

Audit of Total Parenteral Nutrition in an Adult Surgical Intensive Care

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Abstract

Introduction: A preliminary one-year review of total parenteral nutrition (TPN) in the adult surgical intensive care unit (SICU) in view of its complications, cost and lack of consistent benefits in the critically ill. **Materials and Methods:** All the case records of patients receiving TPN in the SICU starting from first January to end December 1998 were studied. **Results:** Fifty patients received TPN during the study period. Four case records were unavailable. The indications for starting TPN were comparable with those set up by the Stanford University Hospital. Sepsis with gastrointestinal failure at 30.5% [95% CI, 17.7% to 45.8%] was one of the major indicators for TPN use and also the biggest contributor to mortality (50%) [95% CI, 35% to 65%]. Hyperglycaemia and line sepsis increased with duration of TPN use. Pneumonia, bacteraemia and wound infection peaked by the second week. Patients receiving TPN for inadequate and delayed enteral feeding fared better with 45.8% survival [95% CI, 30.9% to 61%]. None of the patients with polytrauma or malignancy cachexia died. 52.2% [95% CI, 37% to 67.1%] survived to be discharged from hospital. Caloric requirements were calculated using Harris-Benedict's equation and estimated using 30 to 35 kcal/kg/day. 64.3% were overfed and 50% received excessive non-protein calorie-to-nitrogen ratio. Ninety-eight per cent and 81% received less than the recommended amino-acid and glucose, respectively. Fifty-eight per cent received adequate lipids. **Conclusion:** This audit highlights the shortcomings in TPN prescription and characteristics of the attendant complications. Efforts must be directed towards encouraging uniformity and level of practice standards.

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Key words: Complications, Indications, Outcome

Introduction

Total parenteral nutrition (TPN) may contribute to good outcome in selected groups of patients. Parenteral nutrition is highly effective in reversing effects attributable to simple starvation.^{1,2} However, TPN is associated with recognised multiple complications, is expensive and there is a lack of conclusive studies that demonstrate its benefits in the critically ill.³⁻⁵

Recent studies have re-examined the selection criteria for instituting TPN and re-evaluating the efficacy of such nutritional support. There is a continuing search for markers of nutritional improvement that correlate with clinical benefits as well as for the optimal nutrient composition and need for additives.⁶⁻⁹

Hence, we undertook a one-year audit of TPN use in our surgical intensive care unit (SICU).

Materials and Methods

All patients receiving TPN in the unit during the one-year period from January to December 1998 were reviewed retrospectively. The following data were collected:

1. Indications for TPN use;

2. Duration of TPN use;
3. Complications following TPN use including the presence of:
 - a) hyperglycaemia in relation to the rate of glucose infusion,^{6,8,10}
 - b) line sepsis,^{1,10}
 - c) pneumonia,^{1,10}
 - d) bacteraemia,^{1,10}
 - e) wound infection,^{1,2,10}
 - f) hyperlipidaemia,⁶
 - g) liver dysfunction, and⁸
 - h) under/over delivery of calories;⁶
4. Methods of calculating energy requirement;
5. Methods of TPN monitoring;
6. Composition of TPN solutions; and
7. Eventual outcome of patients as related to the:
 - a) indication,
 - b) duration, and
 - c) complication of TPN use.

Results

A total of 50 patients received TPN during the one-year period from January to December 1998. Forty-six patients

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were reviewed. Case records belonging to 4 patients were unobtainable. Patients demographics, baseline nutritional and primary surgical treatment characteristics are presented in Table I.

Indications

Indications for TPN are shown in Figure 1.

Complications

Figure 2 shows the various complications suffered by these patients.

Thirty-two patients suffered hyperglycaemia ($n = 46$). Guent and Nelson⁸ have advocated limiting glucose

infusion to less than 4 mg/kg/min (0.24 gm/kg/h). Still, more diabetic patients suffered from hyperglycaemia despite being given lower glucose infusion rates than those advocated.⁸ This complication also occurred at lower mean glucose infusion rate compared to hyperglycaemic non-diabetic patients (Table II).

