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Enteral Nutrition in Intensive Care Units: Factors that Hinder Adequate Delivery

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Abstract

Enteral nutrition (EN) is the most efficient nutritional support (NS) method in the intensive care units (ICUs). It has gained popularity over other methods in terms of promoting patient's immunity and enhancing better clinical outcomes in addition to its cost effectiveness. However, delivery of EN remains inadequate due to interruptions for various reasons, some of which are avoidable. Frequent interruptions may impact provision of nutrients and therefore, patient's clinical outcome. The aim of this study was to identify factors that hinder the adequate delivery of EN in the ICUs. A descriptive research design was used. Fifty critically ill entirely fed patients were included in the study. The study was carried at Alexandria Main University Hospital ICUs. One tool was used to collect the data namely "Factors Impeding Adequate Delivery of Enteral Nutrition for Critically Ill Patient Assessment Tool". A significant discrepancy between required, prescribed and delivered nutrients was demonstrated during seven consecutive days from ICU admission. Unscheduled basic nursing procedures followed by gastrointestinal complications (GICs) were the most frequent reasons for EN interruption. While interruptions due to diagnostic procedures or airway management were the lowest frequent reasons for EN interruption. In conclusion, multiple factors have been caused inadequate delivery of EN in the current study. It is recommended to develop EN protocol and follow evidence-based EN practices to maximize the delivery of EN.

Introduction

Nutrition support (NS) in intensive care units (ICUs) is an essential part to deliver a comprehensive patient' cares. Critically ill patients (CIPs) are at a higher risk for developing malnutrition due to the nature of their illness and their hyper-metabolic state. Enteral and parenteral routes are routinely used for NS. The Canadian Critical Care Practice Guidelines (CCPGs, 2013) and The American Society of Parenteral and Enteral Nutrition (ASPEN, 2009) recommended that EN is the preferred feeding method for CIPs. EN is superior to parenteral nutrition due to its cost-effectiveness, prevention of intestinal mucosal atrophy; support of intestinal immunological function through maintenance of gut-associated lymphoid tissue; that contains more than half of the body's immune cells that can prohibit the translocation of intestinal bacteria into harmful forms which ultimately will decrease the infectious complications, and enhance wound healing [1-4].

Despite knowledge of these benefits; low nutritional adequacy has been observed by Heyland in 2014 across different sites internationally, with ICUs delivering only approximately 60% of prescribed calories and protein. The barriers that affect the delivery of adequate EN in the ICU shave been classified as patient-related factors, feeding method factors (feeding formula, feeding tube site), feeding process factors (feeding initiation time, time to meet target goal), under-prescription by physicians, and frequent interruption of EN due to procedures as basic nursing procedures. The discrepancy between prescribed and delivered daily volume of EN is a major factor in underfeeding. This study was conducted to shed the light on factors that impede adequate delivery of EN in the ICUs, in order to manage them appropriately that ultimately will improve CIPs outcomes [5-7].

Method

Research design

A descriptive design was used to conduct this study.

Settings

This study was conducted in the ICUs of Alexandria Main University Hospital (AMUH) namely; casualty ICU (unit I) which consist of (15 beds), general ICU (unit III) consists of (15 beds) and triage intensive care unit (8 beds).

Subjects

A convenience sample of 50 newly admitted adult critically ill entirely fed patients were included in the study. Patients' who have been fed parenterally were excluded from the study.

Material

One tool was used to collect the data namely "Factors Impeding Adequate Delivery of Enteral Nutrition for Critically Ill Patient Assessment tool".

Tool

"Factors Impeding Adequate Delivery of Enteral Nutrition for Critically Ill Patient Assessment tool". This tool was developed by the researcher after reviewing the relevant literature [4,8-10]. It was used to assess factors that impede adequate delivery of enteral feeding

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as basic nursing care, GIT complications, diagnostic procedures and therapeutic procedures.

Data collection

Permission to conduct the study was obtained from hospital responsible authority after explanation of aim of the study and delivery of an official letter from the faculty. Study tool was developed by the researcher based on extensive review of related literature [4,8-10]. Pilot study was done on 5% of sample before starting the data collection to test the feasibility and applicability of the tool, and then data collection tool were modified accordingly. Patients fulfilling study criteria were included in this study immediately after admission to the ICU. The nutritional status was assessed using subjective global assessment (SGA) on admission and after 7 days form ICU admission. The severity of patient's condition was assessed daily using Therapeutic Intervention Severity Score version 28 (TISS - 28) for seven days. It was adopted from (Miranda, 1996) [11]. It is composed of 7 items:

1. Basic activities as standard monitoring, lab investigations, medication administration and wound dressing (Total score 16).

2. Ventilatory support as mechanical ventilation, care of artificial airways and chest physiotherapy (Total score 9).

3. Cardiovascular support as vasoactive medication administration, intravenous fluid replacement, arterial catheter care, left atrium monitoring, central venous line and cardiopulmonary resuscitation (Total score 29).

4. Renal support as hemofiltration, quantitative urine output measurement and active dieresis using diuretics (Total score 8).

5. Neurological support as measurement of intracranial pressure (Total score 4).

6. Metabolic support as treatment of complicated metabolic disorder. Intravenous hyperalimentation and enteral feeding (Total score 9).

