IMPROVING THE DELIVERY OF ENTERAL NUTRITION IN THE NEUROCRITICAL CARE UNIT THROUGH THE IMPLEMENTATION OF A VOLUME-BASED FEEDING PROTOCOL

A Project Paper Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Nursing Practice

in

The School of Nursing

Rhode Island College

May 11, 2019

by

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Acknowledgements

Thank you to the following colleagues for their support and input throughout this project:

DNP Project Advisor: Debra Servello DNP, APRN NP, ACNP-BC

Content Expert: Melinda Hodne, DNP, RN, APRN NP

Organizational Mentor: Bradford Thompson MD

Biostatistical Analysis Mentor: Ronald Pitt PhD

Diane Bussick RD

and

The nurses and providers who care for the patients on the neurocritical care unit at

Rhode Island Hospital

Abstract

Background: Neurocritical care patients receiving rate-based enteral nutrition (RBEN) consistently received less than their full prescription of enteral nutrition (EN) volume due to interruptions in feeding. This study investigated the impact of the implementation of a volume-based feeding protocol (VBEN) on the percentage of prescribed volume of EN delivered over the course of patients' neurocritical care unit (NCCU) length of stay. *Aim:* The aim of this study was to better meet the nutritional needs of adult neurocritical care patients receiving nutrition through the enteral route. *Methods:* A retrospective pre and postimplementation chart review was conducted on adult patients with age 18 or greater and less than 90 years with a neurological-related injury or disease process who had EN initiated and delivered for three or more days during their stay in NCCU. *Results*: Despite no significant differences in characteristics or gastrointestinal complications between the groups, there was a significant increase in the percentage of prescribed EN volume delivered over the course of NCCU stay of 23.15% percentage points in the VBEN group (M = 95.3%, SD 4.92) as compared to the RBEN group (M = 72.15%, SD 10.55, t(27, n=40) = 8.89, p <<0.001, two tailed, unequal variances. *Conclusion:* VBEN can be safely implemented in the neurocritical care population and is associated with significant improvement in EN volume delivery.

Keywords: enteral nutrition, volume-based enteral nutrition, neurocritical care, underfeeding, malnutrition

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Improving the Delivery of Enteral Nutrition in the Neurocritical Care Unit Through the Implementation of a Volume-Based Feeding Protocol

Background/Statement of the Problem

Malnutrition is frequently overlooked in hospitalized individuals, with international studies reporting rates in the acute care setting between 20% and 50% (Jensen et al., 2010, Barker et al., 2011, Lim et al., 2012, Corkins et al., 2014). Since patients are at risk for malnutrition and often require enteral delivery of nutrients due to an inability to tolerate or process oral feeding, it is imperative that they receive early and adequate nutrition (McClave et al., 2016). Historically, on the neurocritical care unit (NCCU) at Rhode Island Hospital (RIH) enteral nutrition (EN) was delivered at a set rate (rate-based) for patients. Rate-based EN does not allow the registered nurse (RN) to increase the rate after interruptions leaving patients at risk for underfeeding (Kim et al. 2010, Yeh & Peev, 2016). Low caloric intake over time is associated with a) immunosuppression, b) impaired wound healing, c) muscle wasting, d) increased hospital and intensive care unit (ICU) lengths of stay, e) increased costs, and f) increased mortality (Barker et al. 2011, Elke et al. 2014, Yeh & Fuentes, 2016, Compher et al., 2017, Yeh, et al., 2017).

Further complicating the issue are the many barriers to achieving prescribed 24-hour EN volume delivery in the critical care setting. Barriers include interruptions due to patient care, tests, procedures, equipment issues, and delays in initiating EN (Kim et al., 2012). Multiple studies have shown the effectiveness in improving the delivery of EN utilizing a nurse driven volume-based delivery protocol (Drover et al., 2010; Taylor et al,

2014; Lee et al., 2016, Yerondopoulos et al., 2016); however, there is little evidence in the literature related to implementing such a protocol for the neurocritical care patient population. The purpose of this project was to adopt the American Society of Parenteral and Enteral Nutrition (A.S.P.E.N) and the Society for Critical Care Medicine (SCCM) guidelines (McClave et al., 2016) for delivering EN to adult neurocritical care patients at Rhode Island Hospital. The specific clinical question to be answered was "Will the utilization of a volume-based enteral nutrition (VBEN) feeding schedule in the neurocritical care setting better achieve the prescribed volume of calories than the current rate-based enteral nutrition (RBEN) delivery standard of care?"

Literature Review

A literature search was conducted using nine databases (PubMed, CINAHL, Cochrane Reviews, EBM Reviews, HealthSTAR, MEDLINE, OLDMEDLINE, Nursing @ OVID, and PsychINFO). In addition, reference lists and related articles were reviewed, and the A.S.P.E.N. and Society for Critical Care Medicine websites were searched for guidelines and recommended articles. Search parameters were adult patients, 2008-2019 and included the following search terms and combination of terms: malnutrition; underfeeding, nutrition; nutrition function; critical care; care of intensive care unit patient; enteral nutrition; enteral nutrition and neuroscience and/or critical care; enteral nutrition in neuroscience and/or critical care; nurse perceptions of nutrition in critical care; and critical care and enteral nutrition; and hospital and malnutrition. Exclusions were pediatric related articles or studies focused solely on parenteral nutrition (PN) or combined PN and EN delivery.

Prevalence and Impact of Malnutrition in Hospitalized Patients

Barker et al. (2011) conducted a review of the literature on the definition, identification, prevalence, and impact of hospital-acquired malnutrition; 79 articles were reviewed. Results revealed a high prevalence (20-50% depending on patient population and definition used) of malnutrition in hospital settings, as well as a lack of awareness among healthcare clinicians. The reviewers found that malnutrition may develop due to calorie intake deficit, increased caloric requirements related to disease and stress states, and/or underlying malabsorption states. Malnutrition was associated with immunosuppression, impaired wound healing, muscle wasting (as much as 30% decrease), increased hospital and ICU lengths of stay (3-6-day increase), increased costs, and increased mortality. The authors concluded that all hospital patients should receive a nutritional risk assessment upon admission and clinical practice guidelines should be utilized to maximize the delivery of nutrition. The narrative nature of the report and lack of meta-analysis are limitations of this study.

In a prospective, observational cohort study, Yeh & Fuentes (2016) investigated the effect of caloric and protein deficits on discharge destination for a sample of critical care surgical patients (n = 213). Exclusion criteria included: age under 18 years, less than 72 hours of EN nutrition and/or ICU length of stay, previous ICU admission, receiving EN prior to ICU admission, or a diagnosis of intestinal obstruction prior to ICU admission. Demographics, EN initiation time, prescribed calories/protein vs. actual calories/protein delivered, and cumulative ICU calories/protein deficits were collected and/or calculated. The primary outcome measured was discharge destination and secondary outcomes were 1) ICU length of stay 2) hospital length of stay, 3) 28-day

ventilator-free days, 4) in-hospital mortality, 5) 30-day mortality, and 6) complication rates. Results showed an increased rate of 30-day mortality (23% vs. 11%, $P = 0.39$) and a strong trend toward increased in-hospital mortality (26% vs, 16%, $P = 0.78$) in patients with a high calorie deficit. The authors concluded that high caloric and protein intake deficits were associated with lower rates of home discharge for surgical ICU patients; causality could not be inferred due to the observational design. In addition, the rate of discharge home was low ($n = 33$) in both the high and low nutritional risk groups, which the researchers speculated was due to a high percentage of trauma patients requiring rehabilitation related to their injuries.

Benefits of Adequate Enteral Nutrition

A secondary analysis of pooled data from the International Nutrition Survey and the Enhanced Protein-Energy Provision via the Enteral Route in Critically Ill Patients (PEP uP) was conducted to evaluate the effect of energy and protein intake via EN on the outcomes in septic patients. For this retrospective study, Elke et al. (2014), restricted their sample ($n = 2270$) to those patients in the original studies with an admitting ICU diagnosis of sepsis and pneumonia who were mechanically ventilated and received their nutrition solely through the enteral route. Means, ranges, counts, and percentages were calculated for categorical variables medians and quartiles for ventilator-free days and length of stay, and means and standard deviation for other continuous variables. Logistic and linear regression were used to examine associations between mortality and ventilator-free days with protein and calorie intake. The analysis was adjusted for timing of EN, length of EN delivery and ICU stay, and severity of illness. A sensitivity analysis was conducted to determine the association between the outcomes and EN delivery in the first

seven days. Results revealed that an increase of 1,000 kcal was associated with a decreased 60-day mortality (*OR* 0.61; 95% *CI* 0.48 – 0.77, *P* < 0.001) and 2.81 more ventilator-free days (95% *CI* 0.53 – 5.08, *P* = 0.02). These outcomes were also improved with an increase of 30 g of protein per day (*OR* 0.76; 95% *CI* 0.65 – 0.87, *P* < 0.001 and 1.92 days, *CI* 0.58 = 3.27, *P* = 0.005, respectively). The authors concluded that closer to recommended calorie and protein intake early in the ICU stay was associated with decreased ventilator days and mortality in critically ill sepsis patients. They acknowledge that the results should be viewed with caution due the pooled observational design. These results are not generalizable as they specifically relate to the critically ill medical sepsis patient.

A multicenter, multinational observational study was conducted by Compher et al. (2016) to determine whether EN protein and calorie intake has varying effects on patients with high NUTrition Risk in Critically Ill (NUTRIC) scores as compared to patients with low NUTRIC scores. The researchers utilized a web-based survey to collect data on mortality, ICU and hospital length of stay for patients in the ICU for 60 days. Goal caloric/protein and actual caloric/protein delivery from feedings and medications for 12 consecutive days was also reported. Exclusion criteria included patients with an ICU length of stay less than four days. The final sample consisted of 2,853 patients and a subset sample of patients (*n* = 1605) who remained in the ICU for at least 12 consecutive days. Statistical analysis was conducted utilizing logistic regression with R^2 and *C*-statistic calculation to assess goodness of fit for each model and a sensitivity analysis was done to control type of admission and length of stay among survivors. Time to discharge alive was reported as a hazard ratio. EN was the primary mode of delivery for

the majority (75.5%) of patients. Key significant findings included an 11.6% (*n* = 891; *OR*, 0.884; 95% *CI*, 0.829-0.941; *p*,0.001) decrease in the odds of death and a 9.1% (*n* = 891; *HR*, 1.091; 95% *CI*, 1.032-1.155; *p*,0.002) shorter time to discharge alive for high-risk patients with each 10% increase in delivery of goal calorie intake. The authors concluded that patients with a higher nutritional risk score at time of ICU admission may benefit from protein and caloric intakes closer to goal especially if they will have a prolonged ICU length of stay. Given that greater intake did not negatively impact patients with a low nutritional risk score, the researchers recommended a general strategy of delivering optimal feeding since it is impossible to predict which patients will have a protracted ICU admission. The following limitations were noted: less than two-thirds of the patients reached protein and caloric intake goals, and the potential for data entry misclassification by volunteers entering the data.

Nutrition Practices

Drover et al., 2010 conducted an international, prospective, observational descriptive study focused on nutritional practices in 269 critical care units with at least eight beds and a volunteer with knowledge of clinical nutrition willing to collect and submit data. The goal of the study was to compare nutrition practices and outcomes between medical and surgical patients and identify gaps between actual nutrition delivery and best practices. Each ICU enrolled 20 patients. Inclusion criteria included patients who: were 18 years-of-age or older, mechanically ventilated within 48 hours of admission to the ICU and remained in the ICU for greater than 72 hours. The sample came from 269 international ICUs with a final total of 5447 eligible patients (37.7% surgical). Data were collected and entered on to a secure on-line data collection tool for a

maximum of 12 days for each patient enrolled. Demographics, total amounts of protein and calories delivered, days without EN or PN, morning blood glucose, total insulin dose, supplemental glutamine and selenium use, and prescribed promotility medications were utilized in the tool. Categorical variables were analyzed using the Rao-Scott adjusted X^2 method and continuous variables were analyzed by a linear mixed effects model utilizing statistical analysis software.

The study by Drover et al., 2010, revealed that surgical patients were significantly less likely to be fed by the enteral route as compared to medical patients (54.6% vs. 77.8% respectively) and feeding was initiated an average of 21 hours later (57.8 vs. 36.8 hours, $P < .0001$) and therefore surgical patients received a lower proportion of their initial feeding from EN (33.4% vs. 49.6%, $P < .0001$). In addition, surgical patients were less likely to receive adequate nutrition during the first 12 ICU days (10.5% less) than medical patients. The researchers concluded that surgical patients receive less nutrition during the early stages of their critical illness than medical patients because of delayed initiation and/or less use of the enteral route.

Bloomer, Clark, & Morphet (2017) investigated Australian ICU nurses' prioritization of EN utilizing an anonymous descriptive online questionnaire; scaled and open-ended questions were included. Face validity was conducted using experts including medical and nursing staff and a dietician. Out of the 1,726 questionnaires sent out, 359 were returned complete and included in the sample. The authors used descriptive statistics and Elo and Kyngas' (2008) inductive approach to analyze qualitative data. Representative responses to the open-ended questions were reported by Bloomer et al. to provide a rich sense of the participants perceptions and experiences regarding EN

practices in the ICU. Two themes emerged: competing demands in the ICU lowered EN delivery as a priority and delays in prescribing EN and EN interruptions were contributing factors lower percentages of EN delivery. Limitations included a higher proportion of postgraduate qualified nurses, a low response rate (20.8%), and some confusion regarding the eight care choices that the nurses were asked to prioritize along with EN delivery, which was prioritized as number six out of the eight choice. The authors concluded that other clinical treatments were given higher priority the EN leading to delays and interruptions.

