on pt tolerance. The protocol also included a "do not check" gastric residual policy to streamline feeding practices.	(≥80% of target) 57.0% of the time compared to 26.9% in the pre-PEP uP group, with a statistically significant p-value of <0.001 and an adjusted odds ratio (OR) of 4.98. The post-PEP uP group met or exceeded protein goals 57.4% of the time versus 18.6% pre-PEP uP, also with a p-value <0.001 and an adjusted OR of 11.84. There was a reduction in episodes of hyperglycemia in the post-PEP uP group, with 9% experiencing it compared to 14.4% in the pre-PEP uP group (p-value <0.001). The incidence of emesis did not show a significant difference between the two groups.	patients comparing two protocols/feeding methods: traditional vs VBF. Patients in post-PEP-uP/VBF did meet or exceed energy and protein goals> as for the side effects, the VBF groups had fewer episodes of hyperglycemia. Yet, there was no significant difference in emesis episodes between the two groups. The study provides considerations for future research about the possibilities of conducting prospective chart reviews to validate the efficacy of the protocols and comparing the efficacy of other VBF protocols.
McCartt J, Loszko A, Backes K, et al. Improving enteral nutrition delivery in the critically ill trauma and surgical population. *Journal*	2022	Jason McCartt	488 participants : 256 patients in the pre-protocol (PP) group	They excluded participants who were/had intraabdominal injuries requiring bowel anastomosis, prescribed trophic	The average % of nutrition delivered significantly improved when compared with PP (75.3% PP vs 85.5% EP; P<0.01). The % of patients receiving >80% of nutrition goals also improved	Implementation of a VBF strategy in this enhancement protocol allowed for the average increase of delivered energy. The study had an increase in patients who were receiving >80% kcal needs daily also abiding by ASPEN. Yet, the study's major success was attributed to multidisciplinary collaboration, with appropriate staff education and daily reporting during rounds.

of Parenteral and Enteral Nutrition. Published online March 15, 2022. doi:https://doi.org/10.1002/jpen.2353			and 232 patients in the enteral nutrition enhancement protocol (EP) group. Inclusion criteria were patients aged ≥18 years, admission to ICU for >72 h after traumatic injury or surgical intervention, and hemodynamic stability to receive EN.	tube feeds (10-20 ml/h), and noninvasive positive pressure ventilation. The EP had 3 main elements: revised nonoral guidelines, use of postpyloric enteral tubes, and implementation of a volume-based feeding protocol They monitored primary outcome - average percentage of EN delivered (based on a 24-h kilocalories requirement) daily for the ICU stay, and the secondary outcome was the percentage of patients receiving >80% of nutrition goal.	(52.7% PP vs 65.2% EP; P<0.01). The average percentage of nutrition delivered improved by 9.1% among traumatically injured patients (78.2% PP vs 87.3% EP; P<0.01) and 8.8% among the surgical critical care population (69.9% PP vs 78.7% EP; P<0.01). The % of patients receiving VBF significantly decreased (41.5% PP vs 28.7% EP; P<0.01), and the % of patients receiving postpyloric feedings also significantly decreased (15.5% PP vs 10.9% EP; P<0.01)	
Swiatlo T, Berta JW, Mauldin K. A Quality Improvement Study: Comparison of	2019	Travis Swiatlo	The study included 283 patients,	Patient demographics, enteral nutrition recommendations,	A significantly higher percentage of patients in the VBTF group received adequate nutrition (88.3%)	The main findings of this study suggest that VBTF may enhance nutrition delivery in critically ill patients without increasing the risk of adverse outcomes, supporting its implementation in clinical practice. For hemodynamically stable, critically ill patients,

Volume-Based and Rate-Based Tube Feeding Efficacy and Clinical Outcomes in Critically Ill Patients. *Nutrition in Clinical Practice*. Published online September 23, 2019. doi:https://doi.org/10.1002/ncp.10412			with 77 in the VBTF group and 206 in the RBTF group in level-1 trauma center with multiple ICUs	and clinical outcomes (including incidences of hyperglycemia, hypoglycemia, diarrhea, and mortality) were collected from medical charts. Adequate nutrition was defined as receiving at least 80% of estimated energy requirements (EER).	compared to the RBTF group (36.4%) during the first seven days of enteral nutrition ($p < 0.001$). The VBTF group had a daily average intake of 93.1% of their goal volume, while the RBTF group averaged only 71.3% ($p < 0.001$). There were no significant differences in adverse outcomes between the two groups. Hyperglycemia occurred in 49.4% of the VBTF group versus 62.1% in the RBTF group ($p = 0.052$), and hypoglycemia was observed in 1.3% of the VBTF group compared to 4.9% in the RBTF group ($p = 0.168$).	a VBTF protocol offers an effective method for reducing energy deficits and preventing iatrogenic malnutrition without increasing risks of complications. The study observed critically ill patients receiving more consistent feedings with higher energy content, unlike the traditional, RBTF group. Yet, no significant differences were observed between the two groups when considering the adverse effects of the two feeding methods.
Varghese JA, Keegan S, Nicholson C, Drummond KJ, Kaul N, Fetterplace K. Volume-based enteral feeding for ward patients with acute neurological conditions: a pilot prospective cohort study. *Journal of*	2024	Jessie A. Varghese	32 participants in the intervention group & 35 participants receiving RBF in 38-bed neurosurgery ward with	Participants in RBF group received standard continuous EN at fixed hourly rates during the first five months. In the VBF group, participants received EN with bi-daily adjustments to	The VBF group demonstrated a significantly higher median adequacy of prescribed EN volume delivered at 92% compared to 67% in the RBF group. The VBF received more kJ (131 kJ/kg/day vs. 84 kJ/kg/day) and protein (1.3 g/kg/day vs. 0.9 g/kg/day). There were no significant differences in GI	The VBF protocol significantly improved the delivery of EN volume, energy, and protein in patients with acute neurological conditions compared to traditional RBF. The study allowed a maximum rate of 200 mL/hr. The study has observed a low frequency of feeding intolerance in both groups, implying that higher rates (in VBF groups) were well tolerated by participants. The protocol was feasible to implement and received high acceptability from nursing staff. Nursing compliance with the VBF protocol was high, with 90% adherence reported, and 78% of nursing staff expressed confidence in using the protocol. Further