7. Specific interventions as tracheal intubation, endoscopies, pacemaker introduction, cardioversion, surgery and diagnostic procedures (Total score 13).

Each item was checked and the total score of tool = 88. Scores are ranked as follows:

Class I: Physiologically stable patients requiring prophylactic observation, score between 0 and 19 points.

Class II: Patients required intensive care and continuous monitoring, score between 20 and 34 points.

Class III: Severe and hemodynamically unstable patients, score between 35 and 60 points.

Class IV: Scores higher than 60 indicate that special and continuous care is needed.

Energy requirements [12-14]

Total energy expenditure (requirements) = Resting Energy Expenditure (REE) x (stress factor + activity factor + food thermic effect).

REE was calculated by Harris - Benedict equation [15-17]

- Male (kcal/ D) = 66.5 + (13.75 × weight kg) + (5 × height cm) – (6.775×age in years).

- Females (kcal/D) = 655.1 + (9.563 × weight kg) + (1.85 × height cm) – (4.67 × age in years).

While weight (kg) was

1) Current body weight (CBW) in normal weight subjects.

2) Adjusted body weight [ABW = (CBW + IBW)/2] in obese and underweight subjects.

Table 1: Activity factor according to level of activity [18].

Level of Activity	Activity factor
Bed rest (Bed ridden - Unconscious)	1.0 - 1.1
Sedentary (Little to no exercise)	1.2
Light exercise (1-3 days per week)	1.3
Moderate exercise (3-5 days per week)	1.5
Heavy exercise (6-7 days per week)	1.7
Very heavy exercise (twice per day, extra heavy workouts)	1.9

Table 2: Stress factor according to type of stress [18].

Stress	Stress factor
Fever per degree over 37°C	1.1
Minor injury	1.2
Clean wound	1.2
Mild infection	1.2
Minor surgery	1.2
Major surgery	1.3
Infected wound	1.3
Bone fracture	1.3
Moderate infection	1.4
Malignancy	1.5
Respiratory diseases	1.5
Major trauma	1.5
Major infection (sepsis)	1.5
Severe burn	2.0
Combination	2.0

Table 3: Protein requirements during critical illness [18-21].

Mild stress	1.0 -1.2 g/kg
Moderate stress (most ICU patients)	1.5-2.0 g/kg
Severe Obesity	1.5 g / kg Adj. Wt. - 2.0 g/kg IBW
Severe stress, catabolic, burns	2.0 –2.5 g/kg
Chronic renal failure, no dialysis	0.8-1.3 g/kg
Hemodialysis	1.2 -1.4 g/kg
Continuous Ambulatory Peritoneal Dialysis (CAPD)	1.2 -1.5 g/kg

A stress factor and activity factor were estimated based on the patient's condition and varied up to 2, according to the published standardized factors (Table 1 and Table 2).

Thermic effect of food (TEF) represents the additional energy required to absorb, digest, transport, interconvert and store the constituents of a meal. It represents 10% of daily energy intake for a person consuming a typical mixed meal (Table 3).

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Fluid requirements during critical illness [12,19,22]

30-35 ml/kg plus:

- 500 -750 ml/degree over 37 °C temperature.
- 500 ml for mechanically ventilated patients.

Fiber requirements during critical illness [12,19]

- 36 g/day for man and for women it is approximately 28 g/day (Table 4 and Table 5).

Total calories that have been prescribed and actually administered daily were calculated by researcher and expressed as total energy intake (kcal/day). Prescribed and actual total protein intake was also calculated daily and expressed as total protein intake (g/day). Blended hospital and home prepared formulas given in the hospital are calculated by the use of Egyptian food composition table (2006) and commercial enteral formulas are calculated according to their standard caloric and protein values.

Twenty-four hour estimated energy and protein balance was calculated as the daily difference between total actual delivered and calculated requirements. The difference was expressed as a percentage: provided / requirement x 100. Underfeeding (UF) was defined as a subject's actual average intake being < 90% of total requirements [mildly underfed (89% - 50%), moderately underfed (49% - 30%) and severely underfed (< 30%)], Adequate or appropriate feeding (AF) was defined as reaching ≥ 90% of requirements. For overfeeding (OF), the actual average intake was > 110% of the total requirements.

Factors that impede adequate delivery of enteral feeding were recorded daily by researcher. Noting the reason for each interruption (including the incidence of feeding intolerance) and the length of time the feeding was stopped. The numbers of episodes of GIT complications were assessed and recorded daily, including high gastric residual volume (GRVs), abdominal bloating, vomiting, constipation and diarrhea. Informed written consent has been obtained from each patient before he/she participates in the study, after complete explanation of the study purpose and patient's privacy has been considered during collection of data. The anonymity, the confidentiality, and the right to refuse to participate in the study have been assured.

Table 4: Vitamins and trace elements requirements during critical illness [18].

Element	Recommended Enteral	Recommended Parenteral
Vitamin A (mg)	0.9 - 1	1
Vitamin C (mg)	125 - 250	200
Vitamin E (mg)	25 - 50	10
Vitamin K (µg)	40 - 135	150
Vitamin B1 (mg)	0.9 - 1.3	3
Vitamin B2 (mg)	0.9 - 1.3	3.6
Zinc (mg)	11 - 19	2.5 - 5
Selenium (µg)	20 - 70	20 – 60

Table 5: Electrolytes requirements during critical illness [18].

