Adequacy of protein and energy intake in critically ill adults following liberation from mechanical ventilation is dependent on route of nutrition delivery

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Abstract

Background: Studies examining nutrition intake of critically ill patients following liberation of mechanical ventilation (LMV) are scarce. The objectives of this prospective, observational feasibility study were to quantify and assess protein and energy intake in hospitalized, critically ill patients following LMV, to determine barriers to optimal intake, and to report on the feasibility of recruiting and retaining patients into this study.

Methods: Adult patients requiring mechanical ventilation for >72h in a medical/surgical intensive care unit were recruited. Protein and energy intakes and intakes in relation to prescribed amounts were quantified up to 14 days following LMV. Patients, who were able, identified barriers to eating.

Results: 19 patients with a mean age of 60 years (SD, 12 years) were studied over 125 days. Over all study days, the median amounts of protein and energy consumed in comparison to amounts prescribed by the consulting dietitians were 46% (IQR: 26, 100) and 71% (IQR: 38, 100), respectively. When stratified by the route of nutrition delivery, on days (n=54) where patients consumed an oral diet as the sole source of nutrition, median amount of protein and energy consumed in comparison to prescribed was only 27% (IQR: 15, 41) and 47% (IQR: 29, 66), respectively. Patients met 100% (IQR: 75, 100) of prescribed energy and protein when receiving EN exclusively. The most frequently reported barriers to eating were poor appetite, early satiety and taste changes. Median days each patient contributed to the data were 7 d (IQR: 6, 8); only 37% of patients had measures completed over the entire study protocol.

Conclusions: Protein and calorie intake is below prescribed amounts for patients whose EN is discontinued and an oral diet prescribed as sole source nutrition following LMV. Acceptable

strategies to enhance nutritional intake in post-ICU patients during the recovery stages of critical illness are needed.

Keywords: critical care; nutrition rehabilitation; nutrition assessment; dietary intake; weighed food record; enteral nutrition

Abbreviations:

ICU: intensive care unit

LMV: liberation from mechanical ventilation

MV: mechanical ventilation

MSICU: medical/surgical intensive care unit

OPD: oropharyngeal dysphagia

SLP: Speech-Language Pathologist

Background

Malnutrition is a significant problem affecting critically ill patients throughout the trajectory of their illness. Over the course of an intensive care unit (ICU) admission, patients are frequently underfed and thus accrue large protein and energy deficits.[1,2] These deficits are associated with increased ICU and hospital length of stay (LOS), lower discharge rates to home, and increased mortality.[1-3] Given the high prevalence of malnutrition at ICU admission,[4] inadequate nutrition delivery throughout ICU stay, and the heightened catabolic processes during critical illness that accelerate lean tissue loss,[5,6] most critically ill patients are likely to be malnourished to some degree at the time of liberation from mechanical ventilation (LMV) and ICU discharge. Therefore, nutrition therapies are needed to facilitate recovery in survivors of critical illness, reduce the risk of the negative sequelae associated with malnutrition,[7,8] and improve quality of life.

Studies examining nutrition intake in ICU survivors who are in recovery are scarce, with only three studies to date quantifying both protein and energy intake in various ICU patient populations following ICU discharge.[9-11] Peterson et al.[9] limited their analysis to patients exclusively prescribed oral diets post-LMV and found that 7-day post extubation adequacy of protein and energy intake was quite poor with intake never exceeding 37% and 55% of estimated requirements, respectively. Ridley et al.[10] reported similar findings for patients prescribed oral diets exclusively (without oral supplements), however it was also noted that patients who continued to receive enteral nutrition (EN) in combination with oral diets met their estimated requirements. In both studies, dietary intake was assessed using dietary recall and food records, which rely on well-trained interviewers and patients capable of recalling daily food consumption.[12] However, patients commonly experience decreased level of alertness and/or

delirium in the first few days of ICU discharge.[13] To effectively and accurately evaluate dietary intake in this patient population, methods that do not rely on cognitive capacity are ideal. Researcher completed weighed food records do not rely on the patient's capabilities or staff capacity and is considered the gold standard of evaluating dietary intake due to its high precision and accuracy in comparison to other methods.[12]

Dietary intake is influenced by numerous factors. Survivors of critical illness frequently report poor appetite, nausea, vomiting, early satiety and difficulty swallowing as primary barriers to eating.[9,14-17] Given the paucity of research examining aspects of nutrition rehabilitation in the critically ill, further research is required to comprehensively evaluate nutrition intake and barriers affecting intake. Thus, the primary objectives of this feasibility study were to: 1) precisely quantify protein and energy intakes and relate these to amounts prescribed in hospitalized, critically ill patients admitted to a mixed medical/surgical intensive care unit (MSICU) following LMV; 2) examine how mode of feeding impacts intake relative to requirement; and, 3) characterize patient-reported barriers to eating. A secondary objective was to determine the feasibility of recruiting and retaining hospitalized, critically ill patients following LMV for a larger-scale trial at a single centre.

Methods

Study Population

This prospective, observational, feasibility study was conducted at a teaching hospital in *location deidentified for the purpose of blind review*, where adult critically ill patients requiring MV for at least 72 consecutive hours were recruited from a 24-bed MSICU. Recruitment occurred over a 6-month period; the primary investigator (*initials deidentified for the purpose of*

blind review) was present on site during working hours seven days per week to screen patients for eligibility and obtain consent. *Initials deidentified for the purpose of blind review* is a clinical dietitian but was not previously employed at the study site. Patients for whom death was imminent or were not expected to survive ICU admission, were pregnant, had primary neuromuscular disease, spinal cord injury, limb amputations, traumatic brain injury, admitted to hospital for organ transplant, or enrolled into an intervention study affecting usual nutrition care were excluded. Written informed consent was obtained prior to enrolment into the study. Consent was obtained from the patient's legal substitute decision maker (SDM) if the patient was incapable of providing consent at the time of enrolment. Deferred consent was obtained from patients initially enrolled by an SDM who became capable thereafter. Patient refusal resulted in withdrawal from the study. This protocol was approved by the *deidentified for the purpose of blind review* Office of Human Research Ethics (REB#105268), the *deidentified for the purpose of blind review* (R-14-409), and the *deidentified for the purpose of blind review* Office of Research Ethics (ORE#19766).