Barriers to Enteral Nutrition Delivery

Cahill, Murch, Cook, & Heyland (2012) studied barriers to feeding critically ill patients in a cross-sectional survey of critical care nurses in five North American hospitals. Site inclusion criteria were: a) a minimum of eight ICU beds, b) resourced by a registered dietician, and c) auditing record proving an average of less than 60% delivery of prescribed calories. The survey utilized the Knowledge Action Model framework and was piloted to establish content and face validity and internal reliability. Nurses from five ICUs were sent the survey and had the option of completing either a web-based survey, an electronic fillable PDF, or a paper-based survey. Participation was voluntary and questions were answered on a Likert-like scale. One hundred and thirty-eight nurses volunteered to complete the survey, a 41% response rate. Descriptive statistics were applied and x^2 test was used; statistical significance was set as $P < .05$.

Cahill et al. (2012) reported the following most common barriers a) other aspects of patient care taking priority over nutrition (47%-57%), b) not enough feeding pumps on the unit (27%-70%), c) formula not available on unit (27%-70%), d) delays in obtaining

small bowel access for those not tolerating the gastric route (32%-65%), e) limited or no dietician coverage on weekends and holidays (33%-58%), f) delay in tube placement (25%-80%), g) delay in ordering EN (26%-50%), h) non-ICU physician requesting patients not be fed enterally (27%-58%), i) delays in initiating motility agents (29%-65%), and j) delay in dietician assessment of patient (26%-45%). The researchers recommended a multidisciplinary collaborative approach to overcoming these barriers. Limitations of this study include the voluntary, nonrandom design and is nongeneralizable outside of the geographical region and critical care nursing practice area. In addition, the responses are based on nurses' anecdotal knowledge and perspective rather than actual data entry of barriers at the time of occurrence.

Kim et al. (2012) conducted a review of the literature to determine barriers to the delivery of adequate EN in the critical care setting; 30 articles were included. The researchers excluded reviews, commentaries, editorials, letters, and articles related to practice guidelines. Kim et al. sorted the identified barriers into categories: a) patient-related factors, b) feeding method factors (feeding formula and feeding tube site), c) feeding process factors (initiation time, time to target goal), d) under-prescription by physicians, and e) interruption of EN delivery. Of these, it was determined that interruptions in EN delivery (average 2.3 to 7.0 hours daily per patient, 19.6% to 32% of total feeding time) were a significant barrier to achieving recommended day feeding goals. The researchers reported the following commonly identified issues related to EN interruptions: a) problems with the feeding tube, c) gastrointestinal intolerance, d) procedures/ surgeries, e) radiology, f) nursing care, g) hemodynamic issues, and h) airway issues. They concluded that EN interruptions were critical barriers to adequate EN

delivery and that many of the causes were preventable. Although Kim et al. (2012) were unable to prove a cause and effect relationship between these barriers and failure to achieve adequate nutrition due to the designs of the included studies, they recommended utilization of standardized feeding protocols to minimize interruptions. There is a need to conduct randomized control studies in this area of research.

Huang et al. (2018) conducted a survey to study nurses' perspectives of the barriers to providing enteral nutrition to critical care patients. The cross-sectional descriptive study included registered nurses who had worked in the ICU at least one year and were not nurse interns, advanced study nurses, or nurses rotating through the unit. Eight hundred and twenty questionnaires were returned and 808 were included in the study for a response rate of 98.5%. The researchers reported three factors influencing enteral feeding barriers as related to ICU patients and identified the following strategies to overcome them: a) provided ongoing EN-related training to nurses working in ICUs, assure fulltime nutritionist coverage, and implement hospital protocols for EN delivery. Limitations included a convenience sample, no differentiation between general and specialized ICU data during analysis, and data authenticity was not assured.

Impact of Volume-Base Enteral Nutrition Delivery

Taylor et al. (2014) conducted a pre and postimplementation quasiexperimental study to evaluate the effect of the Feed Early Enteral Diet Adequately for Maximum Effect (FEED ME) protocol in comparison to the rate-based standard of care method in the delivery of EN volume, calories, and protein protocol in a surgical trauma intensive care unit (STICU). The sample included a non-equivalent control group (n = 54) which received EN via a standard of care rate-based delivery approach and an intervention

group (*n* = 56) which received EN via a newly developed volume-based delivery FEED ME protocol. Data was collected retrospectively through the electronic health record. Inclusion criteria for both groups included STICU patients of at least 18 years of age who: 1) achieved EN target goal and received EN for 72 hours after goal achieved, 2) were mechanically ventilated on admission to unit or within 6 hours, and 3) had an STICU length of stay of at least seven days. The Kolmogorov-Smirnov 2-sample test (a goodness of fit test) was used to determine significance of any differences between the control (*n* = 54) and FEED ME (*n* = 56) groups (total *n* = 110). The researchers found significant improvements in the FEED ME group related to mean percent of calories delivered (control: 63% ± 20%; FEED ME: 89% ± 9%; *P*< .0001). The authors concluded that an association exists between volume-based delivery and improved EN delivery as compared to a standard rate-based approach. The sample excluded patients not requiring mechanical ventilation who received EN, a limitation to generalizability; in addition, there was a potential for data entry error. The study is not generalizable outside of the population studied but is useful for developing a similar protocol to implement and evaluate in other ICU settings.

Yerondopoulos et al. (2016) conducted a prospective, pre and postimplementation descriptive study investigating the effects of the Bridging Under-nutrition and Malnutrition in Patients Up to Par (BUMP UP) protocol; this study was reported as a preliminary brief. The sample (*n* = 70) included 20 medical (51.3%), 11 neurologic/ trauma (28.2%), 5 surgical (12.8%), and 4 cardiovascular (10.3%) critically ill patients being cared for in several ICUs. The BUMP UP protocol was a nurse-driven strategy volume-based EN delivery strategy where EN rate was titrated to account for volume

missed due to EN interruptions to increase the likelihood of achieving target nutrition intake goals. Results showed that time to initiation of EN was decreased from 55.6 hours to 36.6 hours ($p = .007$) and the percentage of total daily recommended calories increased from 65% to 79% ($p < .001$). The researchers concluded that a multidisciplinary approach utilizing a nurse-driven protocol which includes early initiation of EN and volume-based delivery has a positive effect on the delivery of EN in patients on a variety of ICUs. The size of the study is a limitation; however, further analysis of the strengths and limitations must be deferred until full publication of the results.

Yeh et al. (2017) conducted a prospective, descriptive, observational study to investigate the effects of the implementation of an aggressive EN protocol in two surgical and trauma ICUs. The control group received EN via the standard of care delivery approach and the intervention group received EN utilizing an aggressive EN protocol which included setting increased protein prescription targets and providing compensatory EN close to the time of any EN delivery interruption. The intervention group ($n = 119$) included patients during the 12 months after implementation who were 18 years of age or older and received >72 hours of EN. Exclusion criteria included patients who received EN prior to admission to ICU and patients who previously been admitted to the ICU during the current hospital admission. The control group ($n = 94$) was made up of patients meeting inclusion criteria in the 12 months prior to the implementation of the intervention, a potentially nonequivalent group.

Yeh et al. (2017) found significantly higher percentages of patients in the intervention group received a) additional protein supplement (58% vs 28%, $P < .0001$), b) more calories (18.6 [5.0] kcal/kg/d vs 16.5 [5.9] kcal/kg/d, $P = .005$) and protein (1.2

[0.4] g/kg/d vs 0.8 [0.3] g/kg/d, *P* < .0001), c) a higher percentage of prescribed calories (77% vs 68%, *P* = .0004) and protein (93% vs 64%, *P* < .0001). In addition, ICU and hospital length of stay were significantly shorter in the intervention group (10 [7–17] vs. 15 [10–27] days, *P* = .0003 and 20 vs 29 days *P* < .0001, respectively) and after the Poisson regression analysis applied controls, there was a significantly lower risk of late infection (adjusted risk ratio, 0.69; 95% *CI*, 0.50–0.95; *P* = .024) in the intervention group.

Limitations of the study included the potential for data entry errors. The results of this study are not generalizable to other patient populations; however, although causation could not be proven, the researchers concluded that the strong association combined with the results of other studies is supportive of a trial of an aggressive EN protocol in other ICU settings.

Bielewicz et al. (2018) studied the effectiveness of the implementation of a tube feeding algorithm on reducing enteral nutrition volume deficits during the first five days of surgical and trauma patients stay in the ICU. The quality improvement (QI) initiative utilize a pre and postimplementation design. The initiative included identification of the 24-hour EN volume goal, calculation of the volume delivery deficit at 23 hours, and delivering a bolus of the deficit volume during the 24th hour of each day. The authors used a systematic approach to chart review to determine the difference between delivered and prescribed EN volume; 214 charts were reviewed and a total of 29 patients met the inclusion criteria of having a minimum ICU LOS of five days and prescribed EN. Significance was set at $\alpha = .05$. The two groups were not significantly different in characteristics and the authors found that there was an improvement in volume of EN

delivered to the study group vs. the control group (60.4% ± 18.5% vs. 49.8% ± 21.6%, *P* = 0.4). Bielewicz et al. concluded that the use of an evidence-based algorithm was useful in improving the delivery of EN to surgical and trauma ICU patients. Limitations to this study included a high staff turnover on the unit, varying practices of the providers on the unit, and a small convenience sample from a single unit.

Enteral Nutrition Guidelines

McClave et al. (2016) conducted a review of the literature to develop evidence-based guidelines for the SCCM and A.S.P.E.N regarding enteral nutrition practices in the ICU. Within the guidelines are the following general recommendations for ICU patients: a) increase the overall percentage of goal calories provided through the use of enteral feeding protocols (moderate to high evidence), b) design and implement volume-based feeding protocols (expert consensus), c) do not routinely monitor GVRs (low level of evidence), and d) if using GVRs, do not hold EN for GVRs < 500 ml in the absence of other signs of intolerance (low level of evidence). In addition, the guidelines recommend initiating EN within 24 to 48 hours of injury once the patient is hemodynamically stable (very low evidence).

Blaser et al. (2017) conducted a review of the literature to develop evidence-based guidelines for the European Society of Intensive Care Medicine regarding early enteral nutrition in the ICU setting. Early EN (EEN) was defined as any EN initiated within 48 hours of ICU admission and recommendations derived from randomized control trials were graded as evidenced-based, whereas any recommendations based on any other type of evidence graded as expert opinion (very low-grade quality evidence). Within the guidelines are the following EEN recommendations regarding neurological ICU patients,

all graded as expert opinion: a) use EEN in patients with traumatic brain injury, b) use EEN in patients with stroke (ischemic or hemorrhagic), and c) use EEN in patients with spinal cord injury. In addition, the following general recommendations are made regarding EEN and ICU patients, all graded as expert opinion: delay EN if gastric aspirate volume is > 500 ml in six hours, b) use EEN regardless of presence of bowel sounds unless bowel ischemia or obstruction is suspected, and c) use EEN in patients with diarrhea.

Enteral Nutrition in Neurocritical Care Patients

Zarbock et al. (2008) investigated EN delivery in the neurosurgical ICU during patients' first of illness utilizing a retrospective cohort chart review design. The authors separated patients into three groups based on Glasgow Coma Scale score (GCS): GCS >11 (*n* = 23), GCS 8-11 (*n* = 23), and GCS 4-7 (*n* = 25). The researchers found that the maximum daily mean calories delivered was 55% of goal on hospital day 6. The median time to EN initiation was three days across all groups and delay in EN initiation contributed to the failure of meeting early EN targets generally related to ordering and feeding tube placement and confirmation delays. EN intolerance did not play a role in failure to achieve EN delivery targets nor did patient acuity. Limitation include inconsistency in medical record documentation, stratification of patients according to GCS which may be a changeable value. The authors concluded that system factors were the major cause of EN initiation delays and that EN protocols should be developed and implemented to overcome these barriers.

Kim et al. (2010) conducted a prospective and descriptive study on underfeeding in patients spontaneous (*n* = 30) or traumatic (*n* = 14) brain hemorrhage, brain tumor

(*n* = 2), or spinal cord injury (*n* = 1) who received intermittent delivery of EN during their stay in the neurosurgical ICU. Patients with missing data, who died or were discharged before day seven of EN support, or for whom there was high suspicion of infection were excluded. Fifty-two patients were identified, and 46 patients met inclusion criteria; data was collected for the first seven days of EN support. Some patients received a combination of EN and PN to meet their nutritional needs. The authors defined underfeeding as an intake of < 80% of estimated required energy and overfeeding as an intake >110% of estimated required energy. Descriptive statistics, Student *t* test, and Pearson's correlation were performed. The authors found that underfeeding occurred in 52.17% (*n* = 24) of patients and overfeeding occurred in 6.52% (*n* = 3). Underfed patients received between 33% to 79% of their EN (*M* = 61.9, *SD* = 12.58). The authors concluded that RN practices were inconsistent related to the provision of EN and that a strict adherence to EN delivery protocols would prove useful in improving the percentage of EN delivered. Limitations of this study include a small sample size and that the study window regarding length of time on EN should be expanded. The results of this study cannot be generalized outside of the identified population.

Chapple et al. (2018) explored the views and attitudes of 18 nurse practitioners and 16 physicians about EN barriers in TBI general and ICU patients. A qualitative exploratory approach utilizing point in time face to face questioning combined with a case study garnering scenario-based responses. The authors used participant quotes extensively when reporting results. The major themes emerged: a) EN practices are dependent on course of recovery, b) EN implementation is influenced by practitioner roles and expectations, and c) TBI patients present the care team with competing

priorities. The authors identified site location as a limitation as both had a high degree of nutritional practice incite. The authors also reported the trend of reacting to undernutrition only when symptoms occurred rather than proactively planning nutritional therapy.