Element	Recommended Enteral	Recommended Parenteral
Sodium (mEq)	22	60 -150
Potassium (mEq)	51	70 - 180
Chloride (mEq)	22	60 - 150
Magnesium (mEq)	20 - 34	10 - 30
Calcium (mEq)	65	10 - 20
Phosphorus (mmol)	40	10 - 40

Table 6: General characteristics of study sample.

Variable	Categories	(n = 50) N	%
Sex	Male	35	70
	Female	15	30
Age	20-39	19	38
	40-60	31	62
Mechanical Ventilation	Yes	45	90
	No	5	10
Reasons of ICU admission	Trauma	25	50
	Cardiovascular disease	8	16
	Pulmonary disease	2	4
	Poisoning	4	8
	Sepsis	5	10
	Neurological disease	6	12

Results

Table 6 illustrates general characteristics of study sample. As regard sex thirty five patients (70%) were male. According to their age, near two thirds (62%) of patients were between (40-60) years. The mean age was 43.5 ± 14.5 years. As regard reasons for ICU admission, the most common encountered reason was trauma; it was twenty five patients (50%). While the least common reason for ICU admission was pulmonary diseases that constitutes about only two patients (4%). About forty five patients (90%) were mechanically ventilated and no patient neither on renal replacement therapy nor have gastrointestinal surgery.

Table 7 illustrates study sample distribution according their severity of illness across the seven days form ICU admission. It was noted that 27% of patients has TISS-28 score of class III (Severe and hemodynamically unstable patients) in the first two days (mean TISS-28 score 38.6 ± 10.85 and 36.28 ± 11.10). In addition to that in days from 4 to 7 the TISS-28 score was more likely class II (Patients requiring intensive care and continuous monitoring) mean score was in the range of (31.88 ± 9.18 to 32.78 ± 9.39). This indicates that there is a slight decrease in the severity of illness and nursing workload during the course of ICU stay.

Table 8 illustrates the studied critically ill patients' distribution according to their nutritional adequacy (regarding calories). About 38 patients (76%) were severely underfed, 11 patients (22%) were moderately underfed, and only 1 patient (2%) was mild underfed. As regard protein, about 47 patients (94%) were severely underfed, 2 patients (4%) were moderately underfed, and only 1 patient (2%) was mild underfed. Regarding enteral feeding volume, about 41 patients (82%) were severely underfed and 9 patients (18%) were moderately underfed.

Table 9 describes the nutritional status of the studied critically ill patients. It was observed that about 22% of patients were malnourished during their admission to ICU, While 58% of patients were malnourished on the seventh day of ICU admission which reflects nutritional inadequacy.

Comparison of critically ill patients' macronutrients requirements, prescription and delivery is shown in table 10. It was observed that there was a significant difference ($p < 0.05$) between required enteral feeding and prescribed enteral feeding, there was a significant difference ($p < 0.05$) between required enteral feeding and delivered enteral feeding and there was a significant difference ($p < 0.05$) between prescribed enteral feeding and delivered enteral feeding.

Table 11 describes the interruptions of EN in the patients along seven consecutive days. The mean number of interruptions in EN during the 7 days was 4.38 ± 2.36. The mean duration per one interruption was 6.10 ± 4.94 hours, which represents a mean interruption duration of 27.48 ± 26 hours per patient during the 7 days.

Table 12 summarized the reasons why EN was withheld.

Table 7: Distribution of sample according to their severity of illness.

TISS-28	Physiologically stable patients requiring prophylactic observation (n = 50) No.	%	Patients requiring intensive care and continuous monitoring (n = 50) No.	%	Severe and hemodynamically unstable patients (n = 50) No.	%	Mean	SD	Median
Day 1	0	0	23	46	27	54	38.60	10.85	38
Day 2	0	0	23	46	27	54	36.28	11.10	35
Day 3	0	0	31	62	19	38	32.68	8.52	31
Day 4	0	0	33	66	17	34	32.78	9.39	30
Day 5	0	0	32	64	18	36	32.38	8.74	31
Day 6	1	2	33	66	16	32	31.88	9.18	29
Day 7	1	2	32	64	17	34	32.00	9.01	29.50

Unscheduled basic nursing care was the most frequent cause for interruption, accounted for 72% of the causes of EN interruption, followed by GI complications (GICs) which accounted for 64% of the causes of EN interruption. While diagnostic procedures were the lowest frequent causes of EN interruption, accounted for 14% of the causes of EN interruption.

Table 13 illustrates the percentage of withholded EN amount from prescribed enteral feeding formula. It was observed that then withholded amount of enteral formula constitutes about 11% of prescribed calories, 14% of prescribed protein and 17% of prescribed enteral volume.

Figure 1 describes the Caloric intake progress during seven consecutive days of enteral feeding. It was observed that there was a gradual increase in caloric intake throughout the first 3 days from ICU admission up to (832 Kcal/day), followed by static state in the 4th day (833 Kcal/day) and drop in the 5th day (799 kcal/day), finally gradual increase in the 6th and 7th day from ICU admission up to (933 Kcal/day).

