Original Article

Effects of a nutrition support team on clinical outcomes, metabolic complications and electrolyte abnormalities in patients receiving parenteral nutrition

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The effectiveness of the Nutrition Support Team (NST) at Hospital Sungai Buloh, a large public hospital in Kuala Lumpur, Malaysia, in optimising parenteral nutrition (PN) has not been evaluated. To evaluate the effects of this NST in optimising patient outcomes, treatment outcomes, and adherence to biochemical monitoring guidelines, two groups of patients, those given PN before (n = 106) NST intervention and those given PN after (n=106) NST intervention, were retrospectively compared. Intervention by the NST significantly reduced metabolic abnormalities, reducing sodium abnormalities from 67% to 44% (p<0.01); potassium abnormalities from 42% to 15% (p<0.01); magnesium abnormalities from 13% to 3% (p<0.05) and phosphate abnormalities from 21% to 9% (p=0.01). Intervention by the NST also significantly reduced the incidence of hypertriglyceridemia from 68% to 45% (p=0.002) and significantly improved adherence to biochemical monitoring guidelines from 46% to 72% (p<0.01). However, the length of hospital stay, patient mortality, and duration of PN were similar in both groups. This study failed to demonstrate that the establishment of a NST gave better outcomes in terms of the common measures of effectiveness. In conclusion, although management by an NST significantly reduced metabolic abnormalities and improved adherence to biochemical monitoring guidelines, the NST did not improve patient mortality rates and length of hospital stay.

Key Words: parenteral, nutrition, support, team, multidisciplinary

INTRODUCTION

Nutritional care is a key component in the management of virtually all acute and chronic diseases. About 8-38% of newly hospitalised patients are malnourished and become more malnourished during hospital stay.[1] Nutritional support is commonly given via the oral, enteral or parenteral route. Whenever possible, a patient's gastrointestinal tract is used for oral or enteral feeding, with parenteral nutrition (PN) reserved for patients with a non-functioning gastrointestinal tract. PN is an important adjunctive nutritional therapy and consists of complex mixtures of macronutrients and micronutrients. The complexity of PN has resulted in the development of many metabolic, mechanical and septic complications, which are associated with increases in both mortality and morbidity. To address this problem, the American Society for Parenteral and Enteral Nutrition (ASPEN) has recommended the establishment of a multidisciplinary Nutrition Support Team (NST), consisting of nutritional experts who oversee the nutritional status and therapy of patients who need nutritional support. NSTs have been found to reduce most of the complications of PN therapy, including metabolic complications associated with PN nutrition, such as electrolyte imbalances,[1,2] and in-hospital mortality associated with nutrition.[1,3] Compliance and adherence to monitoring and infectious control guidelines were also improved when NSTs were involved in managing patients on PN.[4]

Currently only a few hospitals in Malaysia provide the services of NSTs. To be effective, an NST must practice at an evidence-based level and constantly measure their performance. The NST service of Hospital Sungai Buloh in Kuala Lumpur was established in October 2009. This decentralised-managerial NST team is led by a surgeon and includes a surgical medical officer, a surgical ward pharmacist, a total parenteral nutrition (TPN) pharmacist, a dietician, and a nurse. To date, however, the effects and roles of this service have not been evaluated. This NST service is based on referrals. Thus, patients on oral and enteral support may be managed by their respective physicians and may not be referred to the NST, whereas all patients requiring PN will be referred to the NST. We have evaluated the effects of this NST on patient outcomes, treatment outcomes and adherence to biochemical monitoring guidelines.

