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IDENTIFYING POTENTIAL RISK FACTORS IN THE DELIVERY OF ENTERAL NUTRITION IN CRITICALLY ILL PATIENTS - ARGUMENTS FOR INTRODUCING A NUTRITIONAL CARE BUNDLE

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ABSTRACT

Background. Malnutrition is a serious problem in critically ill patients. Identifying patients who are at risk of malnutrition is important in order to find ways of improving the quality of care. This study might form the basis to develop strategies to support intensive care unit (ICU) staff to provide adequate enteral nutrition (EN) and to minimize the risks for malnutrition in critically ill patients.

Methods. This retrospective observational study was conducted in a university hospital in Amsterdam, the Netherlands. Patients admitted to the ICU from January 2012 to December 2014 were included. Ideal calorie intake is calculated as 25 Kcal/kg/day. Ideal protein intake as 1.2 to 1.5 g/kg/day. Multilinear regression was used to describe the factors of success of EN intake.

Results. Overall, patients received 65% of the ideal protein intake and 66% of the ideal caloric intake. The daily success of EN intake has a median of >90%. The multilinear analyses showed that the nasoduodenal-, nasojejunal- and percutaneous endoscopic gastrostomy (PEG) feeding tubes achieved a significant better intake than nasogastric tubes.

Conclusion. The delivery of EN in critically ill patients was moderate to high in the majority of the patients. However, a substantial part of the EN delivery was still suboptimal during admission and needs to be improved. This implies a strong argument to support ICU staff in the adequate delivery of EN. This could be facilitated by a nutritional care bundle to support guideline uptake and thereby improve the delivery of EN.

INTRODUCTION

Malnutrition is a serious problem in critically ill patients. It is associated with increased morbidity and mortality and leads to higher costs of the healthcare system.[1,2] Due to the hypermetabolic response in critically ill patients the energy expenditure is increased.[3] But, feeding critically ill patients can be challenging since patients suffer from gastrointestinal intolerance, due to impaired gastrointestinal motility, digestion or absorption in more than 60%.[3,4] This, in combination with an increased energy expenditure leads to malnutrition.[3] Around 30 to 50% of critically ill patients admitted to intensive cares (ICUs) do not receive their daily protein and energy intake.[5,6]

An important therapy to prevent malnutrition in critically ill patients is Enteral Nutrition (EN).[7] This is usually administered through a nasogastric tube. An early start of EN within 24-48 hours following ICU admission has been advocated to enhance an adequate EN intake.[7] EN has several physiological benefits in the preservations of gut integrity and prevents the increase in intestinal permeability.[7,8] Adequate delivery of EN has positive effects on relevant clinical outcomes, such as the ICU and hospital length of stay, ventilator-free days, wound healing and nosocomial infections.[9,10]

Despite the positive effects of adequate EN, discrepancies exist between the actual intake and optimal EN intake.[2,3,6] Guidelines have been developed to enhance the adequate delivery of EN in critically ill patients. However, poor adherence to the EN guideline still exists.[11] Cahill et al. showed that only 60% of the patients were adequately fed during their ICU admission.[6] Multiple factors negatively affecting the delivery of EN in critically ill patients could be determined. For instance, delayed placement of feeding tubes and subsequent delayed administration of EN, interruptions in EN due to patient transports for advanced diagnostics and procedures outside the ICU. Another contributing factor is the existence of nutrition intolerance, causing for instance abdominal distension, vomiting, constipating or diarrhea.[2,5,12,13]

The delivery of care, such as the delivery of EN, consists of a complex series of interactions between physicians, nurses, patients and medical interventions.[14] Monitoring and systematically analyzing these interactions can be helpful in identifying those areas where optimal care is potentially at risk. The identification of those potential risks is important in finding opportunities in improving the quality of care.[14] We do not exactly know to what extent patients are at risk in receiving adequate EN therapy, nor which patient categories or areas might even be at higher risk. If we could determine if patients are at risk for malnutrition, quality improvement strategies could be used to enhance the EN intake. In this study we aim to assess to what extent patients receive their daily

EN intake during ICU admission in a large cohort of ICU patients. In addition we aim to identify subgroups of patients or areas within the EN practices where the daily EN intake is inadequate. This study might form the basis to develop strategies to support ICU staff to provide adequate EN, thereby minimizing the risk for malnutrition.

