Elimination of Routine Gastric Residual Volume Monitoring Improves Patient Outcomes in Adult Critically Ill Patients in a Community Hospital Setting

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Abstract

Background: A community hospital updated its nutrition support practices in 2016 through the elimination of monitoring gastric residual volume (GRV) in accordance with the 2016 Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient: Society of Critical Care Medicine and American Society for Parenteral and Enteral Nutrition. *Methods:* This retrospective analysis (N = 61) compared incidence of feeding intolerance in 2 cohorts of adult critically ill patients pre-implementation (n = 36) and post-implementation (n = 25) of these guidelines into a nutrition support team's standard of practice policy. Differences in kilocalories and protein (gm) received and percent of daily prescribed kilocalories and protein received were also compared between the 2 cohorts. *Results:* Mean episodes of gastrointestinal intolerance over the number of eligible days of receiving enteral nutrition in the critical care unit did not differ between the pre-implementation and post-implementation groups (*P* = 0.46). Compared with the pre-implementation group, the post-guideline implementation cohort was significantly more likely to meet higher percentages of both prescribed protein (71.8 ± 22.2% vs 55.9 ± 24.0%; *P* = 0.01) and energy requirements (93.4 ± 36.9% vs 69.6 ± 35.3%; *P* = 0.01), even after adjusting for potential confounders (age, body mass index, sex, and primary comorbid medical condition). *Conclusion:* Elimination of routine monitoring of GRV may result in a greater percentage of prescribed daily nutrient requirements met by patients in the critical care setting, without adverse effects on feeding intolerance. (*Nutr Clin Pract.* 2020;00:1–11)

Background

Facility-specific implementation of any component of an evidence-based practice guideline may contribute to improvements in patient outcomes.[1-12] In February 2016, the Society for Critical Care Medicine (SCCM) and the American Society for Enteral and Parenteral Nutrition updated existing guidelines for the provision of nutrition support in critically ill adult patients.[13] These guidelines detailed evidence-based practices for nutrition support, including assessment, intervention, and monitoring practices for the provision of enteral nutrition (EN) in critically ill adult patients. Successful implementation of these guidelines may rely on a gradual adoption within a clinical facility.[1,2,4] For example, a facility could begin with identifying barriers to adequacy of EN provision in the critical care unit (CCU) and then prioritizing how to overcome them. One practice which commonly impedes adequate EN delivery is the inappropriate withholding of EN because of inaccurate characterization of "high" gastric residual volumes (GRVs) by clinical staff. In a facility where this is identified as a barrier, even adopting a single component of the SCCM/American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines, such as the elimination of routine monitoring of GRV, may be useful in improving patient outcomes.

The inappropriate withholding of EN may result from the assumption that any GRV signifies potential intolerance of EN and may be secondary to the differences in clinician knowledge or assessment practices regarding GRV and gastrointestinal intolerance (GI). A universally adopted

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definition of GI or feeding intolerance (FI) in the critically ill adult patient does not exist,[13-18] making comparisons of research outcomes difficult to interpret.[13-18] FI may be described as vomiting, diarrhea, high (250–500 mL) GRV, regurgitation, inability to achieve desired protein and calorie needs through EN, absence of bowel sounds, bowel distention, or any combination of gastrointestinal symptoms depending on severity of illness.[13-18] As standard practice for critically ill patients receiving EN, many health-care facilities hold tube feeding for GRV amounts ranging from 50 to 500 mL.[1,8,11,25] However, monitoring GRV as a marker of FI has not been found to be associated with outcomes such as morbidity and mortality, incidence of ventilator-associated pneumonia, or aspiration in critically ill patients.[1,8,13,16-33] Studies have determined that patients meet more of their estimated protein and kilocalorie (kcal) requirements when EN is interrupted less frequently as a result of the elimination of routine GRV monitoring.[7,8,14-16] Routine patient care practice such as physical abdominal exam may better indicate the presence of FI.[7,8,14-16] It is not known if implementation of guidelines such as those from SCCM/ASPEN in community hospitals results in similar outcomes because it is challenging to compare findings from a controlled research study to clinical practice. Differences in technology, physical environment, acuity level of patients, consistent commitment by key facility stake holders (physicians, hospital administrators, and interdisciplinary clinician leadership), and the ability to deliver extensive education in a short amount of time could influence effective implementation of new practices. If implementation of a guideline related to non-monitoring of GRV results in no increased incidence of FI observed in critically ill patients receiving EN in a community hospital, the findings would further support this guideline as evidence-based practice.

The impact of implementing the 2016 SCCM/ASPEN recommendation of eliminating routine GRV monitoring on patient nutrition care outcomes among adult critically ill patients receiving EN were explored in a community hospital setting. A retrospective historical cohort analysis, before and after intervention design, was utilized for the purposes of this investigation. Incidence of FI and percent of daily prescribed protein and kcal received were compared between pre-implementation and post-implementation cohorts.

Methods

The study took place at a 185-bed community hospital. Over 10 years ago, the Metabolic Support Services (MSS) team was created under a hospital-approved administrative policy directing the scope of practice for management of nutrition support of adult patients receiving EN or parenteral nutrition. Through joint approval processes of the nutrition, pharmacy and therapeutics, and the medical executive committees, the recommendation of the 2016 SCCM/ASPEN guidelines was approved. As a result, GRV is no longer routinely monitored in patients receiving EN.

Selection of Patients

All patients with a CCU stay ≥48 hours and receiving EN for at least 24 hours were included for retrospective review. Patients who were >90 years of age and receiving EN <24 hours were excluded. Data were extracted retrospectively from the facility's electronic medical record (EMR).