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Table 1. Definition of electrolyte and triglyceride abnormalities

Electrolyte	Metabolic complications	Definition	
		SI unit	Conventional unit
Sodium	Hyponatraemia	<135 mmol/L	<135 mEq/L
	Hypernatraemia	>145 mmol/L	>145 mEq/L
Potassium	Hypokalaemia	<3.5 mmol/L	<3.5 mEq/L
	Hyperkalaemia	>4.5 mmol/L	>4.5 mEq/L
Phosphorus	Hypophosphatemia	<0.8 mmol/L	<2.48 mg/dl
	Hyperphophatemia	>1.6 mmol/L	>4.95 mg/dl
Magnesium	Hypomagnesaemia	<0.8 mmol/L	<1.6 mEq/L
	Hypermagnesaemia	>1.2 mmol/L	>2.4 mEq/L
Triglycerides	Hypertriglyceridemia	>1.7 mmol/L	>0.019 mg/dl

METHODS

This retrospective, comparative study was performed at Hospital Sungai Buloh, a public hospital in Kuala Lumpur and was approved by the Ethics and Research Department of the Ministry of Health of Malaysia (ref. no.: NMRR-10-1029-7369). Patients receiving PN alone before October 2009 (pre-NST group) and after October 2009 (NST group) were included. Neonatal and paediatric patients were excluded because management of their nutrition required expertise that was not included in components of the NST policy. Patients receiving PN during dialysis and those prescribed PN concurrently with enteral or oral intake were excluded. Data for the pre-NST and NST years were based on patient PN episodes. A patient PN episode was defined as the period from the start of the first to the end of the last PN infusion. In patients with more than one PN episode, each episode was considered separately.

PN for patients in the pre-NST group were managed primarily by attending physicians, with little or no intervention from health professionals from other disciplines. During this period, PN was started without a complete nutritional assessment, and the decision to initiate PN was usually based on the patient's general condition, including appetite, capacity to eat and body weight. PN regimens were prescribed by the attending physician and filled by the pharmacy department.

PN needs for patients in the NST group were fully under the responsibility of at least one member of the NST, who monitored the patient daily, and were reviewed by the entire NST weekly during NST ward rounds. During the weekly review, the entire team discussed the care of all patients receiving PN. Before PN was initiated, the NST performed a complete nutritional assessment of that patient, including anthropometric measurements, biochemical tests and evaluation of immunocompetence, according to the protocol developed by the NST. This protocol was based on the guidelines of the European Society of Parenteral and Enteral Nutrition (ESPEN). Each patient's nutritional requirements were outlined and the appropriate therapy was formulated. In addition, the surgical medical officer, pharmacists and dietician met every day to review and evaluate the patient's response and to discuss any change to be made to the PN regimen.

During the pre-NST period, data were collected from medical and nursing notes and from PN prescriptions from the pharmacy department. After the establishment of NST, the pharmacists in the team manually maintained daily monitoring sheets for each PN patient, including updates of any changes in the PN regimen. A specialised NST monitoring note was also developed. Patients were identified by code to ensure confidentiality.

Clinical outcomes

Patient outcomes included mortality rates and length of hospital stay (LOS) after the initiation of PN. Treatment outcomes included the incidence of electrolyte imbalances,[4,5] including the occurrence of one or more laboratory values outside the reference range, as compared with baseline values and the total duration of PN. Normal reference ranges were derived from ESPEN guidelines and were reviewed and agreed to by the NST committee. Table 1 shows the definition of metabolic complications and the list of electrolytes and triglycerides monitored.

These laboratory results were selected for evaluation because they were routinely monitored and most likely to cause symptomatic events during PN therapy.[6] The baseline values were defined as laboratory parameters before the initiation of PN therapy.

The level of adherence to NST protocols was determined by measuring the frequency with which laboratory tests were ordered and obtained, compared with the monitoring standards in the NST protocol (Table 2).

Compliance was recorded when all monitoring parameters were performed according to these guidelines and non-compliance was recorded when at least one parameter was not monitored according to the guidelines. Sample size was calculated using the method of Fleiss, 1981 and using appropriate equations for both categorical and continuous data.[7] The largest sample size was selected for the study. C was determined to be 7.85, as the power of study was set as 80% and statistical significance was defined as $p < 0.05$.