Human Nutrition and Dietetics. 2024;37(4):1040-1049. doi:https://doi.org/10.1111/jhn.13319			17 high-acuity observational beds and a 32-bed stroke and neurology ward.	ensure the target daily volume was met, accommodating any feeding interruptions. Comprehensive training for nursing staff was implemented. Data were collected on EN volume prescribed and delivered, energy and protein intake, GI intolerance, protocol compliance, and nutrition-related outcomes.	intolerance between groups. The VBF group experienced less wt loss at discharge.	research is suggested to explore the impact of VBF on broader patient-centered outcomes.

Quality Improvement Report

Assessment of Enteral Nutrition Delivery and Feasibility of Volume-Based Tube Feeding in the Critical Care Setting at OHSU

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Problem Statement

Despite the critical role of enteral nutrition (EN) in improving health outcomes in critically ill patients, underfeeding remains a persistent challenge in intensive care units (ICU) due to delayed EN initiation and frequent interruptions. These issues contribute to suboptimal nutritional intake and increased risk of malnutrition-related complications.

While volume-based tube feeding (VBTF) may offer a promising strategy to improve feeding adequacy by allowing flexibility and compensation for interruptions, the feasibility of this type of protocol in the trauma/surgery intensive care unit (TSICU) at OHSU remains unknown.

Project Goals

The goals of this project were to evaluate the feasibility of VBTF in the TSICU to improve EN delivery, assess the adequacy of current feeding practices, including how often patients meet prescribed nutrition goals, examine feeding initiation and progression timelines, and identify potential delays and interruptions in feeding that affect nutrition adequacy.

Project Introduction

The use of EN is essential for improving the outcomes of critically ill patients[1,2,3]. However, critically ill patients experience significant underfeeding due to numerous reasons including medically-related feeding interruptions[4,5,6]. Research shows inadequate nutrition during ICU admissions can put patients at risk for malnutrition and associated complications[5,7]. Volume-based tube feeding (VBTF) was developed as a promising alternative that allows for greater flexibility in delivering nutrition by prescribing a total daily volume vs. an hourly rate. The VBTF approach allows providers to adjust feeding rates dynamically, compensating for interruptions in feeding and ensuring that patients receive adequate nutrition[8]. Implementation of VBTF in the ICU can have significant implications for critically ill adult patients[9,10]. Improvements made to EN delivery through VBTF could lead to better overall health outcomes and reduce the incidence of malnutrition. These changes could improve the quality of life for patients both during and after their ICU stay[7,11]. Despite its potential benefits, VBTF remains underutilized in many clinical settings, including the ICU. The goal of this project was to examine feeding adequacy and the feasibility of a VBTF protocol in the ICU at OHSU.

Background

Enteral nutrition (EN), commonly known as tube feeding, is a critical component in the management of critically ill patients. Incorporating EN into critical care not only fulfills metabolic demands but also significantly aids in patient recovery post-ICU. Malnutrition in the ICU poses substantial risks of morbidity and mortality[12,13]. Critical illness often leads to inflammation, increased catabolism, and muscle mass loss, contributing to malnutrition[4]. Early initiation is crucial to promote recovery and improve patient outcomes, especially in those who are hemodynamically stable[1,2,3]. Current literature indicates that early initiation of EN is associated with reduced complications from infectious diseases, improved nutrition delivery, and shorter length of stay (LOS) in both the ICU and hospital[5,7]. While additional safety precautions are essential

when implementing an EN protocol for critically ill patients, the potential benefits of early EN initiation generally outweigh the risks of complications, such as aspiration, gastrointestinal intolerance, and hemodynamic instability[5].

There can be many barriers to delivering optimal nutrition in the ICU including physiological (such as poor appetite), functional (like dysphagia), psychological (including low mood), and feeding intterruptions[4]. Interruptions in EN are common in intensive care settings[5]. These interruptions can occur for various reasons, including anticipated procedures, physiotherapy, and routine nursing care, which can impede feeding interruptions and frequently hinder an ICU patient's ability to obtain adequate nutrition and achieve nutritional goals. The study found that at least three-fourths of ICU patients had observed and documented orders for interruption of EN. The causes for interruptions included ventilation dependency, tracheostomy, spontaneous breathing trials with a T-piece, and NPO orders before surgery[6]. Volume-based tube feeding (VBTF), as part of a multimodal approach to nutrition optimization, may be particularly beneficial for vulnerable patients at risk of hospital-acquired malnutrition who depend on EN[8], representing an alternative method of delivering EN. VBTF emphasizes providing a prescribed daily volume of feeding rather than a fixed hourly rate. VBTF allows for a total daily volume of EN to be administered over 24 hours, in contrast to traditional rate-based tube feeding (RBTF), which relies on a fixed hourly infusion rate. When implemented as part of a comprehensive nutrition optimization strategy, VBTF may help address the significant challenges associated with EN in the ICU, such as caloric deficits observed in critically ill patients[6].