Study protocol

Nutrition intake was measured specifically following LMV, a pivotal point in the recovery trajectory of the critically ill, and not following ICU discharge. Thus, study measures occurred over a two-week period following the day a patient was liberated from the ventilator (denoted as study day 0). Study day 1 is denoted as the day following LMV. Protein and calorie intake and patient-identified barriers to eating were assessed daily from day 1 through to day 7 following LMV. If patients remained in hospital for 14 days following LMV, protein and energy intake and barriers to eating were also measured on the fourteenth day following LMV, thus the

total number of days each patient could be studied was 8. The purpose for completing measures on day 14 was to identify the proportion of patients enrolled into the study that remained in hospital for at least 2-weeks following LMV to determine the feasibility of completing future longitudinal studies at this site that examine post-LMV recovery. The study terminated on the fourteenth day following LMV. If a patient was discharged from the study hospital or readmitted to the MSICU from the ward prior to day 14, the study was terminated on the date of discharge from the ward.

Patient age, sex, and ICU admission and diagnostic categories were documented to facilitate description of the study population recruited. Acute Physiology and Chronic Health Evaluation II (APACHE II)[18] and Sequential Organ Failure Assessment (SOFA) scores[19] were calculated to evaluate severity of illness, and the Charlson Comorbidity Index (CCI)[20] and Functional Comorbidity Index (FCI)[21] were calculated to assess health status upon admission to ICU. Clinical outcomes measured included ICU, total hospital, and post-LMV LOS, number of days requiring MV, and in-hospital mortality.

Measurement of protein and energy intake

For all study days, diet orders and protein and calorie prescriptions as determined by the dietitian(s) caring for each patient were obtained from the patient's medical record. Daily protein and energy intake were assessed using a multiple methods approach that included the use of weighed food records, dietary recall and chart reviews. For patients receiving EN or parenteral nutrition (PN), the volume of the EN supplement, amount of modular protein, or PN solution delivered on an hourly basis was obtained from the nursing flow sheets in the patient's medical record and used to calculate protein (grams) and energy (kcal) delivered. To facilitate

measurement of dietary intake using weighed food records, a study investigator was on site all days of the week during all hours that meals were served.

For patients consuming an oral diet, after each meal (breakfast, lunch, dinner) patient meal trays were collected and the remaining waste of each food and fluid item that was served was weighed (i1200 scale, MyWeigh, Phoenix, AZ) to the nearest 0.1 gram. Meal tickets generated by the hospital's Food Services Department were collected to verify each item served. In the event a meal ticket was missing from the patient's tray, the items served were verified through the hospital nutrition management software. When meal trays were collected, patients (and/or their family members or members of the health care team) were asked to recall any other foods and beverages consumed between meals (e.g. snacks, oral nutrition supplements) or foods brought from outside sources. If leftover snacks or other foods remained at the bedside, they were weighed. In the event a meal tray collection was missed, intake was estimated using a dietary recall approach with the patient, his/her family member, or a member of the patient's health care team.[9] The amount of each food and fluid item consumed was calculated by subtracting the measured waste from a reference portion weight. At the hospital where this study was conducted, all patient meals are plated at a separate facility, placed into re-thermalization carts and delivered by truck to the hospital three times daily for breakfast, lunch and dinner. Upon arrival, carts are immediately delivered to each ward and plugged into a docking station to commence the re-thermalization process. This food delivery system precluded weighing individual portions prior to delivery to the patient. Thus, for each food item offered on the hospital menu, three standard portions were weighed and the average weight was used as the reference standard portion size. Protein (grams) and energy (kcal) content of each item was

determined by referring to the nutritional content reported on labels by the food manufacturers or by referring to the Canadian Nutrient File.

Assessment of protein and energy intake in relation to prescribed requirement

Protein and energy intake in relation to prescribed requirements was determined by comparing daily protein and energy intake to the amount of protein and energy prescribed by the dietitian(s) as part of usual care. The dietitian prescriptions were specific to the needs of each patient and calculated using equations based on clinical practice guidelines,[22,23] 24h urinary nitrogen losses and clinical judgment. Patient charts were reviewed daily to identify when dietary prescriptions changed as part of routine monitoring. If the dietary prescription changed (e.g. when a patient transfers from the ICU to the ward, the ward dietitian may reassess the patient and change the dietary prescription), measured intake was compared to the new protein and energy prescription. If the prescription did not change, it was carried forward on subsequent days.

Assessment of barriers to intake

On days that food intake was measured, after the dinner meal capable patients were asked to identify up to 3 barriers to eating they were experiencing. A checklist of barriers to eating commonly experienced by hospitalized patients[9,15,24] was provided to the patients as a reference. Patients also had the opportunity to state any other barriers to eating they experienced that were not a part of the checklist. Patients who were receiving EN or PN as sole source of nutrition were not asked to identify barriers to eating.

Measures of recruitment and retention

To inform our ability to recruit and retain patients, data was kept on when patients were consented in relationship to day of ICU admission and day of LMV, who consented the patient (patient or SDM), why eligible patients were missed, and reasons patients exited the study early.

