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The Effectiveness of a Volume-Based Enteral Feeding Protocol to Provide Energy Intake in Hospitalized Critically Ill Adults

Anna Huffman
Georgia State University

Anita Nucci

Katherine Wiley
Georgia State University

Kathy Taylor
Grady Memorial Hospital

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ACCEPTANCE

This thesis, THE EFFECTIVENESS OF A VOLUME-BASED ENTERAL FEEDING PROTOCOL TO IMPROVE ENERGY INTAKE IN HOSPITALIZED CRITICALLY ILL ADULTS, by Anna Huffman was prepared under the direction of the Master's Thesis Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Master of Science in the Byrdine F. Lewis College of Nursing and Health Professions, Georgia State University. The Master's Thesis Advisory Committee, as representatives of the faculty, certify that this thesis has met all standards of excellence and scholarship as determined by the faculty.

____
Anita M. Nucci, PhD, RD, LD
Committee Chair

____
Kathy Taylor, MS, RD, LD
Committee Member

____
Katherine Wiley, MS, RD, LD
Committee Member

____
Date

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Anna Huffman
5202 Chastain Drive NE
Atlanta, GA 30342

The director of this thesis is:

Anita M. Nucci, PhD, RD, LD
Associate Professor
Department of Nutrition
Byrdine F. Lewis College of Nursing and Health Professions
Georgia State University
Atlanta, Georgia 30302

VITA

Anna Huffman

ADDRESS: 5202 Chastain Drive NE
Atlanta, GA 30342

EDUCATION:	M.S.	2018	Georgia State University Health Sciences
	B.S.	2017	Georgia State University Health Sciences

PROFESSIONAL EXPERIENCE:

- Dietetic Intern — 2017-2018
  Georgia State University, Atlanta, GA
- Graduate Teaching Assistant — 2017-2018
  Georgia State University, Atlanta, GA
- Assistant to Executive Vice President — 2014-2017
  Velocity Productions, Atlanta, GA
- Server — 2017-2018
  Houston’s, Atlanta, GA

PROFESSIONAL SOCIETIES AND ORGANIZATIONS:

- Academy of Nutrition & Dietetics — 2014-Present
- Georgia Academy of Nutrition & Dietetics — 2014-Present
- Ambassador, Byrdine F. Lewis College of Health Professions — 2015-2017
- National Nutrition Month Chair, Greater Atlanta Dietetic Association — 2017-2018
- Co-President, Nutrition Student Network — 2016-2017

AWARDS AND PUBLICATIONS:

- Dean’s List – Georgia State University — 2014-2015
- President’s List – Georgia State University — 2016-2018

ABSTRACT

EFFECTIVENESS OF A VOLUME-BASED ENTERAL FEEDING PROTOCOL TO IMPROVE ENERGY INTAKE IN HOSPITALIZED CRITICALLY ILL ADULTS

by

Anna E. Huffman

Background: Patients determined to be at high nutrition risk are most likely to benefit from early enteral nutrition (EN) therapy. The use of enteral feeding protocols has been associated with significant improvements in nutrition practice and overall nutrition adequacy. The effect of a combined-approach volume-based enteral feeding protocol on the percent of calories received by patients is unknown.

Objective: The aim of this study was to determine if a newly implemented combined-approach volume-based enteral feeding (VBF) protocol is more effective in the delivery of EN volume and calories in intensive care unit (ICU) patients compared with the previous rate-based protocol where 88% of patients achieved 85% of their caloric requirements.

Participants/setting: Eighteen critically ill adults hospitalized in either the burn or neurological ICU at a large urban hospital.

Main outcome measure: The percentage of calories delivered for each patient after a minimum of 7 days of protocol compliance.

Results: Ten patients (50% male, 70% Caucasian) received VBF in compliance with protocol for a median of 5.5 days (Interquartile Range; 4.8, 14.0). The percent of goal volume delivered for those who received at least 7 days of treatment (n = 4) was 104.2 ± 7.9.

Conclusions: The delivery of goal EN volume using VBF exceeded the average volume provided by the previous rate-based approach in a small sample of critically ill adults.

This study supports the use of feeding protocols in order to increase overall percentage of volume delivered. Additional research in a larger patient population is needed to determine the impact of this increase in volume delivery on patient outcomes.

EFFECTIVENESS OF A VOLUME-BASED ENTERAL FEEDING PROTOCOL TO IMPROVE ENERGY INTAKE IN HOSPITALIZED CRITICALLY ILL ADULTS

by
Anna E. Huffman

A Thesis

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ABBREVIATIONS

A	Age
ABW	Actual Body Weight
ASPEN	American Society for Parenteral and Enteral Nutrition
BMI	Body Mass Index
BMR	Basal Metabolic Rate
BSA	Body Surface Area (m^2)
CRRT	Continuous Renal Replacement Therapy
EEE	Estimated Energy Expenditure
EHR	Electronic Health Record
EN	Enteral Nutrition
FEED ME	Feed Early Enteral Diet Adequately for Maximum Effect
FWF	Free Water Flush
GI	Gastrointestinal
GMH	Grady Memorial Hospital
GRV	Gastric Residual Volume
IBW	Ideal Body Weight
IC	Indirect Calorimetry
ICU	Intensive Care Unit
kcal	Kilocalorie
mL/hr	Milliliters per Hour
NPO	Nil Per Os (Nothing by Mouth)
NRS 2002	Nutrition Risk Score 2002