Currently, there are multiple VBTF protocols available for reference and utilization. The protocols emphasize various aspects of feeding; the key components are enhanced protein delivery and meeting >80% caloric needs[14,15,16]. The flexibility of VBTF enables registered nurses (RNs) to adjust the hourly infusion rate to ensure the total prescribed volume is delivered, even in the event of feeding interruptions. The research shows a significant increase in delivered volume when adjusting for missed volume in ICU settings [5,10,17]. A quality improvement project compared EN delivery via RBF and VBF; in the VBF group, patients received at least 80% of the prescribed volume in a neuroscience ICU[8]. Another study found that EN volume delivered at 92% in the VBTF group as compared to 67% in the RBF group[18]. Adaptability allows for "catch-up" on missed nutrition when interruptions occur for procedures[16]. When feeding cannot be administered for specific reasons, a catch-up phase can be implemented to meet energy needs, with at least one daily catch-up phase scheduled to calculate and adjust the volume of EN administered. This ensures that the 24-hour goal volume is achieved. Most importantly, the protocols allow for a catch-up of energy and protein needs[10,19]. Furthermore, most VBTF protocols include standardized guidelines for starting rates, titration, and catch-up calculations, alongside regular evaluations by RDs to ensure appropriateness and individualized adjustments. Safety measures, such as utilizing prokinetic agents, when necessary, are also included in these protocols[19].

The EN challenges associated with VBTF are like those encountered with traditional EN feeding protocols when used in the ICU. Common concerns include issues related to volume tolerance, underlying medical conditions, individual nutritional requirements, frequency and duration of necessary feeding interruptions, glycemic control considerations, GI function, and the type of feeding access (gastric vs. jejunal)[9,10]. A meta-analysis of sixteen studies has analyzed potential side effects and complications that can be attributed to VBTF[10]. The analysis observed potential risks for diarrhea, emesis, feeding intolerance, and gastric retention with VBTF protocols. However, those findings did not increase significantly

compared to the adverse side effects observed in the RBTF group[10]. A UK study has also observed no significant differences in safety measures between VBF and RBF in medical ICUs. There were no differences in GI tolerance, such as vomiting, use of prokinetics, glycemic control, and insulin use[11]. These findings support the safety of VBTF in a critical care setting. Implementing VBTF protocols in clinical settings does present other challenges, including the need for staff education and training, adherence to protocols, effective documentation and monitoring systems, coordination of multidisciplinary efforts, and overcoming resistance to traditional practices[8]. When thorough education is provided and the protocol is implemented correctly, it can increase overall awareness of the importance of nutrition delivery to critically ill patients[8]. Moreover, various patient-specific factors can influence the effectiveness of VBTF protocols.

Enteral nutrition is crucial for improving health outcomes in critically ill patients. VBTF presents a potentially powerful strategy for preventing underfeeding, demonstrating safety and efficacy in tube feeding delivery [1,2,3]. However, the implementation of VBTF requires additional efforts, such as staff training and the creation of additional protocols. Therefore, it is essential to evaluate the current effectiveness of RBTF and the necessity of VBTF before its implementation.

Project Design and Methods

A prospective chart review was conducted to evaluate the current tube feeding practices, including feeding initiation rates and feeding adequacy, in the TSICU to determine if there is a need for a VBTF protocol. This project also assessed the feasibility of a VBTF protocol implementation in the TSICU. Data for this project was collected from January to April 2025 and included patients requiring EN support to meet 100% of their nutritional needs. Data collection included the following information: clinical characteristics such as anthropometric measurements, information related to EN and interruptions, dietitian nutrition prescriptions, information on medication related to nutrition, and possible TF intolerances.

Patient Population

Patients admitted to the TSICU from January 15th, 2025 to April 5th, 2025 were screened for inclusion into this project. Patients were included if they were 18 years or older, receiving care in the TSICU exclusively, and receiving only EN. Exclusion criteria included patients younger than 18 years of age or receiving any oral diet (PO) or total parenteral nutrition (TPN). Patients who were on the unit for less than two days were also excluded. Data collection began as soon as EN was initiated and ended when the patient was discharged from the unit or EN was discontinued for any reason.

Clinical Data

Clinical data included patient demographics, admission details, anthropometrics, dates of admission and discharge from the unit, reason for discharge, medications such as pressors and sedatives, and use of mechanical ventilation. Propofol was documented with the date of administration and volume provided during the day (mL). Calories from propofol were calculated using an Excel formula: volume (mL) * 1.1 kcal. Nutrition-related data included use of EN prior to admission, date and reason for nutrition consultation, and prior diagnosis of malnutrition.

Enteral Nutrition Data

The use of EN was documented daily using data from flowsheets and chart notes from dietitians and other providers. Patients' recommended EN nutrition prescription, including estimated calories (kcal), and estimated protein

needs (g), were obtained from dietitian chart notes, while EN infusion rate, reason for EN interruptions and medication administration were obtained from other chart notes. Detailed EN data was collected including: the EN access site, type of EN formula, rate of initiation, daily volume of EN received, protein modular administration, date of achievement of goal EN rate and number days at EN goal rate, and all changes to EN formula type and administration. For patients who were on the unit for seven or more days, recalculated calories and protein estimates were documented. For protein modulars, the number of packets administered per day was documented, and protein and calorie content were calculated using 60 kcal and 15 gm protein per packet. Data collection was discontinued once a patient transitioned to a different unit or facility, initiated PO intake, or experienced other circumstances that made EN data irrelevant or impossible.