MATERIALS & METHODS

Setting

This retrospective observational study was conducted in an ICU for adult patients in a university hospital in Amsterdam, the Netherlands. The ICU is a closed-format department and has 28-beds with a mixed surgical and medical patient population. Patients are under the direct care of the medical ICU team. The nurse-to-patient ratio is 1:1 or 1:2, depending on the patients' severity of illness.

Protocol for enteral nutritional feeding

Our EN protocol is aimed at the early and continuous administration of EN (Supplementary File 1). The protocol includes instructions on when to start EN, directions to achieve the daily EN targets and directions to manage gastric retention. According to the EN protocol, patients' individual EN requirements are reviewed on a daily basis by the intensivist. These requirements are adjusted according to changes in the clinical conditions of the patient and on the nutritional intake of the previous days. Additionally, twice a week an intensivist, who is an expert in nutritional support, together with a dietician, are monitoring the nutritional conditions of every admitted patient. The EN delivery starts as soon as possible after ICU admission in patients whose length of ICU stay is expected to be more than 24 hours with the exception of surgical patients. These patients do not receive nutrition on the day of surgery or on the first day of ICU admission.

Data collection

Adult patients (≥ 18 years) admitted to the ICU from January 2012 to December 2014 were included in this study. Each bed is equipped with an electronic Patients Data Management System (PDMS) (Metavision, Ite medical Tiel), in which patient data is prospectively collected. Medical and nutritional data were extracted from this database. Data from patients with EN were used from admission until discharge from the ICU or with a maximum of 30 days. Other data we collected are age, gender, body length, last known body weight before hospital admission ICU and hospital length of stay, referral specialty in the ICU and Apache II.

Analysis

Descriptive statistics were used to summarize the baseline patient and feeding characteristics. Continuous variables that were normally distributed were expressed as means with standard deviations and not normally distributed variables as medians and inter-quartile ranges (IQR). To test two independent groups of not normally distributed continuous variables, the Mann-Whitney U test was used. Categorical variables were expressed as percentages, numerators and denominators and were compared with the Chi-square test or Fisher's exact test. Statistical uncertainty was expressed by 95% confidence intervals as appropriate, and statistical significance was defined at a *P* value of < 0.05. Adequate EN intake is defined as the real EN intake at least equal to the ideal EN volume/calorie/protein intake or more. Ideal calorie intake is calculated as 25Kcal/kg last known body weight before hospital admission/day[7], success of calorie intake as percentage of ideal realized calorie intake. Ideal protein intake is calculated as 1.2 to 1.5 g/kg/last known body weight before hospital admission/day[7,15], likewise success of protein intake as percentage of ideal realized protein intake. Patients with a body mass index of > 27-30 were excluded for analysis. To describe the factors of success or failure of feeding intake we used a multilinear regression model. We calculated the total feeding intake during ICU stay in terms of calorie as well as protein intake. We divided this number by the total duration of ICU stay (in hours) as a single outcome measure for overall success of feeding. In the multilinear regression model we included all patients that have been enterally fed during their ICU stay. As candidate predictors we selected age, gender, apache II score, type of admission (medical/surgical) planned admission (yes/no), mechanical ventilation (yes/no), type of feeding tube (nasoduodenal, nasojejunal, percutaneous endoscopic gastrostomy (PEG), naso-gastric tubes). The goal of the analysis by this prediction model was to find the most valid subset of available predictors and the corresponding best fitting regression model for describing the relationship between average EN intake of protein and calories during ICU stay and the predictors. A multiple linear regression model was used with forward selection (by hand) of predictors. Analyses were performed using R (version: 3.3.1; R Foundation for Statistical Computing, Vienna, Austria).

Ethical statement

The study was approved by the Medical Ethics Committee of the Academic Medical Center of Amsterdam, the Netherlands and the need for informed consent was waived.

RESULTS

Demographics

A total of 6862 patients were admitted to the ICU from 2012 to 2014. Table 1 shows the differences between the patients who received enteral nutrition and who were not. Sixty five percent of the patients (4456/6862) received other forms of intake than EN,70% (3115/4456) of these patients, mostly elective admitted were discharged from the ICU within 48 hours after admission. In 34% (2355/6862) patients received EN during ICU admission. Patients who received EN were longer admitted to the ICU and were more severely ill than patients who did not receive EN.