Based on the usual annual patient census for the MSS team, it was anticipated that at least 6 months of time was needed to obtain enough eligible patient data for the study. The pre-implementation time frame was selected from February 1, 2016, to July 31, 2016, and was intentionally selected to include patients prior to the go-live date for the policy change of September 21, 2016. The post-implementation data collection time frame was from December 1, 2016, to May 31, 2017. A 10-week time frame was avoided for data collection after the go-live date. This allowed for a "washout" time frame from September 21, 2016, through November 30, 2016, to allow time for practice change after the new policy was implemented. Figure 1 depicts the differences in MSS policy related to GRV practices for each cohort.

Study Design and Data Collection

The order for MSS to evaluate a patient and implement nutrition support is automatically entered with all EN or parenteral nutrition orders in the hospital. The MSS policy and associated order sets regarding EN support practice were updated in 2009. At that time, the policy and associated order sets regarding EN support practice changed from holding EN feeding for a GRV that was >2 times the EN infusion rate to holding EN feeding for a GRV ≥250 mL. To avoid frequent EN feeding interruptions associated with this practice, a recommendation was made to modify the existing MSS policy in September 2016. To determine the impact of elimination of routine GRV monitoring on patient outcomes, baseline data and outcomes were compared between patients who received care prior to and post-implementation of the policy change. Research approval was obtained from the Institutional Review Board at the university, and facility approval was granted from the quality department at the facility.

The Education Process

Education was targeted to registered dietitian (RD) nutritionists, registered nurses, physicians, administrative staff, and other clinical staff working in the CCU, including certified nutrition support clinicians and the clinical nutrition manager. The principal investigator (PI) and team lead MSS

Figure 1. Comparison of nutrition support practice polices between pre-implementation and post-implementation cohorts. The pre-implementation cohort (left) represents patients selected from a 6-month period of time (February 1, 2016–July 31, 2016) prior to the education and implementation of the Metabolic Support Services (MSS) practice change related to monitoring gastric residual volume (n = 36). The post-implementation cohort (right) represents patients selected from a 6-month period of time after a 10-week washout time period (December 1, 2016–May 31, 2017) from the MSS practice change related to monitoring gastric residual volume in critically ill adult patients (n = 25).

RD developed a PowerPoint presentation based on past AS-PEN webinar presentations and the 2016 SCCM/ASPEN guideline publication itself. The presentations were done both live at various committee meetings, an employee patient safety fair, and on demand on HealthStream mandatory online required learning. Physician education was completed at committee meetings and one-on-one physician education continued by the MSS team clinician as needed on daily rounds if a physician voiced disagreement with the practice change. Although education completion rates were not assessed by this study, it is expected that compliance was high, as the hospital policy requires all assigned learning be completed within a designated time frame or the employee is subject to removal from the schedule and no annual performance increase for 1 year. Figure 2 depicts the study design and educational process.

Clinical Characteristics

Clinical characteristics included age in years, weight in kilograms, body mass index (BMI) in kg/m^2, BMI classification, primary admission diagnosis, and primary comorbid condition. Weights were extracted from recorded weights upon admission that were documented in the EMR. BMI classification (underweight, normal weight, overweight, and obese) was based on the World Health Organization criteria for weight classification.[34] Primary diagnosis type (medical or surgical) and primary diagnosis category (cardiovascular/vascular, respiratory, endocrine, gastrointestinal, neurologic, oncologic, malnutrition, other) on date of admission to CCU were categorized based on the initial diagnosis documented by the physician in the EMR on presentation to CCU.[35] Primary comorbid condition category (cardiovascular/vascular, respiratory, endocrine, gastrointestinal, neurologic, oncologic, other) on admission

to CCU and comorbid condition type (medical or surgical) were categorized according to the initial primary comorbid condition documented by the physician in the history and physical documented in the EMR.[35] For analytical purposes, variables for primary diagnosis category type and comorbid condition category type were collapsed to the most frequently reported categories of cardiovascular, pulmonary, neurological, and other.