Enteral Nutrition Interruptions

Once a patient reached the goal EN rate, interruptions to their EN were documented. Interruptions were any event that resulted in the temporary discontinuation of EN infusion. The reasons for interruptions were determined by looking at flowsheets. If information could not be found in the flowsheet, provider and dietitian notes were examined as well as order history and procedure notes. The reason for each interruption was noted as well as the length of the interruption and the volume of EN that was missed. If multiple interruptions occurred in a day, the total hours of interruption were calculated.

Statistical Analysis

The findings were analyzed using statistical software, StataNOW 19 BE, to evaluate proportions and trends. Mean and standard deviations were calculated using STATA for each variable.

Results

A total of 186 patients were screened for this project and 54 patients were included in the analysis (Figure 1). Patients were excluded due to PO intake being initiated, failure to initiate EN or EN infusion for less than two days, being younger than 18 years of age, and one patient was excluded due to restricted access on their electronic medical record.

Patient Demographics

The average age at admission was 54.9 years (±19.7 years), with most patients being male (77.8%, n = 42), followed by female (20.4%, n = 11), and one non-binary patient (1.9%). The average LOS was 10.1 days (±6.4 days), and the mean BMI was 28.2 kg/m² (±6.1 kg/m²). Only 20.4% (n = 11) of patients received EN prior to admission, while 79.6% (n = 43) did not. The average number of ventilator days was 6.1 days (±5.76 days) (Table 1).