NUTRIC	Nutrition Assessment in Critically Ill
PEP uP	Protein-Energy Provision via the Enteral Route in Critically Ill Patients
PN	Parenteral Nutrition
Pt	Patient
RCT	Randomized Controlled Trial
RDN	Registered Dietitian Nutritionist
REE	Resting Energy Expenditure
SB	Small Bowel
SPSS	Statistical Program for Social Sciences
STICU	Surgical Trauma Intensive Care Unit
T	Temperature in Celsius
TF	Tube Feed
T_{max}	Maximum body temperature in the past 24 hours
TTF	Trophic Tube Feed
V_E	Minute volume (in L/min)
VT	Tidal volume (L/min)

CHAPTER I

EFFECTIVENESS OF A VOLUME-BASED ENTERAL FEEDING PROTOCOL TO IMPROVE ENERGY INTAKE IN HOSPITALIZED CRITICALLY ILL ADULTS

Introduction

Patients determined to be at a high nutrition risk, such as critically ill patients in the Intensive Care Unit (ICU), are most likely to benefit from early enteral nutrition (EN) therapy.[1] Patients in the ICU are often in a high state of inflammation, leading to more prevalent development of nutrition issues such as increased nutrient requirements and malnutrition.[2] When compared to parenteral nutrition (PN) therapy, EN has been shown to aid in reducing infectious morbidity, noninfective complications, and ICU length of stay.[3-8] Additionally, EN has other benefits over PN such as decreasing metabolic response to stress, preventing oxidative cellular damage, maintaining gut integrity, and positively modulating the immune response.[9-11]

Critically ill patients are required to receive a full nutrition assessment by a Registered Dietitian Nutritionist (RDN).[1] Tools designed to assess malnutrition in an adult population include the Mini Nutritional Assessment, the Malnutrition Universal Screening Tool, the Short Nutritional Assessment Questionnaire, the Malnutrition Screening Tool, and the Subjective Global Assessment.[12] However, these tools may not be the best tools to use in a critically ill population. The NRS 2002 and the NUTRIC Score are better screening tools due to their ability to assess both nutrition status and severity of disease state. Additionally, they have been used in randomized controlled trials (RCTs) of the ICU population.[13-16] High risk status is determined by an NRS or NUTRIC score of greater than or equal to five.[13-18] The nutrition assessment of a patient in the ICU should also include an evaluation of comorbid conditions, function of the gastrointestinal (GI) tract, and risk of aspiration.[1]

Previously, the Protein-Energy Provision via the Enteral Route in Critically Ill Patients (The PEP uP Protocol) [19] and the Feed Early Enteral Diet Adequately for Maximum Effect (FEED ME) [20] protocol attempted to address the issue of underfeeding in the critically ill population by transitioning from a traditional rate-based enteral feeding protocol to a volume-based enteral feeding protocol. The use of enteral feeding protocols has been associated with significant improvements in nutrition practice and overall nutrition adequacy.[21]

The PEP uP Protocol prescribes a 24-hour volume goal and gives nurses guidance on how to make up volume if there is an interruption. It also encourages the use of protein supplements and motility agents at the start of EN initiation. In the initial feasibility study, the PEP uP Protocol demonstrated a statistically significant increase in intake during the early part of the ICU stay. Patients who were assigned to receive full volume-based feeds reached 90% of their calculated protein and energy requirements by Day 2 on average. Additionally, the increase in calories provided caused no increase in complications.[19] In a cluster-randomized trial of 1,059 mechanically ventilated critically ill patients, the PEP uP Protocol demonstrated a greater proportion of prescribed energy and protein delivered in the intervention sites. In addition, the authors reported a decrease in average EN initiation time compared to control sites.[21] In a multicenter quality improvement initiative, authors of the PEP uP Protocol found that patients in sites utilizing the protocol were receiving approximately 60.1% of their prescribed energy requirements compared to 49.9% in patients in control hospitals.[23] While the EN volume intake was improved over that of control sites, it is still well below the 80% goal indicated in the literature.[1]

The FEED ME protocol was developed in response to the inadequacies described in the Heyland et al. (2015) quality improvement study.[20,23] The protocol was developed to address barriers to rapid EN initiation in a surgical trauma intensive care unit (STICU), with modifications such as a protocol for nil per os (NPO) after midnight orders and initiation of dextrose solution when EN is held. The hours until initiation of EN did not improve with the introduction of this protocol. However, there was a statistically significant difference in percent volume, protein, and calories delivered. The mean percent of calories delivered also significantly increased in the FEED ME group.[20]

Grady Memorial Hospital (GMH) is an urban, Level I trauma center located in Atlanta, Georgia. With 957 beds[24] it is the largest hospital in the state of Georgia, and also one of the busiest in the United States.[25] Beginning March 5, 2018, GMH formally implemented the combined-approach volume-based enteral feeding protocol across the 103 beds in all the ICUs . In order to maximize the beneficial effects seen in both protocols, GMH developed a volume-based enteral feeding protocol that marries key aspects of both the PEP uP Protocol and FEED ME approaches. This combined-approach protocol addresses the aggressiveness found in the PEP uP Protocol and balances it with the practicality of implementation across the multidisciplinary team, utilizing an easy-to-use volume-based feeding algorithm first developed in the FEED ME protocol, and educating physicians and nurses about the lack of evidence behind using gastric residual volumes (GRVs) as a reason for withholding feeds. The protocol can be used with a variety of enteral formulas, and is initiated when goal rate is achieved. Further similarities and differences are shown in Table 1.