Table 1. Patient demographics

	Enterally fed patients	**Non-enterally fed patients**	**95% CI, *P*-value**
Total number of ICU patients	2355	4456	
Age, mean (sd)	61.3 (15.6)	60.7 (16.9)	-1.46 to 0.15, *P* 0.1086
Gender, Male, % (n/N)	60% (1413/2353)	62% (2778/4455)	*P* 0.0063
Planned admission, % (n/N)	18% (422/2355)	45% (1982/4456)	-0.29 to -0.24, *P* <0.001
Apache II, mean (sd)	19.52 (7.39)	14.70 (6.34)	-5.1743 to -4.4707, *P* <0.001
ICU LOS in hours, median (IQR)	95.0 (45-214)	32.0 (20-63)	*P* <0.001
Died in ICU, % (n/N)	28% (659/2355)	8% (359/4456)	*P* <0.001

Feeding tube locations

In Table 2 the feeding tube locations are shown for the delivery of EN. In the vast majority of patients a nasogastric tube was used (87%, 2037/2355). The median hours fed by using a nasogastric tube remained stable over the years. From 2012 to 2014 the median hours fed by a nasojejunal feeding tube decreased from 128 hours (IQR 43 to 336) to 19 hours (IQR (3 to 45) respectively, *P*-value <0.001.

Table 2. Feeding tubes for enteral nutrition

Patients with:	**2012**	**2013**	**2014**	***P*-value[b]**
Nasogastric tube[a]	729	687	621	
- Median (IQR) hrs. fed	63 (19 to 175)	67 (20 to 188)	79 (27 to 214)	0.9
- Median (IQR) hrs. ICU-LOS	96 (51 to 207)	104 (48 to 233)	117 (57 to 265)	<0.0001
Nasoduodenal tube	19	22	21	
- Median (IQR) hrs. fed	24 (15 to 44)	83 (35 to 246)	65 (47 to 115)	0.02
- Median (IQR) hrs. ICU-LOS	23 (17 to 47)	92 (38 to 167)	126 (63 to 154)	0.03
Nasojejunal tube	22	25	11	
- Median (IQR) hrs. fed	128 (43 to 336)	29 (7 to 113)	19 (3 to 45)	0.001
- Median (IQR) hrs. ICU-LOS	127 (34 to 228)	44 (23 to 121)	25 (21 to 71)	0.01
PEG tube	9	27	20	
- Median (IQR) hrs. fed	82 (33 to 158)	29 (13 to 132)	146 (31 to 238)	0.2
- Median (IQR) hrs. ICU-LOS	69 (44 to 161)	46 (29 to 148)	235 (62 to372)	0.4

[a] Nasogastric tubes used for enteral nutrition
PEG: percutaneous endoscopic gastrostomy
[b] Kruskall Wallis test

Adequacy of enteral nutritional intake

During the first days of admission, the adequacy of mean percentage calorie and protein intake was 22% (413/1878) on day one and increased to 82% (675/823) on day five, difference 60%, 95% CI: -0.63 to -0.57, *P*-value <0.001. Figure 1 shows a wide variation in the delivery of EN. The success of daily EN intake of proteins has a median of more than 90% during ICU admission, except for the first five days of admission (Fig. 1). Furthermore, EN was initiated within 24-48 hours following admission. The differences between the actual and ideal intake was calculated for calories and protein per type of feeding tube over the years (Table 3 and 4). Each type of feeding tube showed an overall moderate EN delivery of calories and proteins. The mean percentage of adequate calories using the nasogastric feeding tube remained the same over the years, 66% (481/729) in 2012 to 67% (416/621) in 2014, difference %, 95% CI: -0.06 to 0.042, *P*-value 0.74. The same applies to the delivery of protein when using the gastric feeding tube. The mean percentage of ideal protein intake by using 1.2 g/kg/day was 64.6% and 55.8% by using 1.5 g/kg/day as an individual target. In ICU patients individual targets are often based on 1.2 g/kg/day.[7,15]