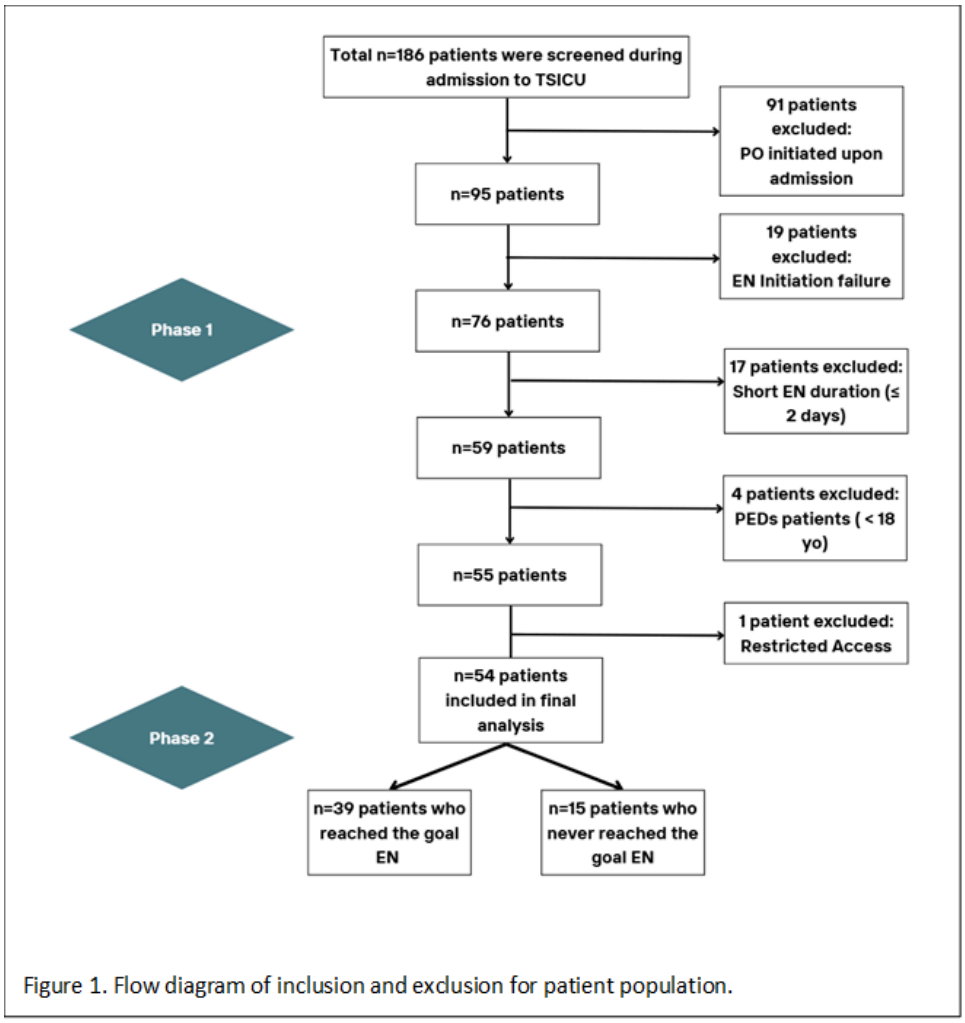


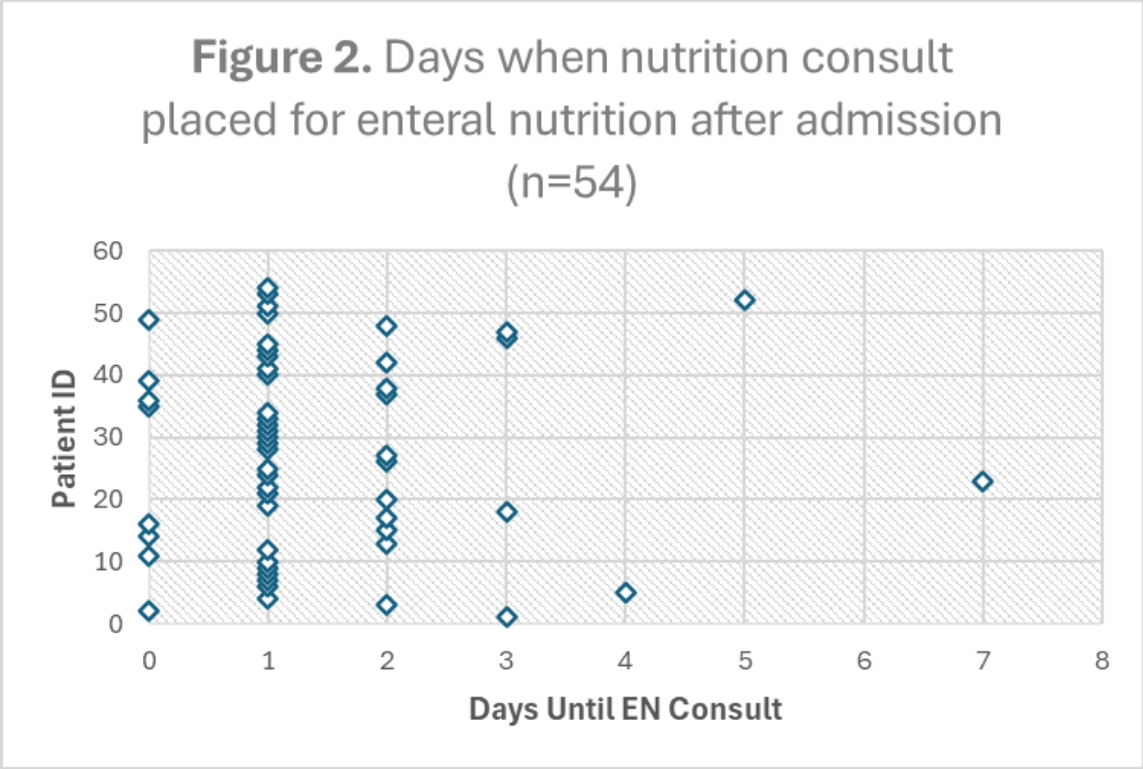
Figure 1. Flow diagram of inclusion and exclusion for patient population.

Table 1. Patient clinical characteristics (n=54)

Characteristic		**Mean (±SD)**
Age (years)		54.9 (±19.7)
BMI (kg/m²)		28.2 (±6.1)
Ventilator Days		6.1 (±5.76)
Length of Stay (days)		10.1 (±6.4)
		n (%)
Gender		
	Female	11 (20.4%)
	Male	42 (77.8%)
	Non-binary	1 (1.9%)
EN Prior to Admission		
	Yes	11 (20.4%)
	No	43 (79.6%)

Early Enteral Nutrition Delivery

Once a patient was admitted to the unit, the average time from admission to a nutrition consult for EN was 1.4 days (Figure 2). However, some consults were placed on the date of admission, in other cases, EN consults for the dietitian were placed on the 7th day of admission.

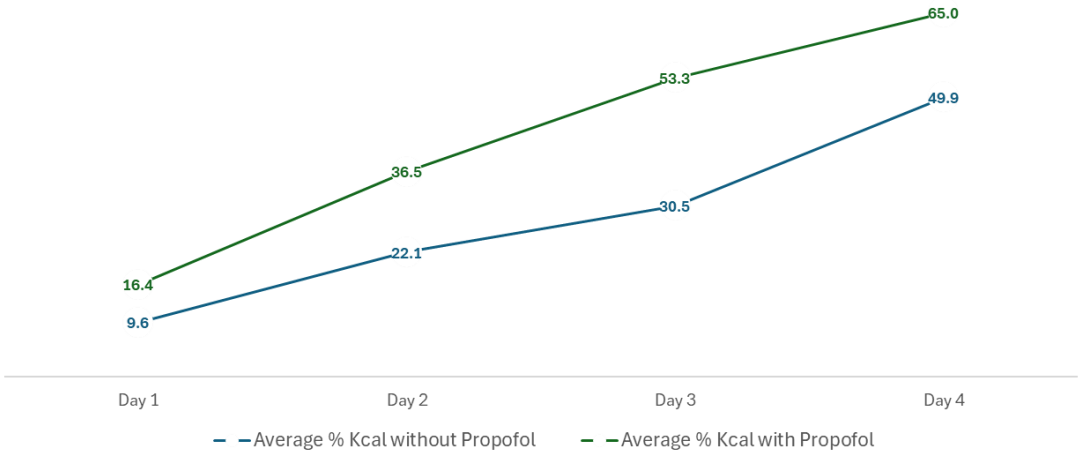


Over the first four days of admission, the progression of EN was tracked for all patients, even those who did not reach their goal EN rate. The amount of propofol administered was also calculated during this time for all patients. Average percentages of kcal and protein goals met, with and without propofol, and total formula volumes received were recorded and calculated (Table 2). Calories, protein and EN volume received all increased over the first four days of admission. Between Day 1 and Day 2, there was an increase in nutritional needs met with the average percent of calories met increasing by 12.1%, without propofol, and 20.1%, with propofol. The average protein goal met increased by 21.8%. Between Day 2 and Day 3, the average percent of calories met increased by 8.4% and 16.8% (with propofol), and the average protein goal met increased by 23.9%. Between Day 3 and Day 4, the average percent of calories met without propofol increased the most by 19.4%, and the average protein goal met increased by 15.2%. On average, the highest percent of estimated calorie goal met during the first four days of admission was 65% on Day 4, with the highest percent of protein goal met reaching 74.3% on Day 4.

