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Protein and Energy Requirements of Children With Burn Trauma

Thesis Submitted to the University of Surrey for the degree
of Master of Philosophy

by

Siobhan Shalaby

July 1992

for
Salah

If you are defeated in your mind there is nothing to fight for.

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ABBREVIATIONS

BEE	Basal Energy Expenditure
BSA	Body Surface Area
BW	Body Weight
CER	Carbohydrate Energy Ratio
EGF GROUP	East Grinstead Formula Group
FER	Fat Energy Ratio
GH	Growth Hormone
IGF-1	Insulin-like Growth Factor 1
MAC	Mid Arm Circumference
MAMC	Mid Arm Muscle Circumference
NPC:N	Non Protein Calorie to Nitrogen Ratio
PER	Protein Energy Ratio
RBP	Retinol Binding Protein
SF GROUP	Sutherland Formula Group
TBPA	Thyroxine Binding Pre Albumin

ABSTRACT

PROTEIN AND ENERGY REQUIREMENTS OF CHILDREN WITH BURN TRAUMA

The Sutherland Formula is widely used in the United Kingdom to determine protein and energy requirements of burned children. Achieving the target of this formula can be difficult because of the high levels of protein and energy intake that are inherent in the Sutherland formula calculation. An alternative formula was devised using new parameters, ie, normal daily nitrogen requirements, wound nitrogen losses and urinary nitrogen losses, which may more closely match the requirements of children with burns.

The aim of the study was to evaluate the new formula and to reappraise the Sutherland Formula using current liquid enteral feeds and feeding methods.

The study was randomly controlled in design, the Sutherland Fed (SF) Group received enteral feeds according to the Sutherland Formula and East Grinstead Formula (EGF) Group received enteral feeds according to the new East Grinstead Formula. Subjects entered the study on day zero of burn injury. Burn size, using the method of Lund and Browder, was used, to indicate the percentage of body surface area burned. All nutritional intakes were recorded, nutritional parameters, clinical assessments, wound status, medication, body weight changes, serum and urine analysis were assessed.

Nine subjects were recruited into the Sutherland Formula Group, mean age 3 years, (range 1-5 years) mean burn size 19% Body Surface Area (BSA), range 10-40%. Eight subjects were recruited into East Grinstead fed Group, mean age 4 years, range 1-13 years mean burn size 15% BSA, range 10-30%. The Sutherland Formula Group achieved 80% of energy targets and 85% of protein targets. The East Grinstead Group achieved 95% of energy targets and 90% of protein targets. Total serum protein and albumin remained within the normal ranges for both groups. Serum Retinol binding protein and thyroxine binding protein showed an upward trend for both groups. Serum IGF-1 and growth hormone remained within the normal range for both groups.

A larger number of patients in Sutherland Formula Group required antibiotics than in East Grinstead Formula Group. The Sutherland Formula Group had a negligible weight change -1.3%, whilst the East Grinstead Formula group had a weight gain +2.4%.

An intake of 3g/kg/day protein is adequate to meet the requirements of young burned children, as was supplied by the EGF formula. A target protein intake at 4g/kg/day as provided by the Sutherland Formula is probably too high and did not appear necessary in the group of children studied. Children can be successfully and comfortably sustained on enteral feeding for 1-3 week periods and this mode of feeding can be instigated within hours of injury. Enteral feeding may be the only way to achieve EGF targets due to the rigorous demands of the surgical and clinical management procedures endured by these patients.

From this work the researcher concluded that the East Grinstead Formula is appropriate for feeding children with burn trauma from a clinical and practical point of view. This study supports the findings of other studies in burned adults in that early enteral feeding of burned children is beneficial in promoting good nutritional status. In addition the low volume, isotonic, high protein enteral feed, with a protein energy ratio of 20 %, used in this study, was tolerated by the children studied.

Simplification of the East Grinstead Formula for burned children is: Protein 3g/kg BW/day with a protein energy ratio of 17-20%.

CHAPTER 1

1.1 INTRODUCTION

Burn injury in children is responsible for a large number of admissions to specialised Burn Units throughout the country. Statistical data on the incidence of burns collected from 22 hospitals, by the Royal Society for the Prevention of Accidents (ROSPA) for 1988, record 65,000 accidents from flame injury, 28% of which were in children aged below five years, 67,000 from scalds of which 43% were in children aged below 5 years. There are no statistics available showing the numbers of hospital admissions with burns. From these figures it appears that the pre-school age group is the most at risk. The curious adventurous nature of this group makes them more accident prone. Children entering Burns Units in the United Kingdom every year following thermal injury makes them an interesting group to study, from a nutritional view point. It is not unreasonable to presume that a child is not a mini adult but has his or her own unique physiologic and developmental characteristics that are different from those in adults. The nutritional needs in childhood vary significantly as the requirements for growth, development and activity change with age. Normal protein requirements may be more than twice the standard adult intake in the basal state and increase proportionally as a result of trauma and stress.

Children have proportionally less body fat and a substantially smaller muscle mass in relation to adults. All of these characteristics predispose children to the rapid development of protein-energy malnutrition in certain situations. During trauma, children represent an especially high risk population, from a nutritional standpoint. These differences may result in a differing or more varied response to trauma, and consequently,

its nutritional management in children compared with adults. The adult response has been well documented (Cuthbertson 1942, 1979; Curreri 1974 & 1978). This, however, has not been the case in the paediatric population, as children are difficult subjects to study. In the opinion of the investigator there is a dearth of research in the area of burns trauma in children and their nutritional requirements.

1.2 THE HYPERCATABOLIC RESPONSE

The metabolic response to burn injury is hypermetabolic. This response is driven by a combination of stress hormones and is typified, when established, by an increased metabolic rate with diversion of amino acids to be used as energy substrates. The increase in resting energy expenditure (REE) after a burn has been extensively documented and may exceed twice the predicted value for an individual patient with large burns, (Cope *et al*, 1953; Harrison *et al*, 1964; Wilmore *et al*, 1974; Bartlett *et al*, 1977; Caldwell *et al*, 1981; Henane *et al*, 1981; Serog *et al*, 1983; Turner *et al*, 1985). This rise in metabolic rate is paralleled by rise in the core temperature and nitrogen excretion (Cuthbertson 1932, 1936). These increased losses of nitrogen result from protein breakdown for gluconeogenesis and from burn wounds.

1.3 NITROGEN LOSSES ACROSS BURN WOUNDS

Burn wound losses are difficult to assess clinically. Considerable protein losses were measured in a study carried out by Waxman and his colleagues. The losses were greater in the first week following burn injury and decreased somewhat to a relatively steady state thereafter. The average daily losses across the burn wound for the first post-burn week can be

estimated by **Waxman's Formula:** $1.2 \times \text{BSA (M}^2) \times \% \text{ BSA burn}$, Average losses are decreased by half in the second post-burn week. (Waxman et al, 1987).

1.4 THE EBB AND FLOW PHASE

The metabolic response following burn injury is biphasic, the "ebb phase" or hypometabolic phase, immediately following burn injury, is characterised by decreased cardiac output, decreased oxygen consumption and resting energy expenditure and by a lowering of the core temperature over a period of hours to days. This gives way to the "flow phase" or hypermetabolic phase, which is characterised by a rise in core temperature, increased cardiac output, a dramatic increase in oxygen consumption, a corresponding increase in metabolic rate (Cuthbertson, 1942 and 1979) and a rise in nitrogen excretion resulting from increased muscle catabolism, all related to the severity of injury. The extent of the response is so great that it is frequently referred to as "burn hypermetabolism".

1.5 WOUND HEALING

For the three stages of wound healing - inflammation, proliferation, (when granulation tissue is formed) and maturation - matrix formation, to proceed normally, energy expenditure, proper fluid and electrolyte balance, oxygenation, circulation, freedom from infection and skilful surgical technique are required. There is no doubt that specific nutritional components are important for the various stages of the wound healing process. When tissues are being repaired, more amino acids, carbohydrates,

lipids Vitamins A and C, minerals, particularly Zinc, water and oxygen are consumed than that usually required for normal tissue metabolism (Levene & Bates 1975). Malnutrition impairs wound healing (Wolbeck & Howe 1925; Crandon, Mikal & Landau 1953). The presence of malnutrition and infection in surgical patients is associated with increased mortality and complication rate.

1.6 ENERGY AND NITROGEN

Normal adaption to starvation involves energy and nitrogen conservation accompanied by a decrease in metabolic rate and a decreased production of insulin (Woolfson 1978). As described above the "flow phase" shows the reverse of this. Excessive energy utilisation coupled with poor nutrient intake puts patients at great risk of protein energy malnutrition. Prior to the introduction of supranormal feeding regimens together with the widespread availability of reliable enteral and parenteral feeding techniques, weight loss was thought to be inevitable. A retrospective study showed weight loss to be proportional to size of burn, and to exceed 20% of pre-burn weight in those patients with burns of 40% BSA or greater (Newsome et al, 1973). Early studies showed that a positive nitrogen balance could be achieved if enough protein was included in the diet (Soroff et al, 1961, Troell & Wretland 1961). Studies with radio labelled amino acids, on adult trauma patients and burned children showed increases in both rates of synthesis and catabolism of protein. The catabolic rate is unaffected by food intake, but synthetic rates vary greatly and exceed catabolism with high levels of nutrition (Kien et al, 1978, Herrman et al, 1980). Nitrogen balance at any given nitrogen intake is influenced by the amount

of energy given concurrently (Trowell & Wretland 1961). Administration of energy in the form of carbohydrate improves nitrogen utilisation (McDougal et al, 1977). Comparison of four isocaloric diets which were of either normal composition, carbohydrate, lipid or protein rich, confirmed this, but showed that lipids were inefficient at promoting nitrogen retention. The best nitrogen balances were achieved using a high protein diet (Serog et al, 1983). Using guinea pigs with 30% burns receiving 175 kcal/kg/day, of which protein contributed 20% of the energy, the optimum lipid content of enteral feed was examined.

Identical feeds were given which contained either 0, 5, 15, 30 or 50% of non protein calories as lipid. At the end of the two week study period the skeletal mass was inversely proportional to the amount of lipid provided. The best nitrogen balances, serum transferrins and least incidence of fatty infiltration of the liver were seen when lower levels of lipid were taken ie, up to 15% of energy from non protein sources. (Mochizuki et al, 1984). The relative amounts of energy and nitrogen, most conveniently expressed as the non protein calorie nitrogen ratio (NPC:N ratio), given to burn patients are important. In the guinea pig model, provision of 175 kcal/kg/day enterally using a feed containing 20% of its energy as protein (NPC:N ratio 100:1) appeared to be the optimum, resulting in significantly less weight loss than those fed with a diet with 10% protein derived calories (NPC:N ratio 225:1), (Dominioni et al, 1985). Similarly, a comparison between two groups of patients fed according to the Curreri formula (Curreri 1974), showed that those receiving NPC:N ratio of 100:1, maintained a positive

nitrogen balance at all times whereas those given a NPC:N ratio of 150:1 showed a less positive balance overall and a consistently negative balance in those with burns greater than 31% BSA (Matsuda et al, 1983).

Alexander and his colleagues (Alexander et al, 1980) carried out controlled studies on 18 children with major burns where the nutritional intakes of two groups of children were compared. The first group was given a normal diet with a balanced nutritional supplement and the second group was supplemented with milk whey protein. The normal protein group received 87% of their desired energy intake with a NPC:N ratio 127:1 (PER 16%); the other group received 78% of their desired intake with a NPC:N ratio 84:1 (PER 23%).

The study showed that those with the greater protein intake, despite receiving less energy in total than the other group, had an improved opsonic index, C₃, IgG, transferrin and total protein levels. These changes were followed by a lesser incidence of bacteraemia and improved morbidity and mortality.

Survival of the patients receiving the higher protein diets was significantly better, 100% verses 56%, and they also had fewer episodes of systemic infection. This study provided evidence that many immunologic functions are dependent on optimal availability of specific amino acids and that routine diets do not provide sufficient protein to satisfy the needs of seriously burned children (Alexander et al, 1980).

1.7 FEEDING REGIMENS

By contrast with Alexander's study a much earlier study by Sutherland and Batchelor (1968) set out to accurately evaluate the energy and protein needs of the burned child. A formula was devised which took into account burn size and body weight.