Nutrition Characteristics

Nutrition characteristics included the number of eligible EN days in the CCU for each patient and daily estimated and daily prescribed kcal and protein per eligible EN day. An eligible EN day was defined as a 24-hour period of time from 12:00 AM to 11:59 PM when the patient was on MSS and should have received continuous EN; the 24-hour time period may or may not have represented a continuous infusion of EN. Eligible EN days of support were calculated from the date and time MSS was initiated and the date and time MSS was discontinued. Thus, some eligible EN days included days when the patient may not have continuously received EN for the entire 24 hours, even though the patient was on the MSS. EN formula type, EN formula volume, presence of diarrhea (≥4 loose stools as documented in the EMR by clinical staff as present and unrelated to medication or procedure, yes or no (y/n), and motility agent use (y/n) were categorical data. Daily estimated nutrient requirements to meet 100% of daily caloric or daily protein needs based on weight, age, and health status were determined by standardized equations as per the 2016 SCCM/ASPEN guidelines for nutrition support of critically ill adults. For each participant, mean daily estimated kcal and protein requirements were calculated by taking the sum of daily estimated kcal and protein
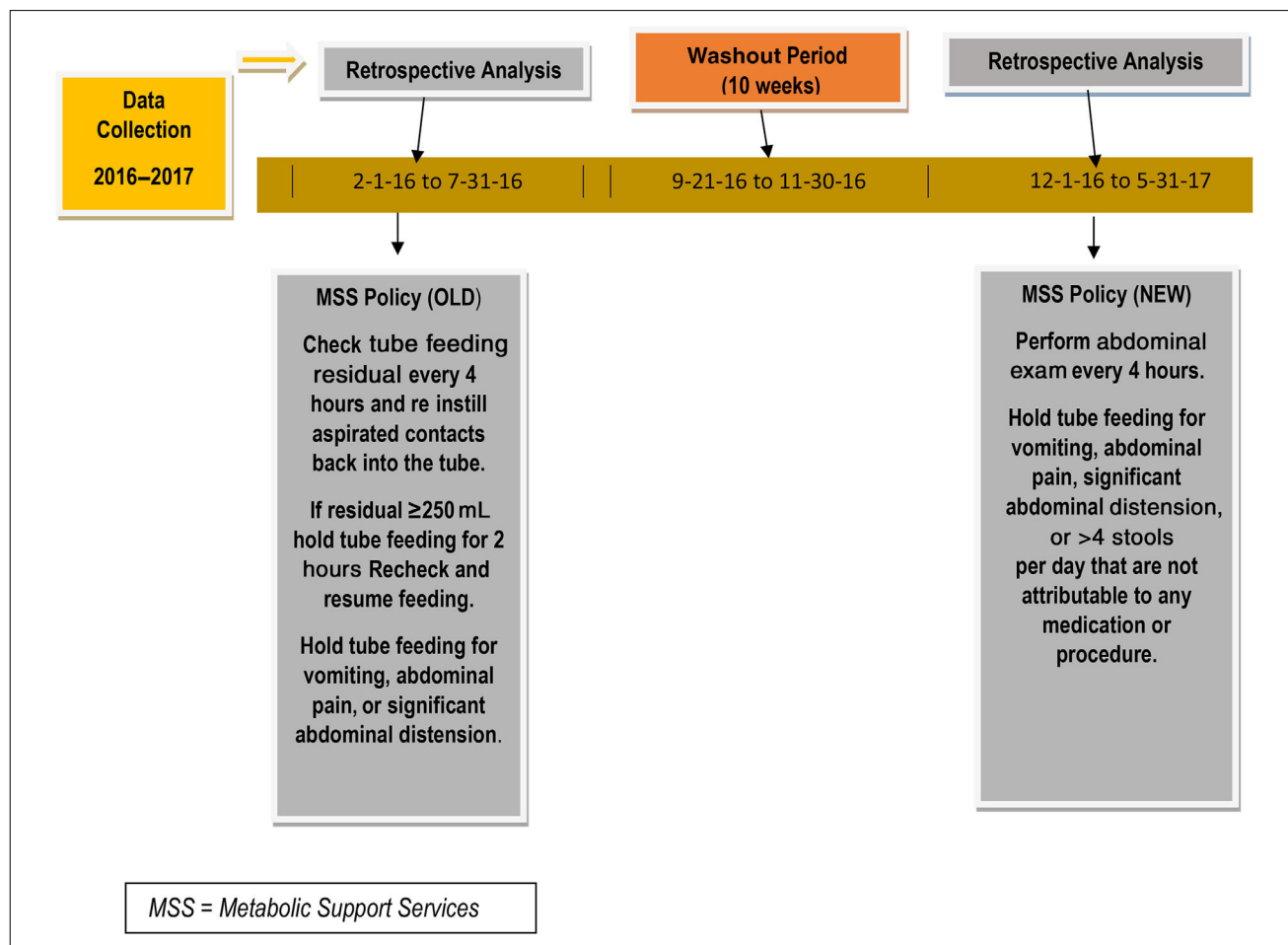
Figure 2. Conceptual model.

requirements over all eligible EN days, respectively, and dividing by the total number of EN-eligible days. Mean kcal and mean protein prescribed per day were calculated by taking the sum of kcal and protein prescribed over all EN-eligible days and dividing by the total number of eligible EN days. These outcomes were compared in the 2 cohorts before (pre-change) and after (post-change) implementation of a nutrition support practice. Total kcal from sedation was included in the calculation of total kcal received per eligible EN day by the MSS RD (Figure 4).

Nutrition Outcomes

Nutrition outcomes included the mean number of episodes of intolerance per eligible EN day, mean percent of prescribed kcal, and mean percent of prescribed protein (g) received per eligible EN day. GI was recorded as dichotomous variable (y/n) for any 1 documented episode of either abdominal distension, vomiting, diarrhea unrelated to medication, or absent bowel sounds. Mean episodes of FI intolerance were calculated by taking the sum of episodes

of intolerance that occurred over all EN-eligible days and dividing by the total number of EN-eligible days. For each eligible EN day, percent of prescribed kcal and protein met was calculated for each participant as follows: ([kcal or protein received/kcal or protein prescribed] $\times$ 100). For each participant, mean percent of prescribed kcal and protein met per eligible EN day were calculated by taking the sum of daily percent of prescribed kcal and protein met over all eligible EN days, respectively, and dividing by the total number of EN-eligible days.