The review of the literature reveals a high prevalence of inadequate EN delivery in the ICU setting potentially leading to low caloric intake placing patients at risk for malnutrition. Low caloric intake over time is associated with a) immunosuppression, b) impaired wound healing, c) muscle wasting, d) increased hospital and intensive care unit (ICU) lengths of stay, e) increased costs, and f) increased mortality (Barker, et al., 2011, Elke et al., 2014, Yeh & Fuentes, 2016, Compher et al., 2017, Yeh, et al., 2017). Many barriers exist to the provision of adequate EN with interruptions in delivery being especially impactful yet frequently preventable or mitigable (Cahill et al., 2012, Kim, et al. 2012). Volume-based EN delivery protocols have been found to increase the percentage of prescribed volume and calorie delivery thereby improving patient outcomes in several ICU settings (Taylor, et al., 2014, Yerondopoulos et al., 2016, Yeh et al., 2017). Although there is a dearth of studies demonstrating the effect of VBEN delivery in neurocritical care patients, the evidence supported the trialing of such a protocol in this practice setting.

Theoretical Underpinnings

Kotter's 8-Step Process for Leading Change served as the theoretical framework for this study. Kotter developed the model after observing that the world was changing with increasing rapidity and that humans were unable to keep up with that change and

organizations were falling behind. Kotter also noted the following obstacles to adopting and implementing change: a) disengagement from roles, colleagues, and customers; b) a constant sense of urgency rather than planning for change; c) complacency, causing a failure to institute change; d) a lopsided focus on management rather than leadership; and e) siloed processes causing more boundaries than opportunities. These barriers encourage the status quo and needed change fails to occur leading to poor outcomes and wasted time, effort, and money (Kotter International [KI], 2017). In healthcare, these barriers directly affect healthcare workers' ability to provide evidence-based care and maximize patient outcomes. The following bulleted steps (KI, 2017) outline how Kotter's model (Appendix A: Model of Kotter's 8-Step Process for Leading Change) were utilized to address the problem of underfeeding ("The Big Opportunity") through the implementation of a VBEN feeding schedule on the neurocritical care unit.

1. Create a sense of urgency: The evidence supporting the prevalence of malnutrition in hospitalized patients was presented in discussions with the neurocritical care nurses and providers. Nurse perception and anecdotal knowledge of EN feeding interruptions was explored and validated by unit specific data from the gap analysis.
2. Building a guiding coalition: A core multidisciplinary team was formed.
3. Form a strategic vision and initiative: Utilizing a project planning tools such as a SWOT analysis and Gantt chart helped identify supports and barriers to the project and outline the steps needed to develop, implement, and evaluate the initiative.
4. Enlist a volunteer army: NCCU RNs were universally supportive of the project.

5. Enable action by removing barriers: This project removed the barriers to standard and consistent ordering of the protocol which will facilitate implementation throughout the organization.
6. Generate short term wins: Providing the frontline clinical staff with feedback regarding the protocol implementation was key to the success of this initiative.
7. Sustain acceleration: Providing feedback related to improvement in EN delivery, listening to nurse and provider feedback regarding barriers, workflow issues, and improvement suggestions helped to maintain and sustain clinical staff engagement.
8. Institute change: Sustainability is key to lasting change; communication of the impact of VBEN on the percentage of prescribed 24-hour EN to the frontline clinical staff showcased how their efforts made a difference to the patients they care for and helped maintain enthusiasm for the initiative.

Needs Assessment

The primary investigator conducted a gap analysis on the NCCU at RIH which revealed the following statistics regarding the frequency of EN delivery and interruptions in the delivery of EN to patients cared for on the NCCU. Seventeen patient electronic records were reviewed. Four patients (23.5%) were not receiving EN; three patients (17.6%) had nasogastric (NGT) or orogastric (OGT) tubes and were awaiting the initiation of EN, and the remaining ten patients (58.8%) were receiving EN. For the patients receiving EN, there were multiple instances of delivery interruption ranging from one to twelve occurrences per patient during their NCCU stay; these did not include the

undocumented daily interruptions related to the provision of patient care. In addition, each patient receiving phenytoin enterally had EN held before and after administration two to three times a day. Other reasons for EN delivery interruptions were multifactorial (Appendix B: Results of Preimplementation Gap Analysis). Three of the interruption causes were related to patient condition: gastrointestinal bleeding, high gastric volume residuals (GVR), and patient decline. All other interruptions were related to procedures and diagnostic imaging on and off the unit, extubation, or pump availability. The duration of these interruptions ranged from 30 minutes to 60 hours (M = 6 hr). Interruptions negatively impacted the delivery of prescribed enteral nutrition volume and calories, leaving NCCU patients at risk for underfeeding. These data demonstrate the gap in the delivery of prescribed EN volume for patients cared for in the NCCU.

Purpose, Aim, and Objectives

Purpose

The purpose of this project was to adopt the American Society of Parenteral and Enteral Nutrition (A.S.P.E.N) and the Society for Critical Care Medicine (SCCM) guidelines (McClave et al., 2016) for delivering EN to adult neurocritical care patients at Rhode Island Hospital. The specific clinical question to be answered was "Will the utilization of a volume-based enteral nutrition (VBEN) feeding schedule in the neurocritical care setting better achieve the prescribed volume of enteral nutrition than the current rate-based enteral nutrition (RBEN) delivery standard of care?"

Aim

The aim of this study was to increase the likelihood of neurocritical care patients 18 years and older receiving the predetermined goal of 85% or more of the prescribed volume of enteral nutrition over the course of the NCCU length of stay through the use of a volume-based feeding schedule which allows the RN to increase tube feeding rate after interruptions occur.

The aim of the project is supported by the hospital-acquired malnutrition prevention critical pathway (Walsh, 2017. [Appendix C: Hospital-Acquired Malnutrition Prevention Critical Pathway]). This fluid pathway highlights the importance of identifying the most appropriate method of nutrition delivery coupled with a continuous reassessment process aimed at a progressive transition to oral nutrition.

Measuring performance allows the organization to document how well nutritional support is being provided and lays the foundation for performance improvement utilizing recommended guidelines from A.S.P.E.N. and SCCM. The following aspects of this measure meet the characteristic of a good performance measure as outlined by the Institute of Medicine (Institute of Medicine, 2001):

- *Relevance*: Hospital-acquired malnutrition is a frequently overlooked complication. In the neurocritical care unit this may be related to interruptions in enteral feeding due to procedures, operations, and traveling off the unit for diagnostic tests.
- *Measurability*: Volume of enteral nutrition and daily caloric intake can be realistically and efficiently measured through auditing of the patient's electronic medical record (EMR).

- *Accuracy*: VBEN delivery is based on the guidelines of the A.S.P.E.N. and SCCM.
- *Feasibility*: The change to VBEN delivery can be realistically implemented within the current care environment of the NCCU

The hospital-acquired malnutrition prevention critical pathway is in alignment with the resources available on the NCCU. Each of the pathway's steps is important to reduce the risk of hospital-acquired malnutrition in the neurocritical care patient and emphasizes the need for reassessment if the patient's mode of nutrition delivery changes in order to achieve optimal nutritional support and delivery of calories and protein:

1. The patient presents for care on the NCCU as a result of any of the following:
    a. admission from the emergency department (ED);
    b. direct admission from the operating room (OR);
    c. admission from the post-anesthesia care unit (PACU);
    d. direct admission from the rehabilitation or psychiatric units; and
    e. transfer from a lower level of care within the hospital.
2. The mode of nutritional intake is determined through multidisciplinary assessment, including any or all the following disciplines:
    a. nursing;
    b. providers;
    c. speech and language pathologist;
    d. clinical nutrition; and
    e. registered dieticians.

3. The registered dietician makes recommendations for daily nutritional goals based on:
    a. the patient's diagnosis and history;
    b. calculation of daily caloric and protein needs; and
    c. whether the patient is receiving any caloric intake related to lipid-based medications.
4. The ordering provider reviews the registered dietician's recommendations and determines the mode of nutritional support appropriate for the patient which may include:
    a. bowel rest without nutritional support;
    b. oral feeding;
    c. enteral feeding;
    d. parenteral feeding; or
    e. a combination of any of the above.
5. If the ordering provider determines that enteral feeding is the appropriate mode of nutritional support, he/she will choose between a:
    a. rate-based EN delivery protocol or
    b. volume-based EN delivery protocol.
6. The multidisciplinary team reviews the patient's status daily and adjusts the plan which may include:
    a. adding nutritional support;
    b. withholding nutritional support;
    c. changing the mode of nutritional support;

d. changing to a combination of nutritional support modes, such as daytime oral feeds and nighttime enteral feeds; and/or
e. increasing or decreasing daily nutritional targets.

Factors impacting the critical pathway.

Patient Factors.

The critical pathway may be affected by patient factors, including, but not limited to:

- increased metabolic needs related to injury, illness, sepsis, infection, fever, and burns;
- gastrointestinal issues related to malabsorption, obstruction, or dietary sensitivities;
- anorexia related to dementia, illness, or drug side-effects,
- poor dentition;
- swallowing difficulties;
- loss of feeding tube or intravenous access;
- interruption in feeding related to surgery, procedures, and/or travel to diagnostic tests;
- esophagitis, and/or;
- dysphagia.

Care team factors.

The critical pathway may be affected by care team factors, including, but not limited to:

- delay in initiating nutritional support;
- delay in confirmation of enteral and parenteral access;
- delay in initiating motility agents;
- failure to view nutritional support as a high priority;
- delay in screening for swallowing difficulties;
- lack of discussion of nutritional support on daily rounds;
- delay in nutritional assessment;
- lack of awareness of ICU nutritional guidelines;
- failure to progress patient feeds according standard protocol, and
- utilization of a rate-based rather than a volume-based EN delivery protocol.

Health system factors.

The critical pathway may be affected by health system factors, including, but not limited to:

- lack of consistent access to a registered dietician or speech and language pathologist;
- no enteral formula stocked on the unit;
- insufficient supply of feeding and intravenous pumps;
- lack of standard EN delivery protocols;
- unappetizing food choices;

- lack of enough staff to assist with feeding; and/or
- lack of appropriate order sets to ensure clear directives and prescriptions related to nutritional support.

Objectives

The goal of this project was to better meet the nutritional needs of adult neurocritical care patients receiving nutrition through the enteral route using a volume-based feeding schedule allowing the RN to increase tube feeding rate after interruptions occur. Success of this project was measured through the following objectives:

1. Merge the two VBEN feeding schedules that are in use within the system into one process through an interdisciplinary collaborative approach.
2. Modify the existing EN delivery order set to reflect volume-based ordering options.
3. Develop and implement an education intervention to prepare neurocritical care RNs and providers to utilize the VBEN feeding schedule.
4. Implement VBEN delivery in the NCCU.
5. Conduct chart audits to collect data on patients receiving RBEN delivery prior to implementation of the change and on patients receiving VBEN delivery postimplementation of the change.
6. Analyze the impact of the VBEN feeding schedule on the percentage of prescribed 24-hour EN volume delivered over the course of patients' NCCU stay.

These objectives span the continuum of the initiative from planning through the implementation and evaluation stages and assured a thorough process for the project.

The goals and the objectives of the project reflect the mission, vision, and values of RIH. Nutrition is a basic human need and delivering adequate sustenance to patients is in alignment with RIH's mission of "Delivering Health with Care" (Our Mission, 2018) and the C.A.R.E. values of the organization which include the following:

Compassion: Delivering care and comfort with empathy and kindness.

Accountability: Taking ownership of actions and their consequences.

Respect: Placing the highest value on every individual's well-being regardless of personal and professional differences.

Excellence: Always providing safe, high quality, innovative care and service (Our Mission, 2018).

Project Plan

Timeline

A Gantt Chart (Smartsheet, 2018) was utilized to ensure the project tasks were completed in a timely chronological order and to identify key milestones and due dates (Appendix D: Project Timeline Utilizing Gannt Chart). All phases of the project planned occurred between May of 2018 and April of 2019.

Strength, Weakness, Opportunity, and Threat (SWOT) Analysis

Strengths and Opportunities.

RIH is a Level I Trauma and Comprehensive Stroke Center and Academic Medical Center affiliated with Brown University. These designations and affiliations provide a strong foundation and support for evidence-based practice, research, and cutting-edge nursing and medical practice. Within this environment, the NCCU is staffed

by a cohesive and collaborative interdisciplinary team, including strong unit leadership comprised of a neurocritical care intensivist director, clinical and assistant clinical nurse managers, an APRN-CNS quality and safety manager (the PI), and a critical care educator. The patients on this unit are further supported by RNs with neurocritical care expertise and certification, including four certified critical care RNs (CCRN), two stroke certified RNs (SCRN), one RN with dual certification as a CCRN and as a certified neuroscience RN (CNRN) and one RN with dual certification as a CNRN and SCRN. Finally, there is a dedicated registered dietician familiar with the patient population, a neurocritical care pharmacist, and multiple advance practice providers and residents as part of the treatment team.

The clinicians and providers on the NCCU are familiar with adopting and adapting to evidence-based practice changes, as well as utilizing protocols and their related algorithms to provide care to their patients. Past protocols which have been successfully implemented on the NCCU include a normothermia protocol and an analgesia and sedation protocol for mechanically ventilated patients. Finally, the quality and safety manager of the unit has a close working relationship with the nursing informatics and electronic medical record development (LifeChart) departments.

Organizational supports outside of the NCCU also exist which supported the development and implementation of a VBEN feeding schedule. The project had the support of the Chief Nursing Officer and the Director of Nursing Professional Practice and Research. The surgical intensive care (SICU) and trauma intensive care (TICU) units instituted a similar protocol in the year prior to the adoption on NCCU. The physician's assistant (PA) and registered dietician who were instrumental in implementation of that

protocol consulted on this project. In addition, the hospital's clinical nutrition support service was available to share their expertise during project development and implementation. The LifeChart Team provided strong support to this project when developing the modifications to the EN order sets and nursing documentation.

Weaknesses and Threats.

