THE NUTRITIONAL MANAGEMENT OF ADULT BURN WOUND PATIENTS IN SOUTH AFRICA

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DECLARATION

I, Marlene Ellmer, declare that this thesis is my own original work and that all sources have been accurately reported and acknowledged, and that this document has not previously in its entirety or in part been submitted at any university in order to obtain an academic qualification.

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ABSTRACT

OBJECTIVE: The objectives of this study were to determine the nutritional practices used in burns units in South Africa and to compare them with the latest available literature in order to make appropriate recommendations for possible implementation.

METHODS: Validated questionnaires were sent out to surgeons, dietitians and professional nurses working in burns units that complied with the inclusion criteria. Information on the units was obtained from an advertisement placed via email through ADSA. Non-random sampling was done and all the burns units were included in the study. Descriptive cross-sectional statistics were used to analyze the data.

RESULTS: Twelve burns units were identified. Ten of the burns units' health professionals (surgeons, dietitians and professional nurses) participated in the study. All the health professionals had experience in burned patients' management judging by the average number of year's experience. The average number of adult burned patients treated was 188 (58-350) and the mortality per year was 16% [Standard Deviation (SD) 6.4%] About half of the professionals indicated they used a protocol for the implementation of nutrition support. A degree of miscommunication was noted between the health professionals working in the units. Very few units (n=2) were able to perform wound excisions within 72 hours post-burn. All the dietitians used predictive equations when estimating energy requirements and the most popular formula remained the Curreri formula. Various different predictive equations were used. Even though most institutions indicated that micronutrient supplementation was routine practice, no standard regimen existed and supplementation varied significantly between units. The oral route, enteral route or a combination were used to feed patients with different degrees of burns, and the majority (60%) of the health professionals stated that they waited until oral diets were tolerated before enteral nutrition was stopped. The nasogastric enteral route remained the most popular route. Very few units used other feeding routes, and they would rather opt for TPN if nasogastric feeding should fail. The estimated nutritional requirements were met in 90% of patients in whom the feeding tube was successfully placed. From the results it appeared that dietitians were less confident regarding the use of immunonutrition in burned patients, in spite of the available literature. Anabolic agents were not very

commonly used in South Africa, probably due to the high cost. Patients were not followed-up regularly by dietitians.

CONCLUSION The results of this study indicated that despite the use of correct recommendations in certain instances there remained a definite degree of variation and uncertainty amongst health professionals. There also appeared to be poor communication between health professionals. The burns units in South Africa should use set standards for nutritional managements, obtain and implement strict feeding protocols and improve communication amongst the health professionals.

OPSOMMING

DOELWIT: Die doelwit van hierdie studie was om die voedingspraktyke wat tans in brandwond eenhede gebruik word, te bepaal, dit te vergelyk met die nuutste literatuur en toepaslike aanbevelings te maak vir implementering in die eenhede.

METODES: ‘n Vraelys, waarvan die geldigheid getoets is, is uitgestuur na chirurge, dieetkundiges en susters wat huidiglik in relevante brandwondeenhede werksaam is. Informasie oor die brandwondeenhede is verkry deur ‘n advertensie wat deur ADSA met behulp van e-pos uitgestuur is. ‘n Nie-ewekansige steekproef is uitgevoer en al die brandwondeenhede was ingesluit in die studie. Beskrywende statistiek is gebruik om die data te analiseer.

RESULTATE: Twaalf brandwondeenhede is geïdentifiseer. Tien brandwondeenhede se gesondheidspersoneel (chirurge, dieetkundiges en susters) het deel geneem aan die studie. Al die gesondheidspersoneel het ervaring in die behandeling van brandwond pasiënte, soos bepaal deur die aantal jare ervaring. Die gemiddelde hoeveelheid brandwond pasiënte wat jaarliks behandel word was 188 (58-350) en die mortaliteit per jaar was 16% (6.4%). Sowat die helfte van die personeel maak gebruik van ‘n protokol vir die implementering van voedingsorg. ‘n Mate van wankommunikasie is opgemerk tussen die gesondheidspersoneel. Baie min eenhede (n=2) voer wondeksisies uit binne 72 uur vanaf besering. Al die dieetkundiges gebruik metaboliese formules om energiebehoeftes te bepaal en persentasie brandwondoppervlak word altyd in aanmerking geneem. Die mees populêre formule is die Curreri formule. ‘n Verskeidenheid van metaboliese formules word gebruik. Die meeste eenhede het aangedui dat mikronutrient supplementasie toegedien word, alhoewel geen standaard protokol bestaan nie en dit beduidend verskil tussen die eenhede. Die orale voedingsroete, die enterale voedingsroete of ‘n kombinasie van beide word gebruik om pasiënte te voed met verskillende grade van brandwonde. Die meerderheid van gesondheidspersoneel (60%) het aangedui dat daar gewag word totdat orale diëte getolereer word voordat enterale voeding gestop word. Die naso-gastriese voedingsroete is die mees gewilde voedingsroete. Ongelukkig maak baie min brandwondeenhede gebruik van ander enterale voedingsroetes en sal TPN eerder gebruik word indien nasogastriese voeding sou misluk. Die geskatte voedingsbehoeftes is bereik in 90% van pasiente wat enterale voeding ontvang. Uit die resultate is dit duidelik dat dieetkundiges nie selfvertroue het in die gebruik van immuno-nutriënte nie, ten spyte van die beskikbare literatuur. Anaboliese steroïde word nie baie algemeen gebruik nie, heel moontlik as gevolg van die hoë koste. Pasiënte word nie op ‘n gereelde basis deur dieetkundiges opgevolg na ontslag nie.

OPSOMMING: Die resultate van hierdie studie dui aan dat ten spyte van die gebruik van toepaslike aanbevelings, daar steeds ‘n definitiewe graad van onsekerheid onder gesondheidspersoneel bestaan. Nog ‘n rede tot kommer is die oënskynlike swak kommunikasie tussen gesondheidspersoneel. Die brandwondeenhede in Suid-Afrika moet standaarde vir voedingsaanbevelings vasstel, streng voedingsprotokolle implementeer en kommunikasie tussen gesondheidspersoneel verbeter.

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LIST OF ABBREVIATIONS

ABW	actual body weight
ADSA	Association for Dietetics in South Africa
AF	activity factor
AIDS	Acquired Immune Deficiency Syndrome
ARDS	Acute Respiratory Distress Syndrome
ASPEN	American Society of Parenteral and Enteral Nutrition
ATP	adenosine tri-phosphate
BEE	basal energy expenditure
BMI	body mass index
BMR	basal metabolic rate
BSA	body surface area
CHO	carbohydrate
CI	confidence interval
CRP	C-Reactive Protein
DHA	docosahexaenoic acid
dL	decilitre
DNA	deoxyribonucleic acid
EN	enteral nutrition
EPA	eicosapentaenoic acid
FAD	flavin adenine di-nucleotide
FFA	free fatty acid
g	gram
GIT	gastro-intestinal tract
HB	Harris-Benedict
hGH	Human Growth Hormone
HIV	Human Immunity Virus
IBW	ideal body weight
IC	indirect calorimetry
ICU	intensive care unit

LIST OF ABBREVIATIONS (continue)

IED	immuno-enhancing diet
IGF-1	Insulin-like Growth Factor
IL-1	Interleukin -1
IL-6	Interleukin -6
IL-8	Interleukin - 8
iNOS	inducible nitric oxide syntheses
IU	international units
IV	intravenous
kcal	kiloenergy
kg	kilograms
kJ	kilojoules
l	Litre
MCT	medium chain triglyceride
MEE	measured energy expenditure
mg	milligram
min	minute
ml	milliliter
N2	nitrogen
NAD	nicotinamide adenine dinucleotide
NADP	nicotinamide adenine dinucleotide phosphate
NDT	nasoduodenal tube
NG	nasogastric
NGT	nasogastric tube
NJT	nasojejunal tube
NPE	non-protein energy
NPE : N	non-protein energy to nitrogen ratio
NPO	nil per os
OKG	Ornithine Alpha-Ketoglutarate
PEG	Percutaneous Endoscopic Gastrostomy

LIST OF ABBREVIATIONS (continue)

PTH	parathyroid hormone
RBP	Retinol-Binding Protein
RDA	recommended daily allowance
REE	Resting Energy Expenditure
RNA	Ribonucleic acid
S	serum
SA	South Africa
SD	standard deviation
SF	stress factor
TB	tuberculosis
TBSA	Total body surface area
TBSAB	Total body surface area burn
TE	total energy
TEN	Total enteral nutrition
TNF	Tumor Necrosis Factor
TPN	Total Parenteral Nutrition
ug	micro-gram
VCO2	carbon dioxide production
VO2	oxygen consumption

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CHAPTER 1

INTRODUCTION AND MOTIVATION

1.1 SIGNIFICANCE OF THE STUDY

The role of nutrition in hypermetabolic patients with burn injury is well known and well described in the literature, and nutritional support is an important part of the management of these critically ill patients. [8]

Supporting the stress response to injury, preventing infection, and encouraging wound healing are the primary factors influencing the burned patient's need for aggressive nutritional management. [6] It is accepted that nutritional support may decrease morbidity and improve mortality after severe thermal injury. However it is also known that energy intake cannot overcome the catabolic response to critical illness, and the detrimental effects of overfeeding are well established. [13] The question can be asked, is the importance of nutrition in the outcome of our thermally injured patients realized and secondly, are experienced registered dietitians, surgeons and chief professional nurses available and actively involved in the determination of macro- and micronutrient requirements and administration and monitoring of nutritional support. Further more are there effective communication and co-operation between our health professionals and are there nutritional protocols available for the nutritional management of these burned patients?

The success of the nutritional management of a thermally injured patient depends on how well this burn-related change in nutritional requirements can be estimated and then matched by an appropriate level and mixture of macronutrients and micronutrients. [13]

As a result, attempts have been made to improve methods for estimating nutritional requirements in thermally injured patients. Unfortunately, the abundance of predictive equations used for estimating energy expenditure may have led to further confusion rather than clarity. [13] More specifically, which methods are most commonly used in South Africa, are they valid for our particular population or are our patients being over- or underfed?

Enteral nutrition is the preferred route of providing nutrition to the acutely injured burned patient. The multiple benefits associated with enteral feeding have been well documented.[45] Total enteral nutrition should start as early as possible and can be increased very rapidly. [4] In fact it has been shown that early aggressive enteral feeding improves clinical outcomes. [45] Specific formulae of enteral nutrition for specific metabolic abnormalities are currently under evaluation. [45] Are these products and formulae available in South Africa and are they affordable? Is the knowledge and experience available to use it appropriately? Are the correct methods, route and amounts for the administration of enteral nutrition and TPN, being used?

It is very important to evaluate the efficiency of nutrition support for the consequence of insufficient nutrition is slower and ineffective wound healing. [6,16] Evaluation of the nutritional status of the patient should start with clinical evaluation. Tolerance to enteral nutrition should be constantly observed, gastric aspirates should be measured and intestinal transit time should be observed. Routine laboratory tests such as blood glucose monitoring, serum electrolytes, full blood count, albumin, pre-albumin levels and CRP should also be carried out for the monitoring of patients. [14] Are these facilities and resources available in South Africa, to implement the effective monitoring of nutrition support and are they being utilised optimally?

Anabolic hormones that are suppressed by the acute response to burn injuries are available exogenously and have been shown to be effective in increasing protein synthesis. [6] Are they available in South Africa and are they being used?

There is currently no literature in South Africa available on population specific methods that differentiate our population from our neighbours in more western and developed countries. Furthermore, no standards or protocols exist on how nutrition should be administered and how patients should be monitored for the South African population. It can be expected for it to be different from Western neighbours due to certain obstacles. Disadvantages and problems facing burn care in South Africa include: lack of specific infrastructure of certain burns units to allow optimal functioning, lack of ICU facilities and basic equipment, lack of expert personnel, rapid staff turn-over and financial restrictions. To add to these challenges we also face an AIDS pandemic that has an influence in terms of resource allocation and treatment programmes. [100] Is it therefore possible to implement recommendations from developed countries?

The author of this thesis maintains that there have not been any studies conducted in South Africa that address or answer the above-mentioned questions. A study exploring this field is thus necessary and a great need exists.

The results of this study could be used to determine whether patients are managed optimally in terms of nutrition support and to make recommendations that will improve nutrition practices and protocols in burned patients.

CHAPTER 2

LITERATURE OVERVIEW

NUTRITION IN BURNED PATIENTS

2.1 INTRODUCTION

In the United States, nearly 2 million people suffer burn injury every year. In about 100 000 of the patients the burns are of a moderate to severe nature and require hospitalization and in about 5 000 patients the burns prove fatal. [1] It is currently unknown how many patients with burn injury are treated annually in South African hospitals.

In South Africa, a study done at Somerset Hospital, Cape Town from 1993 to 1995 showed that the principle epidemiological cause of burns fitted into five groups: 1) shack fires, (mainly due to paraffin stoves) [2] 2) accidental injury (mainly due to hot water) [3] 3) assault, [3] 4) self-injury [3] and 5) assault by spouse. [4] Other South African data also confirmed the first two factors and stated that burns are one of the top causes of injury mortality in children and young adolescents younger than 14 year of age. [5] Poor housing and socio-economic hardship are therefore leading risk factors in this type of injury. Confined space and the toxic fumes released in the burning shack increase the risk of inhalation injury to these patients, hence adversely affecting their prognosis of survival from the burns assault. [3-4]

The role of nutrition in hypermetabolic burn injured patients is very well known and well described in the latest literature. [6] Nutritional support forms a very important part of the management of these critically ill patients [6,7] but it is often neglected. [6-9] Supporting the stress response to injury, preventing infection, preventing loss of lean body mass and encouraging wound healing are the primary factors influencing the burned patient's need for aggressive nutritional management. [6, 7] Post-injury hypermetabolism can also lead to malnutrition and weight loss more rapidly than simple starvation, another aspect which can be ameliorated by nutrition support. [10-12] It is accepted that nutrition support may decrease morbidity and improve mortality after severe thermal injury, [13] and appropriate nutrition support is positively associated with successful recovery. [10] However it is also known that nutritional intake cannot overcome the catabolic response to critical illness, and the detrimental effects of overfeeding are well established. [13]

It is thus clear that the multi-disciplinary team may be of extreme importance in the management of the burned patient. Consequently, it is imperative that a registered dietitian forms a part of the multi-disciplinary team.