The Sutherland Formula (SF) - Protein 3g/kg BW+1g/% BSA burn, energy 60kcal/kg BW+35/% BSA burn was devised. Twenty children under ten years of age were studied, some received intakes calculated according to the SF and others received feeds whose energy and protein requirements were based on the recommended daily amounts for uninjured children of similar age and weight. Sutherland deduced that children did no better on a high protein intake. Both groups showed similar weight losses in the region of 10-15% BSA at around 20 days post-burn. Nitrogen balance showed a similar response pattern in both groups and the very high targets of the formula were not achievable. Sutherland concluded, therefore, that "the needs of the burned child are not in excess of the same child's needs in health" (Sutherland & Batchelor 1968). Her findings have largely been ignored and her formula is still in widespread use in the UK (British Dietetic Association, Burns Special Interest Group unpublished survey).

Other formulae are in use for determining energy requirements in adults (Curreri 1974 & Matsuda 1983). These formulae recommend protein and energy levels greatly in excess of normal but do not make specific adjustments for children. Leuterman and his colleagues at the University of South Alabama in 1987 took a more broadly based view and re-evaluated the Curreri formula. A family of formulae based on retrospective data on 460 surviving burned patients, spanning a wide age spectrum, was devised. This was done with the use of computer modelling and nutrition and weight records. The completed family of formulae is as follows:

Junior	0-1 yr	BEE + 15 kcal (62.7kJ) /% BSA burn
	1-3 yrs	BEE + 25 kcal (104.5kJ) /% BSA burn
	4-15 yrs	BEE + 40 kcal (167.2kJ) /% BSA burn
Adult	16-59 yrs	BEE + 40 kcal (167.2kJ) /% BSA burn
Senior	> 60 yrs	BEE + 65 kcal (271.7kJ) /% BSA burn

(Leuterman et al, 1987). This family of formulae does not however make recommendations for protein requirements.

1.8 NUTRIENT ADMINISTRATION

Animal studies have indicated that not only is the quantity of protein administered important but also the timing, route and type of protein. In the guinea pig model, approximately 15% of body weight was lost during the first 72 hour period of adaption to an enteral feed. Animals fed immediately after injury lost significantly less weight than those in whom feeding was delayed.

Early feeding prevented the characteristic rapid rise of cortisol and glucagon levels as well as reducing the ultimate level of catecholamine secretion and preventing the development of the typical hypermetabolic response (Mochizuki et al, 1984). Delay in instituting enteral feeding resulted in loss of jejunal mucosal thickness, villus height and mass within 24 hours compared to those fed parenterally (Mochizuki et al, 1984). In another group of enterally fed burned guinea pigs the haemodynamic effects of early feeding on blood flow rates to the gut were measured at 24 hrs after burn injury, and compared with a lactated Ringer's fed group. The early fed group had higher blood flow especially in the jejunum. The authors concluded that the increased intestinal blood flow associated with early feeding, may continue to maintain local immunity and barrier function in the gut, (Inoue et al, 1989). In another study comparison of animals fed immediately after injury either enterally or parenterally with an identical diet showed that those fed enterally lost significantly less weight, preserved their mucosal height and had lower cortisol, glucagon and catecholamine levels than the parenterally fed group (Saito et al, 1985). In the same animal model, administration of a feed containing intact whey protein was compared with an identical diet containing free amino acids. The former group had an improved nitrogen balance, lost less weight and preserved their jejunal mucosal mass compared with the latter group. After 14 days they had significantly higher serum albumin, transferrin and C₃ levels (Trochi et al, 1986).

1.9 ENTERAL FEEDING

Early enteral feeding of patients with major burns in a study conducted by McArdle *et al*, 1984, found that feeds were well tolerated and that the small intestine absorbed nutrients readily in the early post-burn period.

This contributed to an early positive nitrogen balance, which was sustained, prevented loss of serum protein, assisted in the maintenance of normal carbohydrate metabolism and restored granulocytes and lymphocytes to normal ratios. The majority of burned patients, including children, can be fed satisfactorily using the enteral route thus avoiding the potential complications of the parenteral route particularly catheter-related sepsis (Popp *et al*, 1974), (Larkin & Moylin). Continuous enteral infusion results in better patient tolerance than intermittent bolus administration and allows for more rapid achievement of nutritional goals (Hiebert *et al*, 1981). Pump assisted feeding is preferable to gravity continuous feeding, it minimises the possibility of fluid overload and facilitates patient management.

1.10 OVERNUTRITION

Improved survival of burned patients has resulted in the widespread use of supranormal feeding regimens. Energy and protein recommendations have been aimed at providing patients with well in excess of anticipated requirements. There are logistical problems in providing these large amounts of nutrients to children primarily because of the size of the child in relation to the volumes of food or enteral feeds required. Sometimes it was necessary to use the parenteral route.

There is now evidence that overnutrition can be detrimental. In adults, glucose infused at 7mmol/kg/min is not oxidised but synthesised into fat. Too much carbohydrate is regarded as deleterious to patients with impaired ventilation because of the increased carbon dioxide production and because of its possible contribution to the adult respiratory distress syndrome (Burke et al, 1979), (Askanazi et al, 1980).

High intakes of carbohydrate may further impair glucose tolerance, a complication commonly seen early in the post trauma phase (Allison et al, 1968). Long term over-administration of glucose results in fatty infiltration of the liver (Wolfe et al, 1979). Similarly excess administration of enteral feeds has been reported in burned patients, to promote calciuresis and may be the cause of heterotrophic calcification and renal stones seen after burns (November & Dusansky 1979).

1.11 MALNUTRITION

In the late 1970's and well into the 1980's iatrogenic malnutrition was reported in the literature from around the world, in the general hospital population. An incidence rate of between 19-80% has been reported by doctors of various specialties. Many patients were considered malnourished on arrival at hospital and up to 30% developed iatrogenic malnutrition whilst in hospital (Bistrian 1974, Hill et al 1977, Steffee 1980, Bastow 1983, Pettigrew 1984). The consequences of this form of malnutrition are wide ranging for the patient and range from an increased tendency to infection, delayed wound healing, muscle weakness, hypoproteinaemia, and can result in prolonged hospitalisation and increased morbidity and mortality.

In view of the availability of a wide range of feeding techniques, and enteral and parenteral feeding formulae, extensive nutritional support in a group of children severely traumatised by burning is certainly justified to compensate for the increased demand for nutrients by the body and to allow for the increased demands of growth in children.

1.12 COMMENT

It is clear from this review that aggressive nutritional support following burn trauma plays a decisive role in outcome. Nutritional needs are altered following burn injury, yet a formula for determining optimum requirements in children with burns has yet to be found. The potential hazards of overfeeding are to be avoided. This, together with a desire to find a practical formula to meet additional requirements, and to enable effective monitoring and evaluation on a day to day basis has led to this study being undertaken.

2.1 INTRODUCTION

Today many burns units take account of burn size using the classical method of Lund and Browder (1944) in an attempt to estimate nutrient requirements. The SF (Sutherland & Batchelor 1968) uses burn size and body weight in its calculations for daily protein and energy requirements for both adults and children. This formula for children recommends:

Energy - 60kcal (251 kJ) /kg + 35 kcal (146kJ) /% BSA burn/day.

Protein - 3g/kg + 1g/% BSA burn/day.

It is widely used in clinical practice, yet these high targets are often difficult to achieve. The present study was undertaken to test the hypothesis that an alternative formula, known hereafter as the East Grinstead Formula (EGF). The composition of this formula has been determined from recently published data relating to nitrogen losses across burn wounds (Waxman et al, 1987); the Recommended Daily Amounts of Food Energy and Nutrients for Groups of people in the United Kingdom (DHSS 1979) and the investigator's own experiences. This forms the basis of requirements and is closely tailored to individual needs. The EGF used in this study was:

Protein requirements = $a + b + c \times 6.25$ / day when:

a = Normal daily nitrogen requirements (DHSS 1979)

b = Urinary nitrogen¹ x % BSA burn x wt kg

c = $(0.1 \times \text{BSA sq m} \times \% \text{BSA burn})^2$ (Waxman et al 1987).

Energy requirements are calculated on the basis that protein contributes 20% of the total energy.³

¹ Calculated urinary nitrogen losses = $0.0045 \times \text{BW kg} \times \% \text{BSA burn}$ (East Grinstead unpublished data) are used when urinary nitrogen measurements are not available.

² Calculated wound losses.

³ When protein requirement was calculated, the total energy requirement was calculated following this, on the basis that protein contributed 20% of the total energy needed.

2.2 STUDY RATIONALE

The aim of the study was to show that accurate replacement of protein losses by altering the protein content of the feed was the optimum method of feeding burned children. It also presented an opportunity to re-investigate the SF in view of the availability of a high protein, low volume, isotonic enteral feed and the more recent practice of 24 hour continuous enteral feeding using a fine bore enteral feeding tube assisted by a volumetric pump. With this objective, the study was designed to compare two groups of children receiving enteral feeds. SF Group received feeds, the energy and protein content of which was calculated according to the Formula of Sutherland. EGF Group received feeds, the energy and protein content of which was calculated according to the Formula devised at the Queen Victoria Hospital, Holtye Road, East Grinstead, Sussex RH19 3DZ. Both formulae are described above.

2.3 METHODS

2.3.1 PATIENT SELECTION

All children with a burn size between 10 - 50% BSA, aged between 1 - 14 years, admitted to the McIndoe Burns Centre within 24 hours of sustaining their burn injuries were deemed eligible for inclusion in this study, unless they fell into the patient exclusion category (2.3.2). Parental consent was sought and when given, patients were then randomly entered into one of the two treatment groups for inclusion in the study (2.1). The recruitment of subjects was between April 1988 and July 1989.

2.3.2 PATIENT EXCLUSION

Before commencing the study, exclusion criteria were established. These were as follows:

- i) Patients with a non-functioning gastro-intestinal tract indicated by malabsorption or absence of bowel sounds were not eligible for inclusion in the study.
- ii) If burn size exceeded 50% BSA.
- iii) If physical limitations to intubation with an enteral feeding tube were present, eg. facial injuries,

2.3.3 ETHICAL COMMITTEE APPROVAL

A protocol of the study was submitted to the Tunbridge Wells Health Authority ethical committee prior to commencing the study and was granted.

Date: 20 October 1987. Ref ME/312.

2.3.4 CONSENT

Parental consent was sought and a form signed (Appendix 1, Form q).

2.3.5 DIET ASSIGNMENT & DATA COLLECTION

Patients were assigned to their respective groups by means of computerised sealed envelopes in randomly paired groupings and divided into four categories of burn size ie, 10 - 19% BSA, 20 - 29% BSA, 30 - 39% BSA and 40 - 49% BSA. This subdivision of burn size and pairing, was to ensure that each sample was comparable for burn size and that there was an equal number of patients assigned to the two groups. **SF Group** received feed

according to the Sutherland formula. EGF Group received feed according to the East Grinstead formula. Patients were intubated with a Silk polyurethane fine bore (1mm) enteral feeding tube from E. Merck Limited (Winchester Road, Four Marks, Alton, Hants GU34 5HG) on day 0, within 6 - 8 hours of admission. Initial patient details and history together with all clinical, nutritional, and biochemical data was collated and recorded on a daily basis where appropriate in the data collection sheets which form Appendix 1.

2.3.6 THE FEEDS

The enteral feeds were supplied by Roussel Laboratories Limited, Broadwater Park, North Orbital Road, Uxbridge, Middlesex UB9 5HP) -Clinifeed Favour with a protein energy ratio (PER) of 15% and Clinifeed Extra with PER of 20%. The feed choice was based on whichever one matched requirements within daily fluid volume restrictions. During the first 12 - 24 hour period, the feed was delivered at 3/4 strength at a rate of 20 - 40 mls per hour as tolerated and the rate of feeding was increased to full strength full volume over a 3 - 4 day period. The feeds were delivered via a "Kangaroo pump" (Sherwood Medical Industries, County Oak Way, Crawley, West Sussex RH11 7YQ). Details of nutritional composition feeds are given in Appendix 2.

Appendices 4 and 5 show estimated volumes of feeds required for children and protein and energy provided, calculated in advance of the study to establish suitability or otherwise.

A comparison was made between Recommended Daily Amounts of Food Energy and Nutrients for groups of people in the United Kingdom and the feeds for most nutrients. For the remaining nutrients for which there were no recommendations, the values in the feeds

were compared with the Recommended Dietary Allowances from the United States National Research Council's 9th Edition 1980. This was to establish that the nutrient requirements of the children to be studied, could be met by the feeds. This was subsequently revised following the publication in the United States of America of the 1989 Recommended Dietary Allowances 10th Edition and outlined in Appendix 3.