Statistical analysis

The distribution of all continuous data was examined using graphical methods; descriptive data are presented as median and interquartile range (Q1, Q3) [minimum, maximum] or mean ± standard deviation, as appropriate. Categorical data are presented as counts (percentages). Descriptive statistics were used to summarize daily protein and calorie intake, adequacy of intake in relation to prescribed amounts across all and specific study days and by route of delivery, and self-reported barriers to eating. Statistical comparisons of nutrition intake between study groups (route of nutrition delivery) and by study day were not possible as several patients received nutrition by different modes of nutrition delivery (e.g. EN, EN with an oral diet, and/or an oral diet exclusively) over the days they were enrolled in the study, thus observations were not independent. Statistical analysis was carried out using SPSS Statistics version 23 (IBM Corp., Armonk, NY, USA).

Results

Between February and September 2015, 538 patients were screened, 65 were eligible to participate, and consent was obtained and data collected for 19 patients (Figure 1). In total, data were collected over 125 study days; median days each patient contributed to the total number of study days was 7 days (IQR 6, 8) [2, 8]. Baseline patient characteristics and outcomes are summarized in Table 1.

Over 125 study days, 227 meal trays were delivered and intake was quantified for all of them. Intake was assessed via weighed food records for 208 (92%) of the meals delivered. For 14 meals, the meal tray was accidentally collected and disposed of by staff before a weighed food record could be performed, and for 5 meals, no research staff were available, however detailed calorie counts were completed by nursing staff who had received detailed training instructions. Patients received EN either exclusively or with an oral diet on 71/125 study days and the amount of enteral formula delivered was retrieved from the patient's medical record on 100% of these occasions. Within the 125 study days, patients received EN as sole source nutrition (EN+NPO) on 48 days, EN supplemented with any type of oral diet (including the use of oral nutritional supplements) (EN+PO) on 23 days, and an oral diet exclusively (including the use of oral nutritional supplements) (PO only) on 54 study days. No patients in this study received PN following LMV. Over the entire duration of the study, 2/19 patients received EN as sole source of nutrition for the entire duration of the study, 5 consumed only oral diets and did not receive any EN following LMV, and the remaining 12 received a combination of EN, EN+PO, and/or PO only throughout their stay.

Protein and energy intakes following liberation from mechanical ventilation

Across all 125 study days, median daily protein intake was 56 g/d (IQR: 29, 107) [0, 151] and median daily energy intake was 1260 kcal/d (IQR: 729, 1757) [0, 2306]. Protein intakes for those receiving EN+NPO (n=48 study days), EN+PO (n=23 study days), and PO only (n=54 study days) were 106 g/d (IQR: 87,119) [0, 137], 75 g/d (IQR: 23, 130) [5, 151] and 32 g/d (IQR: 17, 46) [0, 77], respectively. Energy intakes for those receiving EN+NPO, EN+PO, and PO only were 1628 kcal/d (IQR: 1396, 1920) [0, 2016], 1586 kcal/d (IQR: 619, 1954) [147,

2306], and 870 kcal/d (IQR: 455, 1173) [100, 1856], respectively. Median protein and energy intakes stratified by study protocol day are found in Figure 2. Across all PO only days, when protein and energy intake were related to admission body weight, protein intake was equivalent to 0.4 (IQR: 0.2, 0.5) [0, 1.1] g/kg and 9 (IQR: 6, 14) [1, 34] kcal/kg/d, respectively. In contrast, across all EN+NPO days, median protein intake was equivalent to 1.2 (IQR: 0.8, 1.7) [0, 2.0] g/kg/d and median calorie intake was 19 (IQR: 11, 27) [0, 32] kcal/kg/d.

Across all study days, median adequacy of protein and energy intake when compared to prescribed amounts was 46% (IQR: 26, 100%) [0, 129%] and 71% (IQR: 38, 100%) [0, 125%], respectively. Adequacy of intake within each study groups is presented in Table 2 and the proportion of days in which protein and energy intake as a percent of prescribed across all study days and by route of nutrition delivery is presented in Table 3. Protein and energy intake versus prescribed amounts are examined in Figure 3. In the EN+NPO and EN+PO, the absolute proportions of energy and protein consumed in relation to that prescribed were similar. Conversely, in the PO only group, the absolute proportions of energy and protein intake were disproportionate such that energy intake fell closer to prescribed amounts than protein intake (Figure 3).

Barriers to eating

Of the days patients received an oral diet (n=77), patients were capable of reporting self-perceived barriers to eating on 61 (79%) of these days. The primary reasons patients were not capable were due to decreased level of alertness and delirium/agitation. On 16 (26%) of these days, patients reported no barriers to eating. For the remaining days, a total of 102 barriers were reported. The most frequent barriers reported were poor appetite (24%), early satiety (15%), taste

changes (11%), nausea/vomiting (10%), and disliking the food (10%). Other barriers to eating identified by patients are shown in Figure 4.

Recruitment and retention

Over the 26-week recruiting period, all patients admitted to the MSICU (n=538) were screened for eligibility. Of these, 65 (12%) were eligible, 34 were approached for consent, and 23 were enrolled (68% participation rate) (Figure 1). Those eligible but not approached were unable to consent themselves and were either without an SDM (n=21) or the SDM was missed because they did not visit, or they visited during hours the investigator was not present (n=9). Of the 23 for whom consent was obtained, 7 (30%) patients consented themselves, whereas 16 (70%) were consented via proxy. An average of 0.9 patients per week were initially enrolled. Three patients for whom consent was obtained to participate in the study while still receiving MV died prior to LMV, and one patient was excluded because of discharge to a ward in which the study had not yet been approved leaving 19 patients who started the protocol upon LMV.

Patients were enrolled into the study on average 8 days (IQR: 6, 11) [3, 38] after ICU admission and on average 1 day (IQR: 0, 4) [0, 11] prior to LMV. Of the 19 patients who participated in the study, all completed study day 1, 89% completed study day 4, and 68% and 37% completed study days 7 and 14, respectively. Reasons for exiting the study are included in Figure 1.