There were several internal risks to the success of this project. During the gap analysis EN delivery was found to be consistently documented; however, inconsistent nursing documentation practices have been found in various areas of the electronic medical record (EMR) including daily weights and intake other than EN. It was key to stress the importance of accurate documentation during training to assure accurate data collection. Although priorities and the possibility of nurses who were non-adopters was a concern, all RNs and providers were engaged with the project and the change to use of the VBEN feeding schedule was smooth.

External threats to the project also existed, including the preparation activities for an upcoming comprehensive stroke center recertification survey by The Joint Commission (TJC) which occurred in the autumn of 2018. This did cause a delay in completion of some of the project tasks, but overall proved to be a minor barrier. The inability to roll out the modifications to the existing order set and nursing documentation did not have as great an impact as expected.

The unit and organizational strengths and opportunities for the project outweighed the weaknesses and threats and the risks to the project were not so great that they could not be overcome and though the implementation was slightly delayed, it was an overwhelming success. Appendix E: Strengths, Weaknesses, Opportunities, and Threats

provides an overview of the strengths, weaknesses, opportunities, and threats which impacted the development and implementation of the project.

Financial plan

The VBEN feeding schedule project was a budget neutral initiative. Systems existed within the organization to support the project and the tasks involved were within the scope of standard work for individuals who were consulted. In addition, the PI provided in kind donation time toward project development, staff education and training, expertise, and data collection hours to support the initiative and move it forward. These hours occurred outside of the PI's standard work hours.

Expected Outcomes and Evaluation Plan

The project would be deemed successful if the following objectives were met:

1. Merge the two VBEN feeding schedules that are in use within the system into one process through an interdisciplinary collaborative approach.
2. Modify the existing EN delivery order set to reflect volume-based ordering options.
3. Develop and implement an education intervention to prepare neurocritical care RNs and providers to utilize the VBEN feeding schedule.
4. Implement VBEN delivery in the NCCU.
5. Conduct chart audits to collect data on patients receiving RBEN delivery prior to implementation of the change and on patients receiving VBEN delivery postimplementation of the change.

6. Analyze the impact of the VBEN feeding schedule on the percentage of prescribed 24-hour EN volume delivered over the course of patients' NCCU stay.

Minutes from the collaborative planning meetings together with the creation of a useful adaptation of the current VB protocol and a revised EN order set utilized by ordering providers served as evidence of successful completion of the projects first and second objectives. Appropriate ordering and utilization of the VB protocol and feeding schedule supported the attainment of training of personal and adoption of the protocol. Completed auditing forms, data collation, and results of the data analysis demonstrated successful attainment of the final two objectives. The primary goal of improving EN delivery in the NCCU was attained as evidenced by the VB group receiving greater than 80% percent of prescribed EN volume over the course of the NCCU stay with greater frequency than the RB group.

Procedure

The PI formed a core group on May 18, 2018 to develop a plan for implementing VBEN on the NCCU at RIH. The group was multidisciplinary including the PI (APRN CNS), the neurocritical care director of the unit, the RDs of both the NCCU and trauma ICU TICU, and the physician's assistant (PA) who was the VBEN champion on the TICU. The nursing informatics specialist was identified as an ad hoc member of the team and feedback from the NCCU RNs was sought to inform on the process throughout the duration of the project. Discussions related to order set modification, barriers which prevented full implementation of VBEN on TICU, and modifications the NCCU's RD would make to her consult notes, including adding the 24-hour volume goal in her

recommendations. It was identified that VBEN was used in the ICU at an affiliate, and it was decided that the PI would consult the APRN CNS from that unit.

On May 23, 2018, the PI met with the APRN CNS and RD from the affiliate and discussed their use of VBEN. There were some minor differences between the feeding schedule used between the affiliates, but consensus was achieved, and a single protocol was agreed upon (Appendix F: Volume Based Feeding Schedule [Critical Care Nutrition & Nestle Health Science, 2016]). The affiliate APRN discussed barriers to the modification of the EN electronic order set which they had requested the previous year; modifications never occurred. The APRN CNS and RD fully supported the PI's plan.

The project was submitted to the Lifespan Institutional Review Board (IRB) on 10/15/2018; the project was approved and deemed not human research on 10/23/18. The Rhode Island College IRB approved the project on 12/11/18.

The PI communicated, in-person and electronically, with the core group on multiple occasions between July and October of 2018 to refine the VBEN feeding schedule and order set modifications. The final draft of the order set modifications was approved by the group on 10/11/2018 and was presented to the hospital's ICU Collaborative committee on 10/25/2018; approval and support were given by the committee (Appendix G: Submitted modifications to adult EN order set to enable ordering of VBEN feeding schedule; Appendix H: Submitted modifications to adult EN order set to enable gastric residual volume order options). The PI communicated electronically with the pediatric RD to assure her that the pediatric EN order set would be not be impacted by the proposed modifications to the adult EN order set. The PI presented the project to the RIH Medical Nutrition committee on 12/27/2018 and

received their approval of the proposed order set modifications. On 1/4/2019 the PI met with the Nursing Informatics committee to present the proposed modifications to the adult EN order set and was asked to seek approval from the two affiliates which would be affected by the changes. Nursing, medical, and clinical nutrition from both affiliates approved the changes.

The PI discussed the proposed order set modifications with the clinical informaticist on 1/15/19 and plans were made to set up a meeting in April 2019 to discuss the electronic documentation build. This delayed date was due to the planned implementation of an upgrade to the electronic health record platform occurring at the beginning of March 2019. All noncritical electronic heath record modifications unrelated to the upgrade were on hold during the month of March 2019.

RN training was conducted during the week of 1/14/2019 during NCCU RN competencies utilizing a Power Point (PPT) presentation given by the PI (Appendix I: Power Point presentation used for NCCU RN training prior to VBEN implementation). Provider training was conducted by the PI on 1/29/19 which included an overview of the material included in the RN training and a strong focus on procedure for ordering VBEN using the existing EN order set until the proposed modifications were implemented (Appendix J: Directions for providers on interim procedure for ordering VBEN using the existing order set). Following the provider training, the PI placed a VBEN ordering tip sheet on all provider computers and a VBEN protocol resource in all patient rooms for RN use. The providers changed EN orders to VBEN on all patients for whom it was appropriate on 1/29/19 and over the next five days the PI, through face to face discussion, informed all RNs that VBEN ordering was live.

Methods

Setting

The setting was an 18-bed neurocritical care unit located in an academic Level I Trauma/Comprehensive Stroke Center in Providence, Rhode Island. Medical coverage and gatekeeping, i.e. approval of admissions, are provided by neurocritical care intensivist attendings and advanced practice providers around the clock, 365 days a year. Neurosurgery and interventional neurology consult daily on patients as appropriate. Nurse to patient ratios range from 1:1 to 1:2 depending on patient acuity. The unit is resourced by an acute/critical care board certified APRN CNS fulfilling the role of neuroscience nursing quality and safety manager. Additional leadership is provided by the NCCU clinical manager and two assistant clinical managers and a critical care clinical educator is also assigned to the NCCU. An RD consults on all NCCU patients within 24-hours and reviews nutritional status daily. All stakeholders supported the initiative.

Group

The sample included neurocritical care patients being cared for in the NCCU at RIH who received nutrition delivered through the enteral route. A causal web depicting common, but not exhaustive, neurocritical care admitting diagnoses are shown in *Figure 1: Causal web of common neurological diagnoses of patients admitted to the NCCU.*

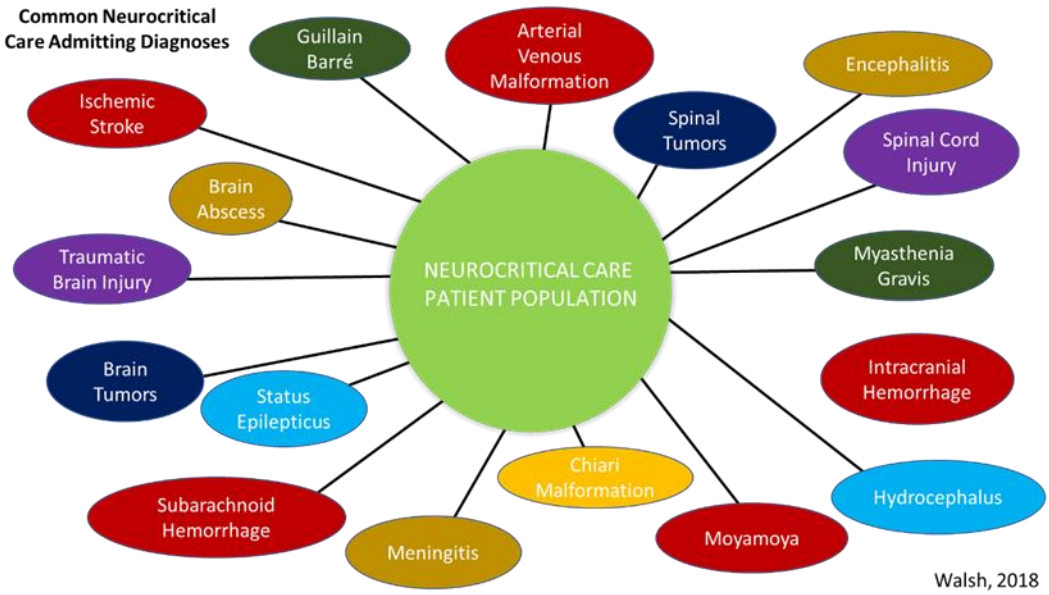


Figure 1. Causal web of common neurological diagnoses of patients admitted to the NCCU (Walsh, 2018).

Inclusion criteria were adults 18 years or greater and less than 90 years with a neurological-related injury or disease process who had EN initiated in NCCU and received EN for three or more days during their stay in NCCU. Exclusion criteria included patients with EN intolerance, malabsorption or gastroparesis, orders for EN at a trophic rate (less than or equal to 25 ml/hour), concomitant oral or parenteral nutrition, and patients for whom high rates of EN delivery were contraindicated. The same inclusion and exclusion criteria were used for both the preimplementation rate-based (RB) and postimplementation volume-based (VB) groups.

All the RB group had orders to initiate EN in an incremental manner: 25 ml/hr for the first four hours and a direction to increase by 25 ml/hr every four hours until the goal rate was met. The VB group all had orders for both 24-hour EN volume goal, base EN rate and directions to initiate EN at goal rate for the first day of EN and to start utilizing the VBEN feeding schedule on the second day. The RD consulted on all patients in both

groups within 24-hours and identified the goal rate for the RB group and the goal 24-hour volume and base rate for all patients in the VB group. Prior to RD consultation, providers included this information within their orders and modified the goals after reviewing RD recommendations. The RD reviewed the status of all patients in both groups daily and modified recommendations as appropriate.

Patients with an order for "Tube Feeding No Tray" were identified from an EMR report for both the RB and the VB groups. Postintervention VB group size was determined by the number of NCCU patients who received VBEN and met inclusion criteria in the two months following the implementation of the initiative (February and March of 2019). Sampling for the preimplementation RB group was done through a systematic and consistent process to eliminate selection bias. Patients with an order for "Tube Feeding No Tray" in the two months prior to the implementation month (November and December of 2018) were identified. The primary investigator (PI) reviewed electronic charts beginning with patients who had the appropriate order on day one of the selection timeframe. Electronic chart review continued through consecutive days until the number of patients in the preimplementation group equaled the number of patients in the postimplementation group.

Tools and measures

Data was collected retrospectively for both the VB and RB groups utilizing an auditing form created by the PI to ensure standardization of the data collection process (Appendix K: Auditing Form). Data collection was approved by the institutional review boards of both Lifespan, the parent company of RIH, and Rhode Island College. All data was collected by the PI from a hospital owned, password protected computer located in

the PI's office on the NCCU. Data collected had no identifiable links to individualized patients and was stored on the above-mentioned secure computer in a file on the PI's hospital provided secure personal drive. The data will be kept on this secure drive and added to with the goal of continued study of the impact of VBEN on patients in the NCCU.

The prescribed 24-hour EN volume goal was collected for the VB group as it was included in the patient order. This value was calculated for the RB group by multiplying the prescribed goal rate by 24 hours since it was not included in the orders. For each patient in both the VB and RB groups, the percentage of prescribed EN volume delivered was calculated by dividing the sum of the "EN volume delivered in 24 hours" column by the sum of the "prescribed EN volume" column. VB and RB group percentages were compared to determine if volume of EN delivered using the VBEN feeding schedule was significantly improved compared to the rate-based feeding group. This was the primary measure. Significance level was set at $\alpha = 0.05$.

Interpretation of the Data

Results

A total of 68 patient electronic records were reviewed. "Tube Feeding No Tray" was ordered for 36 patients in the postimplementation (VB) group; of these, 20 patients were found to meet inclusion criteria. For the preimplementation (RB) group, patient charts with orders for "Tube Feeding No Tray" were reviewed for patients meeting inclusion criteria; chart review continued until 20 patients meeting inclusion criteria were identified. A total of 32 patient charts with "Tube feeding, no tray orders" were reviewed

before the goal of 20 patients was reached. Factors leading to exclusion from the study groups included EN delivery less than 3 days, malabsorption or intolerance issues, age greater than 90 years, and high aspiration risk (*Figure 2: Factors leading to exclusion from RB and VB groups).*

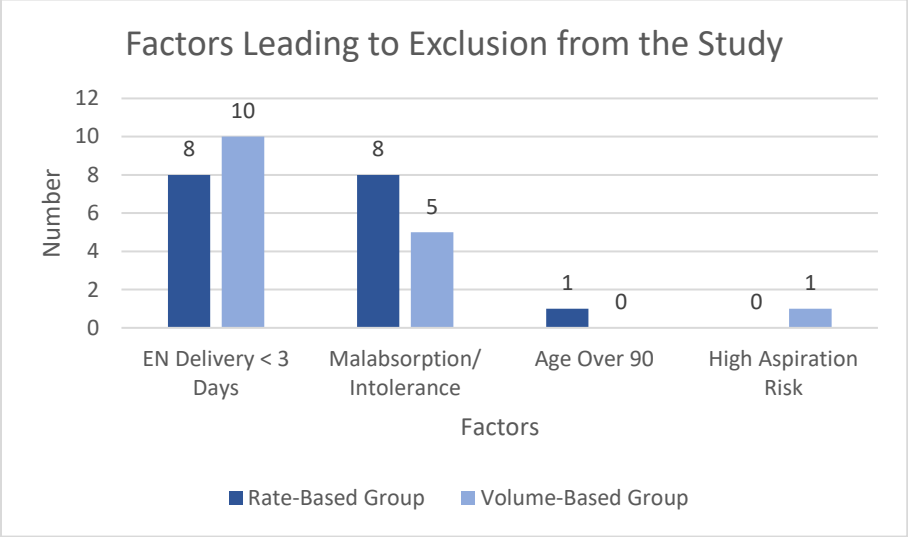


Figure 2. Factors leading to exclusion from RB and VB groups.