2.3.7 RESUSCITATION

Resuscitation was undertaken in accordance with the Muir & Barclay formula (Muir & Barclay 1974), ie, fluid requirement 0.5 ml/kg/% BSA burn. Plasma deficits were corrected and monitored at intervals of 4, 8, 12, 18, 24, 36 hours post burn. Resuscitative fluids used were human albumin solution from Blood Products Laboratories, Elstree, Herts, in conjunction with dextrose saline or normal saline from Baxter Health Care Limited, (Caxton Way, Thedford, Norfolk IP24 3SE).

2.3.8 AD LIBITUM FEEDING

Patients were allowed access to food as this was considered psychologically as well as nutritionally beneficial.

2.3.9 PATIENT CARE

The patients were managed conservatively i.e. immediate surgery was not undertaken to allow spontaneous healing to occur in the expectation that surgical intervention would not be required, in an environmental temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$. The burns were dressed with paraffin gauze with wool and crepe bandages. Patients were catheterised for an average of up to five days post burn or longer if indicated. Patient's bed-heads were tilted to an angle of 30° . This was to prevent regurgitation of feed.

2.4 PATIENT MONITORING - NUTRITIONAL ASSESSMENT

2.4.1 NUTRITIONAL INTAKES

Daily calculations were made of nutritional intakes for total protein, fat and carbohydrate, total energy, percentage of total energy from protein, fat and carbohydrate, sodium and potassium, by means of food and fluid charts. Nutritional analysis of food was carried out with the aid of the Salford University's nutritional analysis computer programme using the data base of Paul & Southgate Food Composition Tables (Paul & Southgate 1985). In the case of intravenous and enteral intakes, this analysis was calculated on a daily basis, by hand.

2.4.2 VENEPUNCTURE SAMPLING

Non-fasting venepuncture samples were taken on day one and twice weekly after that at 09.00 hours. Blood sample handling and analysis methods are discussed in Chapter 3. These were assayed for sodium, potassium, urea, glucose, creatinine, and total protein and white blood cell count. Serum samples were immediately frozen, and later analysed for thyroxine binding pre-albumin (TBPA), albumin, retinol binding protein (RBP), insulin like growth factor-1 (IGF-1), and growth hormone.

2.4.3 TWENTY FOUR HOUR URINE SAMPLING

Daily twenty four hour urine collections were made whilst catheter was *in situ*, usually up to five days post burn and twice weekly thereafter. Aliquots of these urine samples were assayed for sodium, potassium, protein, urea and creatinine, details are given in Chapter 3. The urinary urea was taken into account in the EGF group when the nutritional requirements were re-assessed.

2.4.4 BODY WEIGHT AND HEIGHT MEASUREMENTS

Patients were weighed naked on admission to the unit and twice weekly thereafter with a final net weighing on completion of the study. The scale used was a Viking bed scale, accurate to 0.1kg, F.J. Thornton & Co, London. Recumbent length was measured using a rigid metre stick, accurate to 0.5cm. These measurements were then plotted on growth and development record charts (Tanner & Whitehouse 1970).

2.4.5 OTHER ANTHROPOMETRIC DATA

Whenever possible measurements of mid arm circumference (MAC), mid arm muscle circumference (MAMC), using the Jelliffe & Jelliffe (1960) formula. Tricep and bicep skinfolds were taken. A Harpenden skinfold caliper was used, accurate to 0.1mm, for skinfold measurements using the method described by Jelliffe (1966).

2.4.6 CLINICAL COURSE

The clinical course of each patient was recorded with reference to healing rates and episodes of sepsis requiring antibiotic therapy and surgical intervention. The study was concluded on each patient when the area of burn remaining was healed to 5% BSA or on day twenty post burn, whichever came first. Twenty days post burn is the duration when most spontaneous healing is considered to have occurred. Following that time skin grafting may be carried out on full thickness or deep dermal injuries, where necessary.

2.4.7 STATISTICS

Descriptive statistics were undertaken for variables where appropriate. Much of the data is presented in tabular as well as graphical format. No standard error bars are included in the figures as scattergrams are provided for most of the variables.

2.5 RESULTS

2.5.1 PATIENT CHARACTERISTICS

Seventeen children aged between one and thirteen years were assigned to one of two treatment groups. The characteristic details ie, burn size, depth, age and sex were outlined in Table 2.1 and Fig 2.1 for both groups.

SF Group n = 9, had a mean age of 3 years range 1 to 5 years, mean burn size of 19% BSA range 10 - 40%, mean number of days studied were 13, range 5 - 21 days and consisted of 6 males and 3 females. The individual characteristics for this group are listed in Table 2.2 for their group. All subjects with the exception of one entered the study within 12 hours of having sustained their burn injuries.

EGF Group n = 8 had a mean age of 4 years, range 1 to 13 years, mean burn size 15% BSA, range 10 - 29%, mean number days studied 8, range 5 - 11 days, and consisted of 8 males (Table 2.1). The individual characteristics are listed in Table 2.3. All subjects in this group entered the study within 12 hours of their having sustained their burn injuries.

2.5.2 WEIGHT AND HEIGHT CHARACTERISTICS Tables 2.4 Figs 2.2 & 2.3

At the outset of the study none of the children fell outside the Tanner centile charts for weight and height, although children were recorded as being between the third and tenth centile weight for height. The mean weight of SF Group was 15.2 kg, and EGF Group was 17.0 kg. The mean height of SF Group was 93 cm and EGF Group was 99 cm. SF Group showed a mean overall weight change of -1.3%, EGF Group showed a mean overall weight change of +2.4%.

2.5.3. OTHER ANTHROPOMETRIC DATA Table 2.5

Skinfold measurements were made at the beginning of the study. Measurements taken were mid arm circumference (MAC), mid arm muscle circumference (MAMC). Both groups were well matched and there were no differences between the two groups. It was not always possible to measure skinfolds for all patients as most of the injuries were sustained to the upper part of the body

2.5.4. CLINICAL OUTCOME Tables 2.2 & 2.3

SF Group was studied for a mean of 13 days, range 5-21 days; whilst EGF Group was studied for a mean of 8 days, range 5-11 days. In SF Group three patients had an uneventful clinical course, five patients required antibiotic therapy and two patients required early surgery. Of the patients requiring antibiotic therapy for pyrexia, none had a confirmed septicaemia. In EGF Group six patients had an uneventful clinical course, one patient required surgery and two required antibiotic therapy for pyrexia, yet septicaemia was not confirmed in either case.

2.5.5. NUTRITIONAL INTAKES

Energy Tables 2.6 - 2.8 Figs 2.4 - 2.7

Energy targets differed between the groups. SF Group had a mean energy target of 1560 kcal(6521 kJ)/day, range 1200-2300 kcal (5016-9614 kJ), whilst EGF had a mean target of 1300 kcal(5435 kJ)/day (5435 kJ), range 900-2400 kcal (3762-10032 kJ). SF Group received 80% of targeted energy whilst EGF Group received 95% of target.

Actual intakes of energy did not differ significantly between the two groups. The SF Group had a mean intake of 1230 kcal (5141 kJ)/day and the EGF Group a mean intake of 1200 kcal (5016 kJ)/day a mean difference of 30 kcal (125 kJ)/day between the intake for the groups listed in table 2.6 and the intakes actually achieved are given in Table 2.7. The energy distribution was expressed as protein, fat and carbohydrate energy ratios (PER, FER, CER) Table 2.8 outlines the ratios for both groups. The SF Group had a PER of 18%, FER of 30% and a CER of 52%. The EGF Group had a PER of 17%, a FER of 32% and a CER of 51%. Although the energy ratios of the enteral feed were constant (see Appendix 2), patients were allowed food *ad lib*. This, combined with intravenous fluids given in the resuscitative phase, contributed between 0-15% of the total energy taken and as a consequence marginally altered the energy ratios.

The mean energy intakes for the groups are plotted against time and expressed as kcal(kJ)/day in Fig 2.4 and 2.5. It was evident from these graphs that EGF Group achieved targets sooner than the SF group and in fact exceeded targets for much of the study period.

The SF Group did not come close to achieving targets consistently until the third week. The individual intakes for energy are clearly visible in Fig 2.6 and 2.7. It is evident from Fig 2.6 for SF Group, that there was a see-saw variation in energy intake. This was because feeding was interrupted for periods ranging between 2-6 hours on alternate days to facilitate administration of anaesthesia for dressing changes. Attempts were made to "catch up" on these deficits. This see-saw variation did not appear to occur in EGF Group to quite the same extent even though the policy on dressing change was the same. This was likely because the lower targets of EGF Group were more achievable even with alternate daily feeding interruptions for dressing change. Individual energy intakes are plotted against targets in figures 2.6 and 2.7. The SF group (fig 2.6) patients exceeded targets whilst the remaining six fall short on their energy targets for most of the study period. The EGF group on the other hand had much greater success and six of the eight patients studied reached their targets by day two. Five of these patients remained close to or above the targets for the duration of the study period.

Protein Tables 2.9 & 2.10 Fig 2.8 - 2.11

SF Group had a mean target of 64g, range of 52-83g, whilst EGF Group had a mean target of 53g, range of 39-90g. The percentage of target achieved for SF Group was 85%; whilst for EGF Group it was 90%. This gave a mean intake of 55g/day for SF Group and 49g/day for EGF Group. Thus, there was some difference between the mean protein intakes for the two groups. Despite there being no major difference in mean intakes between the groups the mean protein intake for the SF group per kg of body weight was 4g/kg,

whilst for the EGF group was 3g/kg. The mean protein intake plotted against time for the groups is shown in Figs 2.8 and 2.9. The actual individual daily intakes for protein are indicated in Figs 2.10 & 2.11. Differences are recorded in Tables 2.9 and 2.10. Protein intakes follow a similar pattern, to the energy for the same reasons previously described.

Fat & Carbohydrate Tables 2.11 & 2.12

SF Group had a mean fat intake of 42g/day, range of 19-61, whilst EGF Group had a mean fat intake of 43g/day, range 29-82 see Table 2.11. SF Group had a mean carbohydrate intake of 159g/day, range of 98-237. EGF Group had a mean daily intake of 152g/day range of 113-245. There was little difference between intakes for both groups. For the SF Group the mean FER was 30% and for the EGF Group the mean FER was 32%.

Sodium & Potassium Tables 2.13 & 2.14

SF Group had a mean sodium intake of 50 mmol/day, range 37-72; whilst EGF Group had a mean potassium intake of 47 mmol/day, range 19-79. SF Group had a mean potassium intake of 32 mmol/day, range 16-44; whilst EGF Group had a mean potassium intake of 34 mmol/day, range 16-58. The daily intakes for both groups were similar.

2.5.6. SERUM AND URINE ANALYSIS

These results are discussed in Chapter 3.

2.6 DISCUSSION

2.6.1 Introduction

The study objective was to evaluate the suitability of feeding formula for this group but a significant factor was the amount and type of data generated. The results of the study will be of benefit in the nutritional support, monitoring and further study of this very special group of patients. Studies on children are fraught with difficulties, the primary ones being the ethical consideration and the practicalities involved in collecting blood and urine samples and meeting nutritional targets.

The surgical management of burned children is decided at the outset, usually within 12 hours of the injury. Conservative surgical management means that grafting, from the subject's own donor sites to the damaged area will be carried out at the end of a three week period allowing spontaneous healing to occur and consequently reducing the size of skin graft required. Aggressive surgical management i.e. early surgical intervention by excision of the damaged tissue and grafting of new tissue to cover this area within 48 hours of injury, is preferred when injuries are predominantly full thickness. This produces a donor site which has the effect of further exposing the body to trauma. The policy on surgical management with the McIndoe Burns Centre at the time of the study was for conservative management. Exceptions to this rule were when circumferential injuries occurred ie to the limbs or trunk and escharotomies were necessary to relieve pressure. Another exception was when the sites of burn injury were very large or were of mixed depth. The

surgical management protocol had an effect on the feeding regimen, eg, frequent surgical sessions interrupted continuous feeding, and antibiotic cover became more necessary often affecting tolerance of the enteral feeds. Patients slept for long periods following dressings and oral food intakes were further reduced.

The clinical management for non-surgical patients also interfered with feeding practices. Alternative daily dressings were carried out under anaesthetic using Ketamine and Omnopon. It was practice at the Burns Centre not to recommence enteral feeding until the patient was fully recovered, this could have meant delays of two to six hours in a twenty four hour period.