Discussion

This study is the first to examine the nutrition intake in ICU survivors in the early phases of ward-based rehabilitation in Canada, and the first to evaluate post-ICU nutrition intake using

weighed food records specifically in a mixed MSICU population. Our findings are in agreement with the few other existing studies that examine post-ICU nutrition intake.[9-11,14] Patients exclusively consuming oral diets prescribed as part of usual care following LMV consumed very low protein and calorie intakes relative to prescribed amounts which was less than those receiving EN+NPO and EN+PO. In contrast, those on EN+NPO and EN+PO had higher net intakes of protein and energy and were more apt to meet their nutrition targets. These findings highlight a significant gap in the nutritional care of critically ill patients who are liberated from the ventilator and transition into the early stages of in-hospital recovery.

We report that patients consuming oral diets exclusively consumed only 47% of their estimated energy requirements and 27% of their estimated protein requirements in the immediate days following LMV. These findings are highly congruent with the few other studies that have examined energy and protein intake in ICU survivors in the early phases of ward-based rehabilitation. [9-11] Seminal work by Peterson et al.[9] found that patients, following extubation, never consumed greater than 55% of their estimated caloric requirement and 37% of their estimated protein requirement. Similarly, in the first study to use weighed food records to assess protein and energy intake in critically ill patients with traumatic brain injury, Chapple et al. [11] reported those prescribed oral diets accrued significantly greater energy and protein deficits over the course of hospitalization in comparison to those receiving EN. More recently, Ridley et al.[10] also reported that hospitalized, post-ICU patients prescribed oral diets without oral supplements also consumed 48% and 37% of their predicted energy and protein requirements, respectively. Combined, these data indicate most critically ill patients receiving oral diets as sole source nutrition following LMV are incapable of consuming adequate nutrition and thus are likely to continue to accrue large protein and energy deficits prior to discharge from the hospital. Our

work emphasizes the critical importance of identifying effective strategies to improve nutrition rehabilitation for survivors of critical illness.

The preferred method of feeding a mechanically ventilated critically ill patient is via EN,[25,26] which is also indicated for patients at high nutrition risk who are unable to maintain volitional intake.[27] Following LMV, critically ill patients may continue to receive EN if EN access devices remain in situ;[11,15] however, post-LMV prescription practices and the degree to which route of nutrition delivery influences nutritional outcomes have not been well characterized. Our data suggest that delaying the transition from EN to PO only until a patient can demonstrate the ability to consume adequate nutrition orally may effectively enhance nutrition intake in this population. Successful LMV and transition from the ICU to ward marks a significant point in the trajectory of critical illness[28] and the beginning of the journey to recovery. While no formal guidelines for transitioning patients from EN to an oral diet exist specifically for the recovering critically ill, Massanet et al.[29] propose permanent discontinuation of EN only when a patient has demonstrated the ability to consume >75% of daily caloric needs. Half of the patients who transitioned from EN to an oral diet in the first 7 days following LMV whereby EN was discontinued prior to initiation of any oral diet, did not have the opportunity for assessment of oral intake. While we did not examine the factors that influenced why and when feeding tubes were removed, Merriweather and colleagues have found that early feeding tube removal occurs when ward staff lack the necessary knowledge to attend to the specialized nutrition care needs of post-ICU patients, and when documentation in the medical record on the patient's nutrition problems is erroneous or missing.[15,30] Further research in Canadian ICU's to better understand the barriers and facilitators to providing nutrition care is warranted.

The most common barriers to eating reported by patients in this study related to the physiological effects of illness, including poor appetite, early satiety, taste changes, nausea/vomiting and disliking food served. Our findings are congruent with previous reports[9,14-16] and underscore the challenges faced in adequately feeding sick patients experiencing such barriers that are not easily modified. These findings lend support to more aggressively promoting the use of EN as a therapeutic strategy to adequately feed patients experiencing these barriers. The effectiveness of EN on improving nutritional status, reducing the risk of negative health outcomes, and reducing costs of care warrants further investigation.

Not only is protein essential in maintaining optimal nutritional status and lean body mass, but it is also important in wound healing and immune function.[8] The American Society for Parenteral and Enteral Nutrition and the Academy for Nutrition and Dietetics consider insufficient calorie intake as one of the diagnostic criteria for malnutrition without mention of protein intake.[31] In a group of hospitalized cardiac patients, Van Bokhorst-de van der Schueren et al.[32] reported a strong linear relationship between adequacy calorie and protein consumption, such that the percent of required energy consumed matched the percent of required protein. Although our sample size was small, we observed patients on oral diets who tended consume amounts that were closer to their prescribed calories were still consuming insufficient protein in relationship to that prescribe (Figure 3). From a practical perspective, this finding emphasizes the need to ensure protein dense diets are prescribed. It is also important that meal intake audits where both energy and macronutrient intakes are estimated are completed, versus relying solely on energy intake (i.e. “calorie counts”) which may result in overlooking at risk patients who are not consuming enough protein.

Our secondary objective was to determine the feasibility of recruiting and retaining patients into our study, in anticipation of completing larger scale studies examining nutrition in ICU recovery. Almost half of eligible patients could not be approached due to difficulties contacting SDM's or the absence of an SDM altogether. These findings are consistent with recruitment challenges reported in Canadian intensive care units.[33] Furthermore, one-third of patients who participated in the study were lost to follow-up by study day 7 because they were either discharged from the hospital or repatriated to a referring hospital. As a result, study duration post-ICU discharge is likely limited to a week or less in the incident hospital and any studies examining the continued recovery of patients need to consider how to follow these patients if long-term recovery and the processes that influence this are the subject of the research. Analogous to previous nutrition-related studies in the critically ill,[34,35] we recruited patients who received mechanical ventilation for at least 72 consecutive hours. Of all patients screened for eligibility, 41% were mechanically ventilated for less than 72 hours. Thus, one strategy to increase recruitment could be to decrease the minimum length of mechanical ventilation to 48 hours. However, our aim was to study critically ill patients who are at higher risk for developing the functional morbidities associated with critical illness and may experience greater benefit from targeted nutrition interventions in recovery. Those experiencing an ICU LOS greater than 72 hours are more prone to losing greater amounts of lean tissue mass[6,36] and to develop swallowing disorders,[16] thus increasing the risk of becoming nutritionally compromised.