There was no significant difference in the ratio of male to female patients in the RB (12:8) and VB (11:9) groups, $\chi^2(1, n = 40) = 0.102$, $p = .749$ nor the distribution of admitting diagnoses between groups, $\chi^2(5, n = 40) = 4.505$, $p = .479$ (*Figure 3: Admitting diagnoses for RB and VB groups).* The difference in age distribution (years) in the RB group ($M = 57.12$, $SD = 19.31$) and the VB group ($M = 59.75$, $SD = 12.51$) was not significant, $t(33, n = 40) = -0.51$, $p = .617$, two tailed, unequal variances, nor were the NCCU lengths of stay (days) between the RB ($M = 12.42$, $SD = 5.12$) and the VB ($M = 12.74$, $SD = 4.52$) groups, $t(35, n = 40) = -0.20$, $p = .84$, two tailed, unequal variances.

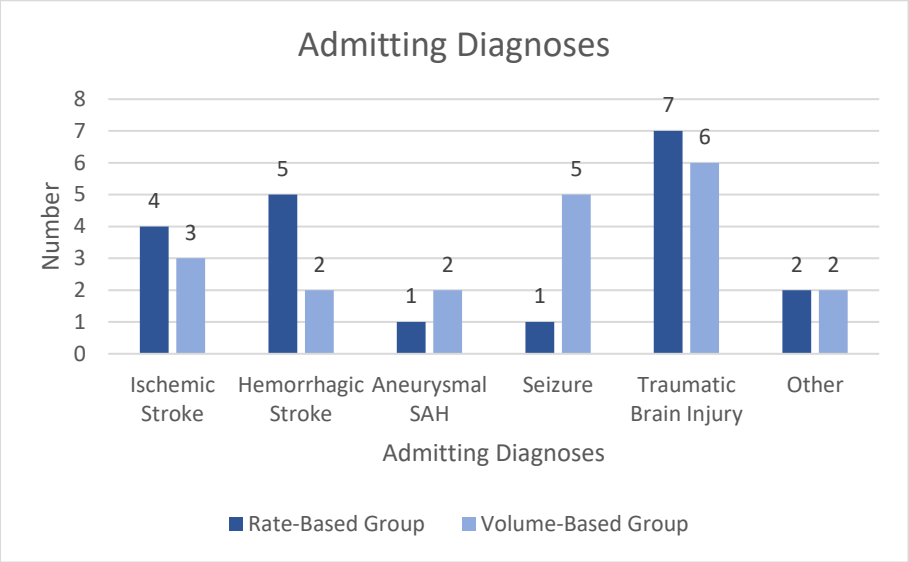


Figure 3. Admitting diagnoses for RB and VB groups.

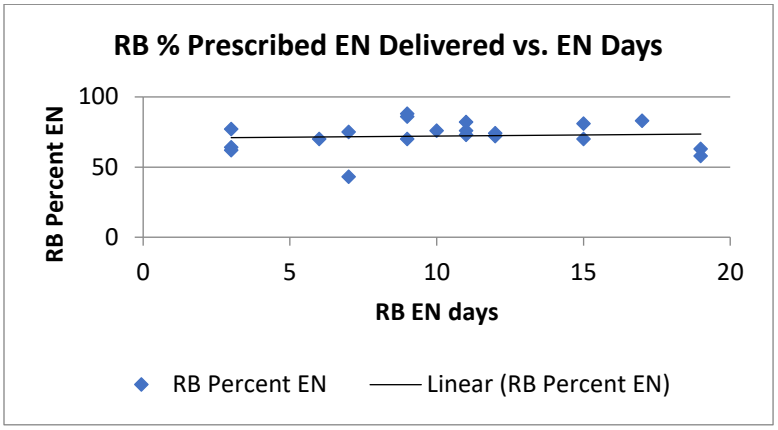
Hospital admission weight was documented on all patients; however, subsequent weight measurements were found on only 30% of the RB patients (n = 6) and 15% of the VB patients (n = 3) rendering the documentation of weight irrelevant to this project. Following interruptions, RN documentation of EN rate increases in the VB group ranged between 7.3% (55 ml/hr increased to 59 ml/hr) and 182% (55 ml/hr increased to 150 ml/hr), none of which led to concerning increases in GVR or emesis. There was only one documented episode of emesis which occurred following a percutaneous endoscopic gastrostomy procedure prior to resumption of tube feeding and was not related to, nor did it delay, the restart of EN delivery. The difference in the number of days patients received EN in the RB group (M = 10.4, SD = 4.88) and the VB group (M = 10.6, SD = 5.25) was not significant, t(38, n = 40) = 0.12, p = .90, two tailed, unequal variances.

Diarrhea and/or loose stools were documented in patients in both the RB (18/20) and the VB (16/20) groups; however, there was no significant difference between the groups, χ^2(1, n = 40) = 0.784, p = 0.376. RN documentation of gastric volume residual

(GVR) was less than 150 ml for patients in both groups and there were no documented incidents of EN being held due to GVRs (300 ml was the ordered threshold for holding EN delivery). The maximum documented GVR for the RB group (140 ml) was greater than that of the VB group (70 ml).

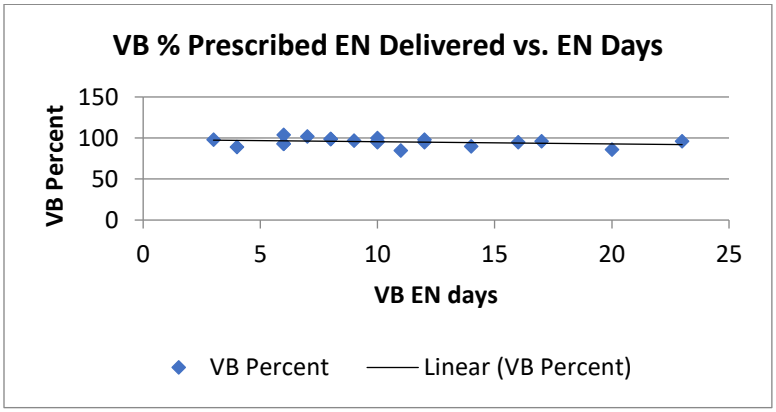
Interruptions in EN delivery occurred in both groups; documented reasons were multifactorial and consistent between groups (Appendix L: Documented Reasons for Interruptions in EN Delivery). In the RB group, there were 20 instances when EN was restarted utilizing an incremental order (25 ml/hr for the first four hours and a direction to increase by 25 ml/hr every four hours until the goal rate was met) in patients who had previously demonstrated tolerance. Fourteen of these interruptions were related to potential extubation and EN was stopped between 4:30 and 5:30 a.m. For these patients, resumption of EN delivery was not standardized and times ranged from 8:00 a.m. to 11:53 p.m. of the same day. For one patient this occurred on six consecutive days and greatly impacted the percentage of prescribed EN volume delivered (total delivered 43%) over the NCCU course of stay.

There was no relationship between the number of days patients received EN and the overall percentage of prescribed EN delivered over the course of their NCCU stay in either the RB or the VB groups (*Figure 4: RB Group percentage of prescribed EN delivered over the course of NCCU length of stay vs. number of EN days* and *5: VB Group percentage of prescribed EN delivered over the course of NCCU length of stay vs. number of EN days*).



% EN = 70.50 + 0.159 (EN Days)
(5.82) (0.508)
R^2 =0.005
For slope coefficient:
t = 0.312 p = 0.759

Figure 4. RB Group percentage of prescribed EN delivered over the course of NCCU length of stay vs. number of EN days. The slope of the line is not significantly different from zero which means the number of EN days had no effect on percentage of prescribed EN volume delivered over the course of the patients' NCCU length of stay.



% EN = 98.17 – 0.271 (EN Days)
(2.49) (0.212)
R^2 = 0.083
For slope coefficient:
t = -1.279 p = 0.217

Figure 5. VB Group percentage of prescribed EN delivered over the course of NCCU length of stay vs. number of EN days. The slope of the line is not significantly different from zero which means the number of EN days had no effect on percentage of prescribed EN volume delivered over the course of the patients' NCCU length of stay.

Despite no significant differences in characteristics between the groups, there was a significant increase in the percentage of prescribed EN volume delivered over the course of NCCU stay of 23.15 percentage points in the VB delivery group (M = 95.3, SD = 4.92) as compared to the RB delivery group (M = 72.15, SD = 10.55), $t(27, n = 40) = 8.89$, p <<0.001, two tailed, unequal variances (*Figure 6: Comparison of RB vs. VB Group percentage of prescribed EN delivered over the course of NCCU length of stay.*).

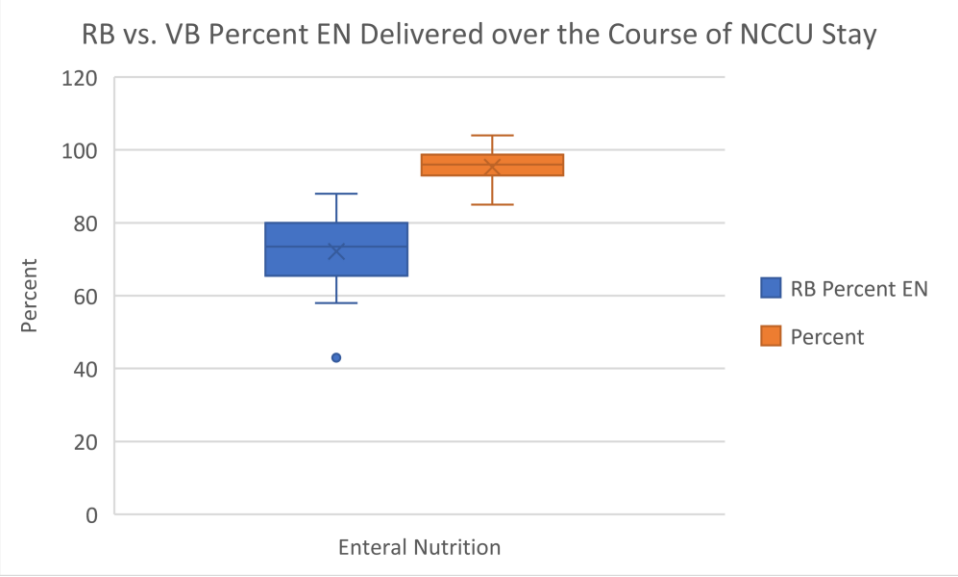


Figure 6: Comparison of RB vs. VB Group percentage of prescribed EN delivered over the course of NCCU length of stay. The plot clearly shows that the percent EN values were much lower for the RB group than the VB group, with almost no overlap between the two groups. Although the RB group shows one outlier (43%), that data point is not an error, and the significant difference between the two groups was not a result of the outlier.

Discussion

This study shows that the use of a volume-based feeding protocol results in a significant increase in the frequency of achieving the predetermined goal of 85% or more of patient's prescribed volume of EN over the course of their NCCU stay. One hundred percent of patients (20/20) in the VB group attained this goal as compared to only 10% of the patients (2/20) in the RB group. In addition, no patient in the RB group received more than 88% of their prescribed volume of EN over the course of their NCCU stay and 10% (2/20) patients received less than 60%. The use of the VBEN feeding schedule was particularly impactful in the following situations: a) improving the percentage of nutrition on days one and two in the VB group by initiating EN at goal rate, b) reducing the impact of a known upcoming fast, such as occurs before surgery or procedure by increasing the rate prior to the interruption, and c) mitigating the effect of daily interruptions related to potential extubation. In addition, there was no significant difference in emesis, diarrhea/loose stools, gastroparesis, or GVRs.

There were some limitations to this study. The documented volumes delivered to patients in both groups may be overestimated, a known phenomenon (Musillo, Grguric-Smith, Coffield, Totino, DiGiacomo, 2017, Kesey, Pucket, & Dissanaike, 2018). Given that RB delivery does not allow the RN to make up for lost EN due to interruptions, it may be that overestimation of the volume delivered was more common in the RB group when 100% of the 24-hour prescribed volume was documented as delivered. The use of a VBEN feeding schedule creates the ability to achieve the 24-hour EN delivery goal. Present documentation practices and tube feeding pump functionality make it unclear

whether all hourly EN volume documentation is accurate, regardless of the mode of delivery.

Patient characteristics between the RB and VB groups were not significantly different for gender, age, admitting diagnoses, lengths of NCCU stay, and number of EN days. Both groups included patients with the most common NCCU admitting diagnoses requiring EN; however, the sample may not fully represent all admitting diagnoses of patients who would require EN during their NCCU stay. Results are not generalizable to other neurological admitting diagnoses, a limitation. Finally, there was a potential for the data collection error; this was mitigated by the systematic approach utilized by the PI who conducted all chart reviews.

This study demonstrates that the use of a volume-based feeding protocol can safely be utilized in the neurocritical care unit and results in a significant increase in the frequency of delivering 85% or more of the prescribed volume of enteral nutrition over the course of the NCCU stay compared to rate-based delivery.