The effect of a combined-approach volume-based enteral feeding protocol on the percent of calories received by patients is unknown. The purpose of the proposed descriptive study will be to determine if a newly implemented combined-approach volume-based enteral feeding protocol is more effective in the delivery of EN volume and calories in ICU patients compared with the previous rate-based protocol.

Research Hypothesis: The percentage of patients who receive at least 85% of their caloric requirements will be higher after receiving 7 days of the combined-approach volume-based EN protocol vs. the rate-based approach

Null Hypothesis: There will be no difference in the number of patients who receive at least 85% of their caloric requirements between the new combined-approach volume-based enteral feeding protocol vs. the rate-based approach.

Literature Review

Caloric Requirements of Adult Patients in the Intensive Care Unit

Caloric requirements of patients in the ICU vary greatly from that of the normal, healthy population. For this reason, the American Society for Parenteral and Enteral Nutrition (ASPEN) has developed guidelines for the care of this specific population. The gold standard to determine calorie needs is indirect calorimetry (IC), and it should be used when available and in the absence of variables that affect its accuracy such as chest tubes, supplemental oxygen, certain ventilator settings, continuous renal replacement therapy (CRRT), anesthesia, physical therapy and excessive movement.[1] When IC is not available or appropriate, a published predictive equation or a simplistic weight based equation (25-30 kcal/kg/day) should be used to determine energy requirements.[1] Commonly used predictive equations are Mifflin St. Jeor[26], Harris-Benedict[27], Penn State[29], Ireton-Jones[30], and Swinamer.[31] The Mifflin St. Jeor equation is a predictive equation for resting energy expenditure (REE) based on the results of a study measuring the REE of both normal weight and obese individuals via indirect calorimetry. The equation is as follows:

REE (males) = 10x weight (kg) + 6.25 x height (cm) – 5x age (y) + 5

REE (females) = 10x weight (kg) + 6.25 x height (cm) – 5x age (y) – 161

The Harris Benedict equation established normal standards for basal energy expenditure. Its purpose was to create a baseline for comparison for individuals with disease states that may cause heightened basal energy requirements. The Harris Benedict equation is the most common equation utilized in clinical and research settings.[28]

BMR (males) = 66 +(6.2 x weight in pounds) + (12.7 x height in inches) – (6.76 x age in years) [27]

BMR (females) = 655.1 + (4.35 x weight in pounds) + (4.7 x height in inches) – (4.7 x age in years) [27]

The original Penn State equation was derived from data from ventilated critically ill trauma and surgery patients, and was modified in 2003 after research on the Mifflin St. Jeor equation demonstrated its superiority over the Harris Benedict equation. The 2003 equation therefore adopted the use of actual body weight.[29]

1998: (1.1 x value from Harris-Benedict equation) + (175 x T_{max}) + (32 x V_E) – 6,433[29]

2003: (0.85 x value from Harris-Benedict equation) + (175 x T_{max}) + (33 x V_E) – 6,433[29]

T_{max} = maximum body temperature in the past 24 hours

V_E = minute volume (in L/min)

The Ireton-Jones equations utilize the Harris-Benedict equations and account for disease state.[30]

1992: EEE for spontaneously breathing patients = 629 – 11 x (age in years) + 25 x (weight in kilograms) – 609 x (obesity: if present =1, absent = 0)[30]

2002: EEE for ventilated patients = 1784 – 11 (age in years) + 5 x (weight in kilograms) + 244 (gender: male = 1, female = 0) + 239 (diagnosis of trauma: present = 1, absent = 0) + 804 x (diagnosis of burn: present = 1, absent = 0)[30]

The Swinamer equation was developed to predict energy expenditure in mechanically ventilated, critically ill patients.[31]

EE = 945 (BSA) – 6.4 (A) + 108 (T) + 24.2 (breaths/min) + 81.7 (VT) – 4349[31]

BSA = body surface area (m^2)

A = age

T = temperature in Celsius

VT = tidal volume (L/min)

There is no evidence to suggest that one equation is superior to another in accuracy in the ICU population.[32-35] Predictive equations may be more inaccurate in obese and underweight patients.[36-38] Multiple studies have attempted to identify which equation is most accurate when compared to IC in these populations, but the results are mixed.[36-39] One study of 927 patients in various weight categories demonstrated that the Harris-Benedict and Mifflin did not agree with measures of REE when compared with IC, regardless of weight category.[38] The Ireton-Jones equation showed agreement with IC in the obese groups, but was not statistically significant when sex was accounted for. Overall precision was very low for all equations.[38] The highest percentage of cases that predicted REE within 10% of IC measurements was 31.3% using the Harris-Benedict equation, 22.2% for Ireton-Jones and only 17.8% for Miflin.[38] Based on the ASPEN recommendations, the condition of critically ill obese patients will not be worsened, and may even be benefitted by high-protein hypocaloric feedings. High-protein hypocaloric feedings have been shown to preserve lean body mass, mobilize adipose stores, and minimize metabolic complications of overfeeding as well as feedings that do not create an energy deficit.[40]