South Africa's burns units face challenges that could affect the burn care and thus also the nutritional management of these patients. Facilities for skin grafting, if available, are often delayed due to inadequate operating time, the shortage of health care staff, unavailability of skin and limited blood products. [6] Financial constraints limit adequate resources such as equipment, medicine, nutritional equipment and adequate staff. Patients are admitted with underlying health problems such as pre-existing malnutrition, tuberculosis and HIV/AIDS. Burns units in general may lack infrastructure to allow for optimal functioning, lack of ICU facilities, hospital bed and basic equipment, lack of expert personnel and rapid staff turn-over. [100,101]

A standard for the nutritional care of burned patients has not yet been established for South African circumstances, where unique conditions influence the quality of patient care. Here it would be difficult to follow the experiences of our more economically advanced Western neighbours as the conditions and the possible facilities are different elsewhere. Consequently questions can be asked as to whether we have the necessary staff to implement nutrition effectively, the resources available and the skills to manage nutritional aspects optimally.

This review of literature will focus on the latest guidelines of the nutritional management of burned patients in the peer-reviewed literature and explore the possibilities of improving the nutritional management in the South African setting.

2.2 THE STRESS RESPONSE TO BURN INJURY

The hypermetabolic response post burn injury is well known and well described in current literature. Burn victims are considered the most extreme example of metabolic stress. [6, 13]

There is a well-known bi-phasic pattern of response to acute injury. The early response is known as the ebb phase, more commonly recognised as shock. This phase is the initial response to burn injury and manifests itself as decreased intravascular volume and decreased cardiac output, hypoperfusion, imbalance of oxygen delivery and consumption and depressed metabolism. [6,10-11,15] Initial goals of burn management address the complications and aggressive treatment of burn shock. [6] This response may continue for a period of several hours post burn to two to three days. [15] Even though evidence is emerging that enteral nutrition may restore splanchnic perfusion and oxygenation in haemodynamically unstable patients, it will still be prudent to delay initiation of feeding until the patient has been fluid resuscitated and has an adequate perfusion pressure. This goal should be achieved within 6 hours of hospitalisation or as soon as possible thereafter in all patients. [16]

The ebb phase then progresses to the second pattern, referred to as the flow phase of injury. In this second phase of injury the patient is more haemodynamically stable and capillary permeability is restored. [1, 6] There are two basic abnormalities produced by any burn during the flow phase: hypermetabolism and catabolism. [17]

2.2.1 Effect of the Stress Response on Energy Metabolism

After the resolution of the ebb-phase there is marked and persistent increased energy utilization and thereby increased energy demands in the body. It is called the hypermetabolic response to injury that may last for many months postburn. [7, 11, 15, 17-18] During this stress response metabolic rate is increased, oxygen consumption is increased, body temperature is raised, immune function is altered, peripheral insulin resistance occurs and there is increased skeletal muscle consumption. [11, 19, 10]

During this hypermetabolic phase, several neuro-hormonal events occur that include the activation of the sympathetic nervous system, stimulation of hypothalamic pituitary-adrenal axis and an increase in the secretion of glucagon relative to that of insulin. The metabolic response to injury is accompanied by elevated serum concentrations of cortisol, catecholamines, glucagon, growth hormone, aldosterone, thyroxin, thyroid stimulating hormone and vasopressin. [10] These changes to metabolism during the flow phase also triggers pro-inflammatory cytokines, (interleukin 1 {IL-1}, tumour necrosis factor {TNF}, interleukin 6 {IL-6}, interleukin 8 {IL-8}) cortisol, glucagon and catecholamines. [6, 7, 10, 20] Resting energy expenditure (REE) is markedly increased [6,10] (up to 200% of normal resting energy expenditure), [15] which may be due to the following reasons: [6, 10, 13, 15, 20-21]

1) Increased oxygen and energy utilisation by injured tissues;
2) Increased energy expenditure by other organs (e.g. the heart);
3) Increased substrate recycling which involves the breakdown and synthesis of glucose and triglycerides, but without a net production of free fatty acids or glucose and such recycling represents a net energy drain.

Other factors that also influence the hypermetabolic response would be the severity of thermal injury [the dynamics of the hypermetabolic response especially manifest when the total body surface area (TBSA) of burn injury is greater than 20-40% [6,7,15]], the presence of smoke inhalation injury, infectious complications and increased ambient temperature. [6,7,13,15,20,21]

The nutritional goal would therefore be to define these increased energy needs, and deliver the appropriate quantity and combination of nutrients to meet the energy demands. [17] It is important that the nutrition support practitioner has an understanding of the metabolic response to injury to intervene effectively with specialised nutritional support. [10]

2.2.2 Effect of Stress Response on Protein Metabolism

The second abnormality is destructive **catabolism**, which means a rapid and persistent breakdown of body and muscle protein. [17, 18, 20, 22] Since protein makes up the metabolic machinery and body structure, most prominently muscle, the loss of protein is deleterious. [17, 20] Protein breakdown and synthesis rates are elevated following burn injury but breakdown is elevated in excess of synthesis, resulting in net protein/nitrogen loss and muscle wasting. [15, 10, 20, 23]

The metabolic response to injury mobilises amino acids from lean tissues to support wound healing, activates an immunological response and accelerates protein synthesis. [9] The same factors leading to the hypermetabolic response are also responsible for the catabolic response, protein degradation, increased amino acid catabolism and nitrogen loss; namely the pro-inflammatory cytokines, catecholamines and catabolic hormones. [6, 10, 15, 17, 22] Under normal physiological conditions, the liver synthesises mainly constitutive-hepatic proteins such as albumin, prealbumin and transferrin. After trauma the synthesis shifts from constitutive-hepatic proteins to acute phase proteins such as haptoglobin, alpha1-acid glycoprotein, amyloid A and C-reactive protein (CRP). This reaction of the liver is called the acute-phase response. The goal of the hepatic acute-phase response is to restore homeostasis and provide energy. [7, 10, 18]

The abnormal amino acid flux is characterized by the peripheral and skeletal mobilization of amino acids, especially glutamine and alanine, from the muscle. This is mirrored by an increased hepatic uptake of these amino acids which serve as substrates for the acute phase proteins, provide fuel for gluconeogenesis and provide glutamine to the gut and immune system for direct metabolism. [10, 15, 22]

However, this reaction has several clinical implications and muscle cachexia results in the muscle atrophy and weakness. [10, 22-24] Severe depletion of lean body mass increases morbidity and mortality in the acute phase and delays recovery from illness and wound healing. [6, 10, 20] The loss of muscle also affects respiratory muscle function, leading to possible respiratory fatigue followed by pneumonia and respiratory distress, prolonged ventilatory support and difficulty in weaning from the ventilator. [10, 17]

Changes in the immune function are also an important clinical consequence of protein catabolism. [6, 10, 20, 23, 24] T-lymphocyte function is primarily decreased, whereas changes in B-cell function are more variable. Complement activity and granulocyte function are also affected. These changes in immune function are thought to contribute significantly to the immunocompetence of the patient. [10]

The nutritional goal would be to provide the required protein intake in order to meet the increased demands for tissue synthesis and repair as well as to minimize the loss of lean body mass. [17] Optimum nutrition support has been shown to decrease morbidity in the critically ill patient by maintaining immuno-competence, improving wound healing and preventing infections. [10]

2.2.3 The Effect of the Stress Response on Carbohydrate Metabolism

Carbohydrate metabolism during the stress response is marked by various degrees of hyperglycaemia, [7, 10, 15] decreased glucose tolerance and insulin resistance. [10] These characteristics are the result of increased glycogenolysis (and loss of muscle glycogen stores) [6] and gluconeogenesis from substrates mobilised peripherally. [6, 10, 11, 20]

The cause of this increased production of glucose is 1) an increase in production; 2) a loss of the normal suppressive action of exogenous glucose on endogenous production and 3) decreased effectiveness of insulin or peripheral glucose uptake. [20] Once again it is the effect of catecholamines, glucagon, cortisol and cytokines to increase availability of substrates required for gluconeogenesis and to maintain blood glucose levels at or above fasting levels until recovery. [6, 15, 20]

In burn injured, stressed patients, muscle glycogenolysis and the metabolism of hypoxic tissue produces lactate. It has been shown that lactate is quantitatively the most important gluconeogenic substrate in burned patients. [10, 11] Lactate is recycled to the liver to produce glucose via gluconeogenic pathways (Cori cycle). [11, 15, 20] The post-injury period is characterized by resistance to insulin as indicated by the elevated concentration of both glucose and insulin, with a more marked rise in insulin concentration. Plasma insulin levels rise to reach a peak several days after injury for up to three times basal levels. The high levels of insulin fail to suppress glucose production and there is a reduction in glycogen storage, lipolysis and fat oxidation. [10]

The stimulation of insulin production does have the added advantage of increasing protein synthesis by insulin, an anabolic hormone. [20]

Fibroblasts, endothelial and inflammatory cells involved in inflammation and wound repair rely on glucose as a primary fuel and they predominantly metabolise glucose anaerobically. The increased glucose turnover provides essential fuel for inflammatory and reparative tissue, which optimises host defences and ensures wound repair. [10, 11]

Large amounts of glucose are required to avoid excessive muscle breakdown. However, hypermetabolic patients have difficulty metabolizing glucose when infused supplements exceed 4-5 mg/kg/min [15] or 500-600g of glucose per day in a 70 kg individual. [20] Lipids and proteins are used to meet the remaining metabolic requirements. [11, 15, 20]

2.2.4 The Effect of the Stress Response on Fat Metabolism

As with other forms of stress, a burn injury leads to increased lipolysis mainly via catecholamines, in particular β_2 adrenergic stimulation, [20] and to a lesser extent glucagon and cortisol. [10] Lipolysis of triglycerides is enhanced immediately after injury. This process leads to the production of free fatty acids (FFA's) and glycerol, thereby increasing their turnover rate after burn injury. [10, 15, 25]

However, the rate of increase in FFA's production is not linked to the body's oxidation for fuel. Instead, at least 70% of FFA's are simply recycled. Therefore, the amount of exogenous fat that can be used as an energy substitute after burn is limited. The provision of fat for fuel is therefore used only to correct an energy deficit due to glucose intolerance. [20]

However, patients with severe burns develop "fatty livers" [15, 25] as normal processing enzymes become overloaded by the large amounts of free fatty acids and glycerol released by lipases under the stimulation of catecholamines. These patients have central redistribution of fat stores. [15]

The available literature indicates that hypertriglyceridemia and fatty infiltration of the liver have been related to sepsis. The liver and Kupffer cells play an important role in the immune system and alterations of their function could challenge the response of the host to bacterial overload, making the patient very vulnerable to the development of sepsis. [25]

2.2.5. The Effect of the Stress Response on Vitamins and Minerals

Micronutrient redistribution and deficiencies have been shown to occur after burn injury as a result of increased micronutrient losses through wounds, increased consumption during metabolism and inadequate replacement. [10,20] The exact consequences of the acute-phase response on micronutrient requirements are still largely unknown. [10] However, as micronutrients are essential for cellular function, a deficiency state amplifies the already severe burned-induced metabolic derangements and ongoing catabolism. [10, 20] Depleted patients are then at a high risk for nosocomial infections due to immunosupression, a decrease or delay in wound healing and tissue repair and a loss of muscle strength and diminished activity. [10]

2.3. STRATEGIES TO REDUCE THE HYPERMETABOLIC RESPONSE

The underlying disease process and the degree and time course of the energy and protein depletion can be modulated by: 1) prevention of infection and sepsis through early wound excision and closure, [7,11] 2) increasing the process of anabolism through nutrition and by increased muscle activity, [7, 20] 3) decreasing heat loss using the closed dressing technique and maintaining a warm patient environment, as heat loss markedly accelerates metabolic demand, [7, 20] 4) pharmacological modulation to limit the hypermetabolic response such as anabolic hormones and steroids [7 ,20] 5) controlling secondary stresses (pain and anxiety) which would further increase hypermetabolism [20] and 6) early enteral nutrition to decrease bacterial translocation. [7]

It is thus clear that it is imperative to involve the whole multi-disciplinary team in the effort to manage the hypermetabolic response.

2.3.1 Early Wound Excision and Wound Coverage

Prevention of infection and sepsis are important therapeutic approaches to diminish the hypermetabolic response. The primary treatment modality that has a pronounced effect on metabolic rate and infection is the early excision and closure of full thickness burn wound. If a large burn wound (>50% TBSAB) is totally excised and covered with autograft, cadaver skin or aerosol delivery of human fibrin sealant, within two to three days of injury, the patient's metabolic rate may decrease by as much as 40% when compared with a complete burn that is not covered until one week post-injury. [11] Early burn excision and wound coverage results in less operative blood loss, reduced length of stay, decreased scarring, faster functional rehabilitation process, fewer septic complications and decreased mortality. [1, 7, 11, 19, 22] Delay in wound excisions doubles the rate of catabolism. [11]

2.3.2 Nutritional Support

As described earlier, a burned patient enters a severe catabolic state characterized by elevated metabolic rate, increased protein mobilization and gluconeogenesis. These changes lead to significant increases in energy and protein requirements. Weight loss during this phase is virtually inevitable and it is important that aggressive nutritional therapy is instituted soon after the burn injury. Weight loss of more than 10% has been shown to increase mortality and a weight loss of more than 30% is associated with almost 100% mortality. [12]

It is accepted that nutrition support may decrease morbidity and improve mortality after severe thermal injury, [13] and is essential for burned patients. [9, 26] Certain aspects are important to consider when nutrition support is initiated in critical care patients: [22] 1) composition of the nutrition support 2) route of administration (enteral vs. parenteral vs. oral nutrition) and method of enteral feeding [i.e. nasogastric, nasoduodenal, nasojejunal or percutaneous endoscopic gastrostomy (PEG) route] 3) timing (early vs. delayed) 4) immunological properties of nutrition support and 5) monitoring of nutritional support.

The goals for nutrition support can be defined as follows: [7, 17]

1) To provide sufficient energy to keep up with the metabolic demands using the appropriate nutrient composition. The type and amount of nutrients are critical to success.
2) To provide the necessary protein intake sufficient to maintain adequate protein synthesis for healing and repair while decreasing the lean body mass loss. However, some lean mass loss is inevitable.
3) To protect gut function maintaining gut mucosal integrity .[1]
4) To avoid complications caused by excess or inadequate nutrient intake or improper timing of delivery.