Duration

The duration of TPN was arbitrarily divided into 3 periods of 1-7 days, 8-14 days and those lasting more than 14 days. Figure 3 relates the duration of use to the occurrence of complications. Most patients received up to 1 week of TPN (69.6% or 32 out of 46 patients). Twenty-six per cent (12 patients) received TPN for up to 2 weeks and 4.4% (2

TABLE I: PATIENT AND PRIMARY SURGICAL TREATMENT CHARACTERISTICS

Characteristic	
Age (y)	
Median (range)	62.7 (34 to 84)
Sex	
Male/female	32 / 14
Baseline serum albumin (g/L)	
Mean (range)	21 (15 to 23)
Primary surgical treatment	No.(%)
a) evacuation of intra-abdominal sepsis and related repair procedures	
i) for perforated gut	11 (23.9)
ii) for visceral abscess	4 (8.7)
b) resection of intra-abdominal malignancy	13 (28.3)
c) resection of bleeding gastrointestinal ulcers	3 (6.5)
d) resection of ischaemic/gangrenous gut	4 (8.7)
e) remedial surgery for surgical complications	
i) anastomotic leak	3 (6.5)
ii) gastrointestinal complications secondary to abdominal aneurysm repair	3 (6.5)
f) polytrauma surgery	2 (4.3)
g) others	
i) small bowel resection for bleeding Meckel's diverticulum	1 (2.3)
ii) acute pancreatitis	2 (4.3)

TABLE II: TOTAL PARENTERAL NUTRITION GLUCOSE INFUSION RATES IN HYPERGLYCAEMIC PATIENTS WITH OR WITHOUT CO-EXISTING DIABETES MELLITUS

Glucose infusion rate	Non-diabetic patients (n = 20)	Diabetic patients (n = 12)*
<0.24 g/kg/h		
No.	18	8
Mean (range)	0.17 (0.10 – 0.23)	0.15 (0.11 – 0.22)
>0.24 g/kg/h		
No.	2	2
Mean (range)	0.27 (0.25 – 0.28)	0.26 (0.25 – 0.26)

* Two diabetic hyperglycaemic patients were omitted from the above calculations because their body weights were not recorded in the prescription forms for TPN.

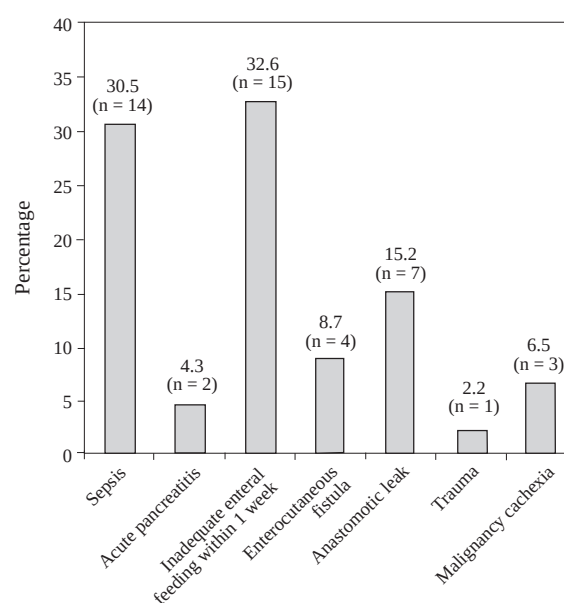


Fig. 1. Indications.

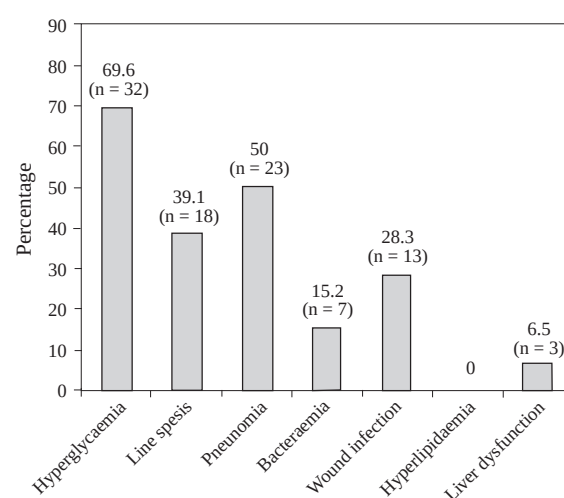


Fig. 2. Complications.