Prevalence and Consequences of Underfeeding in the Intensive Care Unit

Patients in the ICU are especially susceptible to underfeeding due to volatility of disease state, high levels of variation in energy requirements, and additional confounders such as medication, mechanical ventilation, and hypercatabolism related to critical illness.[44] Malnutrition in this patient population is also extremely prevalent, with some studies reporting up to 40% of patients being malnourished.[45] Numerous studies have noted calorie intakes of patients in the ICU at only 49-70% of calculated requirements.[46-50] Dvir et al. (2006) found that a population of ICU patients (N = 50) were receiving an average of 1512 kcal per 24 hours,[44] which is roughly equivalent to the calories necessary for a five foot three inch tall female to lose one pound per week. Additionally, the mean energy balance was -460 kcal per 24 hours, and mean cumulative energy balance was -4767 kcal for an overall ICU stay of 566 days (average length of stay was 26.0 ± 18.3 days).[44] One study comparing mechanically ventilated to non-mechanically ventilated patients demonstrated that percentage of energy delivered was significantly lower in ventilated patients.[50] Additionally, the energy requirements were higher for the mechanically ventilated group, leading to a more severe energy deficit.[50] Energy deficits in this population have been shown to increase clinical complications such as respiratory distress syndrome, sepsis, renal failure, pressure sores, and need for surgery.[44]

Tsai et al. (2011) found that patients receiving less than 60% of caloric requirements within the first week of illness to be at 2.43 times the risk of mortality than patients fed greater than 60% of energy requirements.[51] Another study that evaluated energy balance found that negative energy balance in the critically ill population led to higher incidence of complications, primarily infection, and that delay of feeding initiation often leads to energy deficits that cannot be recovered.[53] Especially in patients who are mechanically ventilated, delivery of 90% of energy requirements as well as a minimum of 1.2kcal/kg protein has been reported to result in decreased mortality.[54] The literature supports early and adequate delivery of energy requirements to establish better outcomes in this population.[52-55]

When to Initiate Enteral Nutrition

Early initiation of enteral feeding in the ICU population has been shown to improve outcomes such as reduced nosocomial infection, total complications, and mortality.[13,18] For these reasons, it is recommended that EN be initiated within 24-48 hours of admission in patients determined to be at risk.[1] When comparing early EN initiation with delayed initiation, a meta-analysis of 21 randomized controlled trials found that there was a significant reduction in mortality and infectious morbidity with early initiation.[1] In addition, in high-risk patients, the greater the percentage of goal energy delivered, the greater the reduction in mortality.[41] These findings lead to the recommendation to provide greater than 80% of goal energy in order to assume the lowest mortality risk.[13] To achieve clinical benefit of EN over the first week of hospitalization, ASPEN Guidelines suggest that efforts should be made to provide 80% of goal energy within 48-72 hours.[1]

Despite these guidelines, high-risk patients in the ICU are more likely to receive PN than EN due to concerns of aspiration, postoperative ileus, and anastomotic dehiscence.[42] Additionally, this patient population is also more likely to encounter a delay in EN initiation and fewer goal calories delivered due to increased incidences of holding feeds for diagnostic tests, surgeries, and other hospital procedures.[42] In an effort to increase the number of patients receiving goal calories, the ASPEN guidelines recommend that enteral feeding protocols be designed and implemented to increase the overall percentage of goal calories provided.[1.] In order to “make up” for calories lost during holding times, the focus of EN has shifted from a traditional rate-based approach prescribed in mL/hour to a volume-based approach prescribed in mL/day.

Current Volume-Based Protocols

PEP uP

The Protein-Energy Provision via the Enteral Route in Critically Ill Patients (PEP uP) Protocol provides a prescribed volume per day, which allows the nurse freedom in adjusting the hourly rate dependent upon the hours EN was held for various procedures. The key components of the PEP uP Protocol are starting feeds at the target rate and moving to a 24-hour volume goal when patients are relatively hemodynamically stable, initiating trophic feeds in patients deemed unsuitable for high-volume intragastric feeds, and initiation of protein supplements and motility agents with the start of EN.[19] In the initial feasibility study in mechanically ventilated adult patients in the ICU for more than 72 hours, the patients in the experimental group (n=30) received 67.9% of energy needs and 73.6% of protein needs as compared to the rate-based group (n=20) who received only 58.8% of energy needs and 61.2% of protein needs, although the differences were not statistically significant.[19] Of those in the experimental group who received full volume feedings (n=18), 83.2% of calorie and 89.4% of protein needs were met. By Day 2 of the protocol, patients receiving full volume-feeds received >90% of their calorie and protein requirements on average ($P = 0.02$ and P = 0.002, respectively compared to the rate-based group).[19] This study also showed no adverse effects resulting from implementation of the PEP uP Protocol.[19] In a multicenter, quality improvement study comparing PEP uP sites to control sites, Heyland et al. (2014) found that the number of calories and total nutrition received from EN was significantly greater in the sites utilizing the PEP uP protocol.[23] On average, patients at PEP uP sites received 60.1% of their prescribed energy requirements,[23] still well below the literature-based goal of 80%.[1]