Sustaining the Change

Once the organization has redesigned the process for improving the delivery on enteral nutrition, it can be tempting to move on to other issues and stop monitoring the process. Ongoing monitoring ensures that an organization holds the gains over time. The frequency of the monitoring may be reduced; however, it is important to assess adherence at regular intervals identify whether the practice change has been enculturated and that new employees are aware of the initiative. Several simple things can be embedded into the daily work, including, but not limited to:

- standardize orientation processes to assure all RNs, RDs, and providers demonstrate competency with VBEN protocol use;
- embed reference links within the EMR to the protocol, policy, algorithm, and volume-based feeding schedule tool;
- create a daily prompt linked to the VBEN order to remind the nurse to reset the 24-hour volume-based feeding delivery period each day; and
- periodically conduct assessments to assure RNs remain competent in the use of the VBEN protocol.

In addition, the organization can utilize continuous quality improvement strategies, such as

the Plan-Do-Study-Act (PDSA) cycle methodology (Appendix M: PDSA model) to ensure ongoing improvement. The PDSA model includes the following strategies:

- Step 1: Plan—Plan the test or observation, including a plan for collecting data
- Step 2: Do—Try out the test on a small scale
- Step 3: Study—Set aside time to analyze the data and study the results
- Step 4: Act—Refine the change, based on what was learned from the test (PDSA Cycle, 2018)

The organization should utilize this tool when data trends indicate a decrease in adherence or a decrease in patient outcomes. Feedback should be requested from the end-users of protocol (RNs and APPs) to assure ongoing quality improvement surrounding the delivery of enteral nutrition to the neurocritical care patient. Reassessment of the impact of the protocol should occur at six months and one year. Training and utilization of the protocol should be included in clinician and provider orientation to the unit.

Dissemination

The findings from this initiative were disseminated to the RI College academic community on May 9, 2019 and an abstract will be submitted to the American Association of Neuroscience Nurses to be considered for publication. In addition, an abstract will be submitted to be considered for presentation at the annual conference of either the National Association of Clinical Nurse Specialists or the American Association of Neuroscience Nurses. The results will also be shared at an organizational level at RIH at multiple leadership meetings including, but not limited to, the ICU Collaborative, the Critical Care Leadership Committee, the Medical Nutrition Committee, and the Nursing Professional Practice and Research Departmental Meeting.

Recommendations and Implications for Practice

Despite obvious engagement with the opportunity to improve patients' nutritional status, the RNs became frustrated with the barriers to accurate documentation of EN volume delivered and voiced concerns to the PI. In actuality, the same issues existed prior to this initiative but went unrecognized until priorities shifted, and focus was placed on improving EN delivery. One nurse voiced how impactful it was to pause for just a moment and consider the patients' nutritional status, which is often moved down on the priority list, not because it is unimportant, but because it is generally not perceived as urgent and immediately life threatening.

The documentation issues that came to light through this and other studies reveal a pressing need to make use of the technology that supports pump integration with the electronic medical record. The benefits of this would be two-fold: efficient

documentation of intake would give a clearer picture of the patient's fluid volume status and less time would be spent on hourly data entry, freeing the nurse to focus more time on the less urgent, but still vital therapies such as EN delivery.

Further investigation is needed regarding the prevalence of diarrhea and loose stools in the neurocritical care patients who are being fed through the enteral route. The use of VBEN in NCCU patients with other neurological diagnoses should be studied, as well as the effect of improved EN delivery on blood glucose levels, infection, and hospital length of stay. In addition, fasting times for patients who are awaiting potential extubation should be standardized to minimize time without food. Guideline recommendations should be followed for patients scheduled for procedures or surgeries to minimize the impact on EN delivery. The effect of improved enteral nutrition on long term outcomes should be investigated. Finally, VBEN protocols should be adopted in other ICUs and in the general care setting when appropriate (Boullata et al., 2017).

Malnutrition is frequently overlooked in hospitalized individuals, with multiple studies internationally reporting rates between twenty and fifty percent in the acute care setting (Barker, Gout, & Crowe, 2011, Corkins et al., 2014, Lim et al., 2012). This initiative assured that clinicians and providers proactively took ownership of ensuring optimal delivery of nutrition based on recommended guidelines, individualized to the needs of each critically ill patient.

The Doctor of Nursing Practice (DNP) is uniquely positioned to synthesize research findings and move evidence into practice through translational science, (Pearson, 2012) thus narrowing the theory to practice gap. Utilizing the skills of project management, collaboration, and facilitation, the DNP works to elevate nursing practice

while bridging the distance between medical providers and clinical nurses. The DNP embraces interprofessional practice, recognizing that each member of the healthcare team views issues through a different lens allowing for richness and diversity of thought, strategy, and action which ultimately make a difference to the health and wellbeing of the individuals they care for.

The findings of this study demonstrate that volume-based enteral nutrition delivery can be safely implemented in the neurocritical care population and is associated with significant improvement in EN volume delivery.

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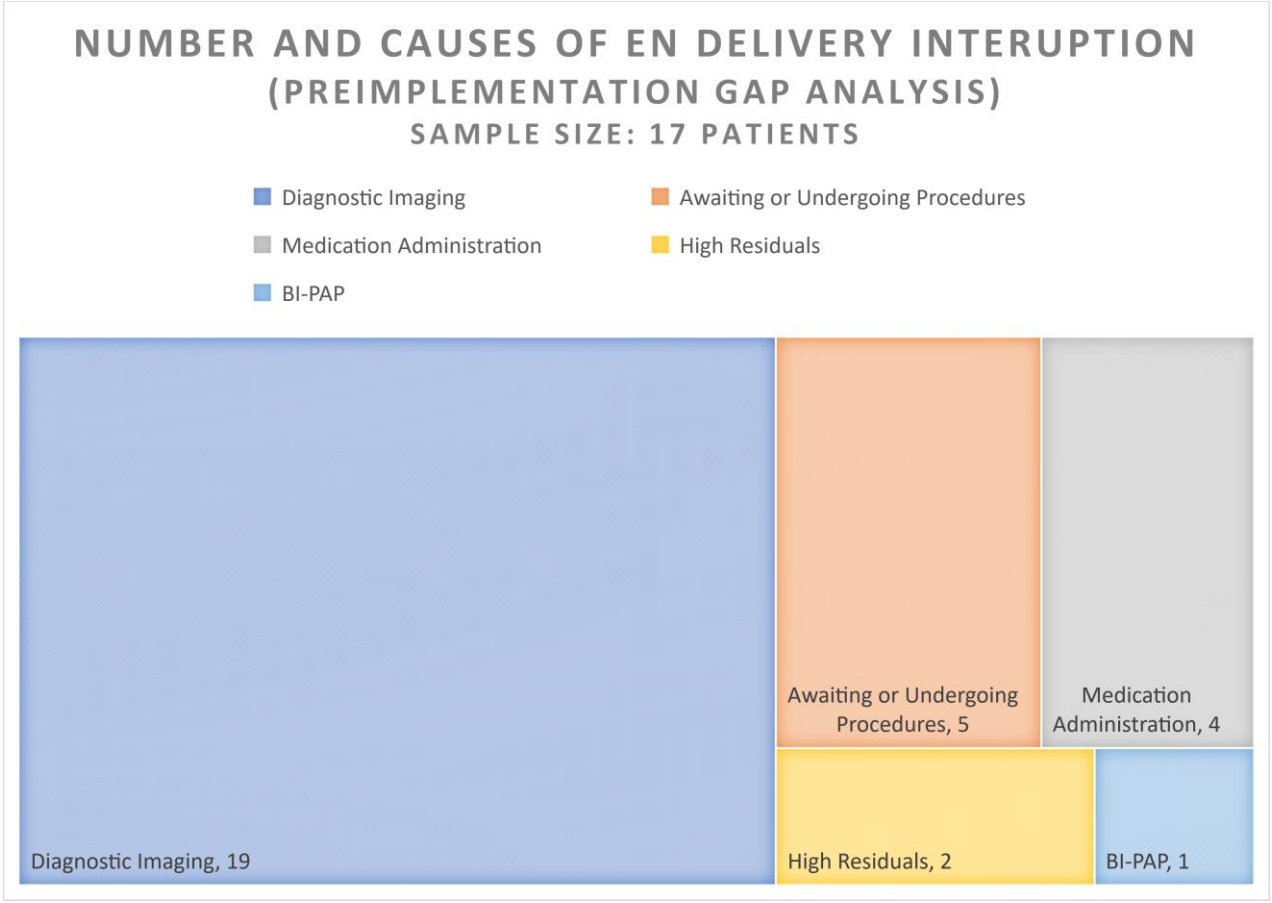
Appendices

Appendix A

Model of Kotter's 8-Step Process for Leading Change (Kotter International, 2017)

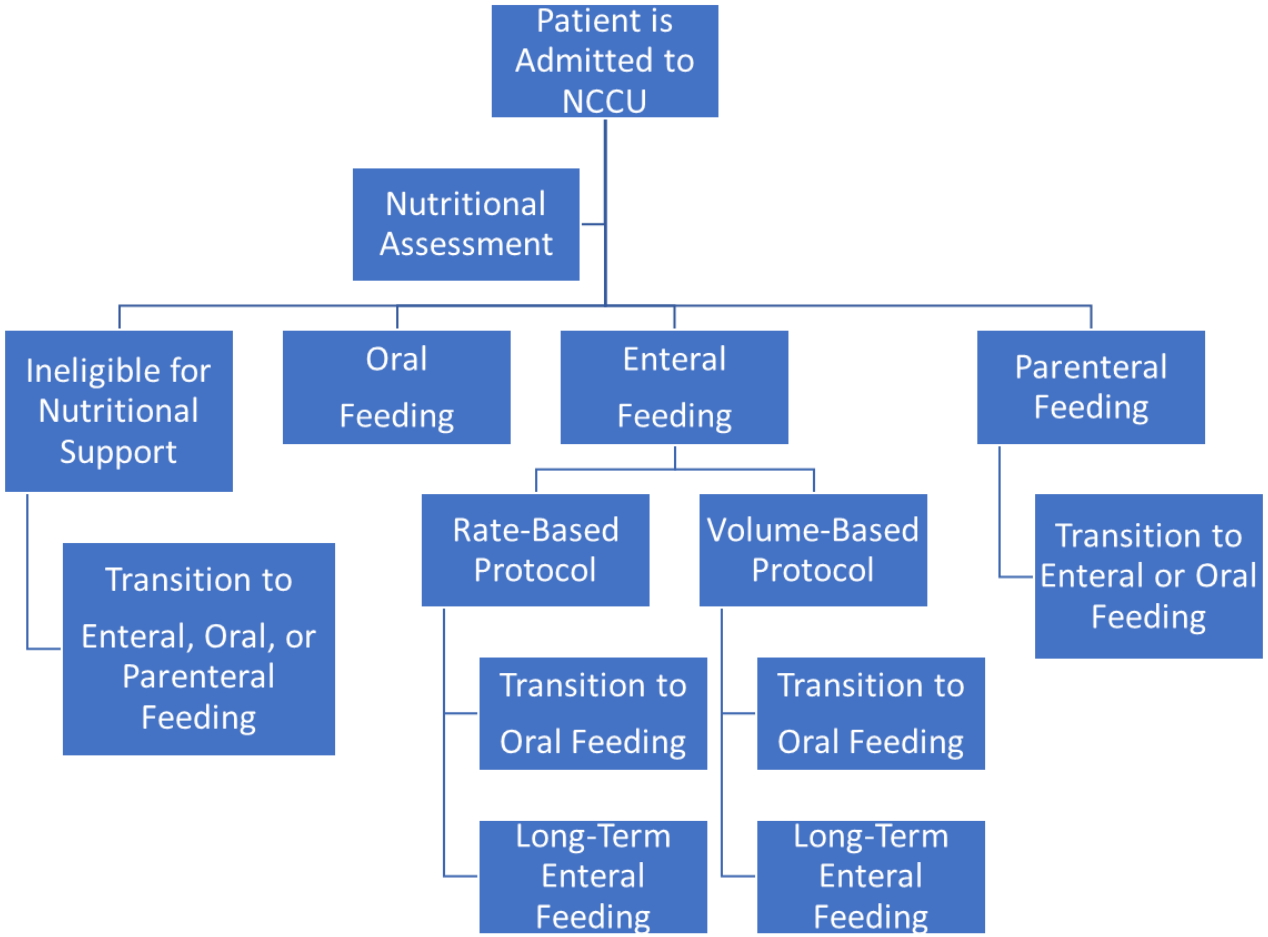
Appendix B

Results of the Preimplementation Gap Analysis



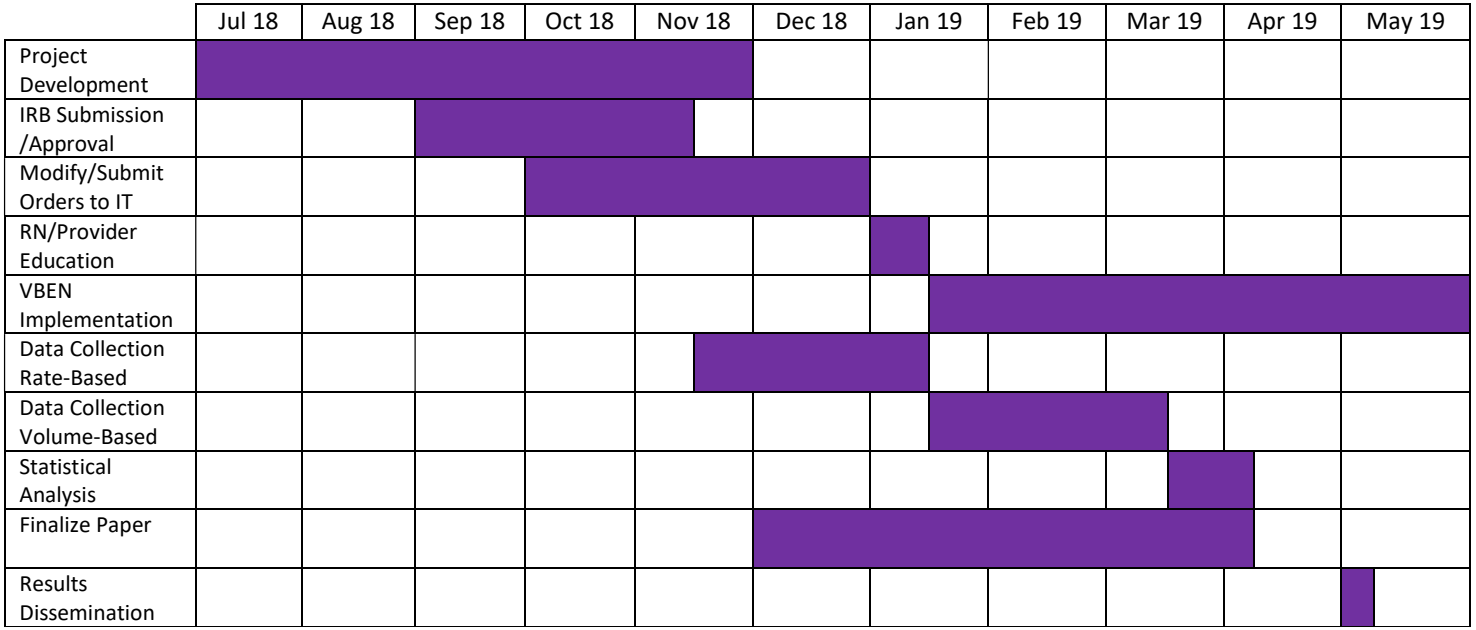
Appendix C

Hospital-Acquired Malnutrition Prevention Critical Pathway (Walsh, 2017)