Figure 2 illustrates the protein intake progress during seven consecutive days of enteral nutrition. It was observed that there was a gradual increase in protein intake throughout the first 4 days from ICU admission up to (21 g/day), followed drop in the 5th day (19 g/day), finally gradual increase in the 6th and 7th day from ICU admission up to (27 g/day).

Figure 3 illustrates the enteral volume intake progress during seven consecutive days. It was observed that there was a gradual

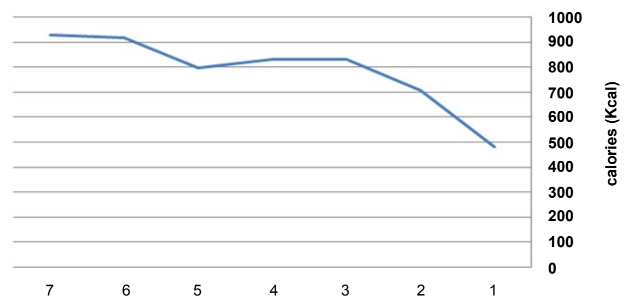

Figure 1: Calories intake progress throughout seven consecutive days.

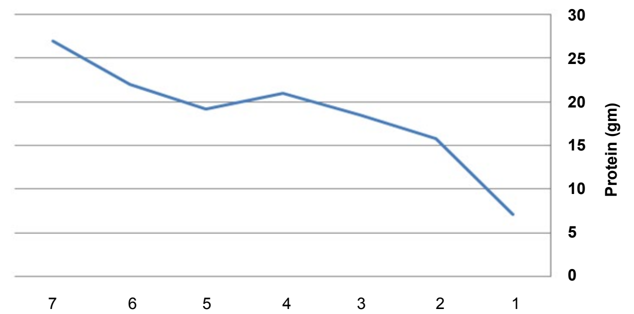

Figure 2: Protein intake progress throughout seven consecutive days.

Table 8: Distribution of the studied critically ill patients according to their nutritional adequacy.

Variable	Categories	(n = 50) N	%
Nutritional adequacy (Calories)	Mild underfeeding	1	2
	Moderate underfeeding	11	22
	Severely underfeeding	38	76
Nutritional adequacy (Protein)	Mild underfeeding	1	2
	Moderate underfeeding	2	4
	Severely underfeeding	47	94
Nutritional adequacy (Enteral Volume)	Moderate underfeeding	9	18
	Severely underfeeding	41	82

Table 9: Nutritional status of the studied critically ill patients.

Nutritional Status	First Day (n = 50)		Seventh Day (n = 50)	
	No.	%	No.	%
Normal	39	78	21	42
Malnourished	11	22	29	58

Table 10: Relationship between of required, prescribed & actual enteral feeding regarding macronutrients among the critically ill patients.

Variable		Mean	T	Sig.
Calories (Kcal)	Prescribed: Delivered	366.20 ± 303.10	8.54	0.000*
	Required: Delivered	2398.25 ± 435.58	38.93	0.000*
	Required: Prescribed	2032.05 ± 394.88	36.38	0.000*
Protein (g)	Required: Prescribed	94.49 ± 20.97	31.85	0.000*
	Prescribed: Delivered	18.69 ± 13.63	9.69	0.000*
	Required : Delivered	113.18 ± 26.86	29.79	0.000*
Enteral Volume (ml)	Required : Delivered	4718.57 ± 832.55	40.07	0.000*
	Required : Prescribed	3666.43 ± 819.20	31.64	0.000*
	Prescribed: Delivered	1052.14± 687.07	10.82	0.000 *

Table 11: EN interruptions during the 7 days among the critically ill patients.

Item	Mean	Standard Deviation	Median
EN initiation time from ICU admission (hrs.)	13.08	13.41	8.00
Duration of EN formula intake (days)	6.22	1.15	7.00
No. of EN withholding	4.38	2.36	4.00
Mean duration of each EN withholding (hrs.)	6.10	4.94	4.50
Total duration of each EN withholding (hrs.)	27.48	26.59	20.00

Table 12: Reasons for EN interruptions among the studied critically ill patients during the 7 days.

Item	No	%
Severity of patient condition	21	42
Therapeutic interventions	12	24
Diagnostic procedures	7	14
Gastrointestinal complications (GICs)	32	64
Mechanical complications of tube feeding	8	16
Basic nursing care	36	72

*Total number was not equal 100% as it was a multiple response variable.

Table 13: Percentage of withholded enteral nutrition amount from prescribed enteral feeding formula.

Item	Requirement	Prescribed		Actual intake			Withholded amount %
	Mean ± SD	Mean ± SD	% from Req.	Mean ± SD	% from Req.	% from Presc.	
Calories	3184.92 ± 349.31	1152.87 ±248.63	36	786.66 ± 234.63	25	68	11
Protein	131.87 ± 21.27	37.38 ± 8.63	28	18.69 ± 12.07	14	50	14
Enteral .Vol.	6009.29 ± 659.07	2342.85 ± 613.09	39	1290.71 ± 410.75	22	55	17

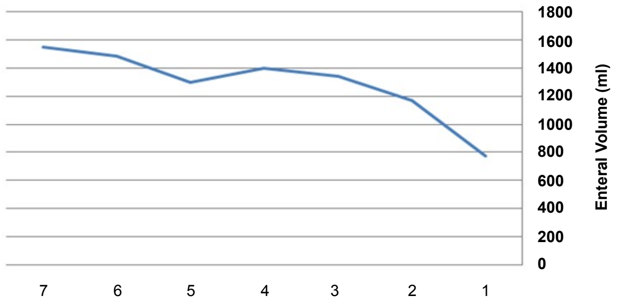

Figure 3: Enteral volume intake progress during seven consecutive days.