When feeding the burned patient the aims therefore are to decrease muscle break-down and peripheral lipolysis, [15] to prevent infection [27] and to maintain adequate nutrition to allow wound healing. [15, 27]

Providing appropriate energy and macronutrients

It is essential that an adequate energy is provided to maintain energy levels and decrease the catabolic stimulus. [20]

It is well known that inappropriate nutrition support leads to the deterioration of nutritional status and may be associated with delayed wound healing, erosion of body protein mass, decreased resistance to infection and impaired organ function, all of which contribute to the prolonged length of hospitalisation, increased rate of complications and increased mortality. [28]

Excessive energy intake from overfeeding may also have deleterious effects on patient outcome for example, high rates of glucose infusion may promote development of a fatty liver, and a patient already compromised by respiratory impairment, increased carbon dioxide production can result in a significant ventilatory load. [28, 36]

Success of the nutrition management of the burned patient may depend on how well this burn-related change in energy expenditure can be estimated and then matched by an appropriate level and mixture of macronutrients. [13]

Predictive equations

A number of formulae are currently used to assess the increased energy needs. [20] Unfortunately, the abundance of predictive equations used for estimating energy expenditure and requirements in thermally injured patients may have led to confusion rather than clarity for the clinician. [13, 21] Furthermore, some of the predictive equations might be flawed by the inability to account for added stress (pain, anxiety, dressing changes) or decreased stress or activity (from narcotics and sedative infusions). [20, 29]

A study by Dickenson et al. [13] investigated the bias and precision of several nutritional assessment methods published or used commonly in burned patients. The investigators evaluated 46 methods available for estimating the resting energy expenditure of 24 thermally injured patients, requiring specialised nutritional support. These authors reported that burn injured patients have highly variable hypermetabolic and energy-expenditure needs that cannot be precisely predicted by formulae. [6, 13]

The most commonly used methods used in clinical practice include: [6, 7, 13, 20, 29]

1) Curreri formulae [13, 30] and its variations (1974) [31] [It must be noted however that the Curreri formulae was developed in burned patients with 40-70% total body surface are burn (TBSAB)] [30]

2) Variations of the Harris-Benedict (1989) equation for basal energy expenditure (BEE) which uses a predicted stress "factor" of basal energy needs on burn size. [20, 31]

3) Harris-Benedict multiplied with a stress factor of 1.3-1.5 or 2 (1987-1997). [13]

4) 35 kcal/kg/day. [13]

5) 40 kcal/kg/day. [13]

The methods were evaluated against the so-called "gold standard" of estimating energy requirements, namely indirect calorimetry. The study determined that none of the methods (including those commonly used in clinical practice) accurately predicted the REE in thermally ill patients. They indicated that about one-third of the publications provided methods that are biased toward over-predicting measured energy expenditure (MEE), whereas about one-fifth of the methods were biased toward under-predicting MEE. [13] There are several advantages and limitations of each formula according to the study. (Table 2.1)

The most precise, unbiased methods for estimating REE in the burned patient population included [13] the methods for Milner et al, Xie et al [33] and Zawacki et al. [34] (Table 2.1). A study is needed to determine the accuracy, bias and practicality of these predictive equations in the South African burn population.

Table 2.1: The predictive equations used in burned patients, as well as advantages and disadvantages [13] of each:

Method	Description/ Formulae	Advantages [13]	Disadvantages [13]
Curreri et al. [30]	(25 x kg body weight) + (40 x %TBSAB)	• A well known, commonly used formula. • Practical to use in the clinical setting.	• Overestimate MEE. • Does not take age into consideration. • Developed in patients with 40-70% TBSA burned patients and thus not used in patients with a smaller %TBSAB.
Curreri Senior. [31]	(25 kcal / kg + 65 kcal / (% TBSAB)	• Takes elderly age into consideration.	• Not well known and commonly used in clinical practice.
Age-adjusted Curreri-formula [31]	♂ : (25kcal/kg x BMR factor) + (40 x % TBSA burn) ♀ : (22kcal/kg x BMR factor) = (40 x % TBSA burn) Where BMR factor = 20-40 year: 1 40-45 year: 0.95 50-75 year: 0.9 75-100 year: 0.8	• Takes elderly age into consideration.	• Not well known or commonly used in clinical practice.

Table 2.1: The predictive equations used in burned patients, as well as advantages and disadvantages [13] of each (continue):

Method	Description/ Formulae	Advantages [13]	Disadvantages [13]
Harris-Benedict with injury factor: [31]	BEE x AF x SF Activity factor (AF) = x 1.2 confined to bed x 1.3 out of bed Stressfactor (SF) : < 20% TBSAB = 1.5 20-25 % TBSAB = 1.6 25 -30 % TBSAB = 1.7 30-35 % TBSAB = 1.8 35–40 % TBSAB = 1.9 40-45% TBSAB = 2.0 > 45% TBSAB = 2.1	• A well known, commonly used formula. • Practical to use in the clinical setting.	• Overestimate MEE. • Inaccurate, defined by CI for error within 15% of MEE.
Milner et al.[6]	{BMR x 24 x BSA (body surface area in m)} x {0.274 + 0.0079 x %TBSAB – 0.004 x Days Post Burn} + {BMR x 24 x BSA}	• A precise unbiased method for estimating REE.	• Difficult calculation detracts from its use in clinical use.
Xie et al.[33]	1000 x m^2 + 25 x % TBSAB	• A precise unbiased method for estimating REE. • Practical to use in the clinical setting.	• Developed in Chinese adults who may differ in body composition from their Western counterparts.
Zawacki et al. [34]	1440 kcal / m^2 /day	• A precise unbiased method for estimating REE.	• Does not take the severity of burns (%TBSAB) into consideration.

Indirect calorimetry

Dickerson et al [13] concluded that measured energy expenditure (MEE) by indirect calorimetry is the best method for determining energy requirements if one obtains the measurement at a time of day that best reflects the average daily metabolic response. [13] Indirect calorimetry (IC) measures oxygen consumption (VO_2) and carbohydrate production (VCO_2).[7, 11, 35] These parameters allow for the calculation of energy expenditure through a series of assumptions and equations. [35] Because stress periods of the day do occur, a factor of 20% to 30% above MEE is recommended to account for activity and added stress. [20] These arguments are also corroborated by other authors. [6, 13]

Multiple arguments can be found in the literature concerning the cost-benefit ratios of using IC in the assessment of nutritional needs of acutely ill patients, but IC has not been clearly established as the criterion standard of nutritional assessment. [6]

The Metabolic Cart used to perform the energy expenditure measurement may however not always be available in all institutions. Furthermore it requires strict protocol, strict measuring techniques and standardised procedures, while paying meticulous attention to accuracy and avoiding error that may not always be possible in a busy, short staffed South African burns unit. It was also reported that dissatisfaction with the use of the Metabolic Cart was related to expense, frequent repairs, calibration difficulties and technical limitations of indirect calorimetry in the critically ill patient. [35] In South Africa, indirect calorimetry seems to be restricted for research purposes only.

Factors influencing energy needs

Regardless of the method used to assess a patient's energy needs, several factors must be considered (Table 2.2). First, nutritional assessments provide a snapshot view of the patient's condition. [6] Dickerson et al also pointed out the hypermetabolic response may reach a plateau 20 days post-burn, [13] and therefore nutritional calculations and IC should be repeated frequently throughout the patient's hospitalisation to ensure that the nutritional plan is meeting patient's requirements [6] and that we are not overfeeding our patients.

Table 2.2: The factors that may influence the resting energy expenditure (REE) of burned patients:

Factors that increase REE:	Factors that decrease REE:
• Flow phase of injury. [6]	• Increasing patient age. [6, 37]
• Extent of thermal injury (large body surface area burns). [7, 13, 29, 36,]	• Early wound excision and skin grafting. [13]
• Days post burn. [13, 36]	• Days post burn. [6]
• Presence of pneumonia and/or sepsis. [13]	• Early nutritional support. [6,98]
• Presence of inhalation injury. [13]	• Obesity. [6]
• Evaporated water and heat loss via wounds. [33, 34]	• Mechanical ventilation. [6, 13]
• Male gender. [6, 37]	• Female gender. [6, 37]
• Fever and ambient temperature. [13, 29, 36]	• Sedatives. [6]
• Thermogenesis (shivering/not shivering) [6] and body core temperature. [29]	• Analgesics. [6]
• Weaning from mechanical ventilation. [6]	• Beta-blocking agents. [6]
• Respiratory distress of hyperventilation. [6]	
• Procedures or surgeries. [6, 13, 29]	
• Wound healing. [6]	
• Pain, anxiety, infection, activity. [6, 13, 29]	
• Interruption of feeds due to surgical procedures [63]	

Burn-injured patients experience all these factors throughout the various stages of burn-injury convalescence. Nursing interventions that address patient's needs, such as thermogenesis, pain and anxiety, activity and wound care, need to be clearly documented or communicated directly to the nutritional specialist so that optimal feeding regimens can be considered. [6]

Overfeeding

It is important to keep a balance when providing energy as not to overload the patient with a vast amount of energy. [6, 14, 32] It is also important to note that excessive energy and protein intake cannot overcome the catabolic response completely. [21] Studies showed that administering a higher amount of energy than needed, will lead to an increase in the quantity of fatty tissue and muscle volume will not change. It was shown that by exceeding the needed amount of energy, the number of complications increases and the mortality rate gets higher. [14, 21] Overfeeding can lead to respiratory complications secondary to hyperglycaemia, fatty liver, increased triglycerides and increased lipogenesis. [14, 38] It is thus not recommended to administer more than 30-40 kcal/kg/day, [14] or twice the BEE. [13, 21, 39] Alternatively, due to the uncertainty that exists, it would be ideal to evaluate the patient's REE bi-weekly and to do 24-hour urea nitrogen assessments until the wounds are closed. [6]

Overweight / Obese patients

Nutrition support in the obese burned patient is complicated and much controversy exits. There is no clear cut answer how to feed the obese, critically ill patient. [40]

Recent studies suggested that acutely injured obese patients have a hypermetabolic response similar to that of normal weight patients, which puts them at equal or greater risk for nutritional depletion. [40, 42] Although obese individuals have excess body fat stores and large lean tissue stores, they are likely to develop protein energy malnutrition in response to metabolic stress. [40] In fact the critically ill, obese patient mobilizes relatively more protein and less fat compared with non-obese patients. A block in lipolysis and fat oxidation occurs in the obese patients resulting in a shift to the preferential use of carbohydrates, which accelerates body protein breakdown even further to fuel gluconeogenesis in obese trauma patients. [40]

In a study done by Ireton-Jones, [42] it was reported that the Harris-Benedict equations underestimate the energy expenditures of burned patients. They found that the Ireton-Jones energy equations accurately predicted the energy expenditure of these patients. [42]

Energy requirement (v) = 1925 – 10 (A) + 5 (W) + 281 (S) = 292 (T) + 851 (B)

Energy requirement (s) = 629 – 11(A) = 25(W)-609(O)

v = ventilator dependant

s = spontaneously breathing

A= age (years), W = weight(kg), S = sex (male=1, female=0)

Diagnosis of T = trauma, B = burn, O=obesity (if present = 1, absent = 0)

Several controversies exist as to the use of actual or ideal body weight. [40, 43] The current recommendation is to use obesity adjusted body weight. [43] Adjusted body weight is calculated by determining 25% of the obese patient's actual body weight (ABW) and adding it to the patient's ideal body weight (IBW).

Adjusted body weight = (ABW x 0.25) + IBW. [41]

Another approach to the management of critically ill, obese patients have been developed, namely hypoenergetic (<20 kcal/kg adjusted body weight or 50% MEE [102,103]), high-protein (1.5-2g/kg IBW/day [102,103]) nutrition, provided by TPN [102] or TEN. [103] The goals are to achieve net protein anabolism, and to increase lean body mass without positive energy balance and consequent deposition of fat. Studies showed that this can increase serum protein and complete wound and tissue healing in patients on TPN. [102] A study done on patients receiving enteral nutrition showed reduced ICU stay, decreased duration of antibiotic therapy and a trend toward decreasing duration of mechanical ventilation. [103]

Obese critically ill patients must be monitored very carefully to prevent over-and underfeeding.

Pre-existing conditions

The effect of certain pre-existing conditions (i.e. malignancy, malnutrition, [44] HIV infection and pregnancy) on the metabolic response and the outcome of the burned patient are unknown and more studies in this field are necessary.

The populations being studied in the above-mentioned examples may not necessarily be comparable to the South African population with regards to presence of infection, timing of excision, grafting and other factors that may potentially alter energy expenditure. It is important to note that predictive equations may not be applicable to different ethnic groups with the same disease process. [7, 28] More studies are desperately needed to determine which if any of these methods are feasible, unbiased and accurate in the South African burn-injured population.

Protein requirements

Protein needs are increased after thermal injury due to accentuated and persistent muscle catabolism, wound losses and tissue repair. Although numerous investigators have discussed the increased needs of thermally ill patients, finding a clear recommendation for a goal is problematic. [21] Wolfe et al assessed the protein metabolic response to a protein intake of 1.4g/kg/day versus 2.2g/kg/day in thermally injured patients. When the protein was increased, nitrogen excretion data demonstrated a significant improvement in nitrogen balance with the higher protein intake. Based on that data, Dickerson et al selected the empiric goal of 2-2.5g/kg/day for critically ill thermally injured patients in their institution. [21]

Other recommendations are 1.5-2.0 g protein/kg/day for adults. [11, 15, 29] Furthermore, it is recommended to provide 23-25% of energy given with proteins. [1, 14, 20] High level of protein may raise urea production without enhancement of muscle protein synthesis or lean body mass accretion. [11] It is therefore necessary not to provide excessive protein and to observe the balance of fluid, level of nitrogen and creatinine in the blood. [14]

There is some suggestion that the form of protein (i.e. amino acids, peptides or intact protein) in the diet may affect the metabolic response to illness. Accumulating data are suggesting that peptide-based enteral feeding may have some advantages in terms of better absorption than amino acids or intact protein, in some critically ill patients.