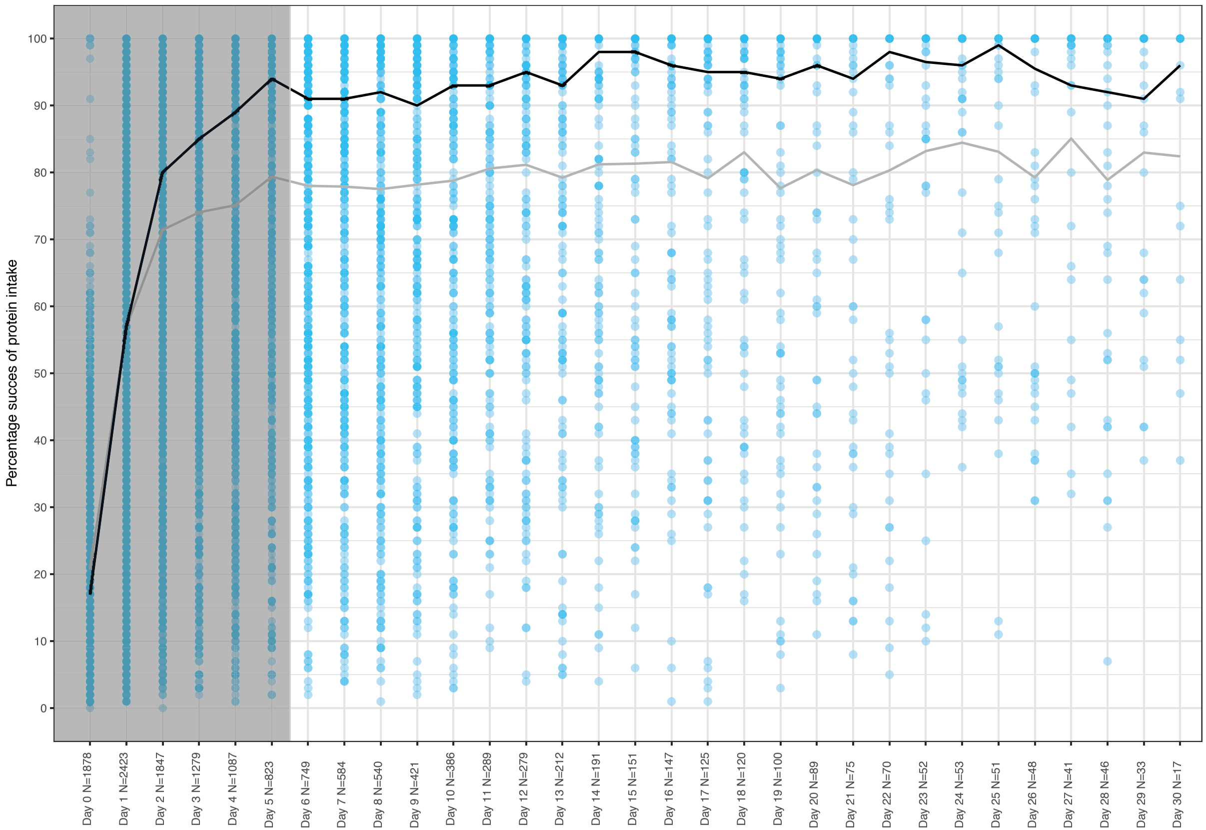

Fig. 1. Plot of the median for the adequacy of protein intake of 1.2g/kg/day for ICU patients.
Each dot represents one patient receiving EN. Black line represent the median percentage of success of protein intake. Grey line represent the mean percentage of success of protein intake.