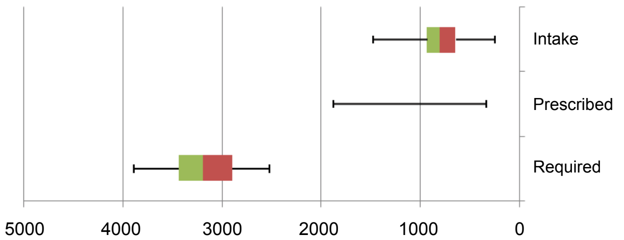

Figure 4: Comparison between calories requirements, prescription and Intake.

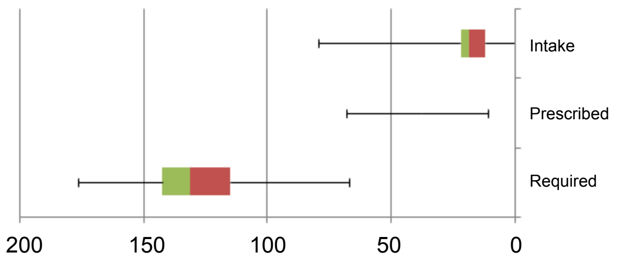

Figure 5: Comparison between Protein requirements, prescription and intake.

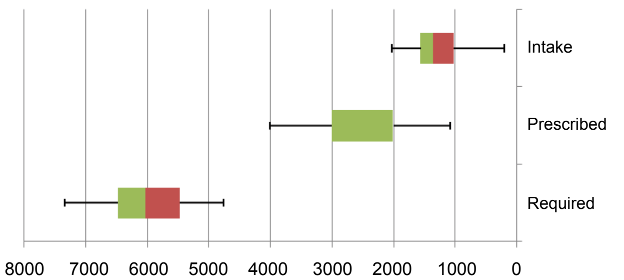

Figure 6: Comparison between EN volume requirements, prescription and intake.

increase in enteral volume intake throughout the first 4 days from ICU admission up to (1400 ml/day), followed drop in the 5th day (1300 ml/day), finally gradual increase in the 6th and 7th day from ICU admission up to (1550 ml/day).

Figure 4 illustrates the differences between required, prescribed and given calories. The distribution of calories is negatively skewed as regard required, prescribed and given calories. There are no outliers. The median calories is higher for requirement (M = 3188 KCal/day) than prescribed (M = 1142 KCal/day) and given calories (M = 802 KCal/day). The IQR is also greater for calories requirement (IQR = 533 KCal/day) than calories prescribed (M = 0 KCal/day) and given calories (IQR = 287 KCal/day). The range of calories is also greater for requirement (R = 1363 KCal/day) than given calories (R = 1224 KCal/day) and less than calories prescribed (R = 1547 KCal/day). For this group, there was a discrepancy between calories requirement, prescription and intake.

Figure 5 illustrates the differences between required, prescribed and given protein. The distribution of protein is negatively skewed as regard required, prescribed and given protein. There are no outliers. The median protein is higher for requirement (M = 131 gm/day) than prescribed (M = 37 gm/day) and given protein (M = 18 gm/day). The IQR is also greater for protein requirement (IQR = 27 gm/day) than protein prescribed (M = 0 gm/day) and given protein (IQR = 10 gm /day). The range of protein is also greater for requirement (R = 109 gm/day) than protein prescribed (R = 57 gm/day) and given protein (R = 79 gm/day). For this group, there was a discrepancy between protein requirement, prescription and intake.

Figure 6 illustrates the differences between required, prescribed and given EN volume. The distribution of EN Volume is symmetric as regard required EN volume and negatively skewed as regard prescribed and given EN volume. There are no outliers. The median EN Volume is higher for requirement (M = 6016 ml/day) than prescribed (M = 2000 ml/day) and given EN volume (M = 1353 ml/day). The IQR is also greater for EN Volume requirement (IQR = 1007 ml/day) than given EN volume (IQR = 539 ml/day), while slightly equal EN Volume prescribed (M = 1000 ml/day). The range of EN Volume is also greater for requirement (R = 2573 ml/day) than given EN volume (R = 1835 ml/day) and less than EN Volume prescribed (R = 2928 ml/day). For this group, there was a discrepancy between EN volume requirement, prescription and intake.

Discussion

Nutritional adequacy is considered the core concept in nutrition care process. EN is mainly determined by variable staff tendencies to feed and practice variation rather than on patient actual characteristics. These variations may have a significant effect on patient's nutritional adequacy state. Therefore, the current study was conducted.