The physiological effect of small peptides have been to shown to possibly improve absorption, and decrease diarrhoea, improve liver function, decrease gut permeability and/or sepsis, improve nitrogen retention and growth, and stimulate gut and growth hormone production. [99]

In a variety of animal models and patient disease states, small-peptide diets have been shown to be more readily and efficiently absorbed and are associated with fewer complications such as weight loss. [99]

Studies also suggested that there may be possible higher levels of visceral proteins such as albumin, pre-albumin and transferrin in critically ill patients on peptide-based diets, where others showed no significant difference in these patient groups. [106]

More clinical randomized controlled studies are however needed to warrant the use of peptide-based formula in burned patients. [99]

Carbohydrate needs

A study done by Hart et al. [23] showed that a high carbohydrate diet-consisting of 3% fat, 82% carbohydrate and 15% protein stimulates protein synthesis, increases endogenous insulin production and improves lean body mass accretion relative to an isocaloric, isonitrogenous but high fat enteral diet of 44% fat, 42% carbohydrates (CHO) and 14% protein. Furthermore, muscle protein degradation declined with the high carbohydrate diet. Endogenous insulin concentrations were enhanced with a high carbohydrate diet, which could have contributed to the improved muscle protein synthesis seen. Carbohydrate might be a better energy source compared with fat in the preservation of muscle mass. [11]

Carbohydrate energy should be provided at about 50-60% of total energy. [1, 17, 20] Excess CHO (more than approximately 5 mg/kg/min or 500-600g of glucose in a 70 kg individual [20]) however is deleterious leading to hyperglycaemia and fat formation. [14, 17, 33] This amount should not exceed the oxidation limits of the body; carbohydrates should be given not more than 5-7 mg/kg/min or 25 kcal/kg/min. [7, 14, 21, 29, 32] Furthermore, high calorie enteral nutrition may lead to an impairment of the splanchnic oxygen balance in burned septic patients, [45] as well as increased carbon dioxide production which can result in a significant ventilatory load in a patient already compromised by respiratory impairment. [32, 36] It is necessary to measure blood glucose levels and urine glucose levels since excess carbohydrates are transformed to fat. [14]

Lipid requirements

Fat energy (20-25% of total energy) are provided to reach the energy demands. [1, 17, 20] Endogenous fat stores are also used. Fat will not spare protein loss. [17] Because of the special metabolism after burns, low-fat mixtures are recommended. Other authors recommend a fat intake of less than 20% total energy [20] or less than 40% non-protein energy (NPE). [14, 29]

Increased fat administration has been associated with increased infectious complications, hyperlipidemia, hypoxemia and a higher post-operative mortality rate. [23] Furthermore, it has also been found that whole body proteolysis occurs concurrently with net fat gain when subjects receive a high-fat diet. Because there is no evidence of the direct role of fat in controlling muscle protein metabolism, they may not give reason to believe that a high-fat diet abolishes protein and muscle mass wasting in the setting of catabolic illness. Rather it is hypothesized that nutrition supplied predominantly as carbohydrate rather than fat will improve protein metabolism in ill, catabolic patients. A high-carbohydrate load should stimulate endogenous insulin production. Several recent studies have shown insulin to be a protein-sparing anabolic hormone in the face of severe illness or injury. Studies showed that carbohydrate-based diet is preferable to fat-based diets in those who are hypermetabolic and catabolic, which cannot be extended to other nutritional states without further study. It showed that increased carbohydrate intake improved muscle protein net balance. Skeletal muscle protein degradation was diminished, whereas protein synthesis was unaltered. This improvement in protein net balance correlated directly with stimulated endogenous insulin production. It also seems that high-carbohydrate intake is safe in paediatric burned patients. [23]

Dietary fatty acids provide a rich source of energy, are important for cell-membrane composition and provide substrates for the production of eicosanoids (immuno-active substances such as prostagladins, leukotrienes, lipoxins and platelet-aggregating factor). The fatty acids most commonly used in enteral nutrition are omega-6 fatty acids, which may have an adverse effect on immunological function and susceptibility to infection. Omega-3 fatty acids on the other hand, are thought to prevent the immunosuppressive effect of other dietary lipids, perhaps enhance immune function. [61] There is some evidence that replacing omega-6 fatty acids with omega-3 fatty acids from fish oils may limit post-burn immunosupression by decreasing the production of immunosuppressive prostagladins. [15, 20, 61] Recent recommendations of the optimal omega-6: omega 3 ration range from 2:1 to 8:1. More studies are needed to clarify this issue.

Table 2.3 summarises the recommendations on macronutrient requirements of adult burned patients.

Table 2.3: The macronutrient requirements in adult burned patients:

Macronutrient requirement	Recommendation in the literature
Protein	1.5-2.5g/kg [11,15,21,29] or 23-25% TE [1,14,20]
Carbohydrate	50-60% TE [1,17,20] to maximum of 5-7 mg/kg/min [7,14,21] >60% NPE
Fat	20-25% TE [1,17,20] <40% NPE

Providing appropriate micronutrients

Nutritional support of the critically ill patient includes the daily provision of vitamins, minerals and trace elements. [46] Vitamin supplementation is an extremely important component of the therapeutic nutrition care plan for the patient with acute burns. [47] The micronutrients are not only important as intermediaries in metabolism but also for their potential roles in wound healing, cellular immunity and anti-oxidant activity. [46]

Although micronutrient supplementation is common practice, guidelines for their provision during critical illness are completely empiric. [38, 46, 48, 49] Evidence of micronutrient deficiency is blurred by the clinical manifestation of traumatic injury.

Benefits of micronutrient supplementation may be subtle and therefore difficult to establish. [46, 48]

Micronutrient needs are elevated during acute illness because of increased urinary and cutaneous losses. [17, 46, 48] Furthermore, studies demonstrating increased free radical activity accompanied by a loss in plasma anti-oxidant levels during injury imply a greater need for nutrients with anti-oxidant capabilities. [46, 48, 49] Once again in the South African setting, certain micronutrient deficiencies may already exist in a patient that may not have a sufficient nutritional intake, have an intake of excessive alcohol, have chronic diseases i.e. HIV, TB or Cancer, or have increased losses as in the case of diarrhoea or vomiting, prior to, or during the burn injury. This is another factor to consider when the need for micronutrient supplementation is decided upon. [48]

Although the factors mentioned earlier all increase the requirement for micronutrients, severely ill patients often have reduced levels of provision. [48, 49] This situation results partly from the delay in provision of a full nutrition regimen whilst stabilisation of the condition of the patient is achieved, and partly from the fact that provision of the nutrition regimen itself is frequently interrupted as part of other clinical or diagnostic procedures. [48]

It is well documented that depleted patients are at high risk for nosocomial infections due to immuno-suppression, a delay in wound healing and tissue repair and a loss of muscle strength and diminished activity. Maintaining adequate micronutrient stores in the critically ill patient is thus of obvious importance, although this field remains relatively unexplored and recommendations are inconclusive. [49] Administration of minimum daily requirements of vitamins and minerals should be routine practice. [38]

Vitamin A

Among vitamin A's many functions is its well-known role in vision, cellular differentiation, cell immunity and preventing and treating infection. [17, 46, 47] Vitamin A is also necessary for epithelial integrity and optimal wound healing. [47] Low circulating levels are associated with increased risk of epithelial damage, with direct consequences for gut mucosal integrity. Vitamin A deficiency has been proposed as an etiological factor in the formation of stress ulcers in burned patients. Its enrichment in the diet of enterally fed burned patients is associated with a decrease in diarrhoeal complications. Low serum vitamin A levels in the burn population are generally attributed to decreased hepatic synthesis and release of retinol-binding protein (RBP) during the inflammatory response. In support of increased vitamin A use, dosages ranging from 10 000 to 25 000 international units (IU) has been suggested for critically ill adult patients. Given that retinol transport is compromised during stress, individual supplementation of this nutrient is not advised and provision as part of a multi-vitamin supplement seems prudent. [46] Possible toxic effects of excess vitamin A supplementation exist of which one must be aware. [47]

Vitamin D

Vitamin D is involved in the regulation of calcium and phosphorus metabolism. It is important for maintenance of skeletal integrity and has immuno-regulatory functions. [47] Patients with burns may be at risk for vitamin D deficiency because of long-term institutionalisation and wound coverage with dressings, and thus reduced sun exposure. Signs for vitamin D deficiency include bone pain and tenderness, demineralization of bone, elevated serum alkaline phosphatase level and low serum calcium and phosphate levels. [47] Currently no recommendation exists for the additional supplementation of vitamin D, but deficiency states must be checked in burned patients.

Vitamin E

Vitamin E is an anti-oxidant, [14, 17, 46, 47] and enhances immune response. [47] It also functions as a cell wall membrane-stabilizing agent, [47] and is essential for minimising cell damage from oxidative stress. [46] Decreased levels of serum vitamin E are associated with intra-cellular peroxidation [46, 47] and shortened survival of red and white blood cells. [47] Low vitamin E levels have been reported in some patients with burns, and plasma values further decline with inhalation injury. Vitamin E supplementation appears to provide some protection from acute lung injury that

follows thermal trauma. [47] Dietary requirement of vitamin E is increased when large amounts of poly-unsaturated fatty acids are consumed. [47]
Although there is evidence to suggest that vitamin E requirements are increased, there is insufficient data to estimate the appropriate dose for supplementation at this time. Provision as part of a multivitamin supplement daily seems prudent. [46] Vitamin E is relatively non-toxic, although mega-doses of vitamin E in healthy volunteers inhibit multiple immune functions. [47]

Vitamin C

Vitamin C has a role in collagen formation [46, 47] and it maintains normal matrices of cartilage and bone. [47] It is thought to play a role in the healing of the skin and it protects tissue from super-oxides by scavenging oxygen. It has been reported that ascorbic acid is involved in the immunological and anti-bacterial function of white blood cells. Mild deficiencies can occur under stressful situations and patients with burns have increased requirements. [46, 47]

Deficiency of this vitamin leads to scurvy, impaired wound healing, weakness and decreased resistance to infection. [14, 46, 48] As a direct scavenger of oxygen radicals within the cytosol, [14, 46, 48] or perhaps because of its capacity for regenerating vitamin E within cell membranes, vitamin C protects against micro-vascular epithelial damage immediately after burn. [46] The consequence of such damage is increased capillary permeability and plasma leakage into interstitial space. Consequently high dose vitamin C therapy has been shown to reduce fluid resuscitation requirements when administered during the first 24 hours after burn. [46]

A supplement in addition to nutritional therapy to approximately 200-1000 mg/day seems sufficient to meet the accelerated use of this nutrient. [46]

Vitamin C supplementation must however be used with caution. Burn injury may be complicated by acute renal failure as a result of hypovolaemia, sepsis, nephrotoxic substances or myoglobnuria. Oxalate, a naturally occurring compound is absorbed by the gastro-intestinal tract and produced endogenously as a metabolic by-product of glycine and ascorbic acid. In normal individuals, oxalate excretion is stable even at high vitamin C intakes. The patient with renal failure, however, can neither excrete ascorbic acid nor oxalate. There are no studies to date in the literature that have investigated vitamin C-related hyperoxalaemia in the burn population. It is reasonable to speculate that patients with burns who are given standard vitamin C may develop hyperoxalaemia, with secondary worsening of renal function. [50]

B-Vitamins

The B-complex vitamins include thiamine (Vitamin B1), riboflavin (Vitamin B2), niacin, (Vitamin B3) pyridoxine (Vitamin B6), folic acid, biotin and cobalamien (Vitamin B12). These vitamins act as co-factors in a variety of biochemical reactions. Thiamine, riboflavin, pyridoxine and niacin all participate in energy and protein metabolism. [46, 47]

Wound healing is retarded in the presence of riboflavin deficiency, and pyridoxine and folic acid is important for normal nucleic acid and protein synthesis. [47] Their deficiencies can lead to altered energy metabolism such as decreased oxidation of fatty acids, and impaired gluconeogenesis. Because B-vitamins are water-soluble and have shorter half-lives, they may become more rapidly depleted than the fat-soluble vitamins. Many drugs (including antibiotics) can also interfere with their absorption or metabolism. [46]

To date there is little existing knowledge regarding supplemental intakes of the B-vitamins. For many such as riboflavin, dietary vitamin levels and/or body stores regulate intestinal uptake, the implication being that during deficiency, transport is increased whereby over-supplementation results in decreased uptake by the intestinal brush border. Assuming B-complex vitamins are required in proportion to energy and protein use rate, amounts provided in standard enteral products should suffice, since increased intake will accompany energy intake. [46]

Calcium, Magnesium and Phosphorus

The goal of macro-mineral supplementation is to maintain adequate circulating plasma levels. Judicious monitoring of calcium, magnesium, and phosphorus is therefore needed. Several risk factors for deficiency states in these minerals exist. They include, intracellular shift due to glucose administration, stress response and the release of catecholamines, drug interaction, renal excretion during diuresis or hypocalcaemia, failure of parathyroid hormone (PTH) secretion, sepsis, chelation, inadequate intake, excessive gastro-intestinal (GIT) losses to only name a few. The existence of there factors provides the basis for the need and frequency of monitoring a particular nutrient. [46]

During severe and mild to moderate deficiency states replacement therapy is needed and as soon as values are normalised, daily basal requirements should be estimated and maintenance therapy provided. The purpose of maintenance therapy would be to offset ongoing nutrient losses that occur as a result of physiological stress and clinical therapy. Few guidelines exist for actual maintenance of macro-mineral requirements during critical illness. However, data consistently show that maintenance is not possible without supplementation to standard enteral formulae. [46]

It is important to note that calcium deficiency can occur during hypomagnesaemia as well as with increased phosphorus intake. It therefore, seems prudent to correct imbalances of phosphorus and magnesium intake before supplementing calcium (Table 2.4). [46]

Table 2.4: The administration of calcium, magnesium and phosphorus in burned patients:

	Calcium	Magnesium	Phosphorus
Maintenance therapy	EN: 1-4 g elemental calcium	EN+IV: 2g/day or 9.6 mg/kg/day	EN: 62 mg/day IV: 10-45 mmol/day

Zinc and Copper

As constituents of metalloenzymes, zinc and copper play a fundamental role in cellular growth and replication, protein synthesis, rapid epithelialisation, wound healing, cellular immunity, and anti-oxidant levels. Increased urinary zinc and copper excretion despite low or normal serum values is evidence that disturbances in the metabolism of these trace elements occur during illness or injury. Because zinc and copper are largely protein bound, losses are said to occur due to chelation with dietary amino acids or as by-products of accelerated muscle catabolism after surgery or traumatic injury. [46, 51] Copper deficiencies are often accredited to disturbances in the metabolism of its carrier protein ceruloplasmin. Typically, ceruloplasmin is a positive acute phase reactant although low levels have been observed during burn injury. In this group, serum levels of copper and ceruloplasmin decrease as burn injury size increases, suggesting that cutaneous wound losses are a significant factor in copper and ceruloplasmin deficiency. Furthermore, the magnitude of decline in ceruloplasmin was largely influenced by the amount of open wound area. [46]