Calculations showed that the sample size needed to achieve a power of 80% with a statistical significance of 0.05 ranged from 81 to 106 subjects per group. Since the power of study will increase with increase in sample size, the largest calculated sample size of 106 subjects per

Table 2. Guidelines for the frequency of biochemical monitoring

Monitoring Parameters	Frequency
Sodium (Na^+), Potassium (K^+)	Every other day
Magnesium (Mg^{2+}), Phosphate (PO_4^-)	Weekly or 2x/week
Lipid Profile: Triglycerides (TG)	Weekly or 2x/week

group was utilised. All patients solely on PN before and after the establishment of the NST were selected for the study. Patients were selected by the convenience sampling method. Selection of patients in the pre-NST group was started in October 2009, working backward until 106 patients were obtained; whereas selection of patients in the NST group started in October 2009, working forward until 106 patients were obtained. Since this was a retrospective observational study, there were no patient interventions.

Data collected on patient data collection forms included gender, race, and age of each subject; admitting discipline (surgical or medical); ward of admission (ICU or non-ICU), length of hospital stay; body weight upon starting PN; indications for PN; type of PN regime (Kabiven®, manufactured by Fresenius Kabi, Germany or Nutriflex®, manufactured by B Braun, Germany); duration of PN; route of PN administration (central or peripheral); caloric achievement of 25 kcal/kg/day within 3 days of starting PN (yes or no); patient mortality after PN (alive or deceased); metabolic complications during PN therapy, including abnormal sodium (Na), potassium (K), magnesium (Mg), phosphate (PO_4) and triglyceride (TG) levels; compliance with NST biochemical monitoring guidelines (yes or no); and transition time to enteral or oral feeding (Appendix A: Data collection form).

Statistical analysis was performed using SPSS version 18. Differences between the pre-NST and NST groups were assessed using Student's t-tests for continuous variables, such as age, body weight, duration of PN and length of hospital stay, with appropriate t-tests used to correct unequal variances when they occurred[8]; and the χ^2 test, with Yate's correction if necessary, to evaluate categorical variables, such as gender, race, ward of admission, route of PN administration, type of PN, patient outcome after PN, caloric achievement of 25 kcal/kg/day within 3 days of starting PN, transition to enteral or oral feeding, metabolic and TG complications, and compliance with NST monitoring guidelines. The level of statistical significance was set at 0.05 and power of the study at 80%. As clinical outcomes may have been due to patient care aspects other than PN, demographic data, patient conditions and diagnosis were matched as closely as possible in the two groups.

RESULTS

Characterisation of study subjects

The pre-NST group consisted of 106 patients who received PN from January to September 2009, whereas the NST group consisted of 106 patients who received PN from October 2009 to August 2010. Table 3 shows the demographic and clinical characteristics of these subjects. There were no significant between group differences in gender distribution, mean and range of age, race, ward admitted, admitting discipline, indications for PN, route of PN administration and PN regimen. PN was more frequently administered to ICU than non-ICU patients and to surgical than to medical patients. Central vein route of administration and use of Kabiven®PN were more frequent in both groups of patients, with no correlation between route of administration and duration of PN. Body weight was more frequently measured in the NST than in the pre-NST group, with a weak positive correlation between body weight measurement and intervention by an NST ($r = 0.386$, $p < 0.01$).

Clinical outcomes

Since length of hospital stay (LOS) may be confounded by mortality, as early in-hospital mortality reduced the length of hospital stay, paradoxically suggesting improved outcome, LOS was calculated only for patients who survived throughout PN therapy. There were no significant differences between the pre-NST and NST groups in LOS, mortality rate, and time of transition to enteral or oral nutrition (Table 4). However, a significantly higher percentage of patients in the NST than in the pre-NST group received ≥25 kcal/kg/day nutrition, as recommended by the ESPEN guidelines (49% vs 18%, $p<0.01$). However, receiving ≥25 kcal/kg/day was not correlated with length of hospital stay or mortality after PN.