In the present study, 76% of patients were severely underfed, 22% of patients were moderately underfed, and 2% of patients were mildly underfed. Moreover, patients have been received only 25% of their caloric requirements and 68% of their prescribed calories. In relation to protein intake, patients received only 14% of their protein requirements and 50% of their prescribed proteins. Additionally, regarding enteral volume intake, patients received only 22% of their enteral volume requirements and 55% of their prescribed enteral volume.

This may be attributed to the lack of training programs to hospital staff involved in preparing, prescribing, and providing nutrition related care to the critically ill patients, the absence of nutrition support team in ICU especially the dietitian, lack of collaboration between hospital staff involved in preparing, prescribing, and providing nutrition related care to evaluate the adequacy of nutritional support. Additionally, low density of hospital formula that constitutes about half of the density of the standard isotonic enteral formula makes the achievement of target nutrition requirements difficult. Also, Frequent EN interruption may be an important factor in the development of nutritional inadequacy. Consequently, all previously mentioned factors when combined with the clinical status of the critically ill patients, who have higher catabolism, lower oral intake, rapid massive tissue breakdown, increased requirements, GI hypo perfusion, disturbances and hemodynamic instability, may give us a logic interpretation of current study results as regard nutritional adequacy.

In accordance to these findings, Refaat et al. [23] reported that all patients were underfed in their assessment of factors contributing to nosocomial anemia in sixty five critically ill patients in Alexandria-Egypt. Another South Korean study conducted by Kim et al. [24] to study the nutritional changes in forty eight entirely fed ICU patients reported that about 62.5% of the patients were underfed. Also, a secondary analysis of pooled data collected prospectively from international nutrition studies conducted by Elke et al. [25] in Canada. Two thousands two hundred and seventy patients were included in this study to evaluate the effect of energy and protein amount given by EN on their clinical outcomes; it showed that patients received only 61% of their prescribed calories, and 57% of their prescribed proteins. Also, a Spanish retrospective study done by Arbeloa et al. [26] to determine whether early nutritional support reduces mortality and the incidence of nosocomial infection, in ninety-two critically ill patients reported that patients received about 37% of their caloric of their caloric prescription [23-26].

The current study shows a significant discrepancy between patients' actual nutrients needs as regard calories, protein and enteral volume and their actual nutrients intake. This may attributed to lack of staff knowledge and experience as most of them were novice nurses and physicians who were perplexed with airway and circulation stabilization at the expense of nutrition care, absence of registered dietitian who's role to calculate patients requirements based on focused nutrition assessment, and low density of served formulas.

This finding was similar to the finding that reported by Gibrail et al. [27] who evaluate tube feeding in two hundreds and two critically ill mechanically ventilated patients in Alexandria-Egypt and O'Meara et al. [28] who assess the factors associated with interruptions in EN in fifty nine critically ill patients receiving mechanical ventilation in the United States. On the other hand, the assessment of the nutritional care provided to one hundred and ten critically ill patients in the ICU of United Arab Emirates hospitals by Hammad et al. [29] demonstrated that all patients achieved the target caloric and protein requirements during their ICU stay [27-29].

Importantly, the present study revealed that the main source of calories was packed fruit juice and the main source for protein was milk and milk-egg mixture that was given to all patients despite their actual requirements. The served formula meets most of physician's prescription as a quantity (half liter of milk-egg mixture, half liter of vegetable's soup, four packs of fruit juice and one pack of packed milk), it's about two liters/day for all patients regardless actual patient's requirement's and this prescribed amount as a quality covers only one third of patient's caloric and protein requirements. It was an important factor that leads to nutritional inadequacy in the current study. This may be attributed to the lack of staff knowledge about the concept of nutritional adequacy and it's relation with formula density, rate of formula and interruption of formula. The issue begins from hospital kitchen where the formula was prepared from vegetables and juice, then by prescription of physician in a form of amount that not based on nutrition assessment or estimation of patients nutrients needs, and finally with nurses' administration practices that prefer packed juice and milk over any formula even ready-made powdered formula or homemade formula. These results were supported by three consecutive studies in Alexandria-Egypt. The first one done by Hemeda et al. [10] to assess the nutritional needs of fifty mechanically ventilated critically ill patients, the second study by Al Sayaghi et al. [8] to study the effect of EEN on the clinical outcomes of fifty mechanically ventilated critically ill patients and the third study conducted by Gibrail et al. [29] to evaluate tube feeding in two hundreds and two critically ill mechanically ventilated patients [8,10,29].

Isotonic formula is standard for enteral nutrition of critically ill patients, but nutrient dense formulas are preferred in some ICU settings to facilitate nutrient delivery using smaller fluid volumes. In the current study, the hospital formula that constitutes the most of patient's feeding formula was low in density about half of density of ideal isotonic formula that made the patients away from the target calories and proteins as compared to ready-made formulas. This may be attributed to the lack of knowledge of the staff responsible for formula preparation about formula density and it's relation with adequacy, they use only vegetables as zucchini, potatoes, and carrots without a valuable source of protein that makes patients didn't achieve their target nutrients.