An amount of 25-30 mg/day of elemental zinc has been proposed to meet the needs of critically ill patients. This amount is sufficient to accommodate urinary and cutaneous losses in most adult burned patients. Additional zinc supplementation may be advantageous for some patients who demonstrate poor wound healing or who have a pre-existing deficiency. However, improved wound healing is generally only observed in those patients with previously low tissue levels or a history of poor wound healing. Furthermore, bio-availability of excessive intakes of zinc in zinc-sufficient patients is likely to be poor, since absorption and retention of zinc diminish with greater intakes or as body stores are repleted. Enteral intakes of 50 mg elemental zinc per day or more, (which is the amount retained during zinc deficiency) are accompanied by substantially increased urinary zinc excretion in zinc-sufficient patients. In general, supplementing of two times the recommended daily allowance (RDA) is considered reasonable and safe. [46] In patients with larger burns (>50% TBSAB) 55 mg/day may better accommodate these individuals. [46] Larger pharmacological doses should be given with caution and in the context of a monitoring protocol for copper and iron status. [46]

There is little research documenting the benefit of copper supplementation during acute injury. Likewise, guidelines for its provision are sparse. Although urinary copper excretion is further increased with copper supplementation, ceruloplasmin synthesis can be moderately stimulated with increased copper intake. Because ceruloplasmin levels do not normalise as copper intake increases, exceeding the threshold for ceruloplasmin synthesis and thereby increasing non-ceruloplasmin-bound copper is a risk factor hepatotoxicity and oxidative damage. [46]

Standard enteral feedings, when provided consistently at goal rate, seem sufficient to offset urinary copper losses in adults. In adults, supplemental intakes to standard enteral therapy approximating 5 mg/day are necessary to offset cutaneous losses. [46]

Iron

Observed iron deficiency may be a functional deficiency in burned patients, since total body iron stores do not appear to be decreased during injury. Supplementing iron under these conditions can increase severity of infection and increase levels of free iron, which may be harmful as a chelator of free radical formation. [46, 49, 52] Because iron supplementation during stress and infection remains controversial, the routine supplementation for adult burned patients is not recommended. [46, 52]

Selenium

Selenium is best known for its role in the destruction of hydroperoxides as a component of glutathione peroxidase. Since it is contained within the active site of this enzyme, it is fundamental to cellular protection against oxidation. Consistent with other trace elements, plasma selenium levels are decreased during critical illness. Selenium deficiency may also be the result of a catabolic state, increased cutaneous losses, antagonisms, and insufficient intake. [46]

Selenium supplementation during critical illness appears beneficial. Low plasma levels are inversely correlated with severity scores and in one study, surviving patients demonstrated a slight increase in plasma selenium levels in response to supplementation as opposed to non-survivors. [46]

Although more evidence is needed to support the benefit of selenium supplementation on outcome, preventing a deficiency state by maintaining plasma and urine levels is prudent. This is unlikely to occur with standard nutritional therapy and requires additional supplemental intakes ranging from 60-190 ug/day. [46] Other sources indicate that selenium supplementation may rise to 375 ug/day in burn injured patients. [48]

Anti-oxidant therapy

Vitamin supplementation as a means of antioxidant therapy is attractive. However the pathophysiology of oxidative damage and the complex network of antioxidant defence systems limit our ability to define therapeutic modalities. The benefit of single versus multimodal antioxidant therapy, appropriate dosing, administration schedules and identifiable risks and toxicities must be clarified. At best, supplementation to standard nutritional therapy, as part of a multivitamin regimen, to accommodate increased use is advised. [46]

Table 2.5 outlines a summary of the micronutrient requirements of healthy individuals and critically ill patients.

Route of nutritional support

After deciding on the appropriate macro- and micronutrient composition for our burn injured patients, the next step would be to decide on the appropriate route for nutrition support. Thus we should consider oral diets vs. total enteral nutrition (TEN) vs. total parenteral nutrition (TPN), or a combination of these when feeding our burned patients. The particular route chosen should depend on the severity of burn injury, the site of the burn injury and the functioning of the gastro-intestinal system.

Table 2.5: The micronutrient requirements in healthy adults and in critically ill patients:

Micronutrient	DRI's for healthy individuals. [53]	Possible requirements of critically ill patients.
Vitamin A	700-900 ug/day or 2400-3000 IU	10 000-25 000 IU [20, 46, 47,] or 3000 – 7500 ug/day
Vitamin D	50 ug/day	No current recommendations available
Vitamin E	15 mg/day	100-1000 mg/day [20, 48]
Vitamin C	75-90 mg/day	200 mg/day [46] 1000 mg/day [47,51] 500-1500 mg/day [50] 2000 mg [20]
Thiamine	1.2 mg/day	10 mg [20]
Riboflavin	1.3 mg/day	10 mg [20]
Niacin	16 mg/day	200 mg [20]
Vitamin B6	1.3 mg/day	20 mg [20]
Folic Acid	400 ug/day	2 mg [20]
Vitamin B12	2.4 ug/day	20 ug [20]
Pantothenic acid	5 mg/day	100 mg [20]
Biotin	5 mg/day	5 mg [20]
Selenium	55 ug/day	60-190 ug/day [20,46,] 350 ug/day [48, 51]
Copper	0.5-1.5 mg/day	2-5 mg/day [51]
Zinc	11 mg/day	25-35 mg/day, [46, 51] 50 mg [20]

Oral diet

The use of the gut plays an important role in patient outcome in the critical care setting. [54] The acquisition of early enteral access and use of the gut promote an increase in the mass of gut- and mucosa-associated lymphoid tissue (GALT and MALT). This contributes to an orderly immune response mediated by mature T- and B-lymphocytes, and the incidence of complications and adverse outcomes diminishes. [54] It thus seems logical to use oral diets or TEN as the first options when considering the route for nutrition.

In patients with less severe burn injury, it is often possible to make use of oral diets. Adequate oral intakes can often be achieved by patients with less than 20% TBSA burns if attention is given to their food preferences. [29] Consistency changes may be necessary in cases where facial burns are present or where dysphagia is a problem. Also, burned patients may often experience decrease in appetite during the acute phase post-burn period. [30] It is important to encourage and motivate the patient to ensure adequate oral intake.

Food intake must be guided and monitored so as to meet nutritional goals, especially in terms of energy and protein.

Oral nutrition supplements (commercial or homemade) are often used to increase the energy and protein intake of the patients. Appropriate supplements should be considered that is not to high simple sugar or fat (increasing the risk of hyperglycaemia) and a protein and energy content that is sufficient to meet the requirements. Osmolarity must be considered to decrease hyperosmolarity-induced problems such as diarrhoea. Finally, palatability is a big problem and selecting the supplement that the patient will actually drink is of importance. [17]

However, recently, The American Society of Parenteral and Enteral Nutrition (A.S.P.E.N) concluded that "specialised nutrition support' [i.e. total enteral nutrition (TEN) or total parenteral nutrition (TPN)] should be initiated when it is anticipated that critically ill patients will be unable to meet their nutrients orally for a period of 5 to 10 days", [55] and Rodriques [29] suggested that more aggressive nutrition is warranted when patients with more than 20% TBSA burns are unable to meet dietary intake goals orally. [29] Other feeding routes may therefore be warranted, either alone or in combination with oral diets.

Total enteral nutrition (TEN)

Enteral nutrition after burn injury is necessary when the needs for energy are not guaranteed with oral diets. The literature refers to these indications for enteral nutrition: [14]

1) More than 20% of TBSAB is affected by burn.
2) Natural nutrition is impossible because of certain state of consciousness.
3) Face burn, injury of the respiratory tract, artificial ventilation or tracheostomy.

4) Malnutrition prior to burn injury.

Failure to obtain enteral access and to provide nutrients via the enteral route may result in a pro-inflammatory state mediated by macrophages and monocytes. Oxidant stress is increased, severity of illness is exacerbated, and the likelihood for the systemic inflammatory response syndrome, infectious morbidity, multiple organ failure, and prolonged length of stay is increased. [27, 54,]

There is overwhelming evidence that the enteral route for nutrition delivery is far superior to the parenteral route (Table 2.6). [6, 8, 9, 14, 20, 22, 29, 38, 45, 55-60]

Table 2.6: The advantages and potential complications for using the enteral route in burned patients:

Advantages:	Possible complications
• Effective preservation of gut barrier functions [20, 22, 26, 56-58] and protects intestinal mucous membrane. [14, 22]	• Enteral feeds are withheld before, during, and after surgical procedures, leading to loss of important nutrition. [63,64]
• Gut absorption of protein leads to higher nitrogen retention than delivery of TPN proteins. [16, 20, 56]	• Possible diarrhoea and vomiting. [57,60]
• Preserves the immunological function of the gut, [8] prevents bacterial translocation [14, 56, 58, 61] and thus fewer septic complications [8, 22, 56, 58, 59] and infection. [6, 16, 26, 61]	• Aspiration pneumonia. [6,7]
• Cost benefits over TPN. [8, 14, 26, 55, 56, 59]	• High gastric residuals and abdominal distension. [6,7,14,55]
• Decreased hospital length of stay. [6, 16, 56,]	• Intestinal necrosis. [16]
• Suppress the hypermetabolic response to stress. [22, 45, 56, 57]	• Problems with tube obstruction and placement [14,60]
• Higher survival rate [14, 22, 56, 59, 61, 61,] and improved clinical outcome. [22]	• Metabolic complications such as hyperglycaemia, electrolyte imbalance, hypercapnia. [56]

The main disadvantage of enteral feeding is that the feeds need to be withheld for several hours before, during and after surgery. Burned patients often undergo several surgeries during a short period, thus leading to frequent disruption of feeds. This procedure has long been believed to be necessary to decrease the chance of gastric reflux and vomiting which can result in aspiration. [63, 64] However, in at least 2 well-designed studies it was shown that when enteral feedings were placed past the pylorus and careful attention was given to the peri-operative procedures designed to decrease the reflux and to monitor for its occurrence, peri-operative feeding was a safe strategy. It is suggested in the literature that facilities who discontinue feedings for patients with burn during surgical procedures should reconsider this practice, since more than about 30% of the calculated energy needs were not met due to interruption of feeding, which may be important to a hypermetabolic burned patient. [63] Further studies are needed to determine the feasibility of peri-operative feeding and the impact of nutrient losses during surgical interventions on the recovery and outcome of burned patients. [63]

Bowel necrosis is always a concern in critically ill patients. Although the aetiology of necrosis is unknown, pre-disposing factors include the use of vasopressors, the presence of haemodynamic instability or shock, and then of course the presence of enteral substitute. In patients with severe physiological stress, perfusion of the gut is significantly reduced in favour of perfusion of other more immediately vital organs. As a consequence it has been suggested that the body's attempt to increase mesenteric blood flow in response to aggressive enteral feeding in combination with a metabolically stressed bowel is the underlying mechanism that precipitates bowel necrosis. [16, 56] Feeding practices such as the choice of substrate, (e.g. polymeric vs. elemental vs. fibre enriched etc.) energy density, osmolality, implementation time and rate of progression of feedings could consequently be related to the occurrence of intestinal necrosis. [56] It seems that while the patient is still unstable, administering hyperosmolar feeds or fibre-enhanced feeds could be risk factors of developing intestinal necrosis, although data on this is not clear. [56]

Bowel necrosis has been reported to be extremely rare in burn injured patients [16, 60] and the relationship to enteral nutrition is not clear. Feeding-associated bowel necrosis does not seem to be directly related to early aggressive enteral nutrition support in incompletely resuscitated patients. [16]

Factors that might decrease possible TEN complications can include:

- Early initiation of nutrition to prevent or shorten post-operative ileus. [57]

- Starting the formula at a low rate (10-25 ml / hour) and increasing the formula rate based on the patient's condition. [57]
- Elevating the head of the bed to 45° or more to prevent aspiration. [9, 55]
- Post-pyloric placement of the feeding tube. [6, 54, 58]
- Frequent assessment of residual volume. [6]
- Use of pharmacological agents that may increase gastric motility. [6,55, 58]
- Regular flushing of the tubes with sterile water, before and after administration of medication and feeds .[8]

A study done by Madiba et al [57] in South African critically ill patients concluded that the majority of patients in an intensive care unit (ICU) setting tolerated enteral feeding well. According to the study, enteral feeding appeared to be safe to be commenced in the absence of bowel sounds and that residual gastric volumes did not correlate with the development of enteral feeding-related complications. [57] More studies are however needed in burn wound patients in the South African setting on the tolerance and occurrence of complications with enteral nutrition.

Enteral nutrition could be an optimum approach but patient participation is necessary, which can be problem in the presence of pain, agitation and sedation. [17]

Possible route for enteral nutrition

Despite all the evidence that enteral nutrition may be superior to TPN, obtaining enteral access early in the course of illness may be very difficult. [54]

The nasogastric tube (NGT) is most commonly used to provide access to the gastro-intestinal tract, [26, 59] and this method is agreed to be the most physiological one. [14] However, long-term use of the NGT is not without problems and can even give rise to considerable complications. [26, 59]

Possible problems associated with NGT feeding include:

- Patient discomfort [26]

- Erosion of the naso-pharyngeal mucosa [26]
- Gastric stasis [8, 9, 26, 59]
- Vomiting and subsequent disposition of the tube [8]
- Aspiration [14]
- Diarrhoea [14, 59]

Traditionally TPN has been used with the failure of NGT feedings, especially when gastric stasis or vomiting occurred. [8, 59]

The option of post-pyloric feeding as part of routine clinical practice has not been extensively researched and may be a feasible option when the above-mentioned problems with nasogastric feeding occur in this patient group, [8, 14, 58, 59, 38] rather than giving TPN. In addition to advantages of cost, nasojejunal feeding may be safer than TPN. [59]

Post-pyloric feeding includes nasoduodenal tubes (NDT), nasojejunal tubes (NJT), and jejunostomies. NJT feedings are usually preferred because of better absorption of nutrients and tolerance of enteral feeding despite the absence of bowel sounds or states of slowed intestinal motility. [6, 58] Studies showed nasojejunal feeding to be safe and well tolerated in burned patients. [59]

Gastric feeding in the first post-burn day is known to have an 18% failure rate due to regurgitation, whereas, using the duodenal approach, even early high calorie feeding is very well tolerated with nearly 100% success rate. Therefore duodenal feeding seems to be superior to gastric feeding at least in the immediate feeding regimen after admission. [45]

One study done in 2003 by Boulton-Jones et al. [8] showed that post-pyloric feeding was feasible in a wide variety of critically ill patients including those in intensive care, and those with major burns. They found that post-pyloric placement of the tube had the highest success rate in ventilated patients with burn injury. The estimated nutritional requirements were met in 90% of patients in whom the tube was successfully placed. It must however be kept in mind that only 14 of the 146 patients enrolled in the study were burned patients. Therefore further studies are required to determine the success of post-pyloric feeding in burn injury patients. [8]

The disadvantage of post-pyloric feeding is that it involves using skilled health care personnel (radiologists/endoscopists) [8, 54] and equipment for the correct placement of the tube with added expense. [8] It is possible to pass the tube blindly into the stomach and then let it progress spontaneously past the pylorus but authors report differing success rate for this method. [8, 54] It is not possible to place the tube blindly when gastric stasis has already developed. [59]

Although technically feasible, fluoroscopic placement of a feeding tube is not hazard free. Transporting the patient out of the ICU to the radiology suite is difficult because of medical/surgical instability, the potential loss of lines and tubes and the likelihood for development of serious complications. [54]

Specifications for use of a post-pyloric tube: [6, 8]

- Dedicated radiologist to place post-pyloric tube using fluoroscopic screening to guide tube into the jejunum, OR
- Experienced endoscopists to guide the tube past the pylorus into third part of duodenum under direct vision OR
- Tubes are passed blindly into the stomach and an extra loop is left to allow spontaneous progression of the tube past the pylorus.
- Confirmation of correct placement with endoscopic or radiological screening or abdominal X-ray.
- Regular four hour flushes with sterile water to prevent tube blockages.
- Anti-emetic therapy to reduce vomiting and loss of tube position.
- To securing tube at the cheek rather than the nose is important to prevent displacement of the tube.
- Ongoing nursing assessment of the feeding tube placement to prevent migration of the tube into the oesophagus or pulmonary system.