Table 3. Kcal intake as percentage from the ideal intake

Year	Feeding tube	25 Kcal/kg	
		mean	95% CI
2012	Nasoduodenal tube	71	(60 to 82)
2012	Nasojejunal tube	71	(66 to 76)
2012	Nasogastric tube	66	(65 to 67)
2012	PEG tube	68	(57 to 79)
2013	Nasoduodenal tube	67	(60 to 74)
2013	Nasojejunal tube	69	(61 to 77)
2013	Nasogastric tube	66	(65 to 67)
2013	PEG tube	72	(65 to 79)
2014	Nasoduodenal tube	68	(60 to 76)
2014	Nasojejunal tube	47	(32 to 62)
2014	Nasogastric tube	67	(66 to 68)
2014	PEG tube	61	(53 to 69)

Table 4. Protein intake as percentage from the ideal protein intake

Year	Feeding tube	1.2g/kg		1.5g/kg	
		mean	95% CI	mean	95% CI
2012	Nasoduodenal tube	69	(58 to 80)	62	(51 to 73)
2012	Nasojejunal tube	72	(67 to 77)	64	(59 to 69)
2012	Nasogastric tube	68	(67 to 69)	57	(56 to 58)
2012	PEG tube	66	(55 to 77)	55	(45 to 65)
2013	Nasoduodenal tube	68	(61 to 75)	59	(53 to 65)
2013	Nasojejunal tube	69	(61 to 77)	64	(56 to 72)
2013	Nasogastric tube	68	(67 to 69)	58	(57 to 59)
2013	PEG tube	55	(49 to 61)	48	(42 to 54)
2014	Nasoduodenal tube	66	(58 to 74)	56	(49 to 63)
2014	Nasojejunal tube	47	(33 to 61)	38	(26 to 50)
2014	Nasogastric tube	69	(68 to 70	59	(58 to 60)
2014	PEG tube	59	(51 to 67)	49	(42 to 56)

Multilinear regression analysis for average EN intake

The multilinear analyses showed that the nasoduodenal-, nasojejunal- and PEG feeding tubes were significant better performers in terms of intake per hour than nasogastric tubes (Table 5). For a unit change in medical admissions there was a 5.10-point increase in average EN intake per hour (beta: 5.10, *P*-value <0.001). Planned admission had an adverse effect on EN intake (beta: -7.59, *P*-value <0.001). Age and Apache II score were not associated with an average EN intake per hour. The model accounted for 7.1% of the variance in average hourly EN intake.

Table 5. Multiple linear regression model for average volume feeding intake per hour during ICU stay[a]

	β	Se	β 95% CI	*P* value
Nasoduodenal tube[b]	8.69	3.26	2.29 to 15.08	0.008
Nasojejunal tube[b]	13.33	2.97	7.51 to 19.14	<0.0001
PEG tube[b]	7.89	3.40	1.23 to 14.56	0.020
Gender (male)	2.87	0.90	1.12 to 4.63	0.001
Apache II	0.12	1.26	-0.01 to 0.24	0.068
Mechanical ventilation (yes/no)	2.49	1.26	0.02 to 4.96	0.048
Planned admission (yes/no)	-7.59	1.34	-10.21 to -4.96	<0.0001
Admission type (medical/surgical)	5.10	1.06	3.02 to 7.19	<0.0001

Adjusted R^2: 0.071
[a] Total intake per patient divided by total hours IC stay
[b] Compared with reference Nasogastric tube

DISCUSSION

In the present study we retrospectively observed that overall patients received 65% of the ideal protein intake and 66% of the ideal caloric intake by EN during ICU admission. This is a higher intake than previous studies described.[5,6,12,16,17] Binnekade *et al.* showed that approximately 50% of the patients received the prescribed amount of EN intake.[5] In a prospective observational study of Cahill *et al.* it was shown that there is a poor adherence to the EN guideline resulting in a calorie and protein intake of nearly 60%.[6] However, close to ideal caloric and protein intake by EN is associated with improved clinical outcomes.[9] Furthermore, we showed that the median level of adequate EN intake was high, more than 90% per day. Targets of 80% are used in literature as an indicator for high performance in EN delivery practices.[6,18] In our study, the majority of the patients received their daily protein targets of more than 80%. Our cohort, however, showed a wide variation in the delivery of EN intake as shown in Figure 1. Approximately 30% of the enterally fed patients still received inadequate EN, i.e. values below 80%. This indicates that there is room for further improvement in the delivery of EN.