The incidences of metabolic complications are shown in Table 5. Na and K were the most frequently measured parameters, being measured in 99% and 100% of subjects in both groups. The incidence of Na abnormalities was significantly lower in the NST than in the pre-NST group (44% vs 67%, $p<0.01$), with hyponatraemia being more common in both groups than hypernatremia. Na abnormalities showed a weak negative correlation with patient mortality ($r= -0.201$, $p=0.003$) and weak positive correlations with length of hospital stay ($r= 0.205$, $p=0.003$) and duration of PN ($r= 0.179$, $p=0.009$). The incidence of K abnormalities was also significantly lower in the NST than in the pre-NST group (15% vs 42%, $p<0.01$), with K abnormalities weakly correlated with patient mortality ($r = -0.236$, $p=0.001$).

Mg and PO_4 were measured in 94% and 98% of subjects in the pre-NST and NST groups, respectively. Mg abnormalities were significantly less frequent in the NST than in the pre-NST group (3% vs 13%, Yate's $p<0.05$). Mg abnormalities were observed more often in surgical than in medical wards (94%, $r= -0.148$, $p=0.034$) and for ICU than non-ICU patients (94%, $r = -0.153$, $p=0.029$). PO_4 abnormalities were also significantly less frequent in the NST than in the pre-NST group (9% vs 21%, $p=0.01$) and were observed more often in patients in medical than in surgical wards ($r= -0.174$, $p=0.013$). PO_4 abnormalities showed a weak negative correlation with route of PN administration ($r= -0.186$, $p=0.008$), increasing when PN was administered via the central route. PO_4 abnormalities were also weakly correlated with patient mortality ($r= -0.316$, $p<0.01$).

The incidence of hypertriglyceridemia was also significantly lower in the NST than in the pre-NST group (45% vs 68%, $p=0.002$). Elevated TG concentrations were weakly correlated with patient mortality ($r= -0.232$, $p=0.002$), and were observed more frequently in surgical than in medical wards ($r= -0.338$, $p<0.01$), in ICU than in non-ICU patients ($r= -0.323$, $p<0.01$) and in patients who received central than peripheral PN ($r= -0.249$, $p<0.01$).

The mean duration of PN, was 9 days in the pre-NST group and 8 days in the NST group, but the difference was not significant. The percentage of patients who received PN for less than 5 days were the same in both groups (p=NS), with the duration of PN strongly corre-

Table 3. Demographic and clinical characteristics of the pre-NST and NST groups

Variables	Pre-NST Group	NST Group	Statistics
Gender, n (%)			
Male	75 (71%)	77 (73%)	$\chi^2 = 0.093$, $p = 0.760$ (NS)
Female	31 (29%)	29 (27%)	
Mean ± SD age, yrs (range)	48 ± 17.3 (16-82)	50 ± 19.1 (15-82)	t-test $p = 0.467$ (NS)
Race, n (%)			
Malay	72 (68%)	70 (66%)	$\chi^2 = 7.896$
Chinese	8 (8%)	20 (19%)	Yate's p value = 0.111 (NS)
Indian	19 (17%)	13 (12%)	
Others	7 (7%)	3 (3%)	
Body weight measured on starting PN, n (%)			
Yes	70 (66%)	102 (96%)	$\chi^2 = 31.553$, $p < 0.01$
No	36 (34%)	4 (4%)	
Mean ± SD body weight, kg	65 ± 17.4	59 ± 16.8	t-test 2.241, $p = 0.026$
Ward admitted, n (%)			
ICU	76 (72%)	68 (64%)	$\chi^2 = 1.386$, $p = 0.239$ (NS)
Non-ICU	30 (28%)	38 (36%)	
Admitting discipline, n (%)			
Surgical	78 (74%)	68 (64%)	$\chi^2 = 3.546$
Medical	28 (26%)	38 (36%)	Yate's p value = 0.351 (NS)
Indications for PN, n (%)			
GI surgery	94 (87%)	91 (86%)	$\chi^2 = 4.138$
Pancreatic disease	6 (6%)	3 (3%)	Yate's p value = 0.540 (NS)
Malnutrition	6 (6%)	12 (11%)	
Route of PN administration, n (%)			
Central vein	84 (79%)	76 (72%)	$\chi^2 = 1.631$, $p = 0.202$ (NS)
Peripheral vein	22 (21%)	30 (28%)	
PN regimen, n (%)			
Kabiven®	76 (72%)	80 (75%)	$\chi^2 = 0.388$, $p = 0.533$ (NS)
Nutriflex®	30 (28%)	26 (25%)	