2.6.2 Protein & Energy

The protein level in the feeding regimen may be a vital factor in the nutritional regimens for burned children. A recent study by Cunningham et al, (1990) appears to confirm this. Cunningham's study concluded that when more than 2.5g protein/kg is provided, efficient protein utilisation for recovery is achieved with an energy provision of 120-200% resting metabolic rate in severely burned children. In this study the energy intakes were below the normal reference values, for normal children of similar ages and the protein intakes above this level, the negligible weight change for the groups indicates energy equilibrium (see Tables 2.4 & 2.10 and Figs 2.2, 2.7, 2.10 & 2.11). There appears remarkable similarity between the mean intakes for the total energy and protein consumed by both groups in spite of the 20% difference in targets for protein and energy between the groups. This poses a question regarding the ability

of a child to consume enteral feeds in excess of the EG Formula target, (ie, to the target set by the SF). The Cunningham Study, 1990, would appear to support this.

More recently, there has been more interest in the measurement of energy expenditure in traumatised individuals because it provides more detailed information on individual energy requirements. Recent technology and the development of user friendly computerised indirect calorimeters has made this easier. At the outset of the study the measurement of energy expenditure, and in particular RMR was considered, but for financial and practical reasons, measurement of RMR was ruled out. Since the study, a new indirect calorimeter, Deltatrac, has become available for use on children.

The results of this study raise the question as to whether protein is more significant than energy in the feeding of burned children or whether the protein energy ratio is the significant factor. Further studies measuring energy expenditure might help in answering these important questions so that we can substantiate or otherwise these findings. The study by Cunningham et al, (1990) on pre-school burned children concluded that more than 2.5g protein/kg, 120-200% RMR energy would be adequate for recovery in burned infants and toddlers. The results from the present study supports in part, the findings of the study in that burned children have a protein requirement greater than 2.5g/kg/day but not as high as those recommended by the Sutherland study.

2.6.3

Targets

There was little difference between the two groups in relation to actual intakes despite differing targets. This perhaps begs the question as to whether there is a cut off point where burned children can only consume and metabolise a certain amount of energy and protein. Alexander (1980) in his work also had difficulty in achieving high targets. His targets were not achieved and actual intakes were in the order of 79% in the high protein group and 87% in the normal fed group. Procedures, eg, dressing changes, physiotherapy and theatre sessions all interrupted feeding, making it impossible to achieve targets. Yet in the present study, EGF Group was much more successful at reaching targets sooner than SF Group and exceeding targets in a more sustained manner. Clinically, EGF Group fared rather better than SF Group, with a lower incidence of infection and surgery rate. This may have been because the EGF Group was clinically well compared with the SF Group. However, another explanation may be that SF Group had a larger mean burn size compared with the EGF Group which could have produced a more traumatised group of subjects.

It is difficult to compare this study with that of Sutherland & Batchelor (1968) as different parameters were used to assess the formula in her study compared with this study. The Sutherland research concentrated mainly on weight loss and concluded that weight loss was obligatory and was acceptable at minus 10-15% of original body weight. In this study SF Group achieved negligible weight change in the order of -1.3% and EGF Group in the order of +2.4%. As EGF Group patients appeared to have a slightly positive energy balance, this may be explained by the fact that

fluid is retained in the early post-resuscitative phase and these subjects were studied for a shorter period of time than SF Group. However, given that the actual intakes of energy and protein for both groups was very similar, it is likely that energy balance was comparable for both groups. Although there was no apparent difference between the nutrient intakes of the two groups, the EGF fed group had a better outcome in terms of rates of infection, requirement for antibiotic treatment and duration of healing.

The EG targets were easier to achieve in a shorter period because the targets were lower than for the SF Group. The EGF targets were sustained for the same reason. The EGF Group fared better than the SF Group yet, the patients in the EGF Group remained in the study for a shorter period, mean number of days was eight for the EGF Group compared with 13 days for the SF Group. This was because the recovery and healing time was faster for the EGF Group and this may have been linked to the lower incidence of infection which occurred in the EGF Group. Only two of the EGF Group required antibiotic treatment in EGF Group, compared with five in the SF Group.

2.6.4 Fat Intake

In clinical practice, it is sometimes the case that high fat intakes are necessary to achieve high energy intakes because of the energy density of fat, yet a FER of 30% and 32% was achieved in the EGF and SF groups respectively.

2.6.5 Weight changes and anthropometric measurements

Body weight changes were interesting as the feeding regimen appeared adequate to maintain a positive energy balance in the EGF Group with a % weight change of +2.4%, whilst the SF Group exhibited a -1.3% weight change which is negligible and indicates the patients were in energy balance.

2.6.6 Comparison with the recommended daily allowances

Part of the pre-study preparation involved assessing the suitability of the enteral feed for the chosen age group. This was done by comparing the expected intake of feed with the US Recommended Daily Allowances for protein, energy, vitamins and minerals and it was deemed suitable (see Appendix 6). The results are also compared with the Dietary Reference Values 1991 listed in Appendix 6.

2.6.7 The suitability of the enteral feeds

At the beginning of the study two enteral feeds were available for the study to meet nutritional targets (see Appendix 3 Clinifed Favour and Clinifed Extra compositional data). The choice of feeds was to be made on the basis of energy and protein needs being satisfied with a given volume of liquid. It became apparent that total volume of the enteral feed required might be a restricting factor in attempting to achieve targets for both groups. In practice, Clinifed Extra was the feed of choice. Only one patient in EGF Group received Clinifed Favour, this was a twelve year old boy for whom volume was a less restrictive factor than for the younger children and it was possible to achieve his nutritional targets at a higher volume.

2.6.8 Malnutrition

None of the children were malnourished at the end of the study period. This was confirmed by the maintenance of body weight, muscle and biochemical markers, ie, serum albumin and serum protein in particular. The picture was the similar for both groups. From this, it appears that the higher protein intake of the SF Group is not essential at 4g protein/kg and the clinical outcome of the EGF, with an intake of 3g protein/kg, was acceptable.

TABLE 2.1**SUMMARY OF CHARACTERISTICS**

	SF GROUP	EGF GROUP
n	9	8
AGE/YEARS		
mean	3	4
range	1-5	1-13
SEX DISTRIBUTION	6 male 3 Female	8 male
% BSA BURNED		
mean	19	15
range	10-40	10-29
NUMBER OF DAYS STUDIED		
mean	13	8
range	5-21	5-11

TABLE 2.2**PATIENT CHARACTERISTICS SF GROUP**

n=9					
STUDY NO	AGE years	SEX	%BURN	NO DAYS STUDIED	CLINICAL COURSE
110	4.7	F	17	12	Escharotomies
202	4.0	M	23	7	Pyrexial-Antibiotics
108	2.7	M	10	12	Uneventful
111	2.7	M	12	5	Inhalation injury Pyrexial/antibiotics
103	2.7	M	16	21	Pyrexia/antibiotics
101	1.6	F	17	21	Pyrexia/antibiotics
113	1.6	F	16	9	Pyrexia/antibiotics surgery
401	2.5	M	40	8	Uneventful
204	1.3	M	21	20	Uneventful

TABLE 2.3**PATIENT CHARACTERISTICS EGF GROUP**

n=8					
STUDY NO	AGE years	SEX	% BURN	NO DAYS STUDIED	CLINICAL COURSE
102	12.5	M	13	11	Uneventful
203	4.1	M	29	6	Uneventful
112	3.5	M	12	11	Escharotomies Pyrexia/antibiotics
105	2.2	M	14	7	Uneventful
201	1.5	M	25	7	Pyrexia/antibiotics
109	1.9	M	10	8	Uneventful
104	1.5	M	10	5	Uneventful
114	2.1	M	10	7	Uneventful

TABLE 2.4**WEIGHT AND HEIGHT CHARACTERISTICS**

	SF GROUP	EGF GROUP
n	9	8
HEIGHT cm		
mean	93.0	99.0
range	80-113	80-163
s.d.	±10	±28
WEIGHT kg		
mean	15.2	17.0
range	12-20	10-46
sd	±4	±14
% Weight Change at end of the study	- 1.3%	+2.4%

TABLE 2.5**ANTHROPOMETRIC MEASUREMENT**

	BEGINNING OF STUDY SF GROUP	END OF STUDY SF GROUP	BEGINNING OF STUDY EGF GROUP	END OF STUDY EGF GROUP
M.A.C. cm				
n	6	6	5	5
mean	17.1	17.7	17.5	17.3
range	16.5-19.1	16.5-18.3	15.0-22.0	15.0-21.0
TRICEP SKINFOLD mm				
n	3	3	5	5
mean	9.9	9.3	8.1	8.2
range	7.7-13.0	7.3-12.3	7.1-9.0	7.5-9.1
BICEP SKINFOLD mm				
n	2	2	4	4
mean	6.2	4.3	4.8	4.8
range	4.9-7.5	4.3	4.3-5.2	4.1-5.3
M.A.M.C. mm				
n	3	3	4	4
mean	14.3	14.5	15.3	15.2
range	12.4-13.7	12.6-15.0	12.2-19.6	12.3-18.7

TABLE 2.6

ENERGY TARGETS kcal (kJ)/day

	SF GROUP	EGF GROUP
n	9	8
ENERGY		
mean	1560 (6521)	1300 (5434)
range	1200-2300 (5016-9614)	900-2400 (3762-10032)
range	37 (155)	43 (180)
% TARGET ACHIEVED		
mean	80	95
range	59-97	82-115

TABLE 2.7**ENERGY INTAKES kcal (kJ)/day**

	SF GROUP	EGF GROUP
n	9	8
ENTERAL INTAKE		
mean	970 (4055)	900 (3762)
range	508-1370 (2123-5727)	670-1680 (2814-7022)
s.d.	±26 (±109)	±23 (±96)
TOTAL INTAKE		
mean	1230 (5141)	1200 (5016)
range	690-1750 (2884-7315)	850-2063 (3553-8623)
s.d.	±38 (±159)	±41 (±171)
ENERGY kcal (kJ)/kg BW		
mean	80 (334)	85 (355)
range	55-98 (230-410)	50-134 (209-560)
s.d.	±23 (±96)	±26 (±109)

TABLE 2.8**PERCENTAGE ENERGY DISTRIBUTION OF THE DIETARY REGIMEN**

	SF GROUP	EGF GROUP
n	9	8
Protein Energy Ratio		
mean	18	17
range	17-19	13-21
Fat Energy Ratio		
mean	30	32
range	25-33	29-37
Carbohydrate Energy Ratio		
mean	52	51
range	48-56	49-54

TABLE 2.9**PROTEIN TARGETS α /day**

	SF GROUP	EGF GROUP
n	9	8
PROTEIN (g)		
mean	64	53
range	52-83	39-90
s.d.	± 13	± 15
% TARGET ACHIEVED		
mean	85	90
range	62-103	83-103

TABLE 2.10**PROTEIN INTAKES g/day**

	SF GROUP	EGF GROUP
n	9	8
ENTERAL SOURCE		
mean	47	39
range	23-69	23-63
s.d.	±1	±2
TOTAL INTAKE		
mean	55	49
range	32-77	32-78
s.d.	+15	+17
PROTEIN g/kg BW		
mean	4	3
range	3-4	2-5
s.d.	±1	±1

TABLE 2.11**FAT INTAKES (σ) / day**

	SF GROUP	EGF GROUP
n	9	8
ENTERAL SOURCE		
mean	37	34
range	18-54	25-55
s.d.	± 12	± 10
TOTAL INTAKE		
mean	42	43
range	19-61	29-82
s.d.	± 12	± 16

TABLE 2.12**CARBOHYDRATE INTAKES (α) /day**

	SF GROUP	EGF GROUP
n	9	8
ENTERAL SOURCE		
mean	101	109
range	47-155	81-210
s.d.	± 38	± 44
TOTAL INTAKE		
mean	159	152
range	98-237	113-245
s.d.	± 47	± 47

TABLE 2.13**SODIUM INTAKES mmol/day**

	SF GROUP	EGF GROUP
n	9	8
ENTERAL INTAKE		
mean	16	18
range	8-23	12-37
s.d.	±6	±8
TOTAL INTAKE		
mean	50	47
range	37-72	19-79
s.d.	±11	±21

TABLE 2.14**POTASSIUM INTAKES mmol/day**

	SF GROUP	EGF GROUP
n	9	8
ENTERAL INTAKE		
mean	24	24
range	11-35	16-47
s.d.	±8	±10
TOTAL INTAKE		
mean	32	34
range	16-44	16-58
s.d.	±10	±13

Fig 2.1 Individual burn size plotted with the varying depth of injuries for both group

% BSA Burn SF Group

% BSA Burn EGF Group

PT - Partial thickness
 MD - Mixed depth
 FT - Full thickness
 BSA - Body surface area

Fig 2.2 Graphs showing the mean weights plotted against time for both groups.