Statistical Analyses

The Statistical Package for the Social Sciences version 23.0 (SPSS Inc, Chicago, IL) was used for analyses of all data. α was set at $P \leq 0.05$. Descriptive data are reported as mean $\pm$ SD for parametric continuous variables, median (25th, 75th percentile) for nonparametric continuous variables, and frequency distributions (n, %) for categorical variables. To examine equivalence of the pre-implementation and post-implementation cohort in terms
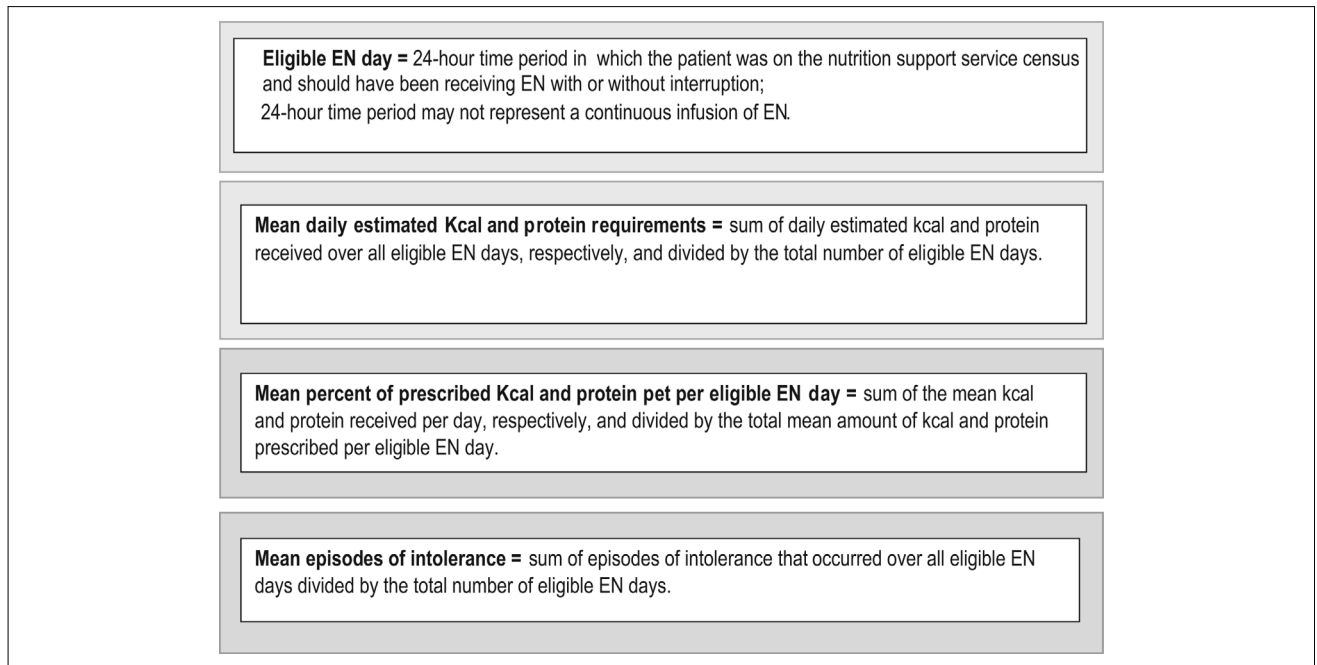
Eligible EN day = 24-hour time period in which the patient was on the nutrition support service census and should have been receiving EN with or without interruption; 24-hour time period may not represent a continuous infusion of EN.

Mean daily estimated Kcal and protein requirements = sum of daily estimated kcal and protein received over all eligible EN days, respectively, and divided by the total number of eligible EN days.

Mean percent of prescribed Kcal and protein pet per eligible EN day = sum of the mean kcal and protein received per day, respectively, and divided by the total mean amount of kcal and protein prescribed per eligible EN day.

Mean episodes of intolerance = sum of episodes of intolerance that occurred over all eligible EN days divided by the total number of eligible EN days.

Figure 3. Definition of nutrition characteristics. EN, enteral nutrition.

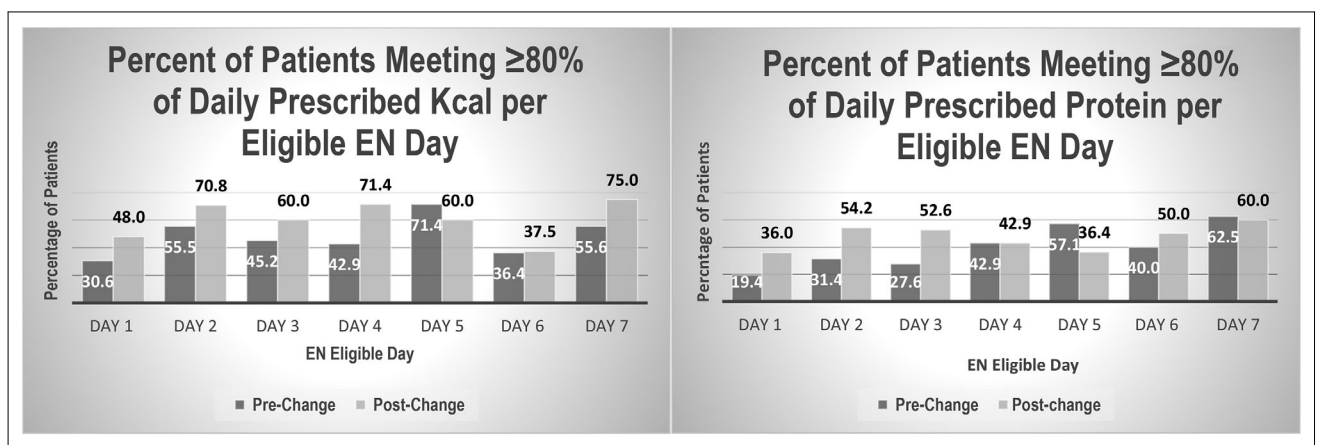**Figure 4.** Percent of patients meeting ≥80% of daily prescribed kcal and protein per eligible enteral nutrition (EN) day. The pre-implementation cohort represents patients selected from a 6-month period of time (February 1, 2016–July 31, 2016) prior to the education and implementation of the Metabolic Support Services (MSS) practice change related to monitoring gastric residual volume (n = 36). The post-implementation cohort represents patients selected from a 6-month period of time after a 10-week washout time period (December 1, 2016–May 31, 2017) from the MSS practice change implementation related to monitoring gastric residual volume in critically ill adult patients (n = 25).