There are several methodological limitations in this study. Statistical comparisons of nutrition intake by route of nutrition delivery and by study day were not possible as several patients received nutrition by different routes over the course of the study and thus observations

were not independent. Interpretation of intake in relationship to amounts prescribed was based on dietitian prescriptions. For the recovering critically ill patient, no guidelines or equations exist to estimate nutrient requirements, likely leading to inaccuracies in the true adequacy of protein and energy intake reported. However, we chose to compare intake to prescriptions determined by the registered dietitian responsible for each patient's care, all of whom have extensive experience and use the most up-do-date evidence and clinical judgement to inform their practice. Despite this small sample size, we were able to precisely and accurately evaluate dietary intake longitudinally with the use of weighed food records.[12] Weighed food records are considered the gold standard of dietary intake assessment, however it is acknowledged that we were not able to measure foods and fluids delivered prior to meal consumption, relying instead on an average weight of standardized portions which introduces error into the measurement. Despite this limitation, this method of intake assessment remains more accurate than dietary recall and food intake records. The use of weighed food records is labor-intensive, however 70% of patients recruited were not capable of providing informed consent, thus reliance on recall or self-reporting methods would have significantly reduced our capacity to accurately quantify daily calorie and protein intake. The only other studies to previously quantify intake specifically in MSICU patients did so using dietary recalls with patients and families or food record charts completed by the members of the health care team with minimal training;[9,10] both methods are open to measurement bias and compromised accuracy.[12]

Conclusions

In conclusion, patients recovering from critical illness have inadequate protein and energy intake following LMV, however adequacy appears to be largely influenced by route of

feeding. Delaying discontinuation of EN after LMV is a promising strategy to enhance protein and calorie intake hospitalized survivors of critical illness, however the impact of doing so on improving overall nutritional status and recovery is unknown. These findings underscore the need for the development and testing of feasible and acceptable interventions that enhance nutrition intake and overall nutritional status of survivors of critical illness.

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Statement of Authorship

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Table 1. Patient ICU admission and outcome characteristics (n=19).

Variables	Value
Sex, male	8 (42)[a]
Age (y)	60 ± 12[b]
ICU admission type	
Medical	16 (84)[a]
Surgical	3 (16)[a]
APACHE II score (n=18)	25 ± 6[b]
SOFA score (n=15)	11 ± 4[b]
Charlson Comorbidity Index	2 (1, 3) [0, 6][c]
Functional Comorbidity Index	4 (2, 5) [0,7][c]
Body Mass Index (kg/m^2)	28 (23, 43) [20, 61][c]
Underweight (<18.5 kg/m^2)	0 (0)
Normal (18.5 – 24.9 kg/m^2)	7 (37)
Overweight (25 – 29.9 kg/m^2)	4 (21)
Obese, all classes (>30 kg/m^2)	8 (42)
Duration of mechanical ventilation (d)	11 (6.6, 14) [3.0, 41]
Patients with a tracheostomy at time of LMV	1 (5.3)
ICU LOS (d)	15 (9.4, 23) [4.2, 101]
Total hospital LOS (d)	24 (19, 30) [9.2, 113]
Post-LMV hospital LOS (d)	11 (7.1, 17) [3.0, 61]
In-hospital mortality	2 (11)

[a]Categorical data are presented as counts (%). APACHE, Acute Physiology and

[b]Mean ± standard deviation

[c]Median and interquartile range (Q1, Q3) [minimum, maximum] as appropriate

Chronic Health Evaluation II; BMI, body mass index; ICU, intensive care unit; LMV, liberation from mechanical ventilation; LOS, length of stay; SOFA, Sequential Organ Failure Assessment.

Table 2. Protein and energy intake in comparison to amounts prescribed across all study days and by route of nutrition delivery.

		Route of nutrition delivery		
	All study days (n=125 days)	EN+NPO (n=48 days)	EN+PO (n=23 days)	PO Only (n=54 days)
Protein (%)	46 (26, 100) [0, 129]	100 (81, 100) [0, 129]	75 (25, 102) [4.2, 122]	27 (15, 41) [0, 61]
Energy (%)	71 (38, 100) [0, 125]	100 (77, 100) [0, 105]	75 (39, 104) [7.7, 125]	47 (29, 66) [4.9, 119]

Data are presented as median and interquartile range (Q1, Q3) [minimum, maximum].

Table 3. Proportion of days in which protein and energy intake as a % of prescribed across all study days and by route of nutrition delivery.

Adequacy of intake	Prescription	All study days (n=125 days)	Route of nutrition delivery		
			EN+NPO (n=48 days)	EN+PO (n=23 days)	PO Only (n=54 days)
Intake <50% of prescribed	Protein	64 (51.2)	6 (12.5)	9 (39.1)	49 (76.6)
	Energy	44 (35.2)	6 (12.5)	7 (30.4)	31 (57.4)
Intake 50-75% of prescribed	Protein	13 (10.4)	5 (10.4)	3 (13.0)	5 (9.3)
	Energy	27 (21.6)	6 (12.5)	5 (21.7)	16 (29.6)
Intake >75% of prescribed	Protein	48 (38.4)	37 (77.1)	11 (47.8)	0 (0)
	Energy	54 (43.2)	36 (75.0)	11 (47.8)	7 (13.0)