Also, nurses' administrations practices may have a role in this finding as they give more liquid formulas as juice and milk that is easy, never cause tube obstruction and take short time in its administration. They don't give home prepared formula, don't store it safely and don't instruct patients' families to prepare home formula earlier that prevent patients from getting more dense formula than one served by hospital which in turn affect nutritional adequacy negatively. Importantly, poor socioeconomic status of families hinders their support to patients with homemade formula. Bryk et al. [30] in the United States found that calorically dense enteral formula did not increase the delivery of energy in one hundred and seventeen patients in surgical and trauma ICUs compared with isotonic formula and hypertonic formulas which may increase the risk for diarrhea and that clinicians, therefore, may stop EN, on the contrary, Ried [31] in the United Kingdom, stated that the highest energy and protein intakes were achieved with nutrient-dense formulas rather than standard formulas in critically ill enterally fed patients [30,31].

There was a significant difference between patient's nutrients requirements and physician's nutrients prescriptions. In which the prescribed nutrients was about 36% of patient's caloric requirements and 28% of protein requirements. It may be attributed to physicians' attitudes towards nutritional intervention that is usually of lower priority compared with other critical interventions that needed for hemodynamic or respiratory stability. This may contribute to the inadequate prescription of enteral nutrition. These findings were supported by many researchers as, McClave et al. [7] in the United States, they stated that physicians prescribed a daily mean volume that was 65.5% of the requirements, but only 78.1% of the volume prescribed was given to forty four critically ill patients in a medical ICU and coronary care unit. Thus, patients received a mean volume that was 51.6% of their goal [7].

Similar results were assured by De Jonghe et al. [32], they stated that prescribed energy represents about 78% of the energy requirements in an assessment of the amount of nutrients delivered, prescribed, and required for fifty one critically ill patients in the United States. Another study done by Hemeda et al. [10] in Alexandria-Egypt reported that the prescribed feeding is in terms of volume to be administered and not in terms of actual calories required for fifty critically ill patients. Another Egyptian study conducted by Gibrail et al. [27] demonstrated that prescribed energy represents about 62% of the energy requirements in two hundred and two critically ill patients. Kim et al. [24] concluded that the strongest predictor of underfeeding was under-prescription in their study of nutritional changes in forty eight entirely fed ICU patients in South Korea [10,24,27,32].

EN interruption is common in critically ill patients until emergent medical problems are stabilized; often it is not started or restarted for days. Across several studies, Petros and Engelmann [33], Elpern et al. [34] and Rice et al. [35] EN was interrupted in critically ill patients, on average, of two to seven hours daily per patient and this agrees with the study findings. Feeding was on hold for 13% to 33% of the total feeding time. Patients received only 50% to 75% of their energy requirements. Underfeeding in these conditions was inevitable secondary to frequent interruptions [33-35].

In the current study, the mean number of EN initiation hours after admission to ICU was thirteen hours. This agrees with the study conducted by Elke et al. [25] in Canada, on two thousands two hundred and seventy patient, to evaluate the effect of energy and protein amount given by EN on their clinical outcomes, they reported that the mean time of EN initiation was twenty six hours from admission to ICU. Importantly, these finding also is congruent with the guidelines that developed by the ESPEN (2006), SCCM (2009), ASPEN (2009), and more recently the ADA (2012) and the CCPGs (2013) that recommended that EN be started within the first twenty four to forty eight hours from admission to the ICU to all critically patients. This help in the prevention of intestinal and mucosal atrophy, support of intestinal immunological function, decrease of infectious complications, enhancement of wound healing [1,25,36,37].

Additionally, the mean number of interruptions in EN during the seven days was four times. As well, the mean duration per one interruption was six hours, and the total duration of interruptions twenty seven hours per patient during the seven days. These findings are similar to Ramakrishnan et al. [38] in their study of causes and duration of interruptions in EN in three hundred and twenty seven critically ill entirely fed patients in India. They reported that the mean duration of interruptions was seven hours. Another study by O'Meara et al. [28] in the United States, reported that enteral feeding was interrupted a mean of six hours in each patient each day, in their assessment of the factors associated with interruptions in EN in fifty nine critically ill patients receiving mechanical ventilation [28,38].

The current study demonstrated that unscheduled basic nursing followed by GICs were the most frequent reasons for EN interruption. As well, interruptions due to diagnostic procedures or airway management were the lowest frequent reasons for EN interruption. This may be attributed to low experience of nurses in managing time of procedure that make the patient not able to benefit completely from EN schedule due to frequent interruptions as in procedures that requires supine position as changing position, bathing and measuring central venous pressure. On the contrary Al Sayaghi et al. [8] reported that GICs followed by nursing practice factors were the most frequent reasons for EN interruption and interruptions due to diagnostic procedures or airway management were the lowest frequent reasons for EN interruption in their study of the effect of EEN on the clinical outcomes of fifty critically ill mechanically ventilated patients in Alexandria-Egypt. While, Kim et al. [24] in South Korea conducted a study among forty seven critically ill neurosurgery patients, they reported that the most frequent reason for the feeding interruption was related to intubation/extubation followed by gastrointestinal problems. In another study done by Refaat et al. [23] they reported that GI related factors followed by nurses' related factors were the most frequent reasons for enteral feeding interruptions while diagnostic and therapeutic related factors were the lowest frequent reason in their assessment of factors contributing to nosocomial anemia in sixty five critically ill patients in Alexandria-Egypt [8,23,24,39].