Table 4. Patient and nutritional outcomes in the pre-NST and NST groups

Variables	Pre-NST	NST Group	Statistics
Patient Outcomes			
Length of stay (LOS)	n = 67	n = 79	t-test 0.473, $p = 0.637$ (NS)
Mean ± SD LOS, days	18 ± 2.0	17 ± 2.0	
Mortality after PN, n (%)			
Alive	67 (63%)	79 (75%)	$\chi^2 = 3.168$, p = 0.075 (NS)
Deceased	39 (37%)	27 (25%)	
Nutritional Outcomes			
Kcal/kg/day after Day 3, n (%)			
≥25	19 (18%)	52 (49%)	$\chi^2 = 23.061$, $p < 0.01$
<25	87 (82%)	54 (51%)	
Transition to enteral/oral feeding after PN, n (%)			
Nil	34 (32%)	23 (22%)	$\chi^2 = 8.755$
Within 1 day	64 (61%)	82 (77%)	Yate's p -value: 0.127 (NS)
Within 2 days	5 (5%)	1 (1%)	
Within 3 days	2 (2%)	0	

lated with LOS (r= 0.4, $p<0.001$).

Adherence to monitoring guidelines

Prior to establishment of the NST, the level of adherence to ESPEN guidelines was low (46%), but increased to 72% after the establishment of the NST ($p<0.001$), as shown in Table 6. Level of adherence to monitoring guidelines was better in patients admitted to the surgical than to the medical ward (r= -0.172, p=0.012) and in ICU compared non-ICU patients (r= -0.166, p=0.015).

DISCUSSION

Demographic and clinical characteristics

Monitoring of body weight before initiating PN was more consistent after the establishment of the NST. The NST, helped by good monitoring notes, was able to document and ensure that all basic monitoring parameters, especially body weight, were recorded before initiation of PN. Nevertheless, body weight was not measured in 4% of subjects in the NST group prior to initiation of PN, perhaps because PN started after office hours or at night

Table 5. Incidences of metabolic abnormalities and length of PN in the pre-NST and NST groups

Variables	Pre-NST Group	NST Group	Statistics
Sodium, n (%)			
Normal	35 (33%)	59 (56%)	*χ^2 = 17.832, p < 0.01
Abnormal	70 (67%)	47 (44%)	
Hyponatraemia	63 (90%)	33 (70%)	
Hypernatraemia	7 (10%)	14 (30%)	
Potassium, n (%)			
Normal	62 (58%)	90 (85%)	*χ^2 = 26.809, p < 0.01
Abnormal	44 (42%)	16 (15%)	
Hypokalaemia	36 (82%)	6 (37.5%)	
Hyperkalaemia	8 (18%)	10 (62.5%)	
Magnesium, n (%)			
Normal	87 (87%)	101 (97%)	*χ^2 = 12.169
Abnormal	13 (13%)	3 (3%)	Yate's p value <0.05
Hypomagnesaemia	11 (85%)	0	(p = 0.006)
Hypermagnesaemia	2 (15%)	3 (100%)	
Phosphate, n (%)			
Normal	79 (79%)	95 (91%)	*χ2 = 13.398, p = 0.01
Abnormal	21 (21%)	9 (9%)	
Hypophosphataemia	12 (57%)	0	
Hyperphosphataemia	9 (43%)	9 (100%)	
Triglyceride, n (%)			
Normal	30 (32%)	48 (55%)	χ^2 = 9.996, p = 0.002
Hypertriglyceridemia	64 (68%)	39 (45%)	
Mean ± SD PN duration, days	9 ± 2.2	8 ± 2.0	t-test 0.823, p = 0.411 (NS)
≤5 days	28 (26%)	28 (26%)	χ^2 = 0.000
>5 days	78 (74%)	78 (74%)	t-test 0.625, p = 1.00 (NS)
Mean duration (days) ± SD central PN PN	11 ± 9.9	10 ± 6.8	t-test -1.117, p = 0.533 (NS)
Mean duration (days) ±SD peripheral PN	8 ± 2.9	9 ± 4.9	t-test -1.117, p = 0.269 (NS)