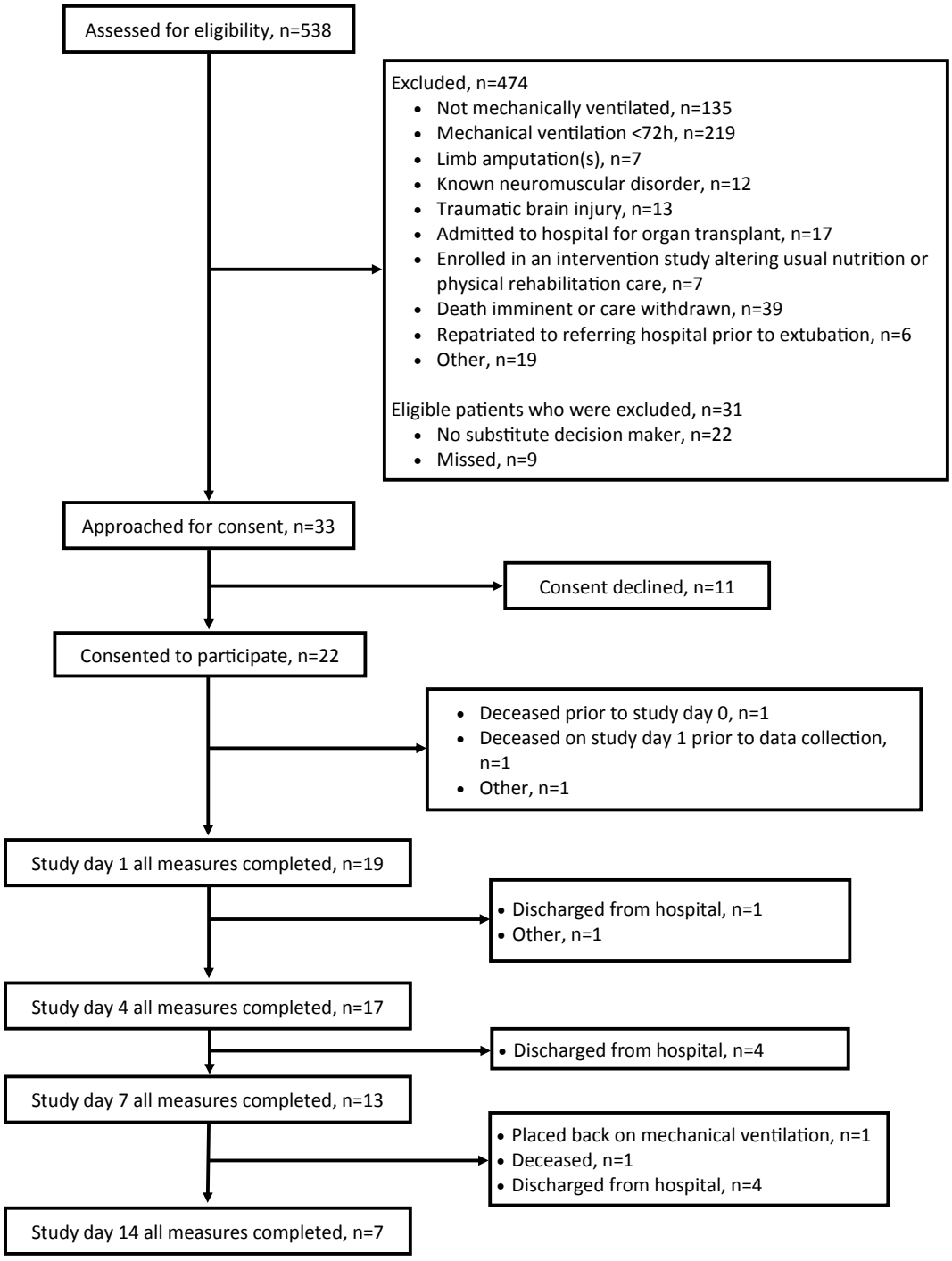
Data are presented as counts (%).