The alternative, especially when planning long-term nutrition, is a percutaneous gastrostomy. Performing nutrition through the PEG also lessens the risk of regurgitation and aspiration. [14]

The previous studies concerning burned patients all concluded that gastrostomy offers a safe, effective and more comfortable access for prolonged enteral feeding than nasogastric tubes. The placement of PEG tubes through burn wounds added no increase in complications and no mortality or major complications occurred due to the use of PEG. The authors of previous studies found no reason to support the view that the abdominal wall overlying the proposed site of PEG placement should be epithelialised with unburned skin, healed donor site, healed burn or durable skin grafts. They do agree that it is important to pay attention to the amount of tension between the stomach and abdominal wall and also between the skin sutures and the tube exit site, allowing for necessary stomal site drainage. For these reasons they recommended daily turning of the PEG tube. [26]

Known contra-indications to PEG placement are missed diaphanoscopy, inability to visualize indention, ascites, extreme obesity, gastric malignancy or ulcer, gastro-intestinal obstruction, severe coagulopathy, Crohn's disease and general contra-indications to enteral feeding such as severe malabsorption or ileus. [26]

Infections of the insertion site, tube blockage, tube dislocation and local pain are reported in the literature as minor complications. Major complications include peritonitis, major haemorrhage, perfusion and gastro-colic fistula. The complication risk after the PEG procedure appears to be related to the nutritional status of the patient. Patients with cachexia, anorexia nervosa or peritonitis show a disturbed adherence of gastric and abdominal walls as a result of which complications are more likely to develop. Accordingly, patients with these conditions should be monitored extra carefully. [26]

PEG tubes can be inserted under intravenous sedation, and local anaesthesia, or alternatively in theatre in conjunction with other surgical procedures e.g. wound excision and grafting. [26]

The authors concluded that the use of PEG in patients with burns who require prolonged nutritional support is a preferable alternative to the use of a NGT. [26] The utilization of PEG is without doubt important for patients having large body surface burned or respiratory tract burn. [14]

Volume and Frequency of the feed

A feed is typically commenced at 25 ml/hour and increased by 25 ml every 12 hours, or slower if the patient is at risk of re-feeding syndrome. [8, 14, 57] Re-feeding may be a greater risk in a country like South Africa where pre-existing malnutrition in individuals is common. The patient's condition must be carefully assessed upon deciding what volume should be started. [57]

Some clinicians use early aggressive enteral nutrition before the patients has reached haemodynamic stability [16] (i.e. goal rate on Day 1) but there is still a concern about the probability of harm associated with aggressive enteral nutrition and there are currently insufficient data to make recommendations. [55]

Accurate documentation on the volume of enteral feeding that the patient actually received is an important element in assessing the attainment of nutritional goals.

The critical volume that may be needed to maintain gut integrity, limit permeability, prevent bacterial translocation, activation of macrophages, and attenuate the overall stress response, may be closer to 50-60% of requirements or "goal feeds".

Greater attenuation of the stress response has been shown to correlate with increasing percentage of goal energy infused. Serum albumin, a marker for the stress response in the intensive care unit, increased significantly (suggesting greater reduction in the stress response) with an increased percentage of goal energy infused. [54]

Whether enteral feeds should be delivered using a continuous or intermittent regimen, however remains controversial. There is limited evidence that shows that higher gastric pH was associated with gastric colonization and that intermittent feeding reduces gastric pH. Other studies contradicted this and showed that intermittent feeding did not consistently reduce gastric microbial growth. [57] Intermittent feedings may even be preferable in terms of nitrogen balance, nutrient absorption and visceral protein synthesis. [65] Note however, that disruption of enteral feeding due to surgery, procedures and complications of enteral nutrition may lead to a smaller volume delivered than proposed. There is a temptation to increase the flow rate of the intermittent feeds to make up for lost volume, however practical experience has taught us not to feed patients more than 130 ml/hour for the prevention of complications.

It is important to note that tubes should be flushed 4 hourly with 50 ml sterile water. [8]

Type of enteral product

Given the above-mentioned evidence that enteral nutrition is beneficial, especially when administered early, does it make a difference which feeding product is used? With a variety of enteral nutrition products available, the decision-making process can be difficult. [61]

Several investigators evaluated the effect of elemental and polymeric diets with or without the addition of fibre on intestinal bacterial overgrowth, translocation and subsequent infections morbidity and death. In critically ill animal models, intact peptide-based formula resulted in less bacterial translocation and improved survival compared with animals receiving elemental amino acid diets. [61] Although the exact mechanism is unclear, predominantly insoluble, bulk forming fibre products are associated with a reduction in translocation in animals. [61]

Gut blood flow is reduced in patients after various forms of critical illness. The presence of luminal nutrients may increase oxygen supply to the gut, beyond that which can be satisfied by the available delivery, which may potentially lead to gut ischemia. Complex nutrient solutions containing protein, carbohydrate and fat induce larger hyperaemic responses than solutions containing the individual constituents. [16] It may thus be wise to start with a semi-elemental or elemental product in the more critically ill burned patients (i.e. patients with more than 40% TBSA burn). Eventually one would look at a product with high energy, high protein and low fat to feed the hypermetabolic burned patient. [8]

One of the following types of feed can be used, depending on what would best meet the patient's requirements [8]:

- 1 kcal/ml feed – whole protein
- 1.5 kcal/ml feed – whole protein
- Fibre feed with soluble and insoluble fibre
- Peptide feed / Semi-elemental feed
- Elemental feed

Open- and closed system feedings

Enteral feeding solutions are media conducive to bacterial growth, and enteral feedings have been identified as a potentially important source of nosocomial infection. [65] This is an important aspect to consider in already immuno-compromised burned patients who have an increased risk of bacterial translocation, infection and sepsis.

Open-system feedings can be defined as feeds that are decanted or opened and poured into a bag or a bottle. They fall into two categories: [65]

1) Products not available in closed-system packaging.
2) Base formulae that were mixed with modular feeds.

Closed-system products are spiked and hung in the manufacturer's sterile container. [65]

It has been shown that use of open-system feedings may present a contamination risk. Most open-system formula mixtures are protein modulators added to high-protein or critical care formulae that otherwise did not meet patients' estimated needs.

If open-system feeding is used, strict hygienic measures needs to be implemented: [65]

1) Closed formula room, specifically used for mixing of formulae and nothing else.
2) Trained food service staff.
3) Clean techniques (gowns, masks, gloves).
4) Tops of cans swabbed with alcohol before opening.
5) Feeding blender properly cleaned and sterilized.
6) Strict 6-hour hang-time for all open-system formulae.
7) Use of sterile water for mixing and diluting the feeds.
8) Feeding sets not used for longer than 24 hours.
9) Feed not kept refrigerated for longer than 24 hours.

Closed system formulae could hang for 24 hours, based on manufacturers recommendations. [65] Thought should be given to the additional cost of closed system as opposed to the open-system, when considering its use.

Timing of enteral nutritional support

Once nutritional needs have been assessed and the route for nutrition has been decided, the next decision is when to start feeding the patient. [6]

There has been increased awareness of the fact that the sooner enteral nutrition is used peri-operatively or post-injury, the more apparent the improvement in outcome variables. Most clinicians advocate the early institution of enteral nutrition in critically ill or injured patients despite the lack of strong clinical evidence.

Furthermore, there is general acceptance that this method of feeding is technically safe. [56]

Most authors agree that feeding should begin as soon as possible, ideally within the first 24-48 hours after injury, [6, 8, 14, 17, 55, 57] presuming that the patient is haemodynamically stable. [19]
This may be especially necessary when the patient is malnourished, prior to the insult. [4, 17]

Studies showed the advantages of early enteral nutrition. They include:

1) Less translocation of bacteria. [14, 16, 56]
2) Lessening the hypermetabolic response and catabolism after burn, [14, 19, 56] due to possible lower levels of cortisol and glucagon and reduced excretion of urinary catecholamines. [14]
3) Protection of gut barrier function [16, 54, 56] and mucosal integrity. [16, 56]
4) Possible prevention of the accrual of energy deficit. [56]
5) Fewer infectious complications. [56, 16]
6) Stimulation of insulin secretion and conservation of lean body mass. [22, 56]

Delay in treatment may exacerbate catabolism, promote more extensive bacterial contamination, and may increase the frequency of clinical sepsis. [19]

Increasing information in human studies suggest that changes in gut integrity occur very early, within hours of acute injury. The timing of initiation of enteral tube feeding significantly affects the degree to which the provision of enteral nutrients protects or maintains gut integrity and protect against adverse patient outcome. Peng et al [66] studied 15 burned patients and 10 healthy control patients to evaluate the effects of early (<24 hours) vs. delayed (> 48 hours) nasogastric or oral feeding. Both serum endotoxin levels and tumour necrosis factor (TNF) levels were increased in all burned patients, but they were significantly higher in the delayed feeding group. The ratio of lactulose to mannitol, a standardised measure of gut permeability, was significantly higher in the delayed feeding group on post-burn days 1, 3 and 5 compared with the early feeding group. Thus the changes in permeability began within 6 hours of the burn, and the effects of feeding on reducing permeability changes, decreasing host exposure to endotoxin, and reducing subsequent TNF levels were seen 7 to 12 hours post-burn. Other studies have confirmed that increases in permeability correlate with the higher incidence of sepsis and clinical infections. The effect of early enteral nutrition in protecting against the permeability changes is more marked in patients with burns and trauma than patients undergoing routine elective surgery. [54]

Prospective studies should be conducted in South Africa's burned patients to determine whether early enteral nutrition will help reduce the amount of infectious complications and reduce the hospital treatment time and whether it will make the possibility of survival higher. [14]

Clinical judgement needs to be exercised with the initiation of feeds close to the time of injury. Patients should be fully resuscitated and off pressor agents, as the initiation of feeds in a haemodynamically unstable patient may precipitate bowel ischaemia. [54]

Total parenteral nutrition (TPN)

Total parenteral nutrition should only be considered when enteral access cannot be obtained, enteral feeding fails to meet the nutritional requirements of the patient or use of the gastro-intestinal tract is contra-indicated by injury or disease processes. [6] Other reasons why TPN may be considered are: need for high-dose vasoactive intravenous medication, [6] and unattainable gastro-intestinal accesses. [6]

The greater the severity of illness, the greater the degree, to which outcome is altered by the decision to use the enteral route. Studies now show that aggressive enteral tube feeding clearly reduces complications when compared with "standard therapy" in which no nutritional support is provided. The timing of initiation of feeds is important, with the greatest benefit realised with early enteral feeds (<72 hours from time of insult or injury). Thus early enteral nutrition may be considered a pharmacological agent, by which the patient's disease course may be altered, leading to a more favourable outcome. [54]

The issue of safety and the possible development of bowel necrosis or ischemia remain unanswered in the literature. It is said that our understanding of the aetiology of adverse events is too limited and multi-factorial to recommend that early enteral nutrition support be withheld for patients perceived to be at increased risk. [56] Further studies are needed to establish precise feeding implementation times that maximize clinical benefit while minimizing morbidity in the critically injured. This should lead to a better understanding of indication and contra-indications of early enteral support, hence optimizing the safety and efficacy of its application in critical care. [56]

Recent recommendations by Jacobs et al in the nutritional support of the trauma patient based on recent Class I-III evidence [9] suggested that the hypermetabolic state of severely injured patients requires that energy and protein goals should be achieved by Day 7. Patients who fail to tolerate at least 50% of their goal rate of enteral feedings by this time should have TPN instituted. [9]

Some authors [11, 55] agree that TPN should not be started at the same time as enteral nutrition. With a combination of parenteral feeding in addition to maximally tolerated enteral nutrition to reach this energy delivery goal, investigators noted that mortality increased, liver function reduced and immune response was impaired relative to enteral feeding alone. This effect could have been related to overfeeding. [11] In the patient who is not tolerating adequate enteral nutrition, there is insufficient data to put forward a recommendation about when TPN should be initiated. It is recommended that TPN should not be started in critically ill patients until all strategies to maximize TEN deliveries (such as the use of small bowel feeding tubes and motility agents) have been attempted. [55]

TPN does not come without complications. The administration of TPN may increase endotoxin translocation and may lead to impairment of mucosal integrity, increased intestinal permeability, [45] increased risk for infection and catheter-related complications. [55, 58] To minimize the risk for complications a dedicated central infusion line should be used for the administration of TPN and the solution should be considered incompatible with other medications because of the pH differences of many medications and TPN solution. [6] A sterile technique in the care of central access and administration of TPN is necessary to prevent local and systemic infections. [6, 58]

Nutrition in the ventilated patient

When a victim inhales hot gases or flaming substance of some type the resulting injury is often confined to the upper airway. Large particulate matter may be trapped in the passages of the naso- or oropharynx. The sub-glottic airway is often protected from severe thermal injury, although erythema and inspiration of smoke residue into the tracheobroncial tree may occur. The result is usually localised trauma above the larynx, with possible mucosal burn and blistering and rapid swelling caused by profound oedema of the affected structures. The patient usually requires intubation to maintain a patent airway until this reaction subsides. The patient is also at a significant risk for developing acute respiratory distress syndrome (ARDS) or pneumonia, requiring prolonged ventilatory support. [67]

In critically ill, ventilated patients, malnutrition is associated with impaired immune function, impaired ventilatory drive and weakened respiratory muscles, leading to prolonged ventilatory dependence and increased infectious morbidity and mortality. [55] However, predictive equations used to calculate energy requirements in burned patients often over-estimate energy expenditure in patients receiving mechanical ventilation, particularly when such patients are chemically paralysed. [68]

During paralysis the REE is significantly decreased by 24-33%. Routine use of indirect calorimetry is once again recommended in ventilated, chemically paralysed, critically ill patients. [68]

Alternatively the predictive equations used for obese patients, can also be used for patients on mechanical ventilation. [40]

Overfeeding should be avoided, especially in the patient with pulmonary injury, because respiratory elimination of excess carbon dioxide production adds the additional work of breathing to an individual already suffering pulmonary compromise. Periodic monitoring of urinary nitrogen (N_2) is easily done, with positive N_2 balance indicating adequate nutrition to allow wound healing. [67]

Patients who do not initially require intubation may still be unable to take adequate nutrition by mouth because of dyspnoea or dysphagia. Oral intake should be the primary dietary support only in patients whose injury is supra-glottic and mild, likely to subside within 2 to 3 days. For all the others with inhalation trauma, early placement (within 24 hours) of enteral access for feeding is recommended. [67]

Evaluation and monitoring of nutrition support

The majority of recommendations for the determination of energy, macro- and micronutrient needs are at best only a rough estimation and thus the potential exits to either over- or underfeed any given patient. Therefore, some form of nutritional monitoring is essential to assess the adequacy of the initial nutritional prescription. [9] It is essential that nutritional support be monitored and adjusted as needed to maintain goals and minimise complications. [14,17] Insufficient nutritional support may lead to poorer wound healing and malnutrition.