of key demographic, clinical, and nutrition characteristics, categorical variables were tested using the Pearson χ^2 or Fisher exact test, and normal continuous variables were tested with independent samples *t*-test. The nutrition outcomes of mean percent of prescribed kcal met per eligible EN day and mean percent of prescribed protein met per eligible EN day were compared between the 2 cohorts using independent samples *t*-test. Because of the non-normal distribution, the mean number of episodes of

intolerance per eligible EN day was compared between the 2 cohorts using the Mann–Whitney *U* test. For outcomes found to be significant in bivariate analyses, 1-way analysis of covariance was conducted to determine whether the 2 cohorts were different in terms of these outcomes after adjusting for potential confounders including age, BMI, gender, and primary comorbid medical condition.[8,25-33] Age, BMI, and sex were selected a priori as potential confounders, as they might have all influenced the ability

Table 1. Clinical Characteristics of Pre-Implementation[a] and Post-Implementation[b] Cohorts.

	Total n = 61	Pre-Implementation n = 36	Post-Implementation n = 25	*P*-Value[d]
Variables[c]				
Age, y	68 ± 13.4	67.9 ± 13.3	68.2 ± 13.8	0.94
Weight, kg	82.2 ± 18.2	78.9 ± 17.4	87 ± 18.6	0.09
BMI, kg/m²	27.9 ± 6.8	26.8 ± 6.2	29.5 ± 7.4	0.12
Sex				
Female	33 (54.1)	21 (58.3)	12 (48)	0.43
Male	28 (45.9)	15 (41.7)	13 (52)	
Race/ethnicity:				
Caucasian	52 (85.2)	32 (88.9)	20 (80)	0.44[e]
African American	8 (13.1)	4 (11.1)	4 (16)	
Pacific Islander	1 (1.6)	0 (0)	1 (4)	
BMI classification:				
Underweight	6 (9.8)	3 (8.3)	3 (12)	0.10[e]
Normal weight	13 (21.3)	11 (30.6)	2 (8)	
Overweight	23 (37.7)	14 (38.9)	9 (36)	
Obese	19 (31.1)	8 (22.2)	11 (44)	
Primary admission Dx:				
Neurological	10 (16.4)	8 (22.2)	2 (8)	1[e]
Pulmonary	29 (47.5)	14 (38.9)	15 (60)	
Cardiovascular	8 (13.1)	7 (19.4)	1 (4)	
Other[f]	14 (23)	7 (19.4)	7 (28)	
Primary comorbid condition:				
Neurological	7 (11.5)	6 (16.7)	1 (4)	.06[e]
Pulmonary	16 (26.2)	6 (16.7)	10 (40)	
Cardiovascular	8 (13.1)	7 (19.4)	1 (4)	
Other[g]	30 (49.2)	17 (47.2)	13 (52)	

BMI, body mass index; Dx, diagnosis; kg, kilograms; m², meters squared; MSS, Metabolic Support Services.

[a]The pre-implementation cohort represents patients selected from a 6-month period of time (02/01/2016–07/31/2016) prior to the education and implementation of the MSS practice change related to monitoring gastric residual volume (n = 36).

[b]The post-implementation cohort represents patients selected from a 6-month period of time after a 10-week washout time period (12/01/2016–05/31/2017) from the MSS practice change implementation related to monitoring gastric residual volume in critically ill adult patients (n = 25).

[c]Data are presented as mean ± SD for continuous variables and as n (%) for categorical variables.

[d]*P*-values for the differences between the pre-implementation and post-implementation groups were obtained by the independent samples *t*-test for continuous variables and Pearson's χ^2 or Fisher's exact test for categorical variables.

[e]*P*-values obtained by Fisher's exact test.

[f]Other primary admission diagnoses included renal, endocrine, oncological, hepatic, psychological, or sepsis.

[g]Other comorbid conditions included renal, hepatic, endocrine, oncological, orthopedic, or sepsis.

of a patient to tolerate EN support and may have impacted the length of time patients required EN support.[8,13,25-33] The primary comorbid medical condition was found to be marginally significant between the 2 cohorts and hence was also included in the analyses as a potential confounder.

Results

During 2 separate 6-month time frames between February 1, 2016, and May 31, 2017, a total of 79 patients was identified from the MSS monthly continuous quality improvement (CQI) data sets for study inclusion. Of these patients, 17 were excluded having received EN support for <24 hours, and 1 was excluded because of patient age >90 years. A total of 61 patients were included for analyses. The pre-

implementation and post-implementation groups included 36 and 25 patients, respectively (Figure 2).

Although the post-implementation cohort had slightly fewer subjects, baseline characteristics of age, weight, BMI, sex, race/ethnicity, BMI classification, and primary and comorbid admission diagnoses were similar between the 2 cohorts (Table 1). Both groups were of older age distribution (mean age 68 years), primarily Caucasian, and overweight or obese. The primary admitting diagnosis for both cohorts was pulmonary in nature (38.9% and 60% for pre-implementation and post-implementation groups, respectively). The post-implementation cohort had slightly more patients with a primarily pulmonary comorbid condition (40%) vs the pre-implementation group (16.7%), but the differences did not achieve statistical significance between

Table 2. Nutrition Characteristics of Pre-Implementation[a] and Post-Implementation[b] Cohorts.