Fig 2.3 Individual weight changes plotted against time for both groups

Fig 2.4

Fig 2.5

Target intake 1 kcal = 4.18kJ
Actual intake

Fig 2.6

INDIVIDUAL ENERGY INTAKES

kcal Pat 110 (5 yrs-17% MD) Male

SF Group

kcal Pat 202 (4 yrs-23% MD) Fem

Pat 108 (3yrs-10% FT) Male

Pat 103 (2 yrs-16%FT) Male

Pat 111 (3 yrs-12% MD) Male

Pat 401 (2.5 yrs-40%PT) Male

Pat 113 (1.3 yrs-16% MD) Fem

Pat 204 (1.5 yrs-21% MD) Male

Pat 101 (1.5 yrs-17% MD) Fem

MD - Mixed depth burn
PT - Partial thickness burn
FT - Full thickness burn
— Target Intake
— Total Intake
- - - Enteral Intake

1kcal = 4.18kJ

EGF Group

Pat 102 (12.5 yrs -13%MD) Male

Pat 104 (1.5 yrs 10% PT) Male

Pat 112 (3.5 yrs-12% FT) Male

Pat 114 (2 yrs - 10% PT) Male

Pat 105 (2 yrs- 14%PT) Male

Pat 201 (1.5 yrs - 25% PT) Male

Pat 109 (1.9 yrs-10%PT) Male

Pat 203 (4 yrs-29%PT) Male

1 kcal = 4.18 kJ

— Target Intake
 —●— Total Intake
 Enteral Intake

MD Mixed Depth
 PT Partial Thickness
 FT Full Thickness

Fig 2.8

MEAN DAILY PROTEIN INTAKE SF Group

g/Day

Fig 2.9

MEAN DAILY PROTEIN INTAKE EGF Group

g/Day

Fig 2.10

INDIVIDUAL PROTEIN INTAKES SF Group

g/day Pat 110 (5 yrs-17% MD) Fem

g/day Pat 202 (4yrs-23% MD) Male

Pat 108 (3yrs-10% FT) Male

Pat 103 (2yrs-16% PT) Male

Pat 111 (3 yrs-10% PT) Male

Pat 401 (2.5yrs-40% PT) Male

Pat 113 (1.5Yrs-16% MD) Fem

Pat 204 (1.5yrs-21%MD) Male

Pat 101(1.5Yrs-17% MD) FEM

MD Mixed depth
PT Partial thickness
FT Full thickness

— Target intake
— Total intake
- - - Enteral intake

Received antibiotics

g/day Pat 102 (12.8 yrs-13% MD) Male

EGF Group

g/day Pat 114 (2 yrs-10% PT) Male

Pat 112 (3.5 yrs-12% FT) Male

Pat 201 (1.5 yrs-25% PT) Male

Pat 105 (2 yrs-14% PT) Male

Pat 203 (4 yrs-29% PT) Male

Pat 109 (1.9 yrs-10% PT) Male

Pat 104 (1.5 yrs-10% PT) Male

— Target intake
 — Total intake
 - - - Enteral intake
 ▨ Received antibiotics

3.1 RATIONALE FOR BIOCHEMICAL PARAMETERS CHOSEN

In addition to the nutritional variables described in Chapter 2, serum and urine biochemical variables were examined. Serum albumin has been and still is frequently used in the assessment of nutritional status under clinical conditions. Albumin levels in children are reported to decrease sharply in the early post burn period of 3-5 days and remain low thereafter (Daniels et al, 1974).

Recently rapid turnover proteins ie thyroxine binding pre albumin (TBPA) and retinol binding protein (RBP) with half lives of 12 and 24 hours respectively, have been studied in relation to changes in diet. They have been reported to be reliable markers when monitoring the effectiveness of supplemental feeding and reflect the ability of the liver to synthesise these proteins. (Inglebleek et al, 1972; Shetty and Watrasiewicz et al, 1979; Maudgal et al, 1982; Cavarocchi et al, 1986). In addition Moody (1982), has reported a correlation between low levels of TBPA and RBP and increased burn size in human subjects. There are no known normal reference ranges for serum rapid turnover proteins in young children. The possibility of collecting control serum samples from a comparable group of unburned children to provide a normal reference range for comparison was considered but rejected as mums of unburned children were hesitant about agreeing to this.

As the hypermetabolic response to the burn injury is hormonally regulated (Kinney et al, 1970), (Wilmore et al, 1974), measurements of serum levels, growth hormone and insulin-like growth factor -1 (IGF-1), were made. In a review of the literature, no studies could be found which reported these variables in a paediatric burn trauma population. However, these measurements may be important, as children are in a positive phase of dynamic growth when compared with an adult.

The controlled study was designed using two groups as described in Chapter 2, to reveal whether differences exist for the two dietary regimens between serum and urine values for nutritional biochemical assessments. Investigations included measurement of IGF-1 and RBP and TPBA.

In addition to measuring serum albumin and total proteins, it was common practice when monitoring burned patients to routinely check urea, electrolytes, glucose, white blood cell count (WBC) and haemoglobin. It was vital to check these parameters daily in the early post-burn phase, in order to monitor the effectiveness of resuscitative fluids and the subsequent adequacy of nutritional intakes subsequently. Adults with burn trauma can and frequently exhibit impaired glucose tolerance, especially in the early post-shock phase. This was attributed to increased insulin resistance and increased glucose production from protein via gluconeogenesis or suppression of insulin production

resulting from increased glucagon levels as part of the overall stress response. Monitoring glucose has relevant clinical significance. Serum urea was also significant in that it was an indicator of first renal function and secondly adequacy of carbohydrate and lipid energy.

With adequate dietary protein and energy, in the presence of adequate renal function, blood urea should remain within normal limits and reflect the adequacy of dietary energy particularly carbohydrate (Wilmore 1974). It was generally assumed that the response to trauma for children is broadly the same as for adults. Burn trauma increases capillary permeability causing oedema and a decreased circulatory volume. The objective of resuscitation was to restore circulatory volume and ensure adequate perfusion of all organs to maintain function. Renal function was carefully monitored by the examination of frequent serum sampling and complete daily 24 hour urine collections for urea, electrolytes, protein and creatinine and as an indication of nutritional status.

3.2 METHODS

3.2.1 SERUM & URINE SAMPLING

Venepuncture samples were taken daily whilst intravenous resuscitation was in progress and twice weekly thereafter. These were assayed for sodium, potassium, urea, glucose, Haemoglobin and full blood count.

A small sample of this blood was clotted, centrifuged and the serum was then frozen at -30°C and later analysed for albumin, TBPA, RBP, Growth hormone and IGF-1.

Twenty four hour urine collections were carried out routinely. This process was performed in the early post burn-phase when a catheter was *in situ*. Subsequently, attempts were made to continue daily twenty four hour urine collections but this was not totally successful owing to the necessity for use of nappies on children. This caused evaporation or spillage from urine bags which were dislodged on occasions despite rigorous attempts to prevent this. Where possible, twenty four hour urine collections were carried out. Since the East Grinstead Formula was based on burn size together with wound and urinary nitrogen excretion the minimum number of two collections per week were made (despite attempts to collect 24 hour samples daily).

3.2.2 LABORATORY ANALYSIS

Serum and urinary urea and electrolytes were measured using a Technicon 2 SMA auto analyser. Glucose was analysed using a glucose oxidase technique. Albumin, TBPA and RBP were measured by radioimmuno assays using Manchini's method on plates supplied by Hoechst Pharmaceuticals, (Salisbury Road, Hounslow, Middlesex TW4 6JH). Growth hormone was assayed by an immunoradiometric method using reagents supplied by NETRIA, St Bartholomew's Hospital, West Smithfield, London EC1V 2PS. The

IGF-1 assay method were measured by the competitive radioimmunoassays developed at the Department of Clinical Biochemistry, St Luke's Hospital, Warren Rd, Guildford, Surrey GU1 3NT.

3.2.3 STATISTICAL ANALYSIS

Descriptive statistics were undertaken for variables, where appropriate. Regression analysis with repeated measures was undertaken for each variable for the effects of age, sex and % burn, before undertaking treatment or time analysis. Much of the biochemical data is plotted in graphical format together with scattergramms depicting individual values. No standard error bars are included in the graphs for this reason. For a comparison between the treatment groups the Wilcoxon 2-sample test was used.

3.3 RESULTS

3.3.1 Serum sodium, potassium and urea Tables 3.1-3.3

SF Group had a mean sodium of 136 mmol/L, range 132-139, EGF Group also had a mean of 136 mmol/L, range 133-138. SF Group had a mean potassium of 4.0 mmol/L, range 3.7-4.3, whilst EGF Group had a mean of 4.2 mmol/L, range 3.9-4.3. These were maintained within the normal range for both groups of children. There was no significant difference between groups. There was no evidence of any renal impairment in either of the two groups. The blood urea remained within normal limits (Table 3.3) indicating that gluconeogenesis was not in evidence and that carbohydrate supplied was adequate to meet requirements. SF groups had a mean value of 3.8 mmol/L. Range 2.9 - 4.9. The EGF group had a mean urea of 4.6, range 2.7 - 6.2.

3.3.2 Serum glucose and creatinine - Tables 3.4 & 3.5

SF Group had a mean glucose value of 6.4 mmol/L, range 4.6-8.6, EGF Group had a mean value of 5.6 mmol/L, range 5.2-7.3. SF Group had a mean creatinine of 41 mmol/L, range 31-50. EGF Group had a mean value of 44 mmol/L, range 38-75. Both metabolites remained within the normal range and there was no significant difference between the two groups.

3.3.3 Serum protein and albumin - Tables 3.6,3.7 & Figs 3.1 & 3.2

The mean value for total serum protein for the SF Group was 61 g/L, range 48-69 g/L. The mean protein value for the EGF Group was 65 g/L, range 49-71 g/L. Total serum protein was in the lower range of normal for the groups, as shown in Fig 3.1. On further inspection of the individual values plotted in the scattergram Fig 3.1 show that some of the patients had values below the normal range at beginning of the study in both groups. These values improved as the study progressed. The mean value for serum albumin in the SF group was 37g/L, range 30-43 g/L. In the EGF Group, the mean value for albumin was 43 g/L, range 37-51g g/L. In the SF group serum albumin dropped earlier in the study but rose slightly at the end of the study whilst remaining within the normal reference band. As for the EGF group albumin was in the lower end of normal as is apparent from Fig 3.2. As might have been expected, the protein and albumin trends did not occur in parallel.

3.3.4 Retinol binding protein Table 3.8 and fig 3.3)

The SF Group had a mean value of 23 mg/L, range 12-39 mg/L, whilst the EGF Group had a mean value of 16 mg/L, range 11-20 mg/L, with an upward trend for both groups. In spite of the differences between the means, regression analysis with repeated measures showed no effect due to sex, age or % burn. No significant difference in RBP between the treatment groups was found. No significant time effect, was found, and no significant interaction between time and treatment was found.

3.3.5 Pre-albumin Table 3.9, Fig 3.4

The SF Group had a mean value of 166 mg/L, range 92-316, whilst the EGF Group had a lower mean of 129 mg/L, range 95-153. Again, as with RBP described in 3.5.5. above, regression analysis showed no effect due to the feeding regimens ($P < 0.61$). The Wilcoxon 2 sample test showed no significant difference between the groups. The same test for the difference in values at the beginning and the end of the study did not reach significance.

3.3.6 Growth hormone Table 3.10 & Fig 3.5

The SF Group had a mean value of 8 mU/L, range 1-25. The EGF Group, on the other hand, had a mean value of 14 m U/L, range 6-31. The mean values for the groups are plotted in Figure 3.5, together with a scattergram of the individual values. The SF Group appear to have a see-saw pattern, yet inspection of the scattergram indicated that the mean value was affected by a high value for one patient. Otherwise, the trend for growth hormone appeared downward for the first 4-7 day interval and marginally upwards thereafter.