Appendix D

Project Timeline Utilizing Gannt Chart (Smartsheet, 2018)



Appendix E

Strengths, Weaknesses, Opportunities, and Threats (SWOT Analysis Tool, 2018)

Appendix F

Volume Based Feeding Schedule (Critical Care Nutrition & Nestle Health Science, 2016)

Volume Based Feeding Schedule

Goal total mL formula per 24 hours	Hours remaining in the day to feed 24 hour volume																							
	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
2400	100	104	109	114	120	126	133	141	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
2350	98	102	107	112	118	124	131	138	147	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
2300	96	100	105	110	115	121	128	135	144	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
2250	94	98	102	107	113	118	125	132	141	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
2200	92	96	100	105	110	116	122	129	138	147	150	150	150	150	150	150	150	150	150	150	150	150	150	150
2150	90	93	98	102	108	113	119	126	134	143	150	150	150	150	150	150	150	150	150	150	150	150	150	150
2100	88	91	95	100	105	111	117	124	131	140	150	150	150	150	150	150	150	150	150	150	150	150	150	150
2050	85	89	93	98	103	108	114	121	128	137	146	150	150	150	150	150	150	150	150	150	150	150	150	150
2000	83	87	91	95	100	105	111	118	125	133	143	150	150	150	150	150	150	150	150	150	150	150	150	150
1950	81	85	89	93	98	103	108	115	122	130	139	150	150	150	150	150	150	150	150	150	150	150	150	150
1900	79	83	86	90	95	100	106	112	119	127	136	146	150	150	150	150	150	150	150	150	150	150	150	150
1850	77	80	84	88	93	97	103	109	116	123	132	142	150	150	150	150	150	150	150	150	150	150	150	150
1800	75	78	82	86	90	95	100	106	113	120	129	138	150	150	150	150	150	150	150	150	150	150	150	150
1750	73	76	80	83	88	92	97	103	109	117	125	135	146	150	150	150	150	150	150	150	150	150	150	150
1700	71	74	77	81	85	89	94	100	106	113	121	131	142	150	150	150	150	150	150	150	150	150	150	150
1650	69	72	75	79	83	87	92	97	103	110	118	127	138	150	150	150	150	150	150	150	150	150	150	150
1600	67	70	73	76	80	84	89	94	100	107	114	123	133	145	150	150	150	150	150	150	150	150	150	150
1550	65	67	70	74	78	82	86	91	97	103	111	119	129	141	150	150	150	150	150	150	150	150	150	150
1500	63	65	68	71	75	79	83	88	94	100	107	115	125	136	150	150	150	150	150	150	150	150	150	150
1450	60	63	66	69	73	76	81	85	91	97	104	112	121	132	145	150	150	150	150	150	150	150	150	150
1400	58	61	64	67	70	74	78	82	88	93	100	108	117	127	140	150	150	150	150	150	150	150	150	150
1350	56	59	61	64	68	71	75	79	84	90	96	104	113	123	135	150	150	150	150	150	150	150	150	150
1300	54	57	59	62	65	68	72	76	81	87	93	100	108	118	130	144	150	150	150	150	150	150	150	150
1250	52	54	57	60	63	66	69	74	78	83	89	96	104	114	125	139	150	150	150	150	150	150	150	150
1200	50	52	55	57	60	63	67	71	75	80	86	92	100	109	120	133	150	150	150	150	150	150	150	150
1150	48	50	52	55	58	61	64	68	72	77	82	88	96	105	115	128	144	150	150	150	150	150	150	150
1100	46	48	50	52	55	58	61	65	69	73	79	85	92	100	110	122	138	150	150	150	150	150	150	150
1050	44	46	48	50	53	55	58	62	66	70	75	81	88	95	105	117	131	150	150	150	150	150	150	150
1000	42	43	45	48	50	53	56	59	63	67	71	77	83	91	100	111	125	143	150	150	150	150	150	150
950	40	41	43	45	48	50	53	56	59	63	68	73	79	86	95	106	119	136	150	150	150	150	150	150
900	38	39	41	43	45	47	50	53	56	60	64	69	75	82	90	100	113	129	150	150	150	150	150	150
850	35	37	39	40	43	45	47	50	53	57	61	65	71	77	85	94	106	121	142	150	150	150	150	150
800	33	35	36	38	40	42	44	47	50	53	57	62	67	73	80	89	100	114	133	150	150	150	150	150
750	31	33	34	36	38	39	42	44	47	50	54	58	63	68	75	83	94	107	125	150	150	150	150	150
700	29	30	32	33	35	37	39	41	44	47	50	54	58	64	70	78	88	100	117	140	150	150	150	150
650	27	28	30	31	33	34	36	38	41	43	46	50	54	59	65	72	81	93	108	130	150	150	150	150
600	25	26	27	29	30	32	33	35	38	40	43	46	50	55	60	67	75	86	100	120	150	150	150	150
550	23	24	25	26	28	29	31	32	34	37	39	42	46	50	55	61	69	79	92	110	138	150	150	150
500	21	22	23	24	25	26	28	29	31	33	36	38	42	45	50	56	63	71	83	100	125	150	150	150

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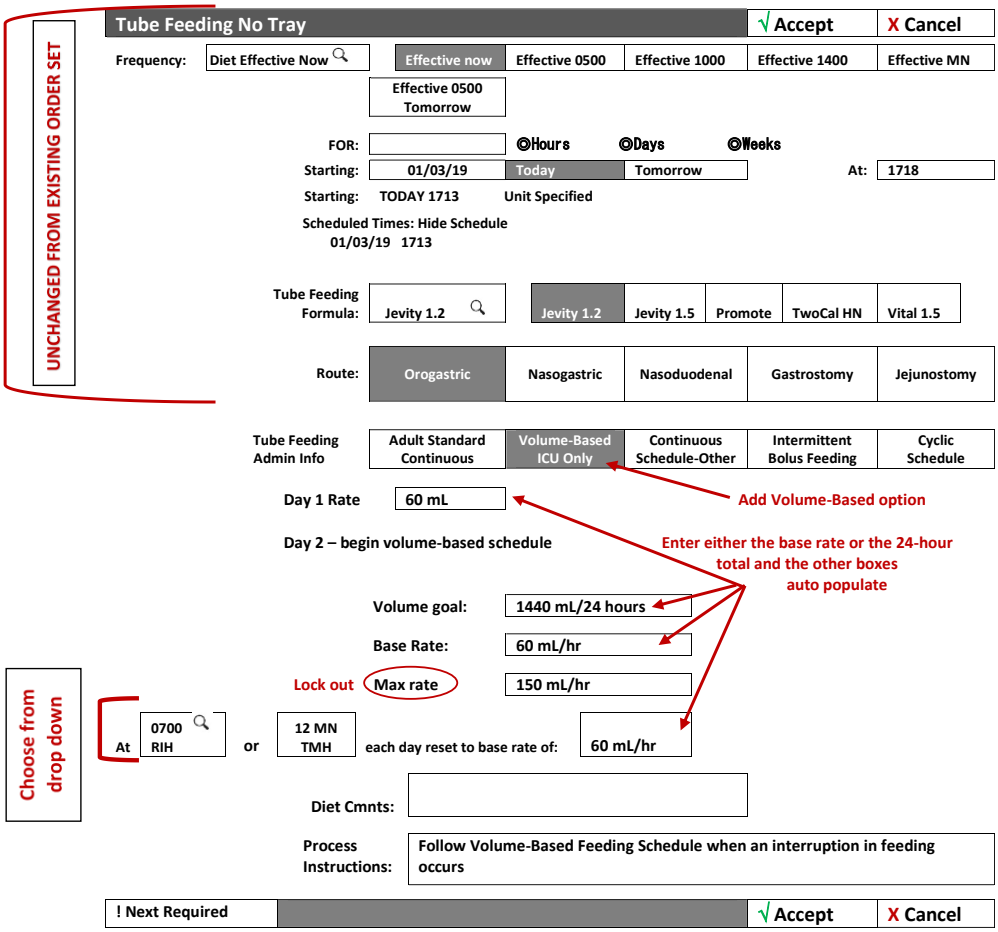
Appendix G

Submitted modifications to adult EN order set to enable ordering of VBEN feeding schedule.



Appendix H

Submitted modifications to adult EN order set to enable gastric residual volume order options.

Existing Gastric Residual Order

Check Gastric Residual every 4 four hours:

- If greater than 300 mL, hold feeding for 1 hour and check residual
- If less than 300mL at recheck, restart feeding using the initial rate and progress
- If still greater than 300 mL, call MD
  - Notify MD if feeding held twice in 24 hours
- Residuals up to 300 mL should be returned to patient; any residual greater than 300 mL should be discarded
- Jejunal Feeding tube: DO NOT check residuals unless ordered by physician (It may cause clogging)

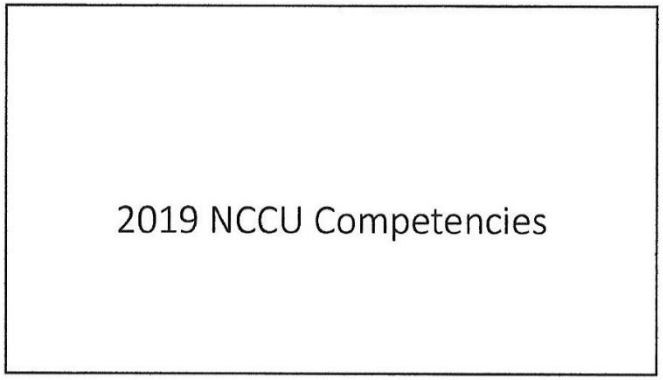
Proposed Modification to Add the Following Option:

No routine gastric residual checks (Critical Care Only):

- If vomiting, stop TF and alert provider
- If signs of gastric intolerance are present (abdominal distension, nausea, abdominal pain), check gastric residual
  - If <500 mL, return residual and resume TF at current rate.
  - If ≥500mL, discard residual, stop TF and alert provider
- If otherwise concerned regarding changing or progressing abdominal symptoms, contact provider
- **Jejunal Feeding tube:** DO NOT check residuals (risk of clogging)

Appendix I

Power Point presentation used for NCCU RN training prior to VBEN implementation.