FEED ME

In order to maximize EN delivery, the Feed Early Enteral Diet adequately for Maximum Effect (FEED ME) protocol modified the PEP uP protocol to address barriers to early EN initiation in STICUs specifically. Similar to the PEP uP protocol, feeding guides were developed to clearly indicate the new feeding rate or bolus when feedings were missed or held for procedures. FEED ME further defined the protocol in an NPO after-midnight order as well as the introduction of a dextrose solution to combat hypoglycemia in the event of GI complications that required holding of EN.

Taylor et al. (2014) examined the effect of the FEED ME protocol compared with a rate-based protocol.[20] With implementation of the FEED ME protocol in 56 patients, mean percent of calories delivered (calories delivered/calories prescribed) significantly increased with the FEED ME protocol as compared to the rate-based group ($P<.0001$).[20] While hours until initiation of EN did not improve with the introduction of this protocol, there was statistically significant difference in percent volume ($P=0.018$), protein ($P=0.017$), and calories ($P=0.018$) delivered.[20] Levels of protein provided (in g/kg/ABW) were also higher in the FEED ME group than the rate based group ($P=0.036$). Measures of tolerance such as emesis, GRVs, and diarrhea were similar in the rate-based and FEED ME groups, which disputes a primary concern for implementing a volume-based protocol. Overall, the protocol led to an average of 89% of prescribed goal being delivered for calories and protein, which exceeds the literature-based goal of 80%.[1] Differences between the PEP uP Protocol, FEED ME, and GMH protocols are shown in Table 1.

Table 1: Variations Between FEED ME, PEP uP, and GMH Protocols

Characteristic	FEED ME	PEP uP Protocol	GMH
Enteral Product	Variety (1.0-2.0 kcal/mL product)	Single semi-elemental, 1.5 kcal/mL	Variety
Volume Based	Yes	Yes	Yes
Start of Protocol	After patient achieved goal rate of EN	As soon as EN started	After patient achieved goal rate of EN
Initiation and Advancement	SB: Initiate 20 mL/hr, increase in 10mL/hr increments every 4 hr to goal Gastric: Initiate 100 mL every 4 hr, increase in 50 mL increments every 4 hr to goal	SB or Gastric: Initiate at goal mL/hr Option to order "trophic" feeds (20mL/hr only)	SB or Gastric: Initiate at goal mL/hr
Time Clock	24-hr clock 7AM-7AM	24 hr clock 7AM-7AM	24 hr clock 9AM-9AM
Makeup Rate Calculation	Based on EN prescribed goal rate, hours EN held, hours remaining *Example:* SB feeds goal 70 mL/hr held for 6 hr (1000-1600) = new rate of 80 mL/hr from 1600 to 0700	Based on EN volume prescribed, volume missed, and hours remaining *Example:* SB feeds goal 1690 mL/24hr held for 6hr; 1470 mL remaining to infuse before 0700 (1470 mL/15 hr) New rate 98 mL/hr from 1600 to 0700	Based on EN prescribed goal rate, hours EN held, hours remaining *Example:* Impact Peptide @ 60 mL/hr with 20 mL FWF q 2 hr Scheduled for surgery at 0900, feeds held 0900-1400 Pt missed 5 hrs of feeds, 0900-1400 = 5 hrs Look at Volume Based Feeding Algorithm – Find goal of 60 mL/hr and follow line over to 5 hours off. New Rate of 75 mL/hr until 0900 the following day

			and then revert back to 60 mL/hr
GRV Threshold	350 mL	250 mL	GRVs do not need to be measured in patients receiving volume based feeding unless requested and ordered by MD
Promotility Agents Routinely Used	No	Yes	No
Protein Supplement Routinely Used	No	Yes	No
Maximum Hourly Infusion Rate-Small Bowel	120 mL/hr	150 mL/hr	120 mL/hr
Gastric Feeding Maximum	400 mL every 4 hr (given as intermittent feeding)	600 mL (given as continuous 150 mL/hr)	120 mL/hr

GMH – Grady Memorial Hospital; mL – milliliters; mL/hr – milliliters per hour; kcal – kilocalorie; EN – enteral nutrition; SB – small bowel; FWF – free water flush; Pt – patient; GRV – gastric residual volume; MD – medical doctor

Methods

Sample Population Description and Study Design

This descriptive study included adult patients admitted to ICUs at GMH in Atlanta, Georgia between March 5, 2018 and October 5, 2018. The electronic health records (EHRs) of adult (>18 years) patients admitted over the study period who received EN were screened for eligibility. The study included patients who received EN via gastric or small bowel tubes as a sole nutrition source. Exclusion criteria included patients with contraindications to receiving EN, patients only receiving trophic tube feeding (TTF), rates defined as less than or equal to 20mL/hour, patients receiving a combination of EN and oral diet or EN and PN, pregnant women, prisoners, and patients less than 18 years of age. All data was extracted or calculated from information available in the patients' EHR. The data was entered onto a data collection form and each patient was assigned a unique identification number. The list of patient names and identification numbers was maintained by a Clinical Dietitian at GMH and stored on a secure GMH hospital server.