This differs from EGF Group, which shows a downward trend in the 4-7 day interval rising marginally toward the end of the study period. Regression analysis indicated that there was no significant difference between treatments when adjusted for the age of the children ($p < 0.81$). There was, however, a significant effect of age between the 2 groups ($p < 0.025$), which one might expect.

3.3.7 Insulin like growth factor-1 - Table 3.11

The mean serum IGF-1 for the SF Group was 0.26 U/ml, range 0.13-0.41, whilst the EGF Group had a mean value of 0.33 U/ml, range 0.15-1.12. Regression analysis showed a significant effect of age on IGF-1 ($p < 0.0001$), a significant effect of sex ($p < 0.03$) and a significant effect of time ($p < 0.02$).

However, no significant difference between treatments in IGF-1 was found. All the IGF-1 values were within the age and sex related normal ranges. There was a significant time effect ($P < 0.02$), indicating that IGF-1 changes with time, yet there appeared to be no significant interaction between time and treatment.

3.3.8 Blood haemoglobin - Table 3.12

The SF Group had a mean value of 11g/dl, range 11-13 the EGF Group has a mean value of 12 mg/dl, range 11-14. One patient in each group was transfused peri-operatively. Haemoglobin levels were found to be on the lower side of normal for the two groups, yet only two children, one in each group, were given blood transfusions during early surgery. Again there was no significant difference between the two groups. The feeding regimens appeared adequate in maintaining blood haemoglobin within acceptable levels for the two groups.

3.3.9 White blood cell count - Table 3.13

Mean count for SF Group was $19 \times 10^9/L$, range 12-26 and for EGF $15 \times 10^9/L$, range 11-23. Both values were in excess of the normal range which is expected in trauma. Five patients in the SF Group required antibiotic therapy for wound infection, in EGF Group only two patients required antibiotics, for the same reason.

3.4 RESULTS - URINE

3.4.1 Urinary urea - Table 3.14 + Fig 3.9

The mean urinary urea for SF Group was 124 mmol/24 hours, range 90-162. The EGF Group had a mean value lower than this of 102 mmol/24 hours, range 50-164. This data was used weekly in the East Grinstead formula when reassessing protein requirements.

3.4.2 Urinary creatinine - Table 3.17 + Fig 3.10

The mean value for the SF Group was 2.0 mmol/24 hours, range 1.0-3.0, whilst for the EGF Group the mean value was 1.7 mmol/24 hours, range also 1.0-3.0. Creatinine clearance is a useful measure for renal function when accurate 24 hour urine collections had been carried out. These values are remarkably consistent for both groups.

3.4.3 Urinary sodium and potassium - Tables 3.16 & 3.17

The mean urinary sodium for the SF Group was 29 mmol/24 hours, range 11-44 mmol. The EGF Group had a mean urinary sodium of 30 mmol/24 hours, range 8-60. All values recorded were within the expected normal range. The mean urinary potassium for SF Group was 14 mmol/24 hours, range 8-27 mmol/24 hours. The EGF Group had a mean value of 10 mmol/24 hours, range 5-18 mmol/24 hours. The urine sodium and potassium concentrations are subject to physiological control. These controls become modified in illness and stress due to haemodynamic and hormonal changes. In particular there may be reduced ability to excrete sodium. Regular measurements of sodium and potassium concentration WAS required to quantify the loss and help assess electrolyte disturbance.

3.5 DISCUSSION

3.5.1 Serum, urea, creatinine, and electrolytes - sodium and potassium

There was no evidence, from the clinical biochemistry data, of any renal impairment in either of the two groups. Urea, creatinine and electrolytes remained within normal limits. Normal blood urea also indicated that gluconeogenesis was not in evidence and that dietary carbohydrate supplied was adequate to meet requirements.

Although the protein intake was greater than the UK Dietary Reference Values 1991 for children of the similar ages in both groups, it appeared that a high protein intake of 3-4g/kg/day did not have any adverse renal effects, as evidenced by the normal values for serum creatinine and urea. Serum sodium and potassium levels were found to be within the normal reference ranges for both groups. The total intakes included intravenous resuscitative fluids and oral and enteral intakes. During the study period following resuscitation, additional sodium and potassium was not required. The enteral feeds provided an adequate level of sodium and potassium.

3.5.2 Blood Glucose

The mean values for the groups were 6.4mmol SF Group and 6.0mmol respectively, for EGF Group were within the normal range. In clinical practice, adults experience elevated blood glucose values leading to hyperglycaemia requiring sliding scale insulin to control this. In this study the percentage of energy derived from

carbohydrate was 52% for SF Group and 50% for EGF Group. These levels of carbohydrate did not appear to add additional stress as the children appeared to have metabolised the dietary carbohydrate without any apparent additional stress. Some individual values were within the upper range of normal. This can be explained as blood samples were taken at random, and therefore, most were taken whilst feeding was in progress.

3.5.3 Serum protein and albumin

It is commonly the case in the clinical management of burned adults and children that low levels of serum albumin and protein occur. This is related to an expansion of the extracellular fluid compartment and decreased osmotic pressure. However, the serum levels of protein and albumin in this study remained within normal reference bands for both groups. The mean serum albumin in the SF group rose from the lower limit of normal in the early post-burn period to the upper limits within the three week study period. However this may be explained by the fact that there were fewer patient samples analysed towards the end of the study period and thus the sample may not be fully representative of the real situation. Nevertheless values did remain within the normal expected range.

3.5.4 Retinol binding protein & prealbumin

These proteins are considered useful as nutritional assessment markers because they reflect current nutritional status. It has proved difficult to assess the value of these parameters in this particular study as there is not, as far as the investigator was aware, a normal reference range available to use as control values. What is difficult to explain is the fact that although the mean dietary protein intakes for both groups were remarkably similar the absolute mean values for RBP & PA in both groups were different, the SF group mean value being higher than the EGF group value for both variables. However the mean protein intake per kg of body weight was different for the groups. The SF group at 4g/kg than the EGF group at 3g/kg. This may account for the differences. The trend for both groups was upwards.

3.5.5 Serum growth hormone

Although the mean serum growth hormone value in the SF Group was higher than in the EGF Group, individual patients exhibited a steady state for this hormone in both groups.

3.5.6 IGF-1

Although there was a difference in the mean values this was not significantly different. The SF Group showed a sharp rise overall by comparison with the EGF Group. On examination of the individual results however, four patients in the SF Group exhibited a sharp rise over the course of the study period and two had a slight fall in value. With the EGF Group however, only two patients showed a similar sharp increase, and as in the SF Group, two patients showed a fall.

3.5.7 COMMENT

It is difficult to identify one definitive nutritional assessment parameter and, as other researchers have found, a range of parameters seems to be the best approach (Alexander et al 1980 Inglebleek et al, 1972). Clinical assessments, biochemical and nutritional assessments are all valuable markers and should provide an overall picture of the patients' nutritional status. In this study serum retinol binding protein levels reflected the intake of dietary protein and was higher at higher levels of protein intake per kg of body weight for both the EGF and the SF formulae. Another finding was that the serum albumin levels remained within the normal range for both groups. This finding was contrary to the general consensus which is that serum albumin levels are invariably below normal in children with severe burns. A larger study would clarify this apparent discrepancy. Early enteral feeding has meant that the targets of the East Grinstead Formula were reached to within 95% for energy and 90% for protein. Other studies have not achieved this (Alexander et al 1980, Cunningham et al 1990). The question is whether the EGF Formula was beneficial in achieving good nutritional status because the formula was nearing requirements or if the patients benefitted from early commencement of the feed. Another question is whether early enteral feeding does in fact alter the hormonal response to trauma, by reducing the extent of the catabolic response in children and that this response differs to that of adults. This study is important in the amount of data generated and the number of subjects studied. Never the less statisticians may argue that

3.5.7 COMMENT

It is difficult to identify one definitive nutritional assessment parameter and, as other researchers have found, a range of parameters seems to be the best approach (Alexander *et al*; Inglebleek *et al*.) Clinical assessments, biochemical and nutritional assessments are all valuable markers and should provide an overall picture of the patients' nutritional status. In this study serum retinol binding protein levels reflected the intake of dietary protein and was higher at higher levels of protein intake per kg of body weight. Another surprising finding was that the serum albumin levels remained within the normal range for both groups and this finding is contrary to the general consensus which is that serum albumin levels are invariably below normal in children with severe burns. A larger study would clarify this apparent discrepancy.

the sample was small and therefore unlikely to produce statistically significant data. It has now become clear that there is a need to analyse the data more closely and compare the results across the board from individual subjects within the groups. To provide an example of the type of analysis that could be done for all subjects for the purpose of these conclusions two individual subjects have been selected one from the SF group and one from the EGF group (see table 3.18 which follows). Comparisons can be made and more revealing information can be extrapolated. For example, subject 110 selected into the SF group, and studied for twelve days demonstrated a -3% weight loss compared with subject 112 (EGF group) who achieved a 5% weight gain, on similar energy and protein intakes over a similar time period. It is noteworthy that the growth hormone levels varied widely between the two subjects (see table 3.18, subject 112 having levels of growth hormone three times that of subject 110. Individual variations in biological parameters and nutritional status at the study onset both contribute to the outcomes as described above. Table 3.18 illustrate the complexity in the analysis of studies of this nature.

Table 3.18

Subject	Age	Sex	% Burn	No Days Studied	Problems	
SF 110	4.7	F	17 MD	12	Surgery	
EGF 112	3.5	M	12 MD	11	Surgery	
					Pyrexia	
					Antibiotics	
	D	I	E	T		
	Protein In	Protein Target	Protein In g/kg	Protein Target g/kg		
SF 110	72g	77g	3.6	3.9	Wt change -3%	
EGF 112	60.7g	60g	4.0	4.0	Wt change + 5%	
	Energy In kcal	Energy Target kcal	Energy In kcal/kg	Energy Target kcal/kg		
SF 110	1720	1800	86	90		
EGF 112	1320	1150	88	77		
	S D	E A	R T	U A	M	
	Protein g/L	Albumin g/L	RBP mg/L	PA mg/L	IGF-1 U/ml	GH mU/L
SF 110	65	40	20.5	239.7	0.28	4.5
EGF 112	57	40	19.6	153.0	0.23	19.2
	U D	R A	I T	N A	E	
	Na mmol/24hrs	K mmol/24hrs	Urea mmol/24hrs	Creat mmol/24hrs		
SF 110	43.5	26.8	153	3.2		
EGF 112	20.0	8.0	151	3.1		