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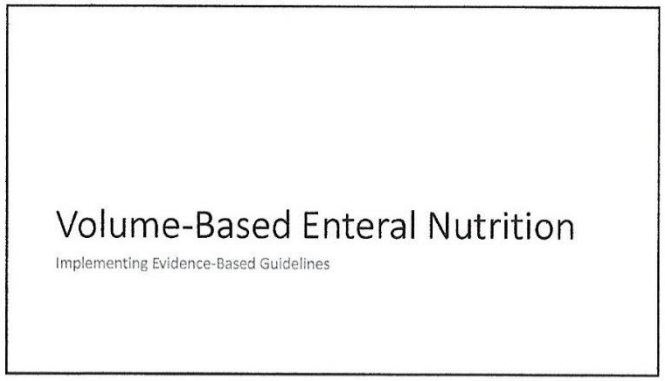

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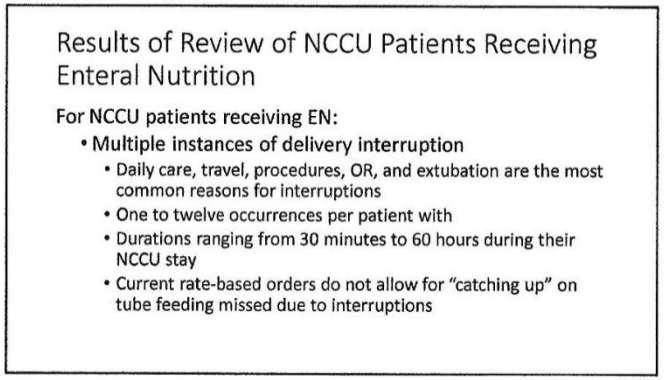

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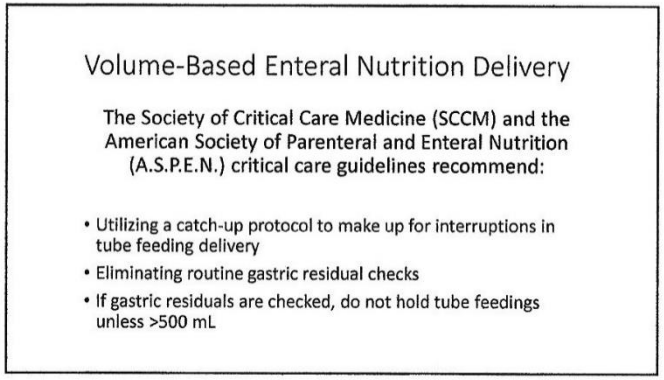
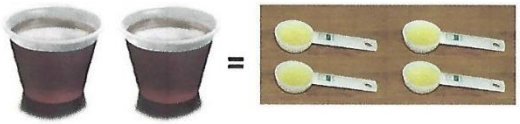


4

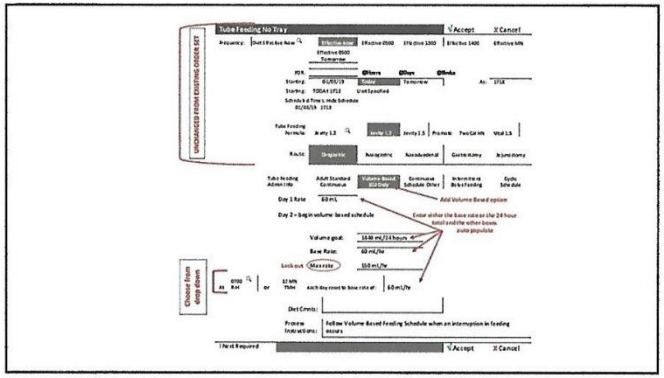
Start at goal rate

Currently we loose nutrition by starting at 25m/hr and increasing by 25 mL/hr every 4 hours until goal



60 milliliter = **4 Tablespoons**

5



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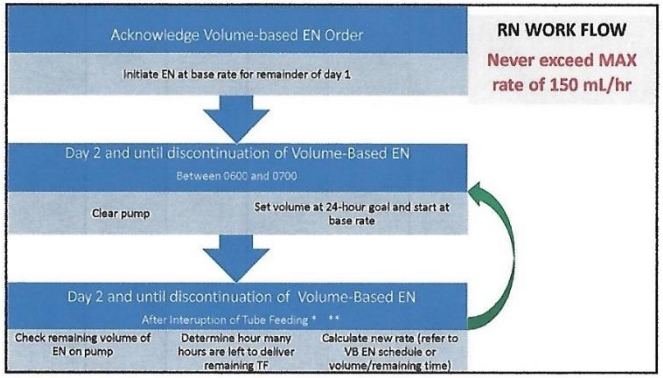


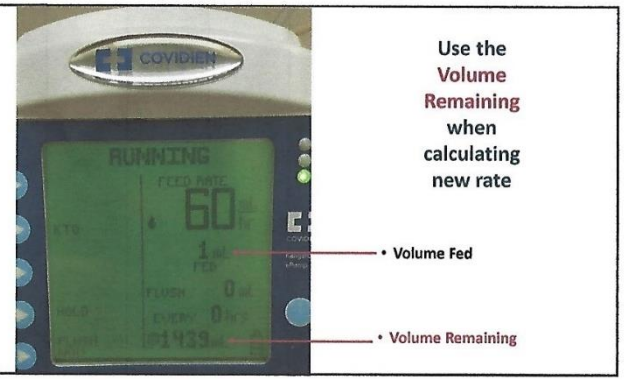
7

Day 2 and until discontinuation of Volume-Based EN After Interuption of Tube Feeding * **		
Check remaining volume of EN on pump	Determine hour many hours are left to deliver remaining TF	Calculate new rate (refer to VB EN schedule or volume/remaining time)

*If **multiple interruptions** are expected (ex. Early morning am care and noon time CT scan) the nurse may opt to wait until the second interruption to increase the rate. Max rate is always 150 mL/hr.

** If there is a **planned long interruption** (such as NPO after MN) the RN may anticipate the interruption and increase the rate prior to the interruption (ex. If an order is placed at 0900 for the patient to be NPO after MN, the RN may increase the rate to run the remaining volume over the remaining 15 hours before the patient needs to NPO. Max rate is always 150 mL/hr.

8



9

Remaining volume (mL) of TF to be delivered (Round to nearest 50 mL)	Number of hours i							
	24	23	22	21	20	19	18	17
								Rate (
2400	100	104	109	114	120	126	133	141
2350	98	102	107	112	118	124	131	138
2300	96	100	105	110	115	121	128	136
2250	94	98	102	107	113	118	125	132
2200	92	96	100	105	110	116	122	129
2150	90	93	98	102	108	113	119	126
2100	88	91	95	100	105	111	117	124
2050	85	89	93	98	103	108	114	121
2000	83	87	91	95	100	106	111	118
1950	81	85	89	93	98	103	108	115
1900	79	83	86	90	95	100	106	112
1850	77	80	84	88	93	97	103	109
1800	75	78	82	86	90	95	100	106
1750	73	76	80	83	88	92	97	103
1700	71	74	77	81	85	89	94	100
1650	69	72	75	79	83	87	92	97
1600	67	70	73	75	80	84	89	94
1550	65	67	70	74	78	82	86	91
1500	63	65	68	71	75	79	83	88
1450	60	63	66	69	73	76	81	85

- It is day 3 of volume-based feeding schedule
- RN clears pump at 0630.
- RN sets pump for 24-hour ordered volume goal of 1,920 mL and base rate of 80 mL/hr
- Pump is off for 0800 care, but RN knows patient is also going to MRI at 1000 and waits to change rate
- Tube feeding (TF) is off for 2 hours during MRI. RN returns at 1200 and checks remaining volume on pump: 1,730 mL
- RN rounds the volume to 1,750 mL and determines that there are 19 hours left to deliver the TF
- RN checks Volume-based Feeding Schedule and sets pump at 92 mL/hr

Or

- RN divides remaining volume by remaining time:

1,730 mL ÷ 19 hrs = 91 mL/hr

10

Scenario Continued

- Several short interruptions (positioning) over the next hours, but the RN did not change the rate
- Care was given at 2030 which took about 45 minutes after which the RN changes the rate. It is now 2115 and the remaining volume on the pump is 1,028 mL.
  - a) What is the new rate?
  - b) What is the max rate which should never be exceeded?
- *c) What does the RN do between 0600 and 0700?*
- *d) What if all of the ordered tube feeding was not delivered?*
- *Does the RN use the volume-based feeding schedule on Day 1 of enteral nutrition?*

11

Optional Opportunity to "Catch-up" Before Prolonged Scheduled Interruption

- Patient's 24-hour goal is 1,440 mL in 24 hours which equals a base rate of 60 mL/hr.
- RN clears pump and programs in 24-hour goal volume of 1,440 mL and base rate of 60 mL/hr at 0620
- NPO after MN for OR order is placed at 1000. The pump shows that 1,260 mL of tube feeding remain
- The RN chooses to deliver the remaining volume by midnight to assure the patient gets ordered daily nutrition
- *a) What rate does the RN program into the pump?*

12

Gastric Residuals: Old Practice

Check Gastric Residual every 4 four hours:

- If greater than 300 mL, hold feeding for 1 hour and check residual
- If less than 300mL at recheck, restart feeding using the initial rate and progress
- If still greater than 300 mL, call MD
- Notify MD if feeding held twice in 24 hours
- Residuals up to 300 mL should be returned to patient; any residual greater than 300 mL should be discarded
- Feeding tube: DO NOT check residuals unless ordered by physician. (It may cause clogging).

13

Gastric Residuals: New Option

No routine gastric residual checks:

- If vomiting, stop TF and alert provider
  - If signs of gastric intolerance are present (abdominal distension, nausea, abdominal pain), check gastric residual
  - If <500 mL, return residual and resume TF at current rate. If >500mL, discard residual, stop TF and alert provider
- If otherwise concerned regarding changing or progressing abdominal symptoms, contact provider
- **Jejunal Feeding tube:** DO NOT check residuals (risk of clogging)

14

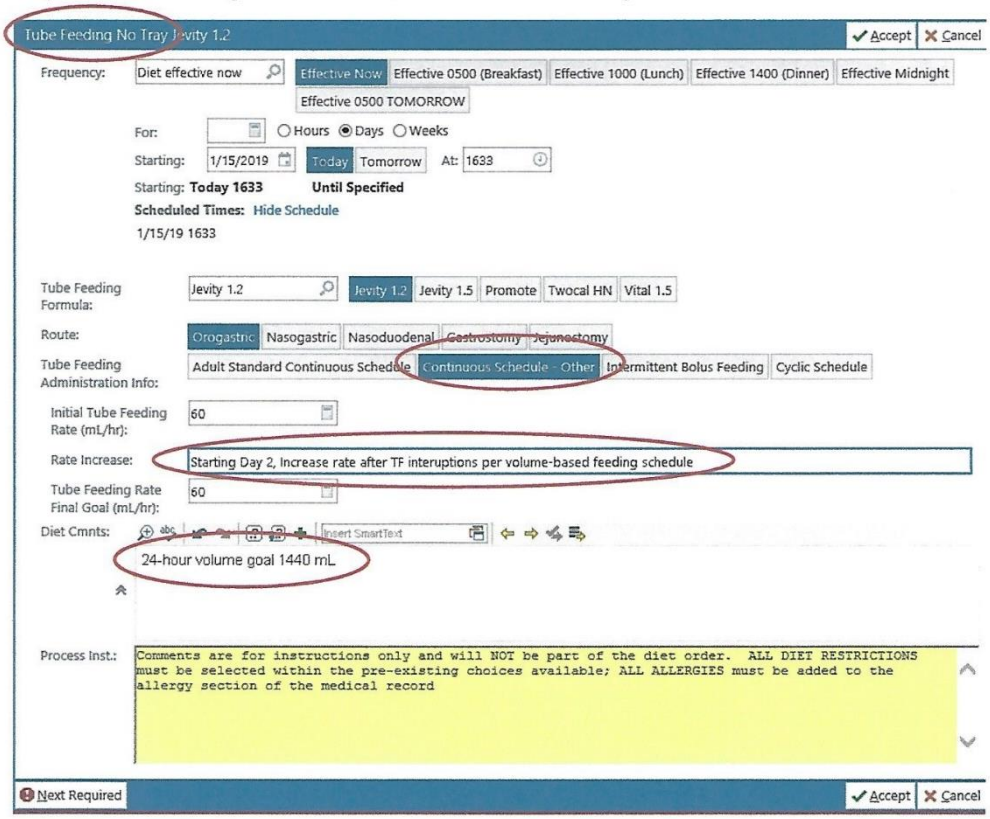
Summary

- The use of volume-based enteral nutrition schedules has been shown to increase the likelihood of patients receiving close to goal daily recommended calorie intake
- SCCM and A.S.P.E.N. support the use of volume-based schedules, starting tube feeding at goal rate, eliminating routine gastric residual checks, and using > 500 mL as the cut off for holding tube feeding when gastric residuals are checked
- This change has been approved and is supported by the Neurocritical Care Team, Medical Nutrition Team (Dr. Albina and clinical nutrition/registered dieticians), Dr. Charles Adams Trauma/Surgery (this has already been instituted in TICU)
- Volume-based EN will not be ordered on patients for whom it is contraindicated
- The goal of this change is to improve the delivery of nutrition for NCCU patients who tolerate tube feeding. The patients will not always receive 100% of their ordered daily nutrition, but we will be closer to goal.

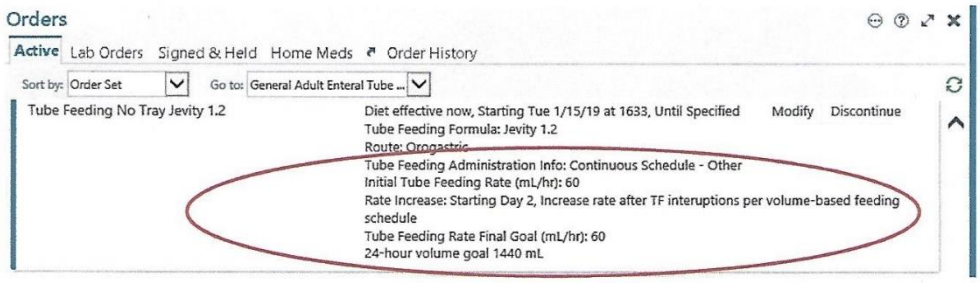
Appendix J

Directions for providers on interim procedure for ordering VBEN using the existing order set.

Proposed use of existing order set to reflect volume-based feeding schedule.



How the nurse will see the order:



Appendix K

Auditing Form (Walsh, 2018)

Day of EN	Admitting Diagnosis	EN Formula	EN Access Type	Weight	Emesis	Diarrhea/loose stool	Gastroparesis	Ordered Rate	Actual rates	Minimum/ Maximum GVR	EN Volume delivered in 24 h	Prescribed EN volume	NCCU LOS (Days)	Comments

Appendix L

Documented Reasons for Interruptions in EN Delivery.

EN held after midnight for OR or procedure
Possibility of extubation
Unit based tests or procedures
Traveling to tests or diagnostic imaging
Daily care activities
Feeding pump not available or malfunctioning
EN formula not available on unit
Decline in patient's neurologic, respiratory, or hemodynamic instability
Patient removed feeding tube
Feeding tube was clogged
Awaiting tube placement
Awaiting confirmation of tube placement
EN held for medications

Note. Reasons for interruptions were common to both RB and VB groups.

Appendix M
Plan-Do-Study-Act (PDSA) Cycle Continuous Quality Improvement Method
(PDSA Image, 2018)