During the first days of admission the actual calorie and protein EN intake was low. This was to be expected since in our EN protocol the first five days are used to build-up to patients' ideal EN intake. Furthermore, our results show that EN was initiated within 24-48 hours following admission. The early initiation of EN within the first 24-48 hours following ICU admission is strongly recommended in EN guidelines.[7] Observational studies have shown that patients who received an early start of EN had lower morbidity and lower mortality rates than patients who did not.[18]

The results from our model explained 7% of the average EN intake per hour, and may be accounted for a large variance in EN intake. This study was, however, not performed as an attempt to identify factors that contribute to a success or failure of EN intake; rather to describe the daily EN intake in critically ill patients and to determine groups of patients or areas where the daily EN intake might be inadequate while controlling for covariates. The model showed, however, that nasoduodenal-, nasojejunal- and PEG feeding tubes were factors for improved success of feeding compared to the nasogastric feeding tube. This can be explained by the fact that patients who fail to be fed by nasogastric tubes are in most cases fed by post pyloric feeding tubes.[19] Furthermore the model shows that medical patients were associated with a 5.10-point increase in average EN intake per hour (beta 5.10, P-value < 0.001) and a decrease in planned admissions (beta -7.59, P-value < 0.001). It may suggest that medical patients are associated with better EN intake than surgical patients. Other studies showed similar findings.[2,20] Dover et al. showed that surgical patients received less EN intake compared to medical patients. While patient undergoing cardiovascular and gastrointestinal surgery are even at higher risk of receiving inadequate nutrition.[20] It is suggested that there might be a delay in initiating EN due to the hemodynamic instability in these patients. Hemodynamic instability might be a barrier for some physicians to start the feeding protocol.[20] In our model we did not account for the different types of surgery.

It is known that using nurse-driven EN protocols or advice from dieticians is associated with improved feeding practices on ICUs.[21] This may have contributed to the moderate to high levels of EN delivery in our ICU. However, we showed that a substantial part of the EN delivery is still suboptimal and needs to be improved. In our view this implies a strong argument for the development of a nutritional care bundle to support guideline uptake and thereby improve the delivery of EN.[7,22] Care bundles are designed by the Institute for Healthcare Improvement (IHI).[23] It is a practical tool to improve the performance of evidence based interventions. Care bundles aim to improve the reliability of care processes by grouping a small set of evidence based interventions together. All interventions should be performed together for every eligible patient to ensure patients receive the care they need.[23] Care bundles monitor professionals' bundle performance over time. Subsequent, the effect of the bundle could then be measured by using predefined outcome measures, i.e. quality indicators.[23,24] The quality indicator reflects a change as a result of the implementation of the care bundle. There is evidence that higher bundle compliance rates are associated with improved outcomes.[25]

In this observational study we retrospectively analyzed the EN delivery in critically ill patients. We observed if patients or groups of patients were at risk of malnutrition and considered whether there was room for improvement. Identifying problems or potential risks within care processes is the beginning of the bundle design process according to the IHI.[23] Multiple steps follow to design an evidence based care bundle.[23,26] This process is described in detail by the IHI.[23] Further research is needed to develop and validate a care bundle for the delivery of EN. Furthermore, research should focus on determining factors to enhance the implementation and sustainability of this care bundle. By continuously monitoring the effect of the care bundle on the predefined quality indicators changes in the performance of professionals can be detected. This provides valuable information on the EN delivery in critically ill patients.

Limitations

Our study has several limitations. We analyzed the data from a single center hospital, which can affect the generalizability of the results. We retrospective analyzed the data and therefore risk of bias could exist. We used a selected set of factors to describe the adequacy of EN intake. Other important factors affecting adequate EN delivery described in the literature are interruptions due to (re)intubation/extubation, fasting for interventions, patient transports, intestinal intolerance, diagnostic tests and problems with feeding tubes.[2,27] In our study we were not able to assess the influence of these factors on malnutrition. Furthermore, we were not able to identify other interfering factors for the adequate delivery of EN such as barriers in knowledge or organization.[28] Given the nature of our study, we did not find patients with a feeding prescription and a zero EN intake.

CONCLUSIONS

The delivery of enteral nutrition in critically ill patients was moderate to high in the majority of the patients in our ICU. However, a substantial part of the EN delivery was still suboptimal and needs to be improved. This implies a strong argument to support ICU staff in the adequate delivery of EN. In our view a nutritional care bundle to support guideline uptake and thereby improve the delivery of EN could facilitate this.

Competing interest

The authors declare that they have no competing interests.

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