TABLE 3.1**BLOOD SODIUM mmol/L**

	SF GROUP	EGF GROUP
n	9	8
mean	136	136
range	132-139	133-138
s.d	±2	±1

TABLE 3.2**BLOOD POTASSIUM mmol/L**

	SF GROUP	EGF GROUP
n	9	8
mean	4.0	4.2
range	3.7-4.3	3.9-4.3
s.d	±1	±0.6

TABLE 3.3**BLOOD UREA mmol/L**

	SF GROUP	EGF GROUP
n	9	8
mean	3.8	4.6
range	2.9-4.9	2.7-6.2
s.d	±1	±1

TABLE 3.4**RANDOM BLOOD GLUCOSE mmol/L**

	SF GROUP	EGF GROUP
n	9	8
mean	6.4	5.6
range	4.6-8.6	5.2-7.3
s.d	±1	±0.6

TABLE 3.5**SERUM CREATININE mmol/L**

	SF GROUP	EGF GROUP
n	9	8
mean	41	44
range	31-50	38-75
s.d	±7	±13

TABLE 3.6**SERUM TOTAL PROTEIN g/L**

	SF GROUP	EGF GROUP
n	9	8
mean	61	65
range	48-69	49-71
s.d	±7	±5

TABLE 3.7**SERUM ALBUMIN g/L**

	SF GROUP	EGF GROUP
n	9	8
mean	37	43
range	30-43	37-51
s.d	±5	±7

TABLE 3.8**SERUM RETINOL BINDING PROTEIN mg/L**

	SF GROUP	EGF GROUP
n	9	8
mean	23	16
range	12-39	11-20
s.d	±10	±2

TABLE 3.9**PREALBUMIN mg/L**

	SF GROUP	EGF GROUP
n	9	8
mean	166	129
range	92-316	95-153
s.d	±73	±19

TABLE 3.10**SERUM GROWTH HORMONE mU/L**

	SF GROUP	EGF GROUP
n	9	8
mean	8	14
range	1-25	6 - 31
s.d	±7	±8

TABLE 3.11**SERUM IGF-1 U/ml**

	SF GROUP	EGF GROUP
n	9	8
mean	0.26	0.33
range	0.13-0.41	0.15-1.12
s.d	±0.1	±0.3

TABLE 3.12**BLOOD HAEMOGLOBIN g/dl**

	SF GROUP	EGF GROUP
n	9	8
mean	11	12
range	11-13	11-14
s.d	±1	±2

TABLE 3.13**WHITE BLOOD CELL COUNT $\times 10^9/L$**

	SF GROUP	EGF GROUP
n	9	8
mean	19	15
range	12-26	11-23
s.d	± 5	± 4

TABLE 3.14**URINARY UREA mmol/L/24 hrs**

	SF GROUP	EGF GROUP
n	9	8
mean	124	102
range	90-162	50-164
s.d	± 22	± 46

URINE BIOCHEMICAL RESULTS

TABLE 3.15

URINARY CREATININE mmol/24 hrs

	SF GROUP	EGF GROUP
n	9	8
mean	2.0	1.7
range	1-3	1-3
s.d	±1	±1

TABLE 3.16

URINARY SODIUM mmol/24 HOURS

	SF GROUP	EGF GROUP
n	9	8
mean	29	30
range	11-44	8-60
s.d	±14	±36

TABLE 3.17**URINARY POTASSIUM mmol/24 HOURS**

	SF GROUP	EGF GROUP
n	9	8
mean	14	10
range	8-27	5-18
s.d	±7	±5

Fig 3.1

SF Group

Mean Total Protein - Serum

EGF Group

Mean Total Protein - Serum

Fig 3.2

Mean Serum Albumin

Mean Serum Albumin

Normal Reference Range

Fig 3.3

BIOCHEMISTRY - SERUM

Retinol Binding Protein

Fig 3.4

BIOCHEMISTRY - SERUM

Prealbumin

BIOCHEMISTRY - SERUM

Fig 3.5

Growth Hormone

Fig 3.6

BIOCHEMISTRY - SERUM
Insulin Like Growth Factor-1

Fig 3.7

BIOCHEMISTRY - SERUM

Insulin Like Growth Factor - 1

NRR - Normal reference range

SF Group

Fig 3.8

EGF Group

Insulin Like Growth Factor-1

NRR - Normal reference range

Fig 3.8

BIOCHEMISTRY - SERUM

Insulin Like Growth Factor 1

NRR Normal Reference Range

Fig 3.9

BIOCHEMISTRY - URINE

Fig 3.10

UK	38	MUT	01
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APPENDIX 1

INVESTIGATION OF A NEW REGIMEN IN FEEDING CHILDREN AND PRE-SCHOOL CHILDREN WITH BURNS

PATIENTS NUMBER

--	--

GROUP ALLOCATION

--

NAME

CHART FOR ESTIMATING SEVERITY OF BURN WOUND

NAME _____ WARD _____ NUMBER _____ DATE _____
 AGE _____ ADMISSION WEIGHT _____

LUND AND BROWDER CHARTS

IGNORE
SIMPLE ERYTHEMA

Partial thickness loss (PTL)
Full thickness loss (FTL)

	%	
REGION	PTL	FTL
HEAD		
NECK		
ANT. TRUNK		
POST. TRUNK		
RIGHT ARM		
LEFT ARM		
BUTTOCKS		
GENITALIA		
RIGHT LEG		
LEFT LEG		
TOTAL BURN		

RELATIVE PERCENTAGE OF BODY SURFACE AREA AFFECTED BY GROWTH

AREA	AGE 0	1	5	10	15	ADULT
A=1/2 OF HEAD	9 1/2	8 1/2	6 1/2	5 1/2	4 1/2	3 1/2
B=1/2 OF ONE THIGH	2 3/4	3 1/4	4	4 1/2	4 1/2	4 3/4
C=1/2 OF ONE LEG	2 1/2	2 1/2	2 3/4	3	3 1/4	3 1/2

For further supplies of this pad or of Flamazine* Cream for the prevention and treatment of infection in burns contact Ingrebourne (04023) 49333 or your Smith & Nephew Pharmaceutical representative.

*Trade mark

UK	88	NUT	01	1-9
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NAME

DOB	DAY		MONTH		YEAR		16-21

FORM	0	1	10-11
WEEK		1	12-13
PATIENT NUMBER			14-15

INITIAL ASSESSMENT & REGIMEN CHOICE

DATE	DAY		MONTH		YEAR		22-27

Sex M or F ☐ 28

Parents Consent Form

N = No Y = Yes ☐ 29

Patient Characteristics

Weight (kg) 30-32

Height (ins) 33-35

Burn Size

Full Thickness % 36-37

Partial Thickness % 38-39

Total % 40-41

Resuscitation

Type of iv fluid

.....

Volume iv fluid/24hrs 42-45

Urine volume/24hrs 46-49

Nasogastric Feed (Regimen Choice)

A = Sutherland Requirements

 50

B = East Grinstead Requirements

Blood Samples Taken

N = No Y = Yes

UK	38	NUT	01	1-9
----	----	-----	----	-----

NAME

DATE

DAY		MONTH		YEAR	

16-21

FORM	0	2	10-11
DAY		1	12-13
PATIENT NUMBER			14-15

RELEVANT MEDICAL HISTORY

Comment

.....

.....

.....

Food (idiosyncrasies)
(comment)

Intolerances

Allergies

History G.I.
Upsets

Eating

Problems

Diet History Recorded

N = No Y = Yes ☐ 22

Photographs Taken

N = No Y = Yes ☐ 23

Concurrent Drug Therapy

Antibiotics N = No Y = Yes ☐ 24

Antiemetics N = No Y = Yes ☐ 25

Anti Diarrhoeal Agents N = No Y = Yes ☐ 26

Vitamin Supplements N = No Y = Yes ☐ 27

Other N = No Y = Yes ☐ 28

TRIAL NO

UK	38	NUT	01	1-3
----	----	-----	----	-----

NAME

DATE	DAY	MONTH	YEAR

FORM	0	3	10-11
WEEK			12-13
PATIENT NUMBER			14-15

NUTRITIONAL TARGETSGroup A (Sutherland) Calculated Once Only

Weight				(kg)	22-24
BSA Burn				(%)	25-26
(Protein				(g)	27-29
Nutritional Targets (					
(Energy				(kcal)	30-33

Group B (East Grinstead) Calculated Weekly

Weight				(kg)	34-36
Height				(inches)	37-39
3 SA Burn (Remaining)				%	40-41
Donor Site				%	42-43

New BSA Burn Total				%	44-45
Urinary Nitrogen				(g)	46-47
Urinary Nitrogen Estimate				(g)	48-49
(Protein				(g)	50-51
Nutritional Targets (					
(Energy				kcal	52-53

UK 88 NUT 01 1-3

NAME

DATE DAY MONTH YEAR 16-21

FORM 0 4 10-11
 WEEK 12-13
 PATIENT NUMBER 14-15

ACTUAL NUTRIENT

INTAKES (DAILY)

DAY	FEED	VOLUME (ml)	PROTEIN (g)	ENERGY (kcal/s)	Na (m mol)	K (m mol)	24 HOUR URINE OUTPUT (ml)
22	N/G FEED FOOD TOTALS IV FLUIDS						90
22	N/G FEED FOOD TOTALS IV FLUIDS						90
22	N/G FEED FOOD TOTALS IV FLUIDS						90
22	N/G FEED FOOD TOTALS IV FLUIDS						90
22	N/G FEED FOOD TOTALS IV FLUIDS						90
22	N/G FEED FOOD TOTALS IV FLUIDS						90
22	N/G FEED FOOD TOTALS IV FLUIDS						90

NAME

DATE

DAY	MONTH	YEAR

 16-21

FORM	0	5	10-11
WEEK			12-13
PATIENT NUMBER			14-15

CLINICAL COURSE (TWICE WEEKLY)

COMMENT

.....

.....

SURGICAL

.....

.....

DRUG CHANGE DATE

DAY	MONTH	YEAR

 22-27

DRUG	INDICATION	1 - START		
.....		2 - STOP <table border="1"> <tr> <td></td> <td>28</td> </tr> </table>		28
	28			
.....		<table border="1"> <tr> <td></td> <td>29</td> </tr> </table>		29
	29			
.....		<table border="1"> <tr> <td></td> <td>30</td> </tr> </table>		30
	30			

ADVERSE EVENT

<u>DESCRIPTION</u>	<u>ACTION</u>	<u>OUTCOME</u>	<u>COMMENT</u>
.....			
.....			
.....			

NAME

DATE DAY MONTH YEAR 16-21

FORM	0	6	10-11
WEEK			12-13
PATIENT NUMBER			14-15

BLOOD & URINALYSIS

(TWICE WEEKLY)

SERUM BIOCHEMISTRY

DATE 22-27

DATE 22-27

Na	m mol/l		34-36		34-36
K	m mol/l		37-39		37-39
Bicarb	m mol/l		40-42		40-42
Urea	m mol/l		43-45		43-45
Glucose	m mol/l		46-48		46-48
Ca	a mol/l		49-51		49-51
Phosphorous	m mol/l		52-54		52-54
Creatinine	m mol/l		55-57		55-57
Protein (Total)	g/l		58-60		58-60
Albumin	g/l		61-63		61-63
Haematology					
HbC	x 10 ⁹ /l		64-66		64-66
Hb	g/dl		67-69		67-69
PCV			70-72		70-72
Transferrin			73-75		73-75

NAME

BORN	U.	8	10-11
WEEK			12-13
PATIENT NUMBER			14-15

DATE DAY MONTH YEAR 16-21

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BLOOD & URINALYSIS

(TWICE WEEKLY)

SERUM BIOCHEMISTRY

DATE 11 11 11 22-27

DATE 11 11 11 22-27

URINALYSIS			
Na	m mol/24hrs	11 11 11 76-78	11 11 11 76-78
K	m mol/24hrs	11 11 11 79-81	11 11 11 79-81
Urea	m mol/24hrs	11 11 11 82-84	11 11 11 82-84
Protein	g/24hrs	11 11 11 85-87	11 11 11 85-87
Creatinine	m mol/24hrs	11 11 11 88-90	11 11 11 88-90
Hormones & Other biochemical indices			
BP		11 11 11 91-93	11 11 11 91-93
T3PA		11 11 11 94-96	11 11 11 94-96
Hormones		11 11 11 97-99	11 11 11 97-99
		11 11 11 100-102	11 11 11 100-102
		11 11 11 103-105	11 11 11 103-105
		11 11 11 106-108	11 11 11 106-108
		11 11 11 109-111	11 11 11 109-111

UK	88	NUT	01	1-3
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NAME

DATE	DAY		MONTH		YEAR		16-21

FORM	0	7	10-11
WEEK			12-13
PATIENT NUMBER			14-15

ANTHROPOMETRIC MEASUREMENTS - (WEEKLY)

22-27	22-27	22-27	22-27
DATE			

	28-30	28-30	28-30	28-30
Weight (kg)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Height (inches)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Trice PS Skinfold (mm)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Subscapular Skinfold (mm)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Biceps (mm)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Suprailiac (mm)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mid ACM Circum (mm)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
N.A.M.C.	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

UK	88	NUT	01	1-9
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NAME

FORM	0	3	10-11
WEEK			12-13
PATIENT NUMBER			14-15

PATIENT WITHDRAWAL

DATE

DAY		MONTH		YEAR	

16-21

REASON FOR WITHDRAWAL

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Comment

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UK	38	NUT	01	1-9
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NAME

DATE

DAY		MONTH		YEAR	

 16-21

FORM	0	9	10-11
WEEK			12-13
PATIENT NUMBER			14-15

McINDOE BURNS UNIT

PARENTAL CONSENT FORM FOR NUTRITION STUDY

ON CHILDREN WITH BURNS

PATIENT'S NAME

The details of the study have been explained to me. I give permission for my child to participate.