Study Protocol

The combined-approached volume-based protocol was implemented at GMH on March 5, 2018. The protocol initiation guidelines and monitoring schedule are as follows:

Initiation

1. Order is placed by primary team under Diet Tube Feeding ->Volume Based Feeding
2. The Registered Dietitian (RD) calculates the 24-hour goal rate and adjust the Volume Based Feeding order per protocol
3. Once goal rate achieved, volume based feeding guidelines are initiated at 9 AM the following calendar day with the 24 Hour Volume-Based Feeding Algorithm (Figure 1)[20]
4. Maximum infusion rate is 120 mL/hour
5. The Tube Feed (TF) pump is reset every morning at 0900. The rate is adjusted back to the initial recommended rate found in the TF order
6. When TFs are held for >1hour, the Registered Nurse (RN) restarts EN at the adjusted goal rate based on number of hours missed per the Volume-Based Feeding Algorithm (the algorithm is available as a hyperlink in the EPIC order)

Example 1:

- Tube feed order: Impact Peptide @ 60 mL/hour with 20 mL water flush q 2 hours.
- Patient is scheduled for a surgery with Ortho at 0900 tomorrow but can start tube feeds back after the surgery
- Tube feeds were held at 0900 and patient was returned to ICU at 1400
- Patient missed 5 hours of tube feeds, 0900 – 1400 = 5 hours
- Look at volume Based Feeding Algorithm – Find goal 60 mL/hour and follow line over to 5 hours off.
- Tube feeding to run at 75 mL/hour until 0900 the following day and then revert to 60 mL/hour. Continue flush of 20 mL every 2 hours.

Example 2:

- Tube feed order is Impact Peptide @ 60 mL/hour FWF 20 mL every 2 hours
- Patient scheduled for tracheostomy placement and Orthopedic surgery tomorrow at 0900
- Patient is going to be NPO at midnight. Patient is returned from OR at 1600
- Patient missed 16 hours of tube feeds, 0000 – 1600 = 16 hours
- Look at volume Based Feeding Algorithm – Find goal 60 mL/hour and follow line over to 16 hours off
- Tube feeding to run at 120 mL/hour until 0900 the following day and then revert to 60 mL/hr. Continue flush of 20 mL every 2 hours.

24 Hour Volume CONTINUOUS FEEDING GUIDE																					
Goal (ml/hr)	Hours TF held for test or procedure																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	≥21
100	105	110	115	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
95	100	105	110	115	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
90	95	100	105	110	115	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
85	90	95	100	105	110	115	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
80	85	90	90	95	100	105	110	120	120	120	120	120	120	120	120	120	120	120	120	120	120
75	80	80	85	90	95	100	105	115	120	120	120	120	120	120	120	120	120	120	120	120	120
70	75	75	80	85	90	90	100	105	115	120	120	120	120	120	120	120	120	120	120	120	120
65	70	70	75	80	80	90	95	100	105	110	120	120	120	120	120	120	120	120	120	120	120
60	65	65	70	70	75	80	85	90	95	105	110	120	120	120	120	120	120	120	120	120	120
55	60	60	65	65	70	75	80	85	90	95	100	110	120	120	120	120	120	120	120	120	120
50	50	55	60	60	65	70	70	75	80	85	90	100	110	120	120	120	120	120	120	120	120
45	50	50	50	55	60	60	65	70	70	80	85	90	100	110	120	120	120	120	120	120	120
40	45	45	50	50	50	55	55	60	65	70	75	80	90	95	105	120	120	120	120	120	120
35	40	40	40	45	45	50	50	55	55	60	65	70	75	85	90	105	120	120	120	120	120
30	30	35	35	35	40	40	45	45	50	50	55	60	65	70	80	90	105	120	120	120	120
25	25	30	30	30	35	35	35	40	40	45	45	50	55	60	65	75	85	100	120	120	120
20	20	20	25	25	25	30	30	30	30	35	35	40	45	50	55	60	70	80	95	120	120
15	15	15	20	20	20	20	20	25	25	25	30	30	35	35	40	45	50	60	70	90	120

TF – tube feeding, mL/hr – milliliters per hour

Figure 1: Feeding Algorithm used at Grady Memorial Hospital

Monitoring

- Refer to GMH policy on management of blood glucose in critically ill patients
- Physical assessment should be completed and documented by the RN based on current GMH protocol
- Gastric residual volumes do not need to be measured in patients receiving volume based feeding unless GRV requested and ordered by MD
- Monitor for signs of intolerance: abdominal distention, cramping, tenderness, patient complaints—if they are able to communicate them—nausea, vomiting, constipation, diarrhea

Registered Nurses were instructed not to hold tube feedings for <500 mL GRVs, which was approved by the Medical Executives Committee and implemented into the EN Orderset.