Nutrition Characteristics	Total n = 61	Pre-Implementation n = 36	Post-Implementation n = 25	P-Value[c]
	Mean ± SD	Mean ± SD	Mean ± SD	
Eligible EN days[d]	4.2 ± 1.9	4.2 ± 1.9	4.1 ± 2	0.86
Mean daily prescribed protein (g) per eligible EN day[e]	61.7 ± 21.5	63.9 ± 22.8	58.5 ± 19.5	0.34
Mean daily estimated protein requirement (g) per eligible EN day[f]	92.5 ± 24.4	95.1 ± 24.9	88.8 ± 23.6	0.32
Mean daily prescribed kcal per eligible EN day[e]	1341.8 ± 508.7	1398.1 ± 537.2	1260.6 ± 463.1	0.30
Mean daily estimated kcal requirements per eligible EN day[f]	2015.6 ± 411.8	2047.9 ± 439.8	1969.1 ± 449.6	0.50

EN, enteral nutrition; g, grams; Kcal, kilocalories; MSS, Metabolic Support Services.
[a]The pre-implementation cohort represents patients selected from a 6-month period of time (02/01/2016–07/31/2016) prior to the education and implementation of the MSS practice change related to monitoring gastric residual volume (n = 36).
[b]The post-implementation cohort represents patients selected from a 6-month period of time after a 10-week washout time period (12/01/2016–05/31/2017) from the MSS practice change implementation related to monitoring gastric residual volume in critically ill adult patients (n = 25).
[c]P-values for the difference between the pre-implementation and post-implementation groups were obtained by independent samples *t*-test.
[d]Eligible EN day = 24-hour time period in which the patient was on the nutrition support service census and should have been receiving EN with or without interruption; 24-hour time period may not represent a continuous infusion of EN.
[e]Mean kcal and mean protein prescribed per day were calculated by taking the sum of kcal and protein prescribed over all EN-eligible days and dividing by the total number of EN-eligible days.
[f]Daily estimated nutrient requirements to meet 100% of daily caloric or daily protein needs based on weight, age, and health status were determined by standardized equations for each participant, mean daily estimated kcal and protein requirements were calculated by taking the sum of daily estimated kcal and protein requirements over all eligible EN days, respectively, and dividing by the total number of EN-eligible days.

cohorts for the primary admission comorbid conditions ($P = 0.06$).

The number of EN-eligible days was not significantly different between the 2 cohorts ($P = 0.86$) (Table 2). Both cohorts had similar nutrition characteristics, with no significant differences in mean estimated kcal/d and mean estimated protein needs per day between the 2 cohorts. Similarly, there were no significant differences in either mean amount of daily prescribed protein or kcal per eligible EN day between the 2 cohorts. In both cohorts, majority of the patients received a low osmolality, concentrated calorie formula, and neither cohort received motility agents.

Nutrition Outcomes

There was no significant difference in the mean number of episodes of intolerance between the pre-implementation and post-implementation cohorts (Table 3). Compared with the pre-implementation group, the post-implementation cohort did receive a significantly higher mean percentage of prescribed daily kcal (93.4% vs 69.6%; $P = 0.01$) and higher mean percentage of prescribed daily protein per eligible EN day (71.8% vs 55.9%; $P = 0.01$). A 1-way analysis of covariance was conducted to determine if these differences still existed after controlling for potential confounders including age, sex, BMI, and primary comorbid condition (Tables 4 and 5). There was a statistically significant effect of cohort on both mean percentages of prescribed daily kcal

met ($F_{[1, 53]} = 5.16$, $P = 0.03$) and mean percentage of prescribed daily protein met ($F_{[1, 53]} = 5.16$, $P = 0.03$) per eligible EN day (Tables 4 and 5). Figure 4 depicts the percent of individuals in the 2 cohorts who achieved ≥80% of prescribed protein and kcal goals over each eligible EN day. During most of the eligible days of EN support, a greater proportion of patients in the post-implementation cohort met ≥80% of both prescribed daily kcal and protein compared with the pre-implementation group.

Discussion

Our findings support our hypothesis that the elimination of routine monitoring of GRV in clinical practice would result in no increase in incidence of GI. In addition, we supported our hypothesis that more patients would achieve a higher percentage of daily prescribed protein and energy needs compared with those whose EN is interrupted for GRV monitoring. Integration of evidence-based guidelines related to nutrition support of critically ill adults led to the achievement of nutrition outcomes in a community hospital or "real-world" setting that are similar to the findings reported in the literature from larger sample sizes and under more controlled environments.[23-26]

No adverse events associated with the elimination of routine monitoring of GRV, including no increases in incidence of FI, were identified by our study.[26-33,35] Intolerance is not universally defined and open to interpretation

Table 3. Nutrition Outcomes of Pre-Implementation[a] and Post-Implementation[b] Cohorts.