Anthropometric measures

The measurement of body weight is one of the recommended assessment methods in burned patients. [14, 29] Care should however be taken when interpreting the results, since fluid shifts and oedema are very common occurrences in burned patients, and could influence measurements. [28] After hospital admission, daily weights without dressings and splints are recommended. [29]

Tolerance to enteral feeding

Tolerance to enteral nutrition should be constantly observed. [14] High gastric residual volumes after a period of rest from feeding are used as a marker of gastric intolerance. In general a value of 150-200 ml has been suggested as the cut-off value.[57, 97] The frequency at which residual volumes should be measured have varied from 4-hourly to 6-hourly daily. [57]

Biochemical evaluation

Routine laboratory analysis should be carried out: blood glucose levels, electrolyte values, measures of kidney and liver function and measures of protein metabolism. [14]

Major electrolyte shifts occur with burn injury and nutrition. Increased provision of key electrolytes is needed to avoid major complications. Hypernatraemia can indicate inadequate hydration. [17]

Albumin levels correlate poorly with nutritional status and should not be used to determine the adequacy of nutritional support. [9, 29] The reason for this is mainly because of its long half-life and its high exchange rate between the intravascular and extra-vascular fluid compartment, which is ten times higher than its synthetic rate. [9] The patient with burns also has fluid shifts and protein losses through the wounds that may distort albumin levels. [29]

Pre-albumin is the most suitable indicator of nutrition in burned patients. [9, 14, 29] Pre-albumin has a much shorter half-life of only 2-3 days. Pre-albumin and transferrin correlate well with negative nitrogen balance. [38]

Protein indicators like albumin, prealbumin and retinol binding protein (RBP) are excellent prognostic indicators of morbidity and mortality. [9, 14]

Stress-induced hyperglycaemia is common in the acutely ill patient and is exaggerated in the hypermetabolic burn-injured patient because of the magnitude of the stress response and the presence of counter-regulatory hormones such as catecholamines, glucocorticoids, and proinflammatory cytokines. [6, 69] Hyperglycaemia can be loosely defined as plasma glucose levels of 8-11 mmol/L, or higher in the absence of a diagnosis of diabetes. Significant adverse outcomes have been documented in patients with persistent hyperglycaemia. The primary complications are impaired immunity, infections, poor wound healing, multiple organ dysfunction and death. [6, 69]

Nurses can play an essential role in monitoring the trend of serum glucose levels that must be treated with intravenous insulin to achieve a nearly normal serum glucose level (4.5-6.1 mmol/L). [69]

The use of exogenous insulin to maintain blood glucose at a level no higher than 6 mmol/L reduces morbidity and mortality among critically ill patients. [69]

If there is no insufficiency of kidney function, nitrogen balance is a good indicator of nutrition state and deficiency. Nitrogen balance is the difference between obtained and lost nitrogen. [14] The nitrogen-balance study, despite its limitations, tends to be the gold standard for assessing the adequacy of a nutritional regimen, particularly when evaluating whether the protein intake is sufficient. [9, 21, 29] One of the most common formulae for determining nitrogen balance follows:
Nitrogen balance (g/day) = protein intake (g/day)/6.25 – (urine urea nitrogen (g/day) + 4).

Some clinicians alternatively estimate total urinary nitrogen as 1.25 times the urine urea nitrogen excretion rate. [21]

Nitrogen balance studies are often fraught with error due to an over-estimation of intake and under-estimation of excretion due to an inadequate urine collection. Meticulous care must be taken on the part of the nursing staff and nutrition support service regarding accurate recording of intake and complete collection of 24 hour urine. [21, 29] Many people will argue that this is not a very practical method in an everyday hospital situation.
Serum triglycerides measure adequacy of fat clearance and should not exceed 250 mg/dL. If elevated, fat intake should be decreased. [14, 17]

Other laboratory tests that should be conducted include phosphorus, magnesium, and carbon dioxide screenings. Decreased phosphorus levels can cause decreased tissue oxygenation and respiratory muscle weakness. Low magnesium levels can cause respiratory muscle weakness and increased weaning difficulties in ventilated patients, and low or high carbon dioxide levels can lead to decreased respiratory effort and prolong ventilatory weaning. [38]

Dietary intake

It is very important to observe and assess the patients' daily dietary intake, whether it is an oral diet, enteral nutrition, TPN or a combination of these. Accurate chartings of food intake, volume of enteral nutrition or TPN administered may give important information as to the total intake of any given patient.

Immuno-nutrition in burn wound patients

The gut is the largest immune organ in the body. As a result, the degree and manner to which the gut is used for nutritional support have significant implications for the nutritional management of the acutely ill burned patient. Nutrition, specifically immune-enhancing agents such as glutamine and arginine administered via the enteral route may provide maximal nutritional benefit. [6]

The importance of some specific nutrients in burned patient has been suggested; these substances have received special attention in recent years. They are called immunomodulators. It is determined that these substances have a positive effect in protein metabolism, immune state and function of the intestines. [14]

Glutamine

Glutamine, its functions and possible benefits are very well described in the recent literature. Glutamine comprises 60% of the total free amino acid pool, [6, 70] (thus the most abundant amino acid in the body) [17, 71, 72] and provides multiple functions. Glutamine is synthesized in large quantities in the muscle, and is a major vehicle of transport of amino-nitrogen to organs like the intestine, liver and the kidney. [71] Glutamine is the preferred respiratory fuel for enterocytes, hepatocytes, lymphocytes, and macrophages. [6, 70-74] Glutamine is a precursor for nucleotide synthesis as well as glutathione an important anti-oxidant. [72, 73, 75] Furthermore, glutamine is involved in ammoniagenesis and therefore largely responsible for acid-base homeostasis. [6, 71, 72, 75]

Under normal circumstances, glutamine is considered to be a non-essential amino acid. [70, 71, 72, 74, 75] Several studies however have shown a significant decrease in plasma glutamine concentrations in critically ill states. In catabolic states, due to conditions such as sepsis or major injury, large amounts of glutamine are released from muscle tissue, [71, 75] and glutamine uptake by the small intestine and immunological active cells may exceed glutamine synthesis and release from skeletal muscle, [6, 70-72, 76] making glutamine conditionally essential [70-75, 77]

Infections remain a serious problem in severely injured patients, [78] and infectious complications are a major cause of death in severe burn injury. [79] These infections are thought to be related to a decreased immune function and translocation of gram negative bacteria from the gut. Glutamine deficiency may contribute to these processes since we have seen that it is the preferred fuel for immune cells. [78, 79]

Provision of supplemental glutamine may also exert favourable effects on tissue concentrations and preservation of intestinal structure. [77, 80]

In 1998 Houdijk et al [78] performed a randomised trial on critically ill patients to test the effects of glutamine supplemented enteral nutrition. Patients with third degree burns greater than 15% TBSAB were excluded from the study population. Results showed that glutamine enriched enteral nutrition reduced the number cases of pneumonia; bacteraemia and septic events in severely injured patients as well as increased the plasma glutamine concentration. [78] This showed promising options for the use of glutamine in critically ill patients.

It has been reported that plasma glutamine levels of burned patients decreased by 58% and remained depressed for more than 21 days after injury. [70, 73- 77, 79, 81- 83] They suggested that the reduction of plasma glutamine may reduce immunological competence after burn injury, [70, 74, 81] and this has been correlated with increased mortality in critically ill patients. [74, 75]

Wischmeyer et al [79] performed a prospective, randomised, double blinded trial and investigated the effects of intravenous glutamine supplementation in patients with severe burns. They found that supplementation of parenteral glutamine (in addition to standard nutrition support), 0.57g/kg/day reduced the incidence of gram-negative bacteraemia, decreased overall inflammation, and improved nutritional status in severely burned patients. All patients represented in the trial had full thickness burn areas. This study is unique in using intravenous glutamine solution in addition to standard enteral nutrition support rather than as a supplement to TPN. [79] This may appear as a feasible option in burned patients where TPN is contra-indicated. Especially since enteral nutrition has become the preferred method of feeding in severely burned patients.

Garrel et al found a reduction of blood infections and decrease in mortality rate in a prospective, randomized clinical trial of 45 adult burn injured patients. Glutamine supplemented amino acid solutions for a total of 26g/day were administered in boluses via the enteral tube. [73]

Controversy exists about the use of glutamine enterally vs. parenterally. It has been argued that parenteral supplementation is preferable over enteral supplementation, as it corrects plasma glutamine levels more efficiently. But there also might be some benefits of enteral glutamine on gastro-intestinal structure. [82]

There was a greater treatment effect with parenteral compared to enteral glutamine observed in a meta-analysis. [7] One of the reasons may be that it is difficult to provide enteral glutamine at high doses, especially early in the course of critical illness, unless the glutamine dose is dissociated from the feeding product. [74] Another reason may be that most glutamine will be taken up by the gut and thus not lead to a significant increase in plasma glutamine levels. This may have implications for the immune system outside the gut. [73]

It is also suggested in the literature that glutamine supplementation should be used for at least 6 days to derive the maximum benefit. [74, 76]

A meta-analysis has shown that overall glutamine does no harm, [74, 75] and was in fact associated with a strong trend towards a reduction in mortality, a lower complication rate and a shorter hospital stay in a combined group of surgical and critically ill patients. [74] Caution must however be exercised in burned patients with renal or liver dysfunction when supplementing glutamine. It is likely that any significant protein load, whether from glutamine or other amino acids, can significantly increase ammonia in these patients. [79]

High dosage glutamine supplementation (> 0.2-0.3g/kg/day) is more effective than low dose glutamine supplementation [74-76] and up to 0.5g/kg/day is shown to be safe. [74]

It is clear from the available evidence that glutamine should be considered in burned patients. [55] To summarize, glutamine supplementation may enhance the immune response and reduce the number of infectious complications. There is a significant increase in plasma glutamine levels when supplemented with intravenous glutamine and a possible increase in the nutritional status of burned patients. In general results in critically ill patients, show an improved nitrogen balance, increased glutathione-antioxidant activity, reduced hospital length of stay and improved mortality.

A large, well designed multi-centre trial of glutamine supplementation, given to burn injured patients as a pharmacological supplement in addition to standard enteral or parenteral nutrition is definitely warranted in South Africa.

Arginine

Arginine is associated with the most controversy, having benefits but also causing possible harm in critical illness. [83, 84] Episodes of stress are associated with inadequate endogenous generation and the development of a deficiency unless it is supplemented in the diet. [83] Arginine can thus also be considered a "conditional essential" amino acid. [6, 83, 84]

Arginine is a building block for proteins, [83] plays a role in protein synthesis [84] and is also a precursor for the formation of polyamines and proline, which are important for cellular division and wound healing [82-84] Arginine is an integral component of the urea cycle and a secretagogue inducing the release of growth hormone and insulin. [81, 83, 84] In the endothelium, arginine is essential for vasodilatation through the production of minute amounts of nitric oxide by endothelial nitric oxide synthase. [81, 83, 84] Any of these functions could be causing physiological or pathological effects upon arginine supplementation. [83]

Strong evidence suggests that dietary supplementation with arginine enhances immuno-competence in adult humans and in animal models. [6, 84] Arginine has been shown to be immuno-stimulatory by increasing thymic size, by promoting T-cell proliferation and macrophage and natural killer cell function. [82]

Much of the research done on the supplementation of arginine, had study methods with many shortcomings, resulting in invalid conclusions and inferences. [84] Heyland et al [55] did a comprehensive meta-analysis of immuno-nutrition and concluded that the treatment effect of immuno-nutrition with arginine varies according to the type of enteral formula, the sub-set of patients and the quality of the study method. [55]

In patients with shock, sepsis or organ failure, arginine may not be beneficial and may actually have harmful effects and exhibit an increase in mortality. [83, 84] Sepsis induces the expression of inducible nitric oxide syntheses (iNOS), an enzyme that produces nitric oxide from arginine. Nitric oxide produced in excessive amounts may result in cell damage and uncontrolled vasodilatation and contribute to the haemodynamic instability of sepsis. Provision of arginine in these patients may be potentially deleterious. [83, 84]

Questions still exit about the effect of treatment with immuno-nutritional formulae containing arginine in critically ill patients and further research is necessary to determine the underlying mechanisms by which arginine may be deleterious. [84] Currently the recommendation exits that diets supplemented with arginine should NOT be used for critically ill patients. [55]

Omega-3 fatty acids

Fatty acids serve as a major component of the cell membrane and are involved in catalysing a large number of processes including dilatation and contraction, inhibition and promotion of clotting and cell division and growth. Unlike arginine, glutamine and nucleotides, omega-3 fatty acids do not stimulate the immune system. However, the omega-fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic (DHA), aid the immune system by competing with arachidonic acid for cyclo-oxegenase metabolism at the cell membrane. Arachidonic acid is an omega-6 fatty acid that at high levels suppresses the immune function and promotes inflammation. [85] Omega-3 fatty acids exert both anti-inflammatory properties by down regulating prostaglandin E2 and pro-inflammatory cytokines, as well as immuno-stimulatory effects by enhancing T-cell and natural killer cell activity. [82]

The ratio of omega-6 and omega-3 fatty acids in an enteral formula may be important for optimising immune function. Studies done in ventilated patients showed improved indicators of ventilator status and shorter times in the ICU with the correct ratio. [85] Recent recommendations of the optimal omega-6 to omega 3 ratio range from 2:1 to 8:1. Doses of up to 3 to 5 g/day of omega-3 fatty acids have been used in critically ill patients but no absolute requirements has yet been established. [86] The effects of fatty acid supplementation alone on burn injured patients are however still unknown.