Following implementation of the GMH protocol, initial education efforts began August 1, 2017 to February 28, 2018. Team education sessions as well as individual instruction by nurse educators were conducted. Frequent reminders via email and at nurses' stations were also used to instruct the entire staff in the participating ICUs.

Dietary Assessment

Daily amounts of energy prescribed by the RDNs were collected and compared to actual amounts received over the 24-hour period. Enteral Nutrition formula and volume delivered (in mL) were extracted from EHR flow sheets kept by nurses. Target calories and protein per day were calculated in the RDN initial assessment. For patients of normal weight (BMI 19-24), 25-30 kcals/kg actual body weight (ABW) was used to calculate energy needs. For patients who were obese (BMI $\geq$35), 11-14 kcals/kg ABW was used to calculate energy requirements. Patients with higher caloric needs, such as individuals with HIV, underweight, malnutrition, and those receiving continuous renal replacement therapy (CRRT), were calculated based on 30-35 kcal/kg.

Definition of Variables

Data analysis was conducted for the population via EHR review and subdivided by age, race, ethnicity, gender, body weight, body mass index (BMI), and clinical characteristics (percentage of goal volume achieved after 72 hours, 7 days, 14 days, and 21 days). Nutrition care practices were recorded on the data collection spreadsheet but not utilized for results purposes. These measures included EN formula, placement of feeding (pre or post-pyloric), calories/kilogram prescribed, nutrition diagnosis, protocol compliance and reasons for protocol non-compliance. Data collection began with first initiation of a volume-based feed.

Statistical Analysis

The primary outcome measure was the percentage of calories delivered for each patient after 72 hours, 7 days, 14 days, and 21 days of protocol compliance. The overall percentage of patients who achieved 85% of their calorie needs via their EN feedings (88%) was compared to the percentage calculated after initiation of the combined-approach volume-based enteral feeding protocol. Descriptive analyses were conducted on the data using frequency analysis. The data was analyzed using the Statistical Program for Social Sciences (SPSS) version 25.0 database (SPSS, Inc., an IBM Company, Chicago, IL).

Results

Eighteen patients were included in the study. The majority of the patient population were non-Hispanic males (83.3%), with a mean age of 51 ± 3.7 years. The mean BMI (kg/m^2) of the total patient population was 31.0 $\underline{+}$ 2.4 (range, 26.1 to 36.9 kg/m^2, with 8 patients in the obese category. The majority of the population (61.1%) were patients in a neurological ICU.

Of the 18 patients whose EHRs were reviewed, 10 received VBF that was fully compliant with the combined-approach protocol. Reasons for noncompliance included lack of documentation, lack of adherence to prescribed TF volume goal, initiating the protocol before the goal rate was reached, holding feedings for GI upset not necessarily related to feeds, and lack of adherence to perioperative feeding guidelines. All subsequent analyses were conducted for the sample of patients who received VBF that was compliant with the protocol.

The sample population had an equal distribution of males and females and was predominantly non-Hispanic Caucasian (Table 1). All of the sample population received the volume-based protocol for 72 hours (Table 2). Patients who received the VBF protocol for 7 days or greater received a higher percentage of goal volume delivered than those who received the protocol for 72 hours. The percentage of goal volume delivered by the VBF protocol exceeded the average goal volume received.

Table 1. Demographic Characteristics of Sample Population

Characteristic	Sample N = 10
Unit [n (%)]	
3B Burn ICU	4 (40)
8B Neuro ICU	6 (60)
Age (years)*	49 ± 14.0
Race [n (%)]	
Caucasian	7 (70)
African American	3 (30)
Ethnicity [n (%)]	
Hispanic	3 (30)
Non-Hispanic	7 (70)
Gender [n (%)]	
Male	5 (50)
Female	5 (50)

*Mean ± Standard Deviation
ICU-Intensive Care Unit, Neuro- Neurological

Table 2. Clinical Characteristics of the Sample Population

Characteristic	Sample n	
BMI (kg/m^2)*	10	28.8 ± 9.2
Days on VBF**	10	5.5 (4.8, 14.0)
Percent Goal Volume (mL) Delivered		
After 72 hours*	10	98.3 ± 13.9
After 7 days*	4	104.2 ± 7.9
After 14 days*	3	105.4 ± 9.0
After 21 days	1	104.2

*Mean ± Standard Deviation
**Median (25th Percentile, 75th Percentile)
BMI - Body Mass Index (kilograms/meters^2); VBF - Volume Based Feedings; mL - milliliters

Discussion

The study evaluated the percentage of calories delivered to 18 critically ill adults hospitalized in either the burn or neurological ICU after a minimum of 7 days of VBF protocol compliance. Ten patients received VBF in compliance with protocol. Of these, four received at least 7 days of treatment where the average percentage of goal volume delivered exceeded 100. The results of the current study demonstrate that when the combined-approach protocol is implemented appropriately, it increases the delivery of EN volume compared to the previous rate-based approach at 7 days or greater after initiation of therapy. Therefore, we reject the null hypothesis that there will be no difference in the number of patients who receive at least 85% of their caloric requirements between the new combined-approach VBF protocol vs. the rate-based approach.