The following were the most common reasons for EN interruption in the current study. Unscheduled basic nursing care was the most frequent cause for interruption, accounted for 72% of the causes of EN interruption. EN is often discontinued whenever patients are placed in the supine position for routine nursing care because of fear of aspiration. This differs from other studies as a cause of interruptions; it represents about 45% of EN interruptions causes in the study of O'Leary-Kelley et al. [40] and only 25% of EN interruption causes in the study by O'Meara et al. [28]. McClave et al. [7] in the United States suggest that procedure interruptions could be avoided by strict protocols for infusion of EN [7,28,40].

GICs accounted for 64% of the causes of EN interruption in the current study. High GRVs and GI intolerance including, vomiting, and abdominal distention were the most common causes of GICs in the current study. It may be attributed to many reasons as severity of patient's condition, GI hypoperfusion, and nurses' practices as incorrect assessment of GRVs by nurses, inadequate assessment of respiratory status before procedure and incorrect administration of formula. Similarly, Roberts et al. [41] in the United States reported that the most common causes of GICs in fifty critically ill patients were High GRVs and GI intolerance including, diarrhea, vomiting, and abdominal distention or pain. Another study conducted by Nassif et al. [42] in Egypt reported that the most common reasons for EN interruption among sixty critically ill enterally fed patients were related to GICs. An Indian study conducted by Ramakrishnan et al. [38] among three hundred and twenty seven critically ill enterally fed patients to assess factors leading to EN interruptions, revealed that GICs accounted for 25% of EN interruption causes [38,41,42].

Poor assessment of GRVs by nurses was an important reason for EN interruption in this study. They withhold EN with low level of GRVs from fifty to one hundred ml and this may be due to fear of aspiration and lack of defined unit protocol to determine the cut-off point for EN withholding due to high GRVs. These findings were supported by Al Sayaghi et al. [8] in Alexandria-Egypt. No data support the commonly assumptions that high GRVs predispose to regurgitation and pulmonary aspiration. High GRVs more than five hundred ml do not necessarily predict aspiration, and low GRVs less than one hundred ml are not guarantee that aspiration will not occur. More recently an enteral feeding protocol has emphasized the threshold of more than two hundred ml to start interventions and more than five hundred ml to stop gastric feeding and start post-pyloric feeding. Experts in EN cautioned that GRVs are unreliable markers of feeding intolerance and feedings should not be stopped for any GRV less than five hundred ml, and that trends in GRVs measurements are more important than any single measurement [8].

Diagnostic and therapeutic procedures accounted for 38% of EN interruption causes in the current study which can be avoidable. Diagnostic and therapeutic procedure's preparations as supine position and fasting were done routinely due to fear of aspiration. There was no compensation for volume delayed by procedures and EN frequently not started immediately after performing the procedures. A well-designed protocol may support health care providers to attain goal volumes after procedures and to replace the missed enteral volume secondary to procedures preparations.

These results were supported by others; McClave et al. [7] in the United States reported that procedures accounts for 35% of EN interruption causes and about 66% of these procedures were avoidable and potentially correctable. Rice et al. [35] in the United States reported that procedures accounts for 41% of EN interruption causes in fifty five enterally fed mechanically ventilated patients. Similar results by Kim et al. [39] in South Korea reported that procedures account for 33% of EN interruption causes. The most common reasons for interruption were related to preparation for extubation and airway procedures in six hundred and fifty three critically ill patients in Australia as reported by Williams et al. [7,35,39,43].

Nutritional support of the critically ill patients is an essential component of patient care. Understanding of the body response to critical illness, benefits of EN, nursing role in providing nutrition related care and the barriers of nutritional adequacy is crucial to deliver adequate nutritional support for critically ill patients. Nutritional adequacy is the ultimate goal of the nutritional support for critically ill patients as it preserves patient's lean body mass and enables critically ill patients to pass the state of catabolic stress safely. Adequate nutritional support could be achieved through accurate estimation of actual patient's nutritional needs. Nurses' role is essential in nutrition related care as they are in close contact with patients conducting nutritional screening, assessment, monitoring and delivery of safe nutritional care according to good standards of nutritional support practices. Nurses can play an important role within a multi-disciplinary team. Understanding of nutrition support practices in ICUs enables nurses to improve the delivery of nutrition leading to improved clinical outcomes.

Conclusion

The current study aimed to identify factors that imped adequate delivery of EN. Patients in this study have developed nutritional inadequacy. All patients were underfed with varying degrees "76% of patients were severely underfed, and 22% of patients were moderately underfed". A significant discrepancy between required, prescribed and delivered nutrients was demonstrated during seven consecutive days from ICU admission. Unscheduled basic nursing procedures followed by gastrointestinal complications (GICs) were the most frequent reasons for enteral feeding interruption. Whereas, interruptions due to diagnostic procedures or airway management were the lowest frequent reasons for enteral feeding interruption.

Recommendations

Based on the findings of the present study, the following recommendations are suggested, development and application of an evidence-based ENprotocol and proper assessment, preparation and management of hospital enteral formula.

Limitations of the Study

The study was conducted only in one hospital (University

Hospital), in general ICU. Replication of the study in other types of hospitals and other ICU specialties and in a wide geographical area will help in generalization of results.

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