Nutrition Outcome	Total n = 61	Pre-Implementation n = 36	Post-Implementation n = 25	*P*-Value[d]
Mean kcal received per eligible EN day[e]	1009.3 ± 480	945.4 ± 485.3	1101.2 ± 466.6	0.22
Mean protein (g) received per eligible EN day[f]	38.3 ± 20.2	36.1 ± 21.4	41.5 ± 18.2	0.31
Mean percent of prescribed kcal met per eligible EN day[g]	79.4 ± 37.6	69.6 ± 35.3	93.4 ± 36.9	0.01
Mean percent of prescribed protein (g) met per eligible EN day[g]	62.4 ± 24.4	55.9 ± 24	71.8 ± 22.2	0.01
Mean number of episodes of intolerance per eligible EN day[h]	0 (0, 0.2)	0 (0, 0)	0 (0, 0.3)	0.46[c]

Data are presented as mean ± SD for parametric continuous variables and median (25th, 75th percentile) for nonparametric continuous variables.
CCU, critical care unit; EN, enteral nutrition; g, grams; kcal, kilocalorie; MSS, Metabolic Support Services.
[a]The pre-implementation cohort represents patients selected from a 6-month period of time (02/01/2016–07/31/2016) prior to the education and implementation related to monitoring gastric residual volume in critically ill adult patients (n = 25).
[b]The post-implementation cohort represents patients selected from a 6-month period of time after a 10-week washout time period (12/01/2016–05/31/2017) of the MSS practice change related to monitoring gastric residual volume (n = 36).
[c]*P*-value for the number of episodes of intolerance per eligible EN day was obtained from the Mann–Whitney *U* test.
[d]*P*-values for the differences between pre-implementation and post-implementation groups were obtained by independent samples *t*-test.
[e]Eligible EN day = 24-hour time period in which the patient was on the nutrition support service census and should have been receiving EN with or without interruption; 24-hour time period may not represent a continuous infusion of EN.
[f]Daily estimated nutrient requirements to meet 100% of daily caloric or daily protein needs based on weight, age, and health status were determined by standardized equations. For each patient, mean daily estimated kcal, and protein requirements were calculated by taking the sum of daily estimated kcal and protein received over all eligible EN days, respectively, and dividing by the total number of EN-eligible days.
[g]Mean percent of prescribed kcal and protein met per eligible EN day was calculated by taking the sum of the mean kcal and protein received per eligible EN day, respectively, and dividing by the total mean amount of kcal and protein prescribed per EN-eligible days.
[h]Mean number of episodes of intolerance was calculated by taking the sum of episodes of intolerance that occurred over all EN-eligible days and dividing by the total number of EN-eligible days.

Table 4. Between-Subject Effects on Mean Percent of Prescribed Daily Protein Met.

Variable[a]	*F*	*P*-Value	Partial η^2
Cohort	5.16	0.03	0.09
Age	0.58	0.45	0.01
BMI	0.45	0.51	0.01
Sex	0.40	0.53	0.01
Primary comorbid condition	1.05	0.38	0.06

BMI, body mass index.
[a]Between-subject effects were measured by analysis of covariance.

Table 5. Between-Subject Effects on Mean Percent of Prescribed Daily Kcal Met.[a]

Variable[a]	*F*	*P*-Value	Partial η^2
Cohort	5.16	0.03	0.09
Age	0.38	0.54	0.01
BMI	1.02	0.32	0.02
Sex	0.00	0.97	0.00
Primary comorbid condition	0.59	0.63	0.03

BMI, body mass index.
[a]Between-subject effects were measured by analysis of covariance.

from clinical staff.[13-15,18] Subjective interpretation of the physical signs and symptoms of intolerance by nursing and clinical support clinicians or a lack of knowledge on EN delivery best practices may impact frequency of interruption of EN.[13,41,51] Our outcomes do not reflect these potential issues. Presumably, because of a comprehensive education process, support of the practice change by key facility leadership, and adherence to the change by support staff, no increased frequency of FI was observed post-implementation. It is worth noting that the unusual primary medical nature of this population could account for better tolerance of EN compared with surgical populations more prone to delayed gastric emptying. The lack of difference in FI between pre-implementation and post-implementation groups support the notion that GRV is an ineffective monitoring parameter for nutrition support in primarily medical, critically ill patients, and therefore eliminating the practice would result in no adverse outcomes.

Similar to previous studies, we observed improved achievement in the percentage of prescribed daily goals for protein and calories, in addition to no difference in the incidence of intolerance by removing practice of routinely monitoring GRV.[26-35] In patients receiving EN, the standard of practice accepted by the MSS team is the achievement of ≥80% of daily prescribed kcal and protein

requirements.[8] Although the pre-implementation cohort did not achieve this target for percent of prescribed daily kcal or protein met, the post-implementation group did so for kcal but not protein. Most patients at the time of the study were receiving concentrated caloric EN formulas, and protein modulars were not routinely utilized, which may account for the achievement of kcal but not protein in the post-implementation group. Previous research has shown that patients receive substantially more kcal and protein when routine monitoring of GRV is eliminated.[8,13,21,22,26-32] Nonetheless, most of the investigations reported only achieving 50%–75% of daily prescribed protein and kcal goals.[13,41] The actual mean percentage of prescribed protein met in the post implementation cohort for this study was ≈72%, which was <80% goal recommended by the SCCM/ASPEN guidelines, but a significant improvement from the mean prescribed protein requirements that was being met (56%) prior to the implementation of the MSS policy. Inadequate protein delivery in the CCU may result in longer patient length of stay, contribute to malnutrition in an already high-risk population, and delay patient recovery.[43-47] Less frequent cessation of EN may be associated with elimination of GRV monitoring.[8,13,21,22,26-32] Although not captured by the current study, possibly reduced cessation of EN contributed to the post-implementation cohort's achievement of a significantly higher mean percent of prescribed kcal per eligible EN day of 93% vs the pre-implementation cohort's mean of 69.6%. By eliminating the time that the EN would be interrupted to monitor GRV, the patients in the post-implementation cohort may have received a higher volume of EN, reflecting in higher mean percent of prescribed kcal and protein goals achieved. This could lead to better patient outcomes in the future, including shortened length of stay or reduced risk of malnutrition. As a result, the MSS team is in a better position to pursue more quality improvement initiatives to help improve the nutrition status of critically ill patients, such as volume-based feeding or standardized EN progression protocols in the future.[35,39,40,42,46,47,49]