Table 2. Enteral nutrition progression during the first four days of admission to the TSICU (n=54)				
Day	**% Kcal Goal Met (w/o Propofol)**	**% Kcal Goal Met (w/ Propofol)**	**% Protein Goal Met**	**EN Volume Received (mL)**
	(Mean ± SD)			
1	9.6 (±20.2)	16.4 (±21.6)	13.4 (±27.3)	79.9 (±179.8)
2	22.1 (±31.9)	36.5 (±30.9)	35.2 (±37.4)	236.8 (±306.7)
3	30.5 (±35.2)	53.3 (±39.5)	59.1 (±43.8)	488.6 (±447.3)
4	49.9 (±37.7)	65.0 (±35.9)	74.3 (±41.9)	570.8 (±457.0)

In the span of the first four days of admission, patients steadily received more calories each day. However, patients received fewer calories with EN alone as compared to receiving propofol and EN (Figure 3). On Day 1, patients met an average of 9.6% of their estimated caloric needs without propofol and 16.4% when propofol calories were included. By Day 4, these values increased to 49.9% and 65.0%, respectively. Propofol contributed a meaningful proportion of total caloric intake across all days, particularly in the early phase of nutrition delivery when EN volumes were titrating upwards.

FIGURE 3. AVERAGE % KCAL MET WITH OR WITHOUT PROPOFOL DURING FIRST 4 DAYS OF ADMISSION (N=54)

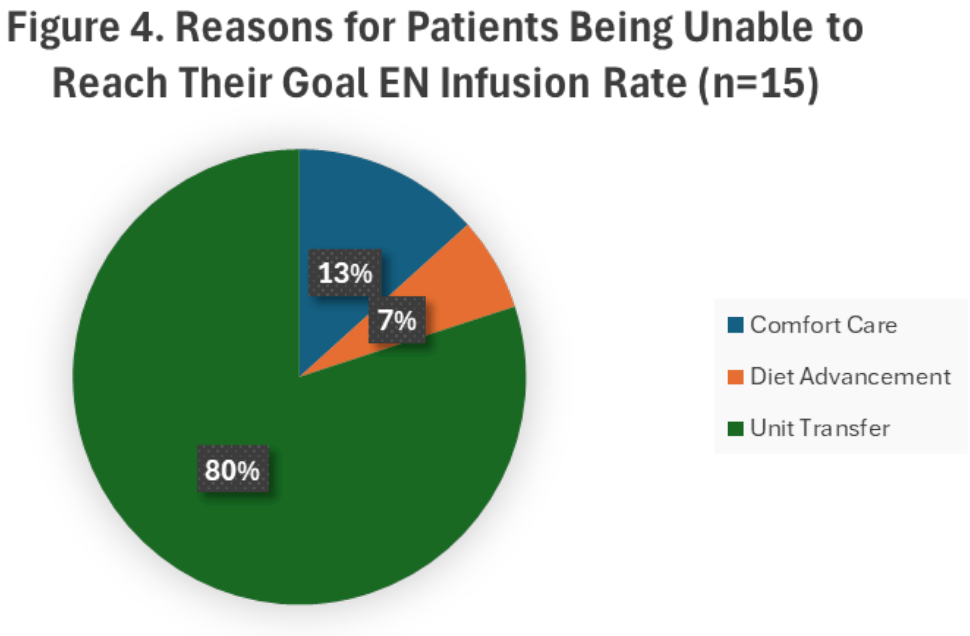


Among patients who received propofol (n = 54), both the volume administered and the caloric contribution from propofol varied over the first four days of admission (Table 3). The highest average volume was administered on Day 2 (227.0 mL ± 182.2 mL), followed by Day 4 (195.1 mL ± 179.1 mL), Day 3 (182.2 mL ± 179.3 mL), and Day 1 (107.9 mL ± 101.9 mL). The average percentage of total calories provided by propofol peaked on Day 2 at 170.1 kcal (± 202.2), before decreasing to 122.0 kcal (± 182.1) on Day 3 and 108.9 kcal (± 176.3) on Day 4. On Day 1, propofol contributed an average of 92.9% (± 110.5) of daily caloric needs.

Table 3. Propofol administration and calorie provision from propofol during the first four days of admission in the TSICU (n=54)

Day	Average mLs of propofol received	Average kcal from propofol received per day
	Mean (± SD)	
1	107.9 (± 101.9)	92.9 (± 110.5)
2	227.0 (± 182.2)	170.1 (± 202.2)
3	182.2 (± 179.3)	122.0 (± 182.1)
4	195.1 (± 179.1)	108.9 (± 176.3)

Fifteen patients never reached their goal EN rate due to several factors (Figure 4). The majority of these patients (80%) were transferred to a different unit for further medical care. Thirteen percent (13%) were transitioned to comfort care or were at the end of life. Lastly, 7% of patients were advanced to an oral diet.



Enteral Nutrition Delivery After Goal rate Achieved

Among patients who reached their goal EN rate (n = 39), the average number of days required to meet their goal rate was 5.4 days ± 2.8 days, with a range of 2 to 13 days (Table 4). After reaching their goal rate, patients spent an average of 70.4% (± 29.8%) of their days at or above 90% of their daily EN goal volume. On average, patients met 91.9% (± 23.3%) of their estimated caloric needs, not including propofol, and 95.4% (± 22.3%) of their estimated caloric needs when propofol was included.