Table 6. Level of adherence to monitoring guidelines in the pre-NST and NST groups

Variables	Pre-NST Group	NST Group	Statistics
Adherence to monitoring guidelines, n (%)			
Yes	49 (46%)	76 (72%)	χ^2=14.211;
No	57 (54%0	30 (28%)	p < 0.01

when NST services were not readily available. Patients in the ICU and those managed in the surgical ward were referred more frequently for PN. Patients in the ICU have increased metabolic needs,[9] and surgical patients undergo many gastrointestinal interventions, which may result in prolonged gastrointestinal dysfunction.[10] The central route of administration was more common than the peripheral route and was significantly associated with the ICU setting. These patients generally required a longer duration of PN and had greater nutrient requirements and therefore, a central venous access device is often required to administer high osmolarity PN mixtures designed to fully cover their nutritional needs.[9]

Clinical outcomes

There were no significant differences between the 2 groups of subjects in length of hospital stay and mortality rate. Although the mortality rate was 12% lower in the NST group, the difference was not statistically significant. Mortality is multifactorial and is affected by factors beyond just nutritional support and intervention by an NST. Rather, mortality is dependent on patient selection and overall medical and surgical management. Patients in the NST group were evaluated by the entire team once per week; therefore, any important changes that would influence mortality would have been treated by their respective physicians. In another study, NST was found to significantly improve hospital mortality rates and the NST was also involved in educating the medical and surgical nursing staff.[3] In contrast, the NST at Hospital Sungai Buloh did not assume any educational role due to limited resources. Another study found that measures of the benefits of an NST should include providing adequate nutrition and preventing PN-associated complications, and not just reducing mortality rates.[11]

We found that intervention by an NST resulted in significant improvements in the supply of calories to patients, with 49% of patients being supplied a minimum of 25 kcal/kg/day, compared with 18% in the pre-NST group. ESPEN guidelines recommend that critically ill and surgical patients receive at least 25 kcal/kg/day.[9,12] The improvement in energy supply was likely due to intervention by the NST, which had skills and expertise in nutrition supply. Times to transition from PN to enteral or oral feeding were similar in the two groups, being generally within 24 hours of weaning from PN. This is in line with ESPEN guidelines, which recommend that surgical patients be transitioned to enteral or oral feeding within 24-48 hours of weaning from PN.[10]

Table 7. Types of Kabiven® and Nutriflex® PN bags prescribed

Regimens	1	2	3	4	5	6	7	8
Route	Central					Peripheral		
Contents	Structo Kabiven® Central 1.5L	Structo Kabiven® Central 2L	Nutriflex® Lipid Plus 1.25L	Nutriflex® Lipid Plus 2.5L	Nutriflex® Lipid Special 1.25L	Nutriflex® Lipid 1.875L	Kabiven® Peri 1.5L	Structo Kabiven® Peri 1.9L
Volume (ml)	1500	2000	1250	2500	1250	1875	1500	1900
Glucose (g)	187	250	150	300	180	120	97	135
Amino acid (g)	75	100	48	96	71.8	60	34	60
Nitrogen (g)	12	16	6.8	13.6	10	8.6	5.4	9.8
Lipids (g)	56	75	50	100	50	75	51	54
Na (mmol)	60	80	50	100	67	75	32	48
Cl (mmol)	52	70	45	90	60	72	47	42
K (mmol)	45	60	35	70	47	45	24	36
Ca (mmol)	3.8	5	4	8	5.3	4.5	2	3
Mg (mmol)	7.5	10	4	8	5.3	4.5	4	6
PO4 (mmol)	19	25	15	30	20	11.3	11	15.6
Acetate (mmol)	157	209	45	30	60	60	39	125
Total energy (kcal)	1600	2100	1265	2530	1475	1435	1000	1300
Osmolarity (mOsmol/L)	1060	1060	1215	1215	1545	840	750	850