PARENT'S SIGNATURE

SIGNED in the PRESENCE OF

SIGNATURE

STATUS

APPENDIX 2

NUTRITIONAL COMPOSITION - CLINIFEED ENTERAL FEEDS

NUTRIENTS	CLINIFEED FAVOUR PER 100 ml	CLINIFEED EXTRA PER 100 ml
Protein (g)	3.75	6.65
FATS (g)	3.90	5.18
Carbohydrate (g)	12.50	15.00
<u>VITAMINS</u>		
Vitamin A (mcg)	80.0	106.0
Vitamin D3 (mcg)	0.5	0.67
Vitamin E (mg)	1.5	2.0
Vitamin K (mcg)	5.0	6.7
Vitamin C (mg)	10.0	13.3
Vitamin B1 (mg)	0.15	0.2
Vitamin B2 (mg)	0.15	0.2
Pantothenate (mg)	0.5	0.67
Vitamin B6 (mg)	0.2	0.27
Nicotinamide (mg)	2.0	2.7
Folic acid (mcg)	25.0	33.0
Vitamin B12 (mcg)	0.15	0.2
Biotin (mcg)	10.0	13.0
Potassium (mg)	110.0	133.0
Sodium (mg)	50.0	50.0
Calcium (mg)	40.0	60.0
Phosphorus (mg)	45.0	60.0
Magnesium (mg)	20.0	27.0
Chloride (mg)	125.0	90.0
Iron (mg)	1.0	1.8
Zinc (mg)	1.0	1.33
Manganese (mg)	0.2	0.27
Copper (mg)	0.1	0.15
Iodine (mcg)	7.5	10.0
Selenium (mcg)	5.0	6.7
Chromium (mcg)	6.2	8.3
ENERGY kCal (kJ)	100 (418)	133 (556)
% From protein	15	20
% From fat	35	35
% From carbohydrate	50	45
NPC:N Ratio	145 : 1	102 : 1
OSMOLARITY	220 m OSM/L	280 m OSM/L

APPENDIX 3

COMPARISON OF ENTERAL FEEDS WITH RDA'S 1979 & 1991*

NUTRIENTS	CLINIFEED FAVOUR /100 ml	CLINIFEED EXTRA /100 ml	RDA'S 1979	RNI'S 1991
Protein (g)	3.75	6.65	39	14.5 -
Fat (g)	3.90	5.18	-	19.7
CHO (g)	12.50	15.00	-	--
Vitamin A (mcg)	80.0	106.0	300	400-500
Vitamin D (mg)	0.5	0.67	10	7
Vitamin E (mg)	1.5	2.0	6-7*	<4♦
Vitamin K (mcg)	5.0	6.7	15-20*	>10♦
Vitamin C (mg)	10.0	13.3	20.0	30
Vitamin B1 (mg)	0.15	0.2	0.6	0.5-0.7
Vitamin B2 (mg)	0.15	0.2	0.8	0.6-0.8
Pantothenic acid	0.5	0.67	3*♦	>1.7♦
Vitamin B6 (mg)	0.2	0.27	1.1*	0.7-0.9
Nicotinamide (mg)	2.0	2.7	9.0	8-11
Folic acid (mcg)	25.0	33.0	50-75*	70-100
Vitamin B12 (mcg)	0.15	0.2	0.7-1.0	0.5-0.8
Biotin (mcg)	10.0	13.0	3*♦	10-200♦
Potassium (mg)	110.0	133.0	-	800-1100
Sodium (mg)	50.0	50.0	-	500-700
Calcium (mg)	40.0	60.0	600	350-450
Phosphorus (mg)	45.0	60.0	800*	270-350
Magnesium (mg)	20.0	27.0	80-120*	85-120
Chloride (mg)	125.0	90.0	-	1100
Iron (mg)	1.0	1.8	8.0	6.9-6.1
Zinc (mg)	1.0	1.33	10*	5.0-6.5
Manganese (mg)	0.2	0.27	1-1.5*♦	16♦
Copper (mg)	0.1	0.15	1-1.5*♦	0.4-0.6
Iodine (mcg)	7.5	10.0	20*	70-100
Selenium (mcg)	5.0	6.7	20*	15-20
Chromium	6.2	8.3	80*♦	0.1-1.0♦

* Requirements based on needs of children aged 3-4 years.

* USA RDA's 1989.

♦ Safe Intake

APPENDIX 4

ESTIMATED NUTRIENT REQUIREMENTS - SUTHERLAND FORMULA

(CHILDREN)

% BURN	10	20	30	40	50
<u>AGE - 1 YEAR</u>					
Weight - 10kg					
Protein (g)	40	50	60	70	80
Nitrogen (g)	6.4	8.0	9.6	11.2	12.8
Energy (cals)	950	1,100	1,650	2,000	2,350
Vol Required (ml)	1,300	1,300	1,300	1,300	1,300
Clinifeed Favour ml	1,100	-	-	-	-
Clinifeed Extra ml	-	750	900	1,050	1,200
Energy	1,100	997.5	1,197	1,400	1,596
<u>AGE - 2 YEARS</u>					
Weight - 12kg					
Protein (g)	46	56	66	76	86
Nitrogen (g)	7.4	9.0	10.5	12.2	13.8
Energy (cals)	1,070	1,420	1,770	2,120	2,470
Vol Required (ml)	1,300	1,300	1,300	1,300	1,300
Clinifeed Favour ml	1,200	-	-	-	-
Clinifeed Extra ml	-	840	990	1,140	1,290
Energy	1,200	1,100	1,316	1,516	1,700
<u>AGE - 3 YEARS</u>					
Weight - 14.7kg					
Protein (g)	54.1	64.1	74.1	84.1	94.1
Nitrogen (g)	8.7	10.2	11.9	13.4	15.0
Energy (cals)	1,232	1,582	1,932	2,282	2,635
Vol Required (ml)	1,300	1,300	1,300	1,300	1,300
Clinifeed Favour ml	-	-	-	-	-
Clinifeed Extra ml	813	960	1,114	1,265	1,415
Energy	1,081	1,276	1,516	1,682	1,880

ESTIMATED NUTRIENT REQUIREMENTS - SUTHERLAND FORMULA

(CHILDREN)

% BURN	10	20	30	40	50
<u>AGE - 5 YEARS</u>					
Weight - 18kg					
Protein (g)	64	74	84	94	104
Nitrogen (g)	10.3	11.8	13.4	15.0	16.6
Energy (cals)	1,630	1,980	2,330	2,680	3,030
Vol Required (ml)	1,600	1,600	1,600	1,600	1,600
Clinifeed Favour ml	1,700	-	-	-	-
Clinifeed Extra ml	-	1,112	1,265	1,400	1,560
Energy	1,330	1,476	1,682	1,862	2,075
<u>AGE - 7 YEARS</u>					
Weight - 24kg					
Protein (g)	82	92	102	112	122
Nitrogen (g)	13.1	14.7	16.2	17.9	19.5
Energy (cals)	1,790	2,140	2,490	2,840	3,190
Vol Required (ml)	1,800	1,800	1,800	1,800	1,800
Clinifeed Favour ml	-	-	-	-	-
Clinifeed Extra ml	1,230	1,380	1,530	1,684	1,834
Energy	1,636	1,835	2,034	2,240	2,439
<u>AGE - 10 YEARS</u>					
Weight - 30kg					
Protein (g)	100	110	120	130	140
Nitrogen (g)	16.0	17.6	19.2	20.8	22.4
Energy (cals)	2,250	2,500	2,850	3,200	3,500
Vol Required (ml)	2,200	2,200	2,200	2,200	2,200
Clinifeed Favour ml	-	-	-	-	-
Clinifeed Extra ml	1,500	1,650	1,800	1,950	2,100
Energy	1,997	2,194	2,394	2,593	2,793

APPENDIX 5

ESTIMATED NUTRIENT REQUIREMENTS - EAST GRINSTEAD FORMULA

(CHILDREN)

% BURN	10	20	30	40	50
<u>AGE - 1 YEAR</u>					
Weight - 10kg					
Height - 28.5"					
Protein (g)	32.0	38.0	43.0	49.0	54.0
Nitrogen (g)	5.1	6.0	6.9	7.8	8.7
Vol Required (ml)	1,300	1,300	1,300	1,300	1,300
Clinifeed Favour ml	853	1,010	1,150	-	-
Clinifeed Extra ml	-	-	-	740	810
Energy	853	1,010	1,150	984	1,077
<u>AGE - 2 YEARS</u>					
Weight - 12kg					
Height - 33"					
Protein (g)	38.6	45.0	52.0	58.3	64.9
Nitrogen (g)	6.2	7.2	8.2	9.3	10.4
Vol Required (ml)	1,300	1,300	1,300	1,300	1,300
Clinifeed Favour ml	1,030	1,200	1,380	-	-
Clinifeed Extra ml	-	-	-	880	980
Energy	1,030	1,200	1,380	1,170	1,300
<u>AGE - 3 YEARS</u>					
Weight - 14.7kg					
Height - 38"					
Protein (g)	45.0	53.0	61.0	69.0	77.0
Nitrogen (g)	7.2	8.5	9.8	11.0	12.3
Vol Required (ml)	1,300	1,300	1,300	1,300	1,300
Clinifeed Favour ml	1,200	1,410	-	-	-
Clinifeed Extra ml	-	-	920	1,040	1,230
Energy	1,200	1,410	1,224	1,383	1,635

ESTIMATED NUTRIENT REQUIREMENTS - EAST GRINSTEAD FORMULA

(CHILDREN)

% BURN	10	20	30	40	50
<u>AGE - 5 YEARS</u>					
Weight - 18kg					
Height - 43"					
Protein (g)	52.0	61.0	71.0	81.0	90.0
Nitrogen (g)	8.3	9.8	11.4	12.9	14.5
Vol Required (ml)	1,600	1,600	1,600	1,600	1,600
Clinifeed Favour ml	1,390	1,620	-	-	-
Clinifeed Extra ml	-	-	1,070	1,220	1,350
Energy	1,390	1,620	1,419	1,609	1,800
<u>AGE - 7 YEARS</u>					
Weight - 24kg					
Height - 47"					
Protein (g)	59.0	72.0	84.0	96.0	109.0
Nitrogen (g)	9.5	11.5	13.4	15.4	17.4
Vol Required (ml)	1,800	1,800	1,800	1,800	1,800
Clinifeed Favour ml	1,570	1,920	-	-	-
Clinifeed Extra ml	-	-	1,230	1,440	1,640
Energy	1,570	1,920	1,680	1,920	2,200
<u>AGE - 10 YEARS</u>					
Weight - 30kg					
Height - 53"					
Protein (g)	72.0	87.0	102.0	117.0	132.0
Nitrogen (g)	11.5	14.0	16.4	18.8	21.1
Vol Required (ml)	2,000	2,000	2,000	2,000	2,000
Clinifeed Favour ml	1,920	-	-	-	-
Clinifeed Extra ml	-	1,300	1,530	1,760	1,980
Energy	1,920	1,739	2,040	2,340	2,639

APPENDIX 6

COMPARISON OF THE SF REQUIREMENTS AND THE EGF REQUIREMENTS WITH AN ESTIMATED REQUIREMENT FOR CLINIFEED EXTRA FOR CHILDREN OF 5 YEARS WITH 30% BSA BURNS

NUTRIENTS	CLINIFEED EXTRA PER 1000 ml	*SF REQUIREMENTS FOR 5 YEARS/ 30% BURNS US 1989	EGF REQUIREMENTS FOR 5 YEARS/ 30% BURNS UK 1991
Protein (g)	66.5	84	71
Fat (g)	51.8	-	-
CHO (g)	150	-	-
Energy (kcal)	1330	2230*	1420
Vitamin A (mcg)	1060	500	500
Vitamin D (mg)	6.7	10	-
Vitamin E (mg)	20	7	3-4♦
Vitamin K (mcg)	67	20	10♦
Vitamin C (mg)	133	45	30
Vitamin B1 (mg)	2	1	0.7
Vitamin B2 (mg)	2	1.2	0.8
Pantothenic acid	6.7	3-4	3-7
Vitamin B6 (mg)	2.7	1.4	0.9
Nicotinamide (mg)	27	13.0	11.0
Folic acid (mcg)	330	100	100
Vitamin B12 (mcg)	2	1.4	0.8
Biotin (mcg)	130	20	10-200♦
Potassium (mg)	1330	-	1100
Sodium (mg)	500	-	700
Calcium (mg)	600	800	450
Phosphorus (mg)	600	800	350
Magnesium (mg)	270	120	120
Chloride (mg)	900	-	-
Iron (mg)	18	10	1100
Zinc (mg)	13.3	10	6.1
Manganese (mg)	2.7	1.5-2.0	6.5
Copper (mg)	1.5	1-1.5	-
Iodine (mcg)	100	90	0.6
Selenium (mcg)	67	20	100
Chromium (mcg)	83	30-120	20
			2-20♦ mcg/kg/day

* The SF children would require 1000-1150 ml of Clinifeed Extra to achieve protein target and the addition of a non-protein energy source.

♦ Safe Intake

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