Probiotics

There is suggestion that probiotics may exert a beneficial effect on the host through the modulation of gastrointestinal microflora. However randomized controlled trials of probiotics in critically ill patients failed to show significant changes in intestinal microflora, intestinal permeability, endotoxin exposure, or septic morbidity or mortality. [105] Further studies are needed before the use thereof is warranted.

Nucleotides

Nucleotides serve as structural units for deoxyribonucleic acid (DNA), ribonucleic acid (RNA), adenosine triphosphate, (ATP) cyclic AMP and other substances important in energy transfer such as nicotinamide adenine dinucleotide (NAD), nicotinadmide adenine dinucleotide phosphate (NADP), and flavin adenine dinucleotide (FAD). In addition to their critical functions in maintaining and transferring the genetic code as well as in energy transfer, nucleotides are thought to have important immuno-modulating properties. Dietary nucleotides are thought to enhance natural killer cell activity in mice and have been shown to reverse the depressed T-lymphocyte function. [68] Dietary nucleotides also promote protein synthesis in tissues and are also believed to be involved in T-cell functions. [68] The role of nucleotides in enteral nutritional formulae are however still being investigated.

Immune-enhancing diets (IED's)

The majority of the studies available on immuno-nutrition looked at arginine, omega-3 fatty acids and nucleotides all supplemented together in enteral formula. Despite the fact that burned patients appear to be the ideal population to benefit from IED's very few studies have prospectively evaluated in this population.

Gottsclich et al and Saffle et al published studies on the effects of IED's in burned patients. [87] Gottslich et al found a decrease in wound infection and a decrease in the total hospital length of stay. Saffle et al's study however revealed no difference in survival, length of hospital stay or ventilator days. [87] Both studies presented several issues of concerns in the methodology and statistical approach. [87]

Many questions still remain concerning the use of IED's in the burn population. The exact population and the exact level of metabolic stress required to yield optimal outcomes with these formulae are yet to be determined. [87] No enteral formula containing arginine, omega-3 fatty acids and nucleotides is currently available on the South African market.

Anabolic agents in burns

Nutrition seems to be relatively ineffective in the prevention of the massive loss of lean body mass, that follows severe trauma, and several reports indicate that a positive nitrogen balance cannot be achieved in severely traumatized patients. Thus, tissue catabolism remains elevated even in patients receiving adequate energy and nutrient supply. A number of therapeutic approaches have been developed in an attempt to improve the anabolic effectiveness of conventional nutrition. [7, 24, 45]

Human growth hormone

Human growth hormone (hGH), normally produced by the pituitary gland, is a potent endogenous anabolic hormone. Numerous studies on exogenous hGH use in burned patients have demonstrated its effectiveness at improving anabolism and decreasing metabolism, increasing the wound healing rate. [7, 11, 20, 22, 24] The quality of wound healing also seems to improve with no rise in scarring. [11] Authors also reported a significant improvement in survival after burn injury with hGH use. [20, 24]

hGH improves net nitrogen balance by decreasing amino acid efflux from skeletal muscle compartment. In addition to improving net nitrogen balance and preserving lean body mass, hGH also increased expression of structural proteins in the skin such as collagen and cytokeratin, which are important in the wound healing processes. [88] Other advantages of hGH include attenuation of the acute-phase response, improved albumin production by the liver and a positive modulatory effect on the immune response. [7, 11]

The mechanism for increased protein synthesis appears to be the increase in amino acid influx into cells via activation of growth hormone and insulin-like growth factor cell receptors. The average dose used is 0.1 – 0.2 mg/kg body weight, [11, 20] or about 10 times normal endogenous production. [20]

A number of complications have been reported, the most common being hyperglycaemia, [7, 11, 20, 22, 24] due to its anti-insulin activity. Increased insulin is often required. [20] Hypocalcaemia, [20] insulin resistance [7, 22] and fluid retention [7, 22] have also been reported.

The concerns regarding side-effects in critically ill patients have dampened enthusiasm for growth hormone therapy in adults. [7] Recent reports indicate that hGH treatment results in increased mortality in critically ill humans. Outcomes such as death, clinically significant change in function, a change in length of hospital stay or need for treatment, and adverse effects were sought. Multi-organ failure and the effects of sepsis/infection accounted for most of the excess mortality. In addition morbidity, in terms of length of ICU stay, was increased by hGH administration. Other less marked effects were increased fluid retention and hyperglycaemia as a consequence of hGH administration. The mechanism(s) of the GH-associated mortality remain poorly understood. Based on current trial evidence, pharmacological GH treatment cannot be recommended for widespread use in critically ill subjects. [104]

Testosterone derivatives

There is a significantly decrease in T-levels in patients with severe burn injuries. The anabolic effects of these androgenic anabolic steroids may play an important role weight gain in these patients. [90]

Oxandrolone is a synthetic testosterone derivative. [15, 20, 91] In contrast to hGH, oxandrolone is given orally, with 99% bioavailability [20], much less expensive [7] and safer. [90]

Treatment with oxandrolone has been shown to attenuate the hypermetabolic response, to significantly enhance muscle protein synthesis, decrease weight loss and net nitrogen loss, [15, 20] increase body mass, [15, 22, 92] improve healing time, [7, 20, 92] and improve mortality and outcome. [91] No side effects were noted in the oxandrolone group. [20, 24]
Treatment of acute burned patients with an oral dose of oxandrolone at 0.1 mg/kg twice daily or 20 mg/day improved muscle protein metabolism by enhanced efficiency of protein synthesis. [11] The use of testosterone derivatives in patients with major burn injuries is recommended. [90] Unfortunately high cost of these treatments poses challenges to health care professionals as to whether these treatments are warranted.

Insulin

Hyperglycaemia, relative insulin deficiency or both during critical illness may confer a predisposition to complications such as severe infections, multiple organ failure and death. Elevations in plasma glucose concentrations impair immune function by altering cytokine production from macrophages, diminishing lymphocyte proliferation and depressing intracellular bactericidal activity of leucocytes. In burned patients beneficial effects of insulin can be expected by a combination of increased immune response due to lower blood glucose levels and improved wound healing due to insulin by itself. [89]

Continuous infusions of insulin in severely burned patients can also stimulate muscle protein synthesis, [11, 22] without increasing hepatic triglyceride production. [11] Furthermore, it was shown to decrease mortality by decreasing the incidence of multi-organ failure with sepsis. [18, 69] There is also evidence that insulin improves hypermetabolism by affecting pro-inflammatory cytokine production and hepatic signal transcription factor expression. However it remains unclear whether insulin affects the systemic inflammatory response and the hepatic acute-phase response in humans and whether insulin exerts its effects directly, or through glucose metabolism.[18]

Intensive insulin therapy to maintain blood glucose at or below 6 mmol/L has been shown to reduce morbidity and mortality among critically ill patients in the intensive care unit. [69]

β- blockade

The most effective anti-catabolic treatment for burns has been to block raised catecholamine effects in patients with an injury. In individuals with burn injury, blocking β- adrenergic stimulation diminishes thermogenesis, tachycardia and resting energy expenditure. [11, 15] After burns, the elevations in basal energy expenditure and muscle-protein catabolism have been to found to be correlated. Because beta-blockade decreases energy expenditure after burns, long-term beta blockade may decrease the rate of muscle-protein catabolism. Beta-blockade is not without risks. It could cause hypo-perfusion as a result of decreased cardiac output, particularly in patients with sepsis. In patients with other conditions it could induce severe bronchospasm. Patients on this treatment should be very closely monitored.

Patients with special considerations

Renal disease

The key to providing safe nutritional support to the burned patient with renal failure is flexibility of approach and close monitoring. Patients with renal failure vary with respect to urinary fluid losses, and non-urinary sources of fluid and electrolyte loss. The massive catabolism of burn injury releases fixed acids, potassium, phosphorus, uric acid and nitrogenous wastes, complicating the nutritional and metabolic management of these patients. [93]

Protein-restricted diets have been recommended as part of the approach to chronic renal insufficiency. At this time, this approach has a role in the nutritional management of burned patients. Although no data are available on the subject, it seems reasonable to initiate feedings with 1 gram protein per kg body weight and advance by 10 gram of protein each day as tolerated. Reasonable goals are to maintain the blood urea nitrogen level below 100 mg/dL with a combination of dialysis and protein restriction. 1.7g protein/kg/day would seem to be the minimally acceptable protein goal for burn dialysis patients. [93] Currently the most efficient means of providing enteral nutrition to hypermetabolic patients with renal failure is to use commercial formulae, of high energy density and relatively low electrolyte content. Phosphate binders, micronutrients and additional protein, fat or carbohydrate can be added as desired. [93]

Diabetes Mellitus

Diabetes, like burn injury, also affects multiple systems. Diabetics have predilection for atherosclerotic occlusion in large vessels facilitating development of ischemic extremities. Hyperglycaemia causes increased blood viscosity, further compromising distal blood flow. Peripheral neuropathy results in decreased motor and sensory function. Finally, the diabetic patient's immune system is impaired secondary to derangements in leukocyte, macrophage, and lymphocyte function. The result of this pathology is that diabetics often exhibit wound repair failures. Their decreased sensation leads to an increased likelihood of incidental trauma with delayed recognition of injury. Poor blood supply slows ingress of oxygen and already-impaired inflammatory cells into wounded areas, thereby hampering the wound healing process and providing an anaerobic environment for opportunistic bacteria. It would seem intuitive that diabetics who incur burn injuries would have much worse courses and outcomes than non-diabetics. [94]

A major goal in the care of the hospitalised diabetic patient is to avoid the extremes of hyperglycaemia, or hypoglycaemia. A reasonable aim is to maintain the plasma glucose level between 5.5-11 mmol/L. Once nutritional support is established, more tightly regulated plasma glucose concentrations (i.e. 5.5-8.3 mmol/L) may be desirable in stable patients. [95]

Enteral products formulated for diabetics may be used, with additional modular protein if needed. Oral diets should include adequate energy and protein with complex carbohydrates and sufficient soluble fibre.

2.4. CONCLUSION

Burn injuries have important implications from a nutritional perspective. In developing countries, like South Africa, where burn injuries are fairly common, this aspect of nutritional needs should receive special attention. Nutrition methods, equations, and feeding routes should be carefully studied and adapted according to our unique circumstances and available human and financial resources in South Africa, so that we can provide our patients with optimal nutritional care during the hypermetabolic catabolic state that they present us with due to their burn injures.

CHAPTER 3

METHODOLOGY

3.1 STUDY AIM

The aim of the study was to investigate the nutritional and other treatment related practices of surgeons, dietitians and professional nurses involved in the management of burned patients in South Africa.

3.2 STUDY OBJECTIVES

1. To determine the protocols and practices regarding nutritional support implemented in burns units in SA.

   Nutritional practices for the purposes of this study included:

   - Involvement of the registered dietitian in the nutritional management of burned patients
   - Use of predictive equations in South Africa to determine nutritional requirements
   - Use of enteral and / or parenteral nutrition
   - Timing and amount of nutritional support
   - Application of immunonutrition
   - Type of products and / or diets used
   - Monitoring of nutritional status and nutritional support
   - Nutritional follow-up of burned patients after discharge
   - Use of agents / methods to reduce the hypermetabolic response
   - Working relationship of staff working in burns units

2. To compare nutritional management practices in South Africa with the latest available literature, and to make subsequent recommendations on the nutritional standards of care.

3.3 STUDY DESIGN

3.3.1 Type of Study

The study was designed as a descriptive cross-sectional study.

3.3.2 Ethics

A research protocol (Appendix 1) for this study was submitted to and approved by (Ref No. NO5/03/041) the Committee for Human Research, Faculty of Health Sciences of the University of Stellenbosch, South Africa.

All questionnaires and study participants were kept anonymous throughout the study and thereafter.

3.4 STUDY POPULATION

3.4.1 Sampling Methods

Non-random sampling was used and the names and contact information of all institutions treating burn wound patients in South Africa that complied with the inclusion criteria were obtained through an email request via the Association for Dietetics in Southern Africa's (ADSA) mailing list. Dietitians were requested to send the investigator information such as names and contact details of dietitians working in burns units in South Africa who comply with the inclusion criteria. A database was compiled of all the known burns units and the contact details of the dietitians employed there. The relevant dietitians were contacted, requested to participate in the study and were also requested to distribute the questionnaires to the surgeons in charge of the units and chief professional nurses that served as unit managers of the burns units. All the health professionals of the known burns units were included in the study. Participation in the study was voluntary and each study participant gave written informed consent (Appendix 2).

3.4.2 Inclusion and Exclusion Criteria

All institutions in South Africa with adult burns units that comprise the following were included in the study:

- Six or more beds specifically intended for the treatment of burn wound patients with or without ICU for burned patients. The purpose of this criterion was to exclude all burned patients treated as part of the surgical wards.
- One or more registered dietitians employed on a fulltime basis in the particular hospital with the burns unit.
- Patients 18 years and older (adults) irrespective of gender.

Burned patients treated in smaller surgical units or medical wards as well as children (<18 yrs) were excluded from the study.

3.5 DATA COLLECTION

Three different questionnaires (Appendix 3-5) were compiled by the investigator in order to determine the current nutritional practices in burns units in South Africa. The three questionnaires were intended for the surgeon in charge of units, the dietitian employed full-time in the units and the chief professional nurse that served as unit managers of the units, respectively. Therefore only one person representing each of the three groups were used per unit i.e. three questionnaires per unit in total.

The three questionnaires comprised questions relating to the involvement of each health professional in the nutrition and general management of burned wound patients. The questions mainly tested the current nutritional practices implemented by the various health professionals. Nutritional practices that were tested included:

- Feeding routes in patients with various degrees of injury (oral diets vs. enteral nutrition vs. TPN)
- Determination of macronutrient requirements
- The use of enteral feeding and TPN
- Volume, frequency, administration rate and products used during enteral nutrition

- The use of immunonutrition
- The use of micronutrients
- Monitoring of nutritional status via clinical evaluation, biochemical parameters, anthropometric measurements and charting of nutritional intake.
- The use of anabolic agents
- Nutritional practices in specific disease states such as diabetes mellitus and kidney failure