Treatment outcomes

The percentage of patients with metabolic abnormalities were significantly reduced by NST intervention. ESPEN guidelines state that metabolic disturbances are more likely to occur in the absence of a NST, or when physicians do not perceive PN as a powerful adjunct therapy but rather use it as urgent and 'life-saving'.[13] Most of the metabolic abnormalities in the pre-NST group may be due to inadequate monitoring of patients, coupled with individual physicians' inability to diagnose and correctly manage these complications.[5,14] Daily monitoring of laboratory values and routine bedside monitoring by the NST can identify and correct abnormalities in a timely fashion. Correction of metabolic abnormalities is important and should be carried out as soon as detected. Hyponatraemia can cause acute cerebral edema and lead to confusion, seizures, coma and even brain stem herniation.[15]. Hypokalaemia can result in neuromuscular effects such as cramps and muscle weakness, cardiac effects such as ECG changes, arrhythmias, atrial and ventricular tachycardias.[16] Concurrent hypomagnesaemia occurs in up to 40% of cases of hypokalaemia and therefore must also be corrected for effective correction of hypokalaemia. Hypomagnesaemia may manifest as neuromuscular effects such as muscle weakness or cramps and tremor, neuropsychiatric effects such as apathy, depression and agitation and cardiac effects such as arrythmias [17] Electrolyte dysregulation including hypokalemia, hypomagnesemia and more importantly hypophosphatemia can lead to refeeding syndrome.[18] Refeeding syndrome, if not recognised and corrected promptly, can lead to multisystem organ failure and death in the most severe cases.[18] Hypophosphatemia can lead to hemolysis, anaemia, susceptibility to infections and generalised ischaemia due to insufficient oxygen delivery, diminished cellular regulation and growth.[18]

In the period during this study, the choice of parenteral nutrition products was limited to the first generation parenteral admixtures. However, currently a larger range of products, enhanced with glutamine, fish oil, soybean oil and olive oil are available. These improved admixtures have been shown to lead to a reduction in mortality.[19]

Adoption of agreed protocols for monitoring, as part of an NST, has led to more effective detection and earlier treatment of biochemical abnormalities. The establishment of the NST has resulted in the development of standardised daily PN order forms and in-patient pharmacist monitoring forms for each patient on PN nutrition. Moreover, the NST protocol has enabled all patients on PN to be monitored more closely, with prompt corrective action taken when abnormalities occur. Prior to the establishment of the NST, PN could be ordered as a default or repeat prescription and supplied without routine patient monitoring.

The mean duration of PN was 1 day shorter in the NST group, but the reduction was not significant. Although these results were consistent with several previous studies,[4,20] they differed from those of studies which showed that NST increased the mean duration of PN.[5,11] These results are also different from that of a study which found that the duration of PN was similar before and after NST intervention.[21] The duration of PN may be influenced by the management strategy of individual physicians or by premature termination or inappropriate extension on a weekend or public holiday when NST services are not available.