The protein goals were met through EN as well as protein modulars. On average, patients met 104.7% (± 21.2%) of their estimated protein goals with EN and modular supplements. Protein content from modulars contributed 41.3 g (± 4.2 g)

per day on average and accounted for 35.9% (± 5.7%) of total estimated protein needs. However, documentation of the protein modulars was inconsistent. Due to gaps in the documentation of protein modulars, it was assumed that all prescribed modulars were given. However, this assumption might lead to inaccuracies, potentially underestimating the actual amount of protein received by a patient throughout their day.

Table 4. Enteral nutrition provisions in patients who reached their goal enteral nutrition infusion rate (n = 39)

Characteristic	**Mean (±SD)**
Days to Reach Goal Rate	5.4 ± 2.8 (min: 2, max: 13)
% of Days at Goal After Reaching Goal	70.4 ± 29.8
% Kcal Goal Met (without propofol)	91.9 ± 23.3
% Kcal Goal Met (with propofol)	95.4 ± 22.3
% Protein Goal Met	104.7 ± 21.2
Protein from Modulars per Day (g)	41.3 ± 4.2 g
% of Protein Goal Met by Modulars per Day	35.9 ± 5.7

Enteral Delivery Interruptions

In patients who reached their goal EN rate, interruptions to EN delivery were documented after they reached their goal rate. The reason for and length of each interruption was collected. Many of these interruptions were medically necessary (Figure 5). Procedure-related interruptions were the most common, contributing to 28% of all cases. Those procedures could include major or minor surgeries involving NPO status and GI rest, such as tracheostomy, craniotomy, laparotomy, percutaneous endoscopic gastrostomy (PEG), hip replacement, and more. Side effects were the second most common reason for interruptions, encompassing 16% of interruptions. Side effects would include abdominal cramping, nausea, vomiting, and stomach distension. In these instances, EN would be re-adjusted to run at a lower rate until tolerance was established. Other reasons (e.g, formula spilled, barium swallow study, establishing clearance after procedures, and status NPO) contributed to 15% of interruptions. Imaging, such as CT, MRI, and bronchoscopy, contributed to 13% of interruptions. The rest of the reasons for interruptions encompassed feeding tube being dislodged or pulled, patients being extubated or intubated, and in certain instances, EN would not be restarted immediately after the procedure leading to a loss of feeding volume. Lastly, 10% of the interruptions in feeding were not documented by medical staff. On average, 4.3 hours ± 5.6 hours were lost due to interruptions resulting in an average of 149.6 mL ± 196.5 mL of formula missed per day (Table 5).

FIGURE 5. REASONS FOR ENTERAL NUTRITION INTERRUPTIONS IN PATIENTS WHO REACHED THEIR GOAL ENTERAL NUTRITION INFUSION RATE (N=39)

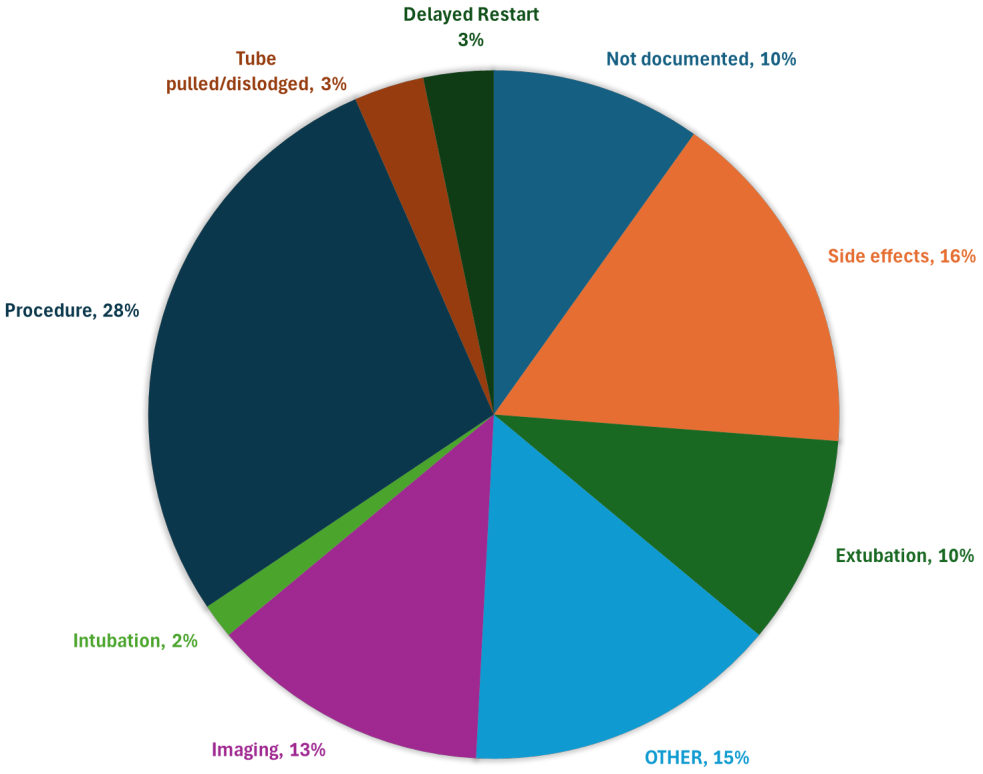


Table 5. Feeding interruptions in patients who reached their goal enteral nutrition infusion rate (n = 39)

	Mean (±SD)
Hours of Feeding Lost per Day	4.3 ± 5.6
Volume of Feeding Missed per Day (mL)	149.6 ± 196.5

Recommendations

This QI report summarizes the data collected on the feasibility of VBTF in the TSICU, adequacy of current feeding practices, feeding initiation and progression timelines, and frequency of enteral feeding interruptions. Based on the results of this QI project, the following three key recommendations have been identified:

Key Recommendation #1: Increase nutrition delivery in the first four days of admission by implementing a feeding protocol that can be initiated by medical providers.