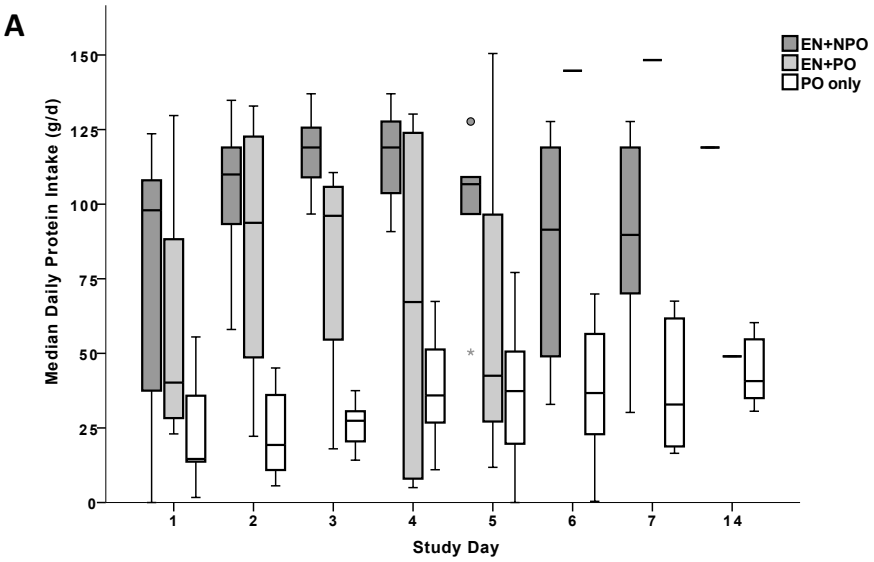
Figure 1. Study flow diagram

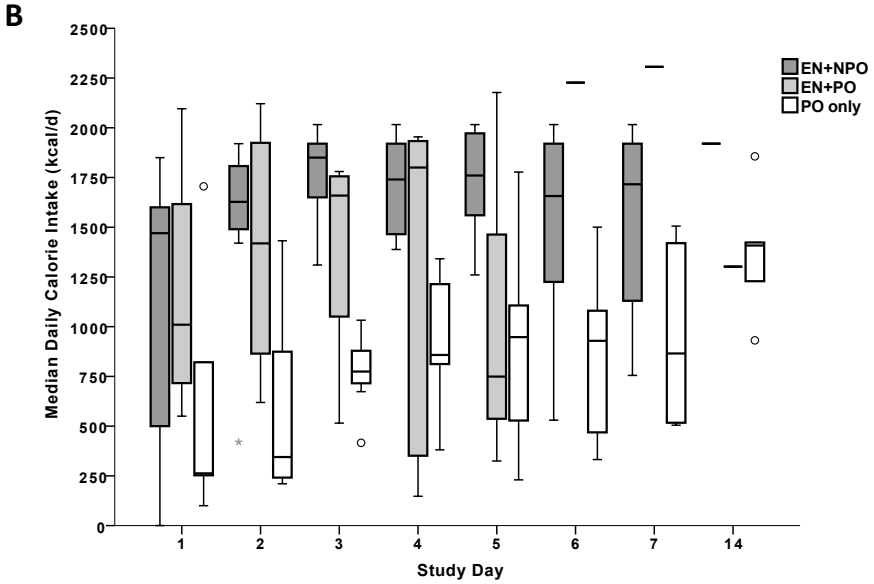
Figure 2. Median daily protein intake (A) and calorie intake (B) on each study day stratified by route of nutrition delivery. Boxplots represent the median and interquartile range, tails indicate minimum and maximum values, circles represent outliers, stars represent extreme outliers, and solid dashes represent data for n=1.

Figure 3. Protein and calorie intake versus amounts prescribed. Lines represent the line of best fit for the EN+NPO group (n=48, – –), EN+PO group (n=23, ·—·), and PO only group (n=54, - - -). The line of identity (x=y) is denoted by (—).

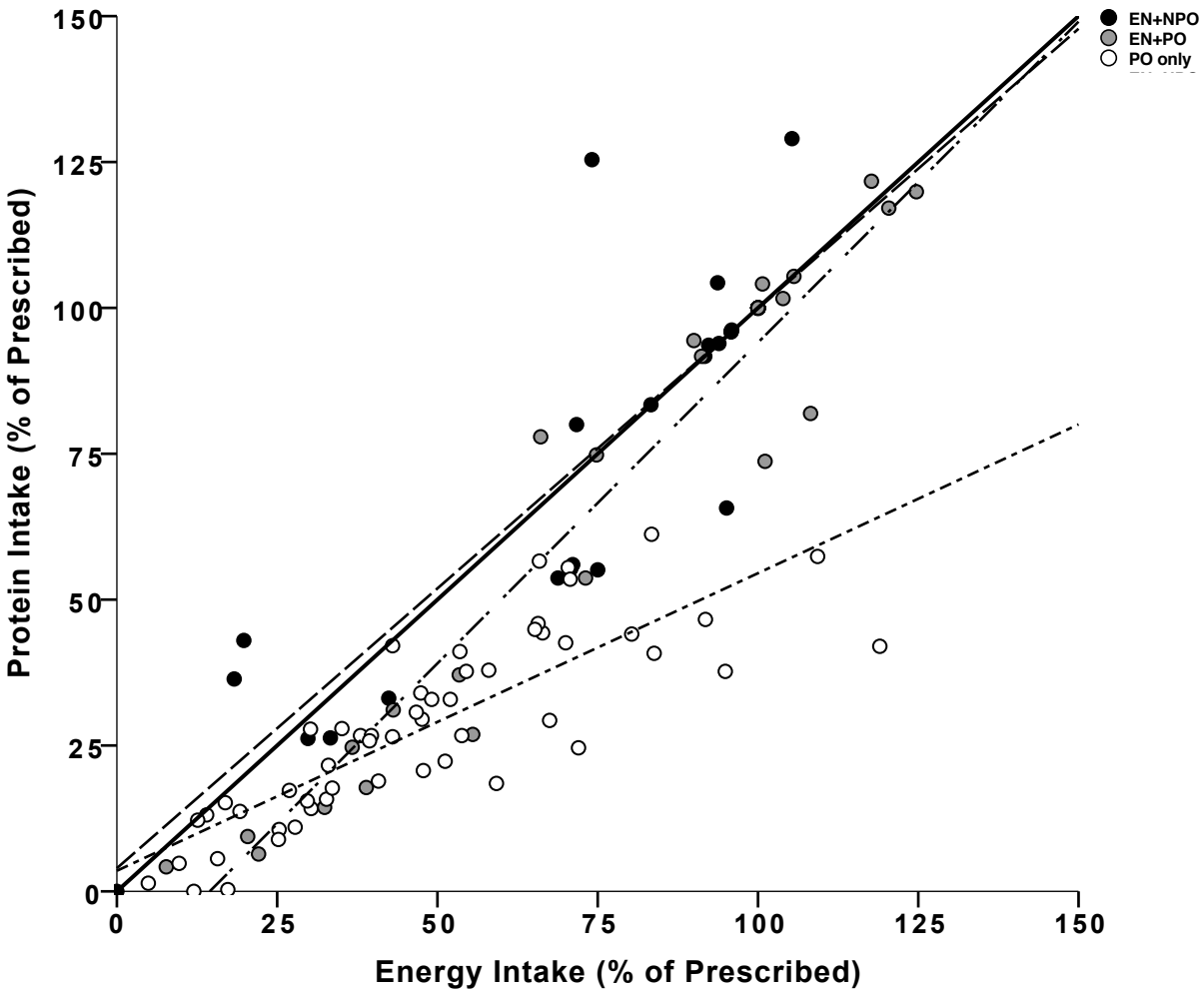
Figure 4. Patient reported barriers to eating.