These results are consistent with those of previous studies such as the PEP uP[19, 21-23] and FEED ME[20] trials, in that they emphasize the advantage of utilizing feeding protocols in order to make up calories lost for holding of EN and increase overall percentage of feedings delivered. Similar to findings of a multicenter observational study evaluating the effectiveness of enteral feeding protocols in a critical care setting, which saw an increase in EN delivered for protocolized sites (70.4% compared to 63.6% in non-protocolized sites $P= 0.0036$),[21] we found an increase in EN delivered once patients were initiated on the VBF protocol. Our findings also indicated an increase in percent of volume delivered with implementation of the VBF protocol, similar to results observed with utilization of the FEED ME protocol by Taylor et al. (2014).[20] A 2015 quality improvement study by Heyland et al. noted that most sites utilizing the PEP uP protocol were smaller hospitals with fewer ICU beds.[23] Our research demonstrates that EN protocol use can be translated to a large, multi-ICU facility. In addition to increasing EN delivered, the data confirmed conclusions from previous studies[19-23] stating obvious improvements in nutrition care practices and nutritional adequacy when volume-based feeding protocols are utilized. We observed that once patients are initiated on a volume-based feeding regimen, they are more likely to be closely monitored for feeding status, GI intolerance, weight gain or loss, and overall outcome improvements.

The results of the current study reveal that the longer that a patient receives the protocol, the higher the percentage of goal volume delivered. This observation could be due to a couple of factors. Many patients miss excessive hours of feeds due to lack of compliance with perioperative guidelines and/or multiple procedures.[43] While the volume-based feeding algorithm is designed to make-up the volume based on hours missed, the maximum infusion rate is 120 mL/hr. For example, if a patient with an original goal feeding rate of 90 mL/hr (2,160 mL/day) missed 10 hours of feeds in a day, they would have missed 900 mL. The new rate of 120 mL/hr would need to be provided for more than one day (30 hours) to make up for the loss of volume. For this reason, volume-based feedings often need to be administered for multiple days to make up the initial deficit. Additionally, patients who have been on the protocol for a longer period of time may have an RN who is familiar with the protocol, leading to more appropriate rate adjustments, accurate documentation, and familiarity with guidelines for holding feeds. Those less familiar with the protocol may be hesitant to adjust the rate, may neglect proper documentation of rate changes, and may hold feeds for GI symptoms unrelated to feedings.

This study has several limitations. Lack of documentation and protocol compliance were the main barriers to obtaining a larger sample size and valid data. The protocol was new to GMH at the start of data collection, and while the staff were educated prior to the start of the study, the information needed reinforcement on a regular basis. Each unit is unique and has its own set of challenges. It takes a team of committed individuals to ensure that volume goals are being met, documentation is complete, and changes are communicated. Moreover, each unit has its own set of physician and nursing staff apprehensions to higher EN rates, and determining the root cause and providing guidance throughout the implementation process is a large time investment. Further training on proper volume-based feeding protocol procedures would reduce the lack of adherence to initiating prescribed TF volume goal, initiating protocol before goal rate was reached, holding feeds for GI upset not necessarily related to feeds, and lack of documentation.

The combined-approach volume-based feeding protocol was implemented in close proximity to GMH's new perioperative guidelines, which allow for patients to be fed up until their procedure (depending on the procedure), instead of being placed NPO at midnight. These guidelines will lead to fewer losses in volume delivered when implemented correctly. The implementation and acceptance of this protocol also has its own set of challenges, such as physician apprehension to feeding patients until time of procedure and breaking the habit of placing patients who are not undergoing abdominal surgery NPO at midnight. While the protocols work to compliment one another, they are significant changes that require more time to be accepted by all staff, and their simultaneous implementation may have hindered their acceptance. Initiation on the feeding protocol was also limited to patients who had achieved their target goal rate of EN, which excluded patients who may have acquired large calorie deficits while attempting to reach goal rate, and who may still benefit from a feeding protocol such as in the PEP uP trials.[19, 21-23]

The study did not utilize bodyweight as an outcome measure due to the high level of inaccuracy and lack of documentation at the facility. However, future studies are needed that utilize weight as a primary outcome measure to determine nutritional adequacy. Future studies are also needed to determine the most effective way to implement feeding protocols in various types of ICUs. Potential research should include surveying physicians to determine apprehensions toward volume-based feeding, analyzing efficacy of staff training programs, and exploration of alternative documentation methods. Additionally, apprehension to protocol implementation could be decreased if more research were done exploring innovative ways to increase EN tolerance in especially volatile populations, such as burn patients and those requiring CRRT. Future studies should also evaluate barriers to early EN initiation (within 24 hours), and modifications should be made to the protocol to address timely EN initiation.

Conclusion

Despite it's limitations, this study demonstrated the feasibility of implementing an innovative VBF protocol in a large, multi-ICU facility. Implementation of this combined-approach VBF protocol increases EN delivered in multiple types of ICUs. With proper implementation, these critically ill populations will receive adequate nutrition that will support healing. More research is required to determine the impact that the VBF protocol and subsequent increase in volume delivery will have on patient outcomes. The results of this study are consistent with the existing literature and supports the implementation of feeding protocols as standard practice in critically ill patients receiving EN.

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