Our study sample's demographic and clinical characteristics (age, race/ethnicity, BMI, primary and comorbid conditions) were representative of the average demographic of the community hospital from which subjects were selected for analyses but varied from those in the literature.[26-33] This patient population represented primarily older adults and were overweight or obese, characteristics reported in the literature to be associated with increased FI.[13-18] Although there were no significant differences in age between the cohorts, age is often associated with FI, as the integrity of the gut may become less functional with age, and this could impact the frequency of FI.[48]

Some study limitations are worth noting. The study design was a nonrandomized, retrospective cohort, before and after study design using data from a single center based on a purposeful convenience sample, which limits the generalizability of the findings. A lack of heterogeneity of the CCU population and a lack of consistently accepted definitions of intolerance did not allow for comparison of results with other studies. The facility's critical care population was primarily medical in nature, and the sample was not diverse in terms of race and ethnicity, further limiting generalization and lending to a better tolerance of EN compared with surgical patient populations. Our patient population had lower acuity levels and primary and comorbid conditions that were medical in nature as opposed to surgical and were thus less predisposed to difficulty with FI than the surgical patient population.[13-18,26-33,35]

Implementation of a process change takes time.[50] Despite documented and mandatory learning requirements prior to the process change, much reeducation came into play while on routine daily MSS rounds. A "carryover effect" that was longer than the study's "washout" time frame may have delayed the new practice being fully implemented, impacting results.[2,3,5,50] Qualitative studies in the nursing literature have reported a variance in knowledge of EN and reluctance of support staff to follow protocols despite their availability.[33,52] Although not documented, the facility support staff may have checked residual out of a fear of GI or lack of trust in the practice change. If nurses had failed to incorporate the new protocol and checked residuals without documentation of the practice, our results related to incidence of FI would be inaccurate for the post-change group. However, a significant increase in the percent of daily prescribed protein and kcal were met by the post-change cohort, an outcome that would not be expected if indeed this practice by nursing staff substantially continued post-implementation.

Barriers to EN adequacy in critical care have been noted, including underfeeding, frequent interruptions of EN because of surgery or medical procedures, frequent holding of EN for real or perceived fear of GI, and failure to advance EN.[33,37,40-42,44,45,49] Similarly, our EN may not have advanced or may have had lower daily prescribed goal rates for EN because of medical instability of the patient. Possibility of human error exists in transcribing of data from infusion pumps into the facility EMR. At the time of our study, the facility did not have EN feeding pumps compatible with the EMR to allow for direct data transfer. Recording of intakes and outputs were subject to entry error from staff members, although the degree of error would be expected to be consistent for both pre-implementation and post-implementation cohorts. EN rates often may not have transfused for the whole time period in which prescribed, resulting in records of EN that may or may not reflect a true 24-hour time period. Patient safety outcomes and other outcomes such as length of stay in the CCU and overall hospital stay were not captured in the study. Nursing

time saved from elimination of this practice was likely another benefit, yet not examined by this study other than verbalization from nursing leadership directly to the PI and MSS team members.

We also report many strengths from our implementation of evidence-based practice guidelines. Only 1 PI extracted the data utilizing a detailed extraction process, minimizing errors in data analyses and interpretation. Potential confounders in analyses were determined a priori, and bivariate analyses were conducted to assess their influence on nutrition outcomes. The pre-implementation and post-implementation cohorts were similar in demographic, clinical, and nutrition characteristics for comparison. Strengths of the implementation process itself included the small facility size, allowing for frequent and timely movement through key stakeholder committee approval processes to engage the facility in the change. Education efforts in the implementation process regarding the policy change were consistent from team member to team member, utilizing the same education piece and same team members delivering the education. No attrition or turnover among clinical staff or leadership key to the practice change occurred within the facility, possibly enhancing the implementation success by allowing consistent education and the development of trust in the process as transition from old to new practice evolved. Although not quantitatively assessed, the team of MSS RDs involved in the process change demonstrated a strong commitment to evidence-based best practice in patient care. The policy change was clearly defined prior to implementation, and data extraction was avoided for the time frame in which the influence of the old policy may have overlapped with the implementation of the new policy, allowing for time for education diffusion throughout the staff. No adverse reported events in the post-implementation cohort further strengthened facility key stakeholder belief in the clinical judgment of the team and sustaining the policy change.

Conclusion

A change in nutrition support practice related to the 2016 SCCM/ASPEN guidelines for the provision of nutrition support in the adult critically ill patient was successfully implemented in the "real-world" setting. As a result, prolonged holding of EN for non-evidence-based reasons were avoided, and significant improvements were achieved in meeting daily prescribed protein and kcal requirements among the critically ill patient population in a community hospital setting. Most importantly, these patients did not have more adverse events related to FI as a result of the practice change and anecdotally freed up nursing time usually spent checking GRV to other patient care activities. Informal feedback from nursing and administrative staff regarding the practice change was positive. This study provided the MSS team with the impetus to proceed with more

evidence-based implementation studies such as volume-based feeding or EN protocols, which are also associated with improved outcomes in critically ill adults.[47,49] Elimination of routine monitoring of GRV may result in obtaining a higher percent of patients' nutrient requirements through increasing the time/volume of nutrition in patients receiving EN in the CCU.

Statement of Authorship

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