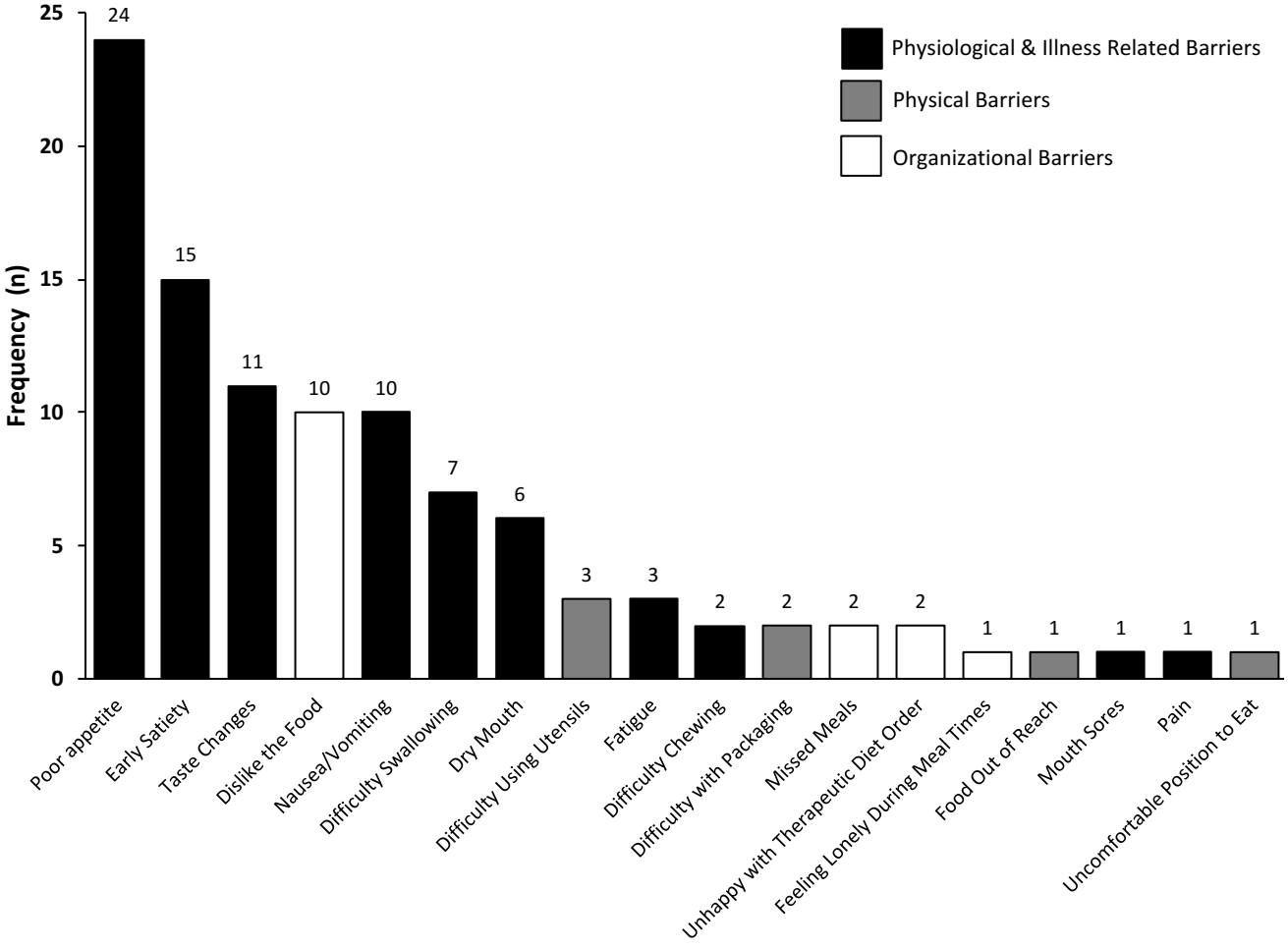

Assessed for eligibility, n=538
Excluded, n=474
Not mechanically ventilated, n=135
Mechanical ventilation <72h, n=219
Limb amputation(s), n=7
Known neuromuscular disorder, n=12
Traumatic brain injury, n=13
Admitted to hospital for organ transplant, n=17
Enrolled in an intervention study altering usual nutrition or physical rehabilitation care, n=7
Death imminent or care withdrawn, n=39
Repatriated to referring hospital prior to extubation, n=6
Other, n=19
Eligible patients who were excluded, n=31
No substitute decision maker, n=22
Missed, n=9
Approached for consent, n=33
Consent declined, n=11
Consented to participate, n=22
Deceased prior to study day 0, n=1
Deceased on study day 1 prior to data collection, n=1
Other, n=1
Study day 1 all measures completed, n=19
Discharged from hospital, n=1
Other, n=1
Study day 4 all measures completed, n=17
Discharged from hospital, n=4
Study day 7 all measures completed, n=13
Placed back on mechanical ventilation, n=1
Deceased, n=1
Discharged from hospital, n=4
Study day 14 all measures completed, n=7





n (total):	19	19	17	18	16	16	13	7
n (EN+NPO):	10	8	7	5	5	6	6	1
n (EN+PO):	4	4	4	5	3	1	1	1
n (PO only):	5	7	7	7	8	9	6	5


EN+NPO
EN+PO
PO only
Protein Intake (% of Prescribed)
Energy Intake (% of Prescribed)
0
25
50
75
100
125
150


Frequency (n)
25
20
15
10
5
0
Physiological & Illness Related Barriers
Physical Barriers
Organizational Barriers
24
15
11
10
10
7
6
3
3
2
2
2
2
1
1
1
1
1
Poor appetite
Early Satiety
Taste Changes
Dislike the Food
Nausea/Vomiting
Difficulty Swallowing
Dry Mouth
Difficulty Using Utensils
Fatigue
Difficulty Chewing
Difficulty with Packaging
Missed Meals
Unhappy with Therapeutic Diet Order
Feeling Lonely During Meal Times
Food Out of Reach
Mouth Sores
Pain
Uncomfortable Position to Eat