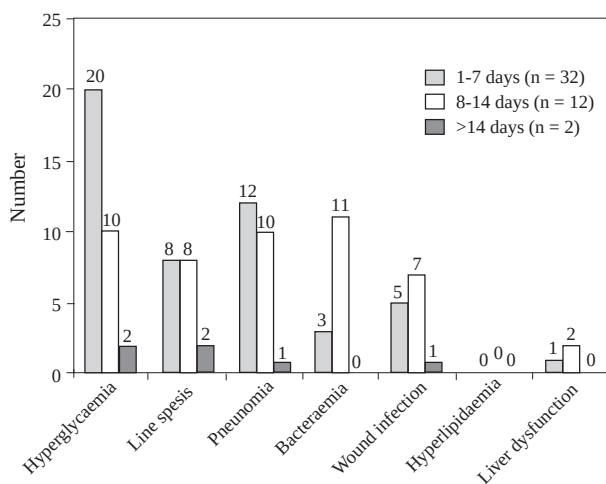


Fig. 3. Complications related to duration of TPN use.

patients) received TPN for more than 2 weeks. It appears that hyperglycaemia and line sepsis occurred in higher proportion in tandem with the longer duration of TPN use; whereas the complications of pneumonia, bacteraemia and wound infections peaked during the first to second week of TPN use.

Outcome

The mean APACHE II score for the study population was 17 (range, 8 to 32), which was higher than the mean score of 13 obtained in an audit of 2431 admissions to this same intensive care unit between January 1994 and June 1997.¹¹

Unfortunately, 47.8% or 22 out of 46 patients died. This outcome could reflect the more critically ill state of these patients as well as the compounded effects of the complications of TPN.

Mortality of patients who received TPN because of sepsis and enterocutaneous fistulae was alarmingly high, at least 75%. Patients who received TPN because of various reasons causing inadequate enteral feeding within 1 week appeared to have better outcome in our pilot review (11 survived compared to 4 who died). Of note, longer duration of TPN use did not seem to relate evidently to adverse patient outcome ($P = 0.981$).

Method of Energy Calculation

The energy requirements of 20 were calculated using the Harris-Benedict equation (Appendix I). Nineteen received calories based on 30 kcal/kg body weight. The method of energy calculation was not recorded or deducible in 7 patients—4 patients had no weight documented and 3 patients had no apparent method of energy calculation.

These patients were monitored by the recommendations set out by the hospital nutrition support service on the TPN order form.

Table III shows the goodness of match between the average calculated and delivered calories.

Composition of TPN solution

Table IV shows the average components of the TPN solutions used.

Frankfort et al⁹ reviewed the recommended doses for TPN and advocated doses as follows: 1.5 to 1.75 g/kg/day of amino acids, glucose infusion rate of less than 0.24 g/kg/day and maximal of 1 to 1.5 g/kg/day of lipids (maximum of 50% energy needs).

Only 1 of the patients receiving more than the recommended rate of glucose infusion did not suffer from

APPENDIX I: FORMULAE FOR ESTIMATING ENERGY EXPENDITURE

A. Harris-Benedict equation

Males: $BEE \text{ (kcal)} = 66.5 + [13.8 \times \text{weight (kg)}] + [5 \times \text{height (cm)}] - [6.8 \times \text{age (year)}]$

Females: $BEE \text{ (kcal)} = 65.1 + [9.6 \times \text{weight (kg)}] + [1.9 \times \text{height (cm)}] - [4.7 \times \text{age (year)}]$

BEE: basal energy expenditure

B. Activity and stress factors

Total estimation of energy requirements = BEE x activity factor x stress factor

Activity factor:

confined to bed = 1.2
out of bed = 1.3

Stress factor:

minor operation = 1.2
skeletal trauma = 1.35
major sepsis = 1.6
major thermal injury = 2.1

TABLE III: GOODNESS OF MATCH BETWEEN CALCULATED AND DELIVERED CALORIES

	Amount of calories mismatched (kcal)			
	1-100	101-200	201-300	>300
With positive calorie balance (n = 27)	7 (26%)	7 (26%)	5 (19%)	8 (29%)
With negative calorie balance (n = 15)	6 (40%)	4 (27%)	1 (6%)	4 (27%)
No. of patients (n = 42)	13 (31%)	11 (26%)	6 (14%)	12 (29%)

hyperglycaemia. Out of the overwhelming 98% of patients who received less than the recommended protein, 24% (10 of 41) had co-existing renal failure. It was difficult to determine the reason for under-delivery of lipids. It may be postulated that the calories required may be deemed sufficient prompting this prescriptive decision.

Discussion

The indications for TPN in our unit were broadly comparable with those set up by the Stanford University

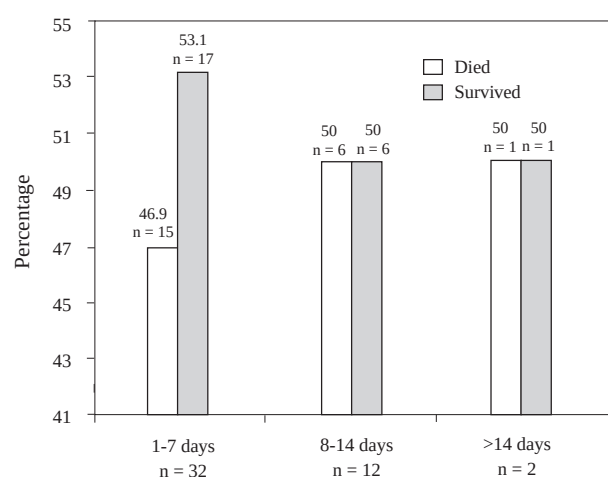


Fig. 4. Outcome of patients related to duration of TPN use.

TABLE IV: COMPONENT MAKE-UP OF TOTAL PARENTERAL NUTRITION SOLUTION [n = 42*]

	No. of patients who received the recommended dose+ (%)	Mean (range)
Glucose infusion (g/kg/h)		
Less than	34 (81)	0.18 (0.10 – 0.23)
More than	5 (12)	0.27 (0.25 – 0.29)
Within	3 (7)	–
Amino acids infusion (g/kg/day)		
Less than	41 (98)	0.9 (0.5 – 1.6)
More than	1 (2)	1.9 (1.9)
Within	–	–
Lipids infusion (g/kg/day)		
Less than	18 (43)	0.7 (0.2 – 0.9)
More than	0	–
Within	24 (57)	1.2 (1.0 – 1.5)
No. of patients receiving non-protein calorie to nitrogen ratio of:		
80 – 100	3 (7)	–
up to 150	18 (43)	–
>150	21 (50)	–

* 4 patients had no recorded weight

+ Recommended doses for TPN infusion:⁹

glucose at less than 0.24 g/kg/day

amino acids at 1.5 to 1.75 g/kg/day

lipids at maximal of 1 to 1.5 g/kg/day

Hospital¹² as part of their continuous quality improvement programme. Their criteria for starting TPN include:

1. patients unable to absorb nutrients via the gastrointestinal (GI) tract,
2. patients with severe acute pancreatitis,
3. patients with severe malnutrition and a non-functional GI tract,
4. patients with severe malnutrition undergoing major surgery,
5. patients with severe catabolism with or without malnutrition when the GI tract is not usable within 5 to 7 days,
6. patients with high output enterocutaneous fistulas (more than 500 mL/day),
7. patients with malnutrition, inflammatory bowel disease and non-functional GI tracts,
8. patients in whom adequate enteral nutrient intake cannot be established within 7 days, and
9. patients undergoing high dose chemo- or radiotherapy with substantial GI distress preventing adequate enteral nutrient intake.

Enteral feeding has been shown to be superior in the septic, burnt or trauma patients.¹³

Sepsis with GI failure was one of our major indications for TPN use and also the biggest contributor to patient mortality. This trend warrants re-examination of the specific type and spectrum of septic processes that may truly benefit from this mode of nutritional support. The selection criteria for starting TPN have to be more stringent in this group of patients. However, it is noteworthy that although a recent meta-analysis does not support the use of TPN in critically ill patient, prolong starvation (more than 14 days) is associated with poor outcome.¹⁴

Complications of hyperglycaemia and line sepsis increased with the duration of TPN use. Seventy per cent of the patients suffered hyperglycaemia which occurred in proportion to the rate of glucose infusion in TPN. Although this hyperglycaemia can be treated with insulin, there are several problems with this approach including increased incidence of fatty liver, impaired gluconeogenesis in the presence of hypoglycaemia and possible adverse effects of blocking amino acid mobilisation.

Of note, only 4 of the 32 hyperglycaemic patients received glucose infusion rate greater than the recommended. Possibly, our cohort has a proportion of undiagnosed diabetic or diabetic states complicated by sepsis, stress or inotrope use.

Complications like pneumonia, bacteraemia and wound infection peaked by the second week of TPN. Progression of the underlying disease process, prolonged endotracheal intubation and ventilation plus immunosuppressive effects of hyperglycaemia could account for these observations.

Other reasons include the management of the central venous lines as well as the material of these lines.

In the group of patients who died, most of them died during the first week of receiving TPN possibly reflecting the severity of the underlying disease (Fig. 4). Similarly, the majority of survivors were those who only received up to 1 week of TPN. This could indicate the combined effects of less severe underlying disease processes as well as lower incidence of TPN-related complications at that time.

Methods of Monitoring TPN Benefits

Improvements in nutritional markers, such as serum albumin concentrations,⁶ nitrogen balance and weight gain,¹⁵ have not been accompanied by clinical benefits. Plasma proteins with shorter half-lives are more sensitive than albumin in detecting acute changes in synthetic rates and substrate requirements. Those being investigated include fibronectin, somatomedin C and various cytokines.¹⁰ We could therefore consider these in our monitoring of the efficacy of TPN. Another way to improve the efficacy of TPN is to accurately determine the calorie requirement.

Sixty-four per cent (95% CI, 47.6% to 76.8%) of the patients were overfed. This could imply that the standard calorie calculation formulae may not describe well the energy requirements of our population or their energy requirement in critical illness state or a combination of such factors.

Indirect calorimetry is a convenient, accessible and highly accurate instrument for the measurement of caloric requirements. The strict determination of goal calories can avoid the overfeeding problem in TPN.¹⁶

Optimal TPN Nutrient Compositions and Additive

It remains unclear what the ideal energy substrate is in critically ill patients receiving TPN. Glucose has known protein-sparing effects. However, critically ill patients often tolerate large glucose loads poorly for the reasons explained earlier.

Fat appears to be an obligatory fuel source in critical illness.⁷ Fat should provide 25% to 30% up to a maximal of 50% of total calories in a hypermetabolic patient.⁷ None of our patients suffered from hyperlipidaemia, which was measured weekly, despite the prevalence of overfeeding. One of the possible reasons could be because the majority of patients received up to 1 week of TPN only.

Protein requirements are increased in the critically ill patient. An increase in protein breakdown relative to synthesis results in a decrease in lean body mass and overall nitrogen loss.⁷ A surveillance programme to elicit the working approach and rationale may be helpful towards understanding the under-prescription of amino acids in the review population.

Conventional TPN formulae have a non-protein calorie-to-nitrogen ratio of 150:1. Stressed, hypermetabolic patients with increased protein requirements and decreased calorie needs require a calorie-to-nitrogen ratio that is less (80 to 100:1).⁷ Unfortunately, 50% of the patients (95% CI, 34.9% to 65.1%) under review received overly high non-protein calorie-to-nitrogen ratio of average 250. This is consistent with the observation that significant proportion of patients received too little amino acids.

Immunonutrition refers to the addition of specific nutrients, in greater than normal concentrations, to enteral or parenteral regimens to modulate immune functions so as to improve outcome in comparison with some isocaloric, isonitrogenous control formula.¹⁷ Glutamine, an immunostimulant, at 0.2 to 0.5 gm/kg/day, is shown to be safe, inexpensive and results in an improvement in nitrogen balance, gut barrier function,¹⁸ a decrease in infections plus number of days of ventilator support,¹⁹ a reduction in hospital stay and expenses and an improvement in survival. In contrast, omega-3 and omega-6 fatty acids are immuno-suppressants and may be beneficial in patients with excessive production of inflammatory mediators and cytokine cascade.²⁰

Conclusion

The level of clinical experience and judgement contributes greatly towards selection of patients who may benefit from TPN. In the light of increasing evidence for superiority of enteral feeding, lack of firm evidence of benefits in TPN use and pressure to practise cost-effective medicine, this audit highlights the pitfalls in TPN prescription and characterises some of the complications. This review could form the platform for formulating relevant studies in TPN. Efforts must be directed towards improving uniformity and standards of practice.

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