The NST protocol has improved the frequency of biochemical monitoring, which, in turn, will improve patient nutrition support. The lack of biochemical monitoring of patients treated by individual physicians may be due to their lack of expertise in nutrition-related complications. Other studies have reported similar improvements in the level of patient monitoring and meeting of nutritional goals with involvement of an NST.[4] However, Gales and Gales, 1994, reported some studies that showed no significant difference in compliance with monitoring standards

with NST intervention and concluded that it was unclear whether the presence of an NST improved patient monitoring.[22] Other studies have shown that nutrition support does not reduce morbidity and mortality, but these studies did not involve specific nutritional support teams.[23,24]

This study had limitations, as it was a retrospective, comparative and observational study. The methodological weaknesses inherent in this type of study design must be considered when interpreting the results. Data on catheter-related infections would have been valuable. However, due to limited resources to investigate the processes of central venous catheter constructions, placement techniques, monitoring and insertion care,[22] this was not done. The NST also assumed a service based on referrals, and all patients were co-managed with their respective primary care team. Therefore, all events or non-events of catheter-related infections may not be a true reflection of NST intervention. Most of the records related to PN before the initiation of NST were incomplete and thus there was insufficient information to carry out better assessment of outcomes such as LOSNDT (length of stay and nutrition discharge index. It was also not possible to evaluate the appropriateness of indication for PN, use of multivitamins and trace elements, glucose levels and glucose homeostasis, BUN and creatinine, before and after the formation of the NST.

Although the clinical outcomes measured in this study may have been influenced by patients' underlying medical and surgical conditions, patients' responses to PN support, drug therapy and management by disciplines other than the NST, this evaluation enabled the effects and feasibility of an NST to be determined before making any enhancements to the team. Our findings may also be generalised to other hospitals throughout Malaysia and in neighbouring countries who have similar demographics and also use similar parenteral nutrition solutions and are starting to have NSTs. Other studies are needed to evaluate the effects of the NST on other treatment outcomes, including mechanical complications and nutritional, infection and financial outcomes. A computerised system of performing nutritional surveillance and continuing education for health professionals involved in nutrition support practice orientation that has proved to be successful may be among improvements that can be made.[25] Other measures that have proved successful are having full-time employment as NST and standardised continuing education.[1] Benefits may not only be improved nutritional status but also other positive outcomes in hypertension and the intensive care settings.[26,27]

In conclusion, although this study did not meet its goal of showing that the introduction of an NST significantly reduced secondary endpoints such as the length of hospital stay and patient mortality rate, it confirmed earlier studies that patients managed by an NST have significant improvements in treatment outcomes, including reduced incidences of metabolic complications, especially electrolyte imbalances, which are strongly associated with improvements in adherence to biochemical monitoring guidelines.

AUTHOR DISCLOSURES

The authors have no conflict of interest to declare.

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Original Article

Effects of a nutrition support team on clinical outcomes, metabolic complications and electrolyte abnormalities in patients receiving parenteral nutrition

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營養支持小組對接受腸道外營養病人之臨床預後、代謝併發症及電解質異常的影響

位於馬來西亞吉隆坡的一所大型公立醫院-Sungai Buloh 醫院，其營養支持小組(NST)對於優化靜脈營養(PN)的效益尚未被評估。兩組病人，一組為 NST 介入前給予 PN (106 位)，另一組則在 NST 介入後給予 PN (106 位)。回溯性比較以評估 NST 對於病人的治療結果及生化監測指南的遵從性之優化效果。NST 介入顯著降低代謝性異常，降低鈉異常由 67%至 44% (p<0.01)；鉀異常從 42%至 15% (p<0.01)；鎂異常從 13%至 3% (p<0.05)及磷酸鹽異常從 21%至 8% (p=0.01)。NST 介入也顯著降低高三酸甘油酯血症發生率從 68%至 45% (p=0.002)及改善生化監測指南的遵從性由 46%到 72% (p<0.01)。然而，兩組的住院天數、病人死亡率及接受 PN 期間則相似。以常用的效益測量為指標來看，這個研究無法證明 NST 有較好的結果。總之，雖然 NST 的管理顯著地降低代謝性異常及改善生化監測指南遵從性，但並未改善病人死亡率及住院天數。

關鍵字：腸道外、營養、支持、團隊、跨領域