Rationale: EN should be initiated within 24 to 48 hours of admission to optimize nutritional intake and improve clinical outcomes [1,20]. Particularly, early initiation benefits GI microflora. EN should reach the goal, preferably, within 48-72 hours of admission [1]. The goal EN is referred to as 100% of needs met. Yet, McClave et al. suggests reaching a

goal of >80% within the time frame to achieve similar results. In this project, EN intake was mostly initiated within an optimal timeframe, but initiation was slow over the first four days of admission. On average, patients received only 9% of their estimated energy needs on Day 1, and by Day 4, EN alone met approximately 50% of estimated energy needs, still below the recommended 80%. Even with the presence of propofol, patients did not reach the desired goal of >80% energy needs. However, the average percent of protein needs almost met the desired >80%, peaking at 72.8% on Day 4. Dietitians play a key role in the timely initiation of EN and in this project, dietitian consults were received on average 33 hours after admission, but some consults took up to seven days. Feeding protocols can allow for early delivery of EN until a dietitian can complete a full assessment and determine a nutrition prescription based on the patient's unique needs. Similar protocols are used in hospital units with higher acuity, such as the burn unit and the NICU[21,22]. In protocols found in the NICU, providers have detailed information on when to initiate EN, what to give, what rates and advancements can be accomplished, fluid adjustments, and what nutrition labs to monitor[22]. In this project, there were only four instances when a provider or medical team initiated a tube feeding for a newly admitted patient. Utilizing feeding protocols to facilitate early EN initiation could improve health outcomes by allowing them to meet their nutritional goals in a timely manner.

Key Recommendation #2: Ensure optimal delivery of enteral prescription by implementing a volume-based tube feeding protocol.

Rationale: While patients did receive a high percent of their prescribed energy and protein needs through EN, interruptions were common and resulted in the loss of EN delivery. Forty-six percent (46%) of patients who reached their goal rate had at least one interruption. On average, patients lost 4.3 hours of feeding and 150 mL of EN due to procedures, side effects, imaging, or delayed restarts. It is feasible to recover this volume of EN through a VBTF protocol. A VBTF protocol would allow for the recovery of lost EN through adjusting pump rates. Such protocols are being successfully used in burn units to 'catch up' on volume, and implementation of VBTF protocols can enhance recovery and improve clinical outcomes[21,23]. Typical VBTF protocols include calculations for volume lost and make-up volume for pump adjustment. The implementation of a VBTF protocol would require support from nursing staff as well as comprehensive education on its use for the entire care team.

Key Recommendation #3: Encourage all providers on the unit to fully document any changes happening to enteral nutrition daily and improve consistency of modular administration by encouraging providers to document in the flowsheet.

Rationale: Interruptions in EN (e.g., paused feeds or rate changes) were often not documented or explained. The medical care team typically used flowsheets to report any changes to EN delivery. However, not all changes were reported in the flowsheets. This inconsistency in documentation may be attributed to a lack of time, limited staff, and differences in training. Documentation for protein modulars faced a similar challenge. Protein modulars were inconsistently recorded on the flowsheet, sometimes hidden in "Other" fields, or omitted entirely. Unclear records of the delivery of EN or modulars might impair dietitians' ability to adjust prescriptions and monitor nutrition status during follow-up assessments. To improve documentation, all members of the medical care team should be educated on the importance of nutrition support as well as the need for accurate documentation related to any alterations in EN delivery such as interruptions and lost volume. In the case of protein modulars, changes in the

electronic medical record could be investigated such as having a designated row in the flowsheet for modulars or adding modulars to the medication administration record. Implementing these changes could improve communication across the care team and support more precise and effective nutrition assessments. Furthermore, gaps in data could limit the accuracy and effectiveness of future QI projects.

Strengths and Limitations

This project had multiple strengths including a large sample size and detailed data collection. Nutritional intake was tracked daily over the patients' LOS, observing EN progression and potential barriers in early nutrition. In terms of limitations, the population included in this report represents only the TSICU and practices may differ in other units. Also, the assumption that all prescribed modulars were administered introduced potential inaccuracies and could weaken conclusions about protein goal achievement. Factors such as sedation levels, GI tolerance, or nursing staffing levels could influence feeding initiation and were not thoroughly controlled in this report.

Conclusion

This project addressed a critical aspect of TSICU care, looking at early and adequate EN. This project highlights challenges in EN delivery in the TSICU, including delays in initiation and frequent feeding interruptions. Despite efforts to meet nutritional goals, some patients failed to reach optimal intake, often due to modifiable barriers. The findings support the need for implementation of a feeding protocol for EN initiation and a VBTF protocol for maximizing EN delivery once patients have reached their goal EN rate. Initiating feeds earlier through a provider-driven protocol can reduce delays and improve intake during the critical first few days. Implementing a VBTF protocol may help recover missed nutrition due to medically necessary interruptions. Furthermore, improvements in documentation of EN and modular delivery could lead to more accurate and timely adjustments to feeding prescriptions. Standardizing documentation practices could also enhance communication across the interdisciplinary team. These efforts could support improved patient outcomes and overall care quality in the intensive care setting.

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