

## ORIGINAL ARTICLE

# Audit of parenteral nutrition: standard parenteral nutrition regimens - feast or famine?

C. Gavri,<sup>1</sup> S.M. Robertson,<sup>2</sup> R. McKee<sup>3</sup>

<sup>1</sup>University of Glasgow, Department of Human Nutrition - Evangelismos General Hospital, Department of Nutrition, Greece,

<sup>2</sup>Department of Colorectal Surgery, Glasgow Royal Infirmary, Glasgow, United Kingdom,

<sup>3</sup>Department of Colorectal Surgery, Glasgow Royal Infirmary, Glasgow, United Kingdom

## LIST OF ABBREVIATIONS

SPN regimens: standard parenteral nutrition regimens  
 TPN: total parenteral nutrition  
 STMA: high output stoma  
 BMI: body mass index  
 MAC: mid-arm circumference  
 TSF: triceps skinfold  
 MAMC: mid arm muscle circumference

**KEY WORDS:** Parenteral nutrition, Standard parenteral nutrition regimes, Surgical patients, Nutritional assessment, Audit

## Address for correspondence:

Christina Gavri, 73 Dimoxarous str.,  
 115 21 Kolonaki, Athens,  
 Tel: 6944474606,  
 E-mail: [chrisgavri@yahoo.gr](mailto:chrisgavri@yahoo.gr)

Submitted: 27-10-06,

Revised: 08-01-07,

Accepted: 20-02-07

## ABSTRACT

**BACKGROUND:** Adequate nutrition of patients at a surgical unit is of great importance since both over- and undernutrition can lead to serious morbidity and even mortality. Surgical patients are frequently unable to meet nutritional needs by the enteral route and the use of SPN regimens is a common practice. Compared with patient-specific prescriptions, SPN solutions require fewer nutritional calculations, are less expensive, more convenient and offer greater biochemical stability. However, the accuracy and consistency with which these regimens meet patients' nutritional requirements remain unclear and are undefined in the literature. To examine whether patients at a surgical unit are adequately fed with SPN regimens, 13 surgical patients were prospectively followed-up and a comparison was made between the nutrients prescribed with the SPN solutions and the nutrients calculated individually for each patient.

**MATERIAL AND METHODS:** The exact amounts of macronutrients calculated and prescribed with the SPN regimens were collected. To calculate individualised nutritional requirement the Schofield equation was used with adjustment for activity and stress. Elia's recommendation was used for protein requirements. Fat/carbohydrate calories were calculated. Anthropometry was used to estimate patients' nutritional status. Prescribed and calculated energy, nitrogen, fat and carbohydrate were compared using Wilcoxon signed rank tests. Spearman's rho correlations were calculated.

**RESULTS:** Statistically significant difference was found between fat (sig.=0,001), carbohydrate (sig.=0,05) and energy (sig.=0,03) provided by SPN regimens and the ones calculated. No statistically significant difference was found between delivered and calculated nitrogen.

**CONCLUSIONS:** For short-term feeding, the potential benefits of SPN regimens may outweigh the risks associated with carbohydrate deficit and fat and energy excess. However, for longer-term feeding these risks may become clinically significant. Some improvement of the quality of feeding can be established by calculating nutritional requirements and by assessing the patients' nutritional status before commencing PN.

## INTRODUCTION

The field of nutritional support has grown rapidly since the introduction of parenteral nutrition (PN) in the late 1960s [1]. PN refers to intravenous feeding and is required when the intestine is unavailable or unable to absorb or digest an adequate supply of nutrients on a temporary or permanent basis [2]. It is used for significant

numbers of surgical patients and patients with intestinal disease to prevent, or correct malnutrition when this cannot be achieved by oral or enteral feeding [2].

The complexity and invasive nature of PN predisposes to both over and under use in hospitalized patients, and places patients at risk for a number of serious complications, such as infection of the line, septicaemia, thrombophlebitis and metabolic complications [1,3].

To deal with these complex problems the provision of PN should be a careful scheduled, step-by-step procedure. The cooperation of a number of disciplines such as those of dieticians, nurses, pharmacists, and clinicians, is required in PN planning and provision [3]. A careful clinical, functional, nutritional and metabolic assessment of the patient before commencing PN is considered necessary. The nutrient prescription should reflect the estimated nutritional requirement and the patient's clinical condition [2].

However, it seems that a detailed nutritional and metabolic assessment of the patient is not always practiced on clinical grounds. One reason for this is the concept that most patients can be managed with a range of standardized regimens, containing balanced amounts of amino acids, carbohydrates, and lipids, together with appropriate quantities of electrolytes, trace elements, vitamins, and water [2].

Patients in some disease states may have significantly altered requirements. It is also worth remembering that the amounts of nutrients delivered in each nutrition bag are designed to meet estimated daily needs of healthy persons [2]. Patients with initial depletion or those who require less nutrients are at risk of malnutrition or overfeeding respectively, both associated with dangerous complications [2,4].

The current study is a pilot observational study in a small prospective series of patients, which compares the nutrition delivered to patients by standard PN (SPN) solutions with the individually calculated nutrient needs. The study addresses the following questions: do SPN regimens expose patients to a parenteral feast, a parenteral famine or do they provide an adequate sufficiency? How important and realistic is the calculation of the patients' requirements before the provision of PN? Is a detailed nutritional and metabolic assessment of the patients justified in clinical practice?

---

## MATERIAL AND METHODS

---

The studied population consisted of 13 consecutive surgical patients (3 males, 10 females) all requiring in-patient total parenteral nutrition (TPN) between June 2001 and January 2002 in a large inner-city hospital in Glasgow, Scotland. Written informed consent was obtained from all participants. Invasive methods were not used in the study.

Anthropometric, dietetic, clinical and laboratory assessments were performed in order to calculate each patient's

nutritional requirements.

Anthropometry consisted of triceps fold thickness (TSF), mid-arm circumference (MAC), height and weight measurements. TSF and MAC were measured three times by the same clinician and with the same instrument using standard methods and a mean value was calculated. TSF was measured to the nearest 0.2mm with a Holtain skinfold caliper (Holtain LTD, Crymch, UK) and MAC was measured with a tape measure (Nestle, Clinutren). Weight and height were measured on a Seca standing scale (Vogel and Halke, Germany) by the nurses, and values were collected from the medical notes. Due to the fact that some patients were unwell and unable to stand at the time of measurements, bedside anthropometry was used in all patients. Anthropometry was performed in a supine position and in the left arm for all the patients, by the use of the methods described for elderly in the report of WHO Expert Committee [5].

Further anthropometric calculations were made. TSF and MAC were converted to mid arm muscle circumference (MAMC) as below [6]:

$$MAMC (cm) = MAC (cm) - 3.14 \times TSF (cm)$$

Furthermore, a body mass index (BMI) was calculated by the use of the patient's weight and height as follows:

$$BMI (kg/m^2) = weight (kg)/height (m)^2$$

Patients were categorized in grades of thinness or overweight in terms of BMI according to the Report of the WHO Expert Committee [5].

They were also classified in percentiles in terms of BMI, MAC, TSF, MAMC, and weight. The elderly patients were classified according to the two existing reference data on elderly British population [7,8]. The remaining patients were classified according to the reference data of Bishop et al [6]. Conclusions were drawn in terms of fat stores and protein (Pr) status.

Eventually, patients were categorised as at risk of depletion (anthropometric values 5-15th centile), or as depleted (anthropometric values <5<sup>th</sup> centile) [9].

A form of the "four question approach" was also used as a simple screening tool [10]. Patients were asked to recall their usual weight and height, and to report whether they feel that they have unintentionally lost weight recently, and how they feel in their present weight. Where possible, weight loss or gain in the previous 3, at least, months expressed as a percentage of initial weight, was taken.

Data including intestinal and absorptional capacity, fever, recent major surgery, oedema, drugs that influence the nutritional status, sepsis, organ failure and the presence of metabolic, and organ disorders, were recorded.

Urinary urea was used to estimate patients' nitrogen (N) balance. Calculation of N balance was based on 24 hours urine urea collection and 24 hours Pr intake as below:

$$N \text{ balance} = N \text{ input} - N \text{ output}$$

$$N \text{ input} = 24 \text{ hour Pr intake}/6.25$$

$N\ output = [urinary\ urea\ (mmol/24\ hours) \times 0.033] + obligatory\ losses$

*Obligatory losses:* approximately 4g N/d (hair, skin, faeces)

If N balance was >5g/day the patient was considered to be in positive balance [11].

The calculation of nutrients requirements was performed using the same nutritional principles and equations for all patients. Specific dietary recommendations were followed for specific disease states, where applicable. In order to maintain or restore lean body mass, macronutrients were provided as nitrogen and non-protein energy substrates [12].

Non-Pr energy requirement was calculated by estimating the basal metabolic rate (BMR) with adjustment for systemic illness and mobility according to a standardised method [13]. Patients' clinical status was taken into consideration. Activity, metabolic and stress factors were defined for each patient [14].

The N requirements were estimated by the use of the method described by Elia, 1990 [14]. Patients were categorized as metabolically normal, hypermetabolic and depleted, their metabolic factor was defined, and were prescribed with the appropriate amount of daily N [14]. Patients with renal failure were given 0.55-0.60g Pr/kg/d [15]. The N balance, when available, was taken into consideration. A non-Pr energy to N ratio of 110-150/1 was aimed. The Pr requirements were estimated by multiplying N by 6.25 [9,16].

The non-Pr energy was then distributed to glucose and fat. A percentage of 40% fat and 60% glucose were prescribed to patients with central PN. Patients with peripheral PN were given 50% fat and 50% glucose in order to succeed lower solution osmolarity, and to avoid inflammation and thrombosis of the veins. Patients with respiratory disorders were prescribed 60% fat and 40% glucose, for preventing further respiratory distress [17]. Glucose and fat were then converted to calories and then to grams by dividing the calories by 3.4 and 9 respectively.

To avoid or minimize adverse metabolic effects the daily dose of fat and carbohydrate was restricted to the current recommendations: fat should not exceed 2.5g/kg/d and carbohydrates should not exceed 6g/kg/d [18]. Moreover, patients' current weights were used for all the calculations with the exception of overweight patients with BMI >25kg/m<sup>2</sup>. Overcalculation of nutrients due to excessive fat mass was avoided by finding and using their maximum desired weight in order to achieve a BMI of 24.99kg/m<sup>2</sup>. All calculations were presented to the first decimal.

A calculation of the individual micronutrient requirements was not attempted. The reason for this is that laboratory tests in injured patients lack sensitivity and specificity, and this situation is being made worse as a result of the acute-phase response [19].

Moreover, the optimal levels of trace element and vitamin requirements of injured patients have not been defined. They

depend on a complex interaction of the status of the patient at the time of admission, ongoing losses and the potential benefit of supplying large amounts of individual micronutrients

The amount of energy, nitrogen, fat and carbohydrate delivered to each patient by the prescribed SPN regime (Kabimix 9 or Kabimix 14) for two consecutive days was recorded.

---

## STATISTICAL CONSIDERATIONS

---

Paired differences between calculated requirements and prescribed nutrients were estimated by the Wilcoxon Signed Rank Test. The Spearman's rho correlations between the administered and calculated amounts of nutrients were calculated. All analyses were performed with SPSS v.13-1. A p-value below 0.05 was considered as statistically significant.

---

## RESULTS

---

There was a wide range of primary diagnoses including ischaemic gut, cholangiocarcinoma, high output stoma, small bowel perforation, leaking anastomosis, chronic intestinal failure, ileus, pharyngeal pouch and small bowel fistulas. Other than a requirement for parenteral feeding, the patient group was unselected. All patients were on a SPN regimen for at least two consecutive days and they were on the final nutrition regime. Two patients had TPN via peripheral line and 11 via central feeding line.

The raw demographic, anthropometric, clinical and biochemical data are shown in [Table 1](#). The differences between calculated and prescribed lipid, carbohydrate, nitrogen and energy are shown in [Table 2](#). The data median and range for each nutritional parameter are presented in [Table 3](#).

We found statistically significant difference between the fat (sig.=0,001), carbohydrate (sig.=0,05) and energy (sig.=0,03) provided with Kabimix regimens and the ones calculated ([Figures 1, 2, 3](#)).

All patients received excessive amount of fat. Insufficient carbohydrate was prescribed to 9 of 13 patients. An excess amount of energy was prescribed in 11 of 13 patients. Seven patients received >50% excess fat and 2 patients >50% less carbohydrate than calculated. Four patients received >40% excess energy and 1 patient 49% less energy than calculated.

No statistically significant difference was found between prescribed and calculated N (sig.=0,889). However, considerable differences were found between calculated and prescribed N for individual patients. Two patients received >40% more N and 1 patient 37% less N than calculated. ([Figure 4](#))

There was no statistically significant correlation between the calculated and prescribed amount of N (r= 0,454; sig.= 0,119), carbohydrate (r= 0,085; sig.= 0,784) and energy (r= 0,124; sig.= 0,687). No correlation was found between the

AUDIT OF PARENTERAL NUTRITION: STANDARD PARENTERAL NUTRITION REGIMENS - FEAST OR FAMINE?

TABLE 1. Raw data.

Patients	1	2	3	4	5	6	7	8	9	10	11	12	13
Sex	F	F	M	F	F	F	M	F	F	F	F	F	M
Age	54	64	44	67	57	66	53	78	56	42	46	70	65
Diagnosis	CAC	IG	IG	PERF	SBF	CAC	ANST	IG	STMA	CIF	IL	PP	STMA
BMI (kg/m <sup>2</sup> )	24,7	19,2	34,2	21,9	37,4	34,6	26,6	16,3	22,1	19,1	23,3	13,8	19,8
MAC (cm)	26,0	24,0	34,0	24,0	30,0	32,5	29,0	21,5	21,2	18,5	27,3	15,3	22,3
TSF (cm)	1,5	1,1	1,4	1,0	2,2	3,2	1,2	0,7	0,5	0,9	1,2	0,7	11,1
MAMC (cm)	21,3	20,5	29,6	20,9	23,1	22,5	25,2	19,3	19,6	15,7	23,5	13,1	18,8
Malnourished	No	Yes	No	Yes	No	No	No	Yes	No	Probable	No	Yes	Yes
Recent surgery	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	No
Infection	Yes	No	No	Yes	No	Yes	No	Yes	Yes	No	No	No	No
CRP	200	61	211	47	187	137	raised	20	40	9	200	raised	Not known

M=male; F=female; IG = ischaemic gut, CAC = cholangiocarcinoma, STMA = high output stoma, PERF = bowel perforation, ANST = leaking anastomosis, CIF = chronic intestinal failure, IL = ileus, PP = pharyngeal pouch, SBF = small bowel fistulas; BMI=body mass index; MAC=mid-arm circumference; TSF=triceps skinfold; MAMC=mid arm muscle circumference; CRP=C-reactive protein.

TABLE 2. Calculated vs. prescribed nitrogen, fat, carbohydrate and energy

Patients	1	2	3	4	5	6	7	8	9	10	11	12	13
Nitrogen calculated (g)	13,1	8,0	15,6	8,6	11,5	12,8	14,4	13,6	8,7	9,9	11,5	9,3	9,2
Nitrogen prescribed (g)	13,5	9	13,5	9	9	13,5	9	13,5	9	13,5	9	9	13,5
Fat calculated (g)	67,1	52,9	94,7	61,8	69,7	65,7	101,9	67	64	91	95	105	101
Fat prescribed (g)	106	106	106	106	106	106	106	106	106	106	106	106	106
Carbohydrates calculated (g)	266,4	210	376	245,4	276,9	260,8	404,6	265	255	362	250	185	179
Carbohydrates prescribed (g)	300	150	300	150	150	300	150	300	150	150	150	150	300
Energy calculated (kcal)	1509,9	1189,9	2131,3	1390,4	1569,3	1478	2293	1501	1444	2054	1701	1575	1521
Energy prescribed (kcal)	2200	1600	2200	1600	1600	2200	1600	2200	1600	2200	1600	1600	2200

TABLE 3. Data median and range

Nutrients	Median prescribed (range)	Median calculated (range)
Nitrogen (g)	9 (4,5)	11,5 (7,6)
Fat (g)	106	69,7 (52,1)
Carbohydrates (g)	150 (150)	260,8 (225,6)
Energy (kcal)	1600 (600)	1521 (1103,1)

calculated and prescribed fat.

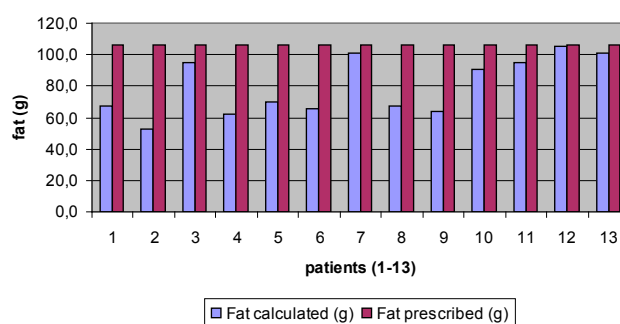


FIGURE 1. Calculated vs. prescribed fat.

DISCUSSION

This pilot, case series study demonstrated several points. Firstly, it was made clear that the nutritional requirements of the patients receiving PN vary greatly depending on age, sex, clinical status, body composition and mobility, and require

several equations and calculations (Tables 2, 3).

Secondly, the calculation of required fluids, trace elements, vitamins, and electrolytes was attempted and found not to be possible. The biochemical results, were proven to be insensitive indicators of the patients' micronutrient status, and their direct interpretation may have led to over or under

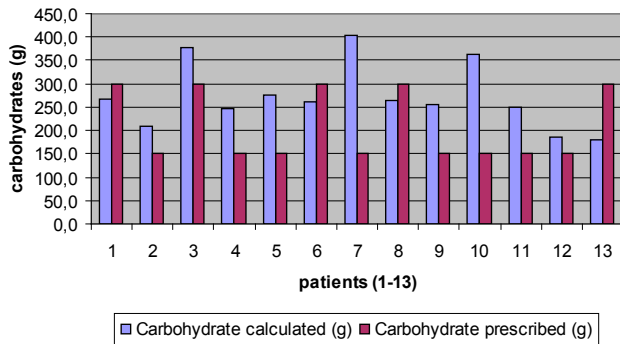


FIGURE 2. Calculated vs. prescribed carbohydrate.

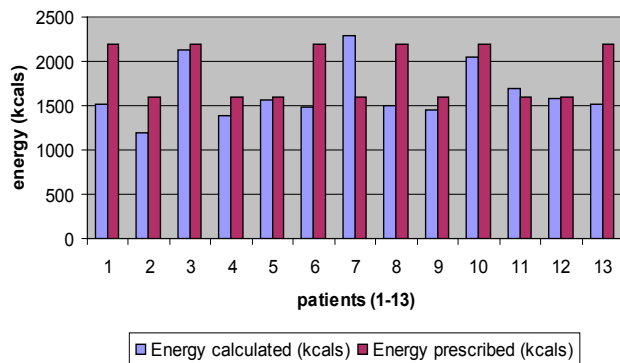


FIGURE 3. Calculated vs. prescribed energy.

estimations. Most of the patients had abdominal stomas and fistulae, and it was not possible to estimate the exact amount of electrolytes and fluids lost. Patients' requirements of fluid and electrolytes change day by day and a close, daily monitoring is required.

Thirdly, the provided amounts of energy and macronutrients were found to be standardized. Patients would receive only two kinds of solutions (Kabimix 9 and Kabimix 14), and

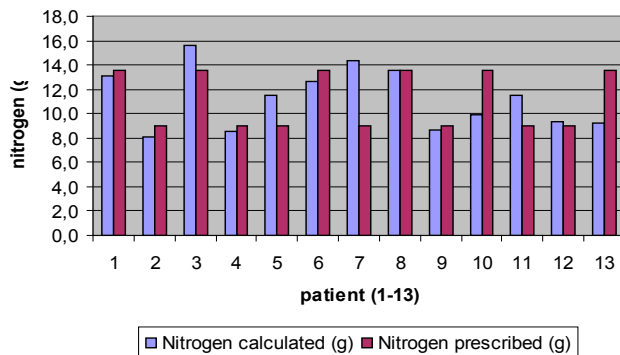


FIGURE 4. Calculated vs. prescribed nitrogen.

were categorized to them according to their roughly estimated nitrogen and energy needs. The use of only these two solutions did not permit prescription flexibility. It is interesting to note that all patients received the same amount of fat (106g).

Moreover, all patients studied were over- or underfed in respect to at least one of the four studied nutrients. Patients 1, 2, 4, 6, 8 received >50% excess fat and >40% kcal excess energy than calculated. Patients 5 and 9 received >50% excess fat. Patient 7 received 63% less carbohydrates, 37% less N and 30% less energy than calculated. Patient 10 received 36% more N and 59% less carbohydrates than calculated. Patient 13 received 45% more energy and 47% excess N than calculated.

The small number of patients and the short period of follow up in the study, did not permit the identification of any clinical significance of these findings. Whether complications such as fat overload or derangement of liver function would occur with longer term feeding using these SPN regimens is unknown. Furthermore, it would be difficult to identify over-prescription, e.g. of parenteral lipid, as the sole cause of liver function derangement because of the co-morbidity of this patients' group.

No direct adverse effects were detected in the study group for the study period, but, within the context of longer-term feeding, complications of under-or overfeeding could be likely.

The use of more than two SPN regimens, the inclusion of disease specific solutions, the standardization of the nutritional calculations and nutrition assessment procedures for their quickest and simplest routine use, and the regular monitoring of the nutrients delivered through PN regimens in hospitals, could reduce the incidences of over-or under-nutrition.

## CONCLUSIONS

It seems that the use of SPN regimens is associated with a tendency to over- or under-prescribe nutrients. Our findings suggest that SPN regimens used did not meet accurately the requirements in fat, carbohydrate and energy. However, no complications of nutrients over-or under-feeding were apparent in the study group and so the clinical significance of our findings remains unclear.

A larger study, randomising patients to receive either a SPN regimen or a patient-specific prescription would be in order. Specific complications of over and under-feeding should be looked for prospectively over a range of feeding times. Only then will it be clear whether SPN regimens meet nutritional requirements with sufficient accuracy and whether the advantages of these regimens i.e. cost, convenience and ease of prescription justify their widespread use.

REFERENCES

1. Ga les BJ, Riley DG. Improved total parenteral nutrition therapy management by the nutritional support team. *Hosp Pharm* 1994; 29:469-470, 473-475.
2. BAPEN Working Party Report. Current perspectives on parenteral nutrition in adults. *Maidenhead*, 1996.
3. King's Fund Report. A positive approach to nutrition as treatment. King's Fund Centre, London, 1992.
4. Maroulis J, Kalfarentzos F. Complications of parenteral nutrition at the end of the century. *Clin Nutr* 2000; 19:295-304.
5. Report of a WHO Expert Committee. Physical status: the use and interpretation of anthropometry. [Technical Report] World Health Organization Technical Report Series – 854, Geneva, 1995.
6. Bishop CW, Bowen PE, Ritchley SI. Norms for nutritional assessment of American adults by upper arm anthropometry. *Am J Clin Nutr* 1981; 34:2530-2539.
7. Burr ML, Phillips KM. Anthropometric norms in the elderly. *Br J Nutr* 1984; 51:165-169.
8. Lehmann AB, Bassej EJ, Morgan K, Dallosso HM. Normal values for weight, skeletal size and body mass indices in 890 men and women aged over 65 years. *Clin Nutr* 1991; 10:18-22.
9. Zeman FJ, Ney DM. Applications in Medical Nutrition Therapy, 2nd ed. Merrill, New Jersey, 1996.
10. Lennards-Jones JE. Nutrition support in the short-bowel syndrome. *In: J Payne-James G Grimble and D Silk (eds). Artificial Nutrition Support in Clinical Practice*, Edward Arnold, London, 1995: 544-555.
11. Lee HA, Hartley TF. A method of determining daily nitrogen requirements. *Postgrad Med J* 1975; 51:441-445.
12. Nordenstrom J, Askanazi J, Elwyn D, Martin P, Carpentier Y, Robin AP, Kinney JM. Nitrogen balance during total parenteral nutrition-glucose vs. fat. *Ann Surg* 1983; 197:27-33.
13. Schofield WN. Predicting basal metabolic rate, new standards and review of previous work. *Hum Nutr Clin Nutr* 1985; 39 sup 1:5-41.
14. Elia M. Artificial Nutrition Support. *Med Int* 1990; 82:3392-3396.
15. Brunori G. Nutrition support in renal disease. *In: Artificial Nutrition Support in Clinical Practice. In: J Payne-James G Grimble and D Silk (eds). Artificial Nutrition Support in Clinical Practice*, Edward Arnold, London, 1995: 415-427.
16. Takala J, Pitkanen O. Nutrition support in trauma and sepsis. *In: J Payne-James G Grimble and D Silk (eds). Artificial Nutrition Support in Clinical Practice*, Edward Arnold, London, 1995: 429-442.
17. Wiese S, Manner T, Katz DP & Askanazi J. Nutrition support in respiratory disease. *In: J Payne-James G Grimble and D Silk (eds). Artificial Nutrition Support in Clinical Practice*, Edward Arnold, London, 1995: 403-413.
18. Montejo JC, Grau T, Acosta J et al. Multicenter, prospective, randomized, single-blind study comparing the efficacy of gastrointestinal complication of early jejunal feeding with early gastric feeding in critically ill patients. *Crit Car Med* 2002; 30:796-800.
19. Shenkin A. Macronutrients in the severely-injured patient. *Proc Nutr Soc* 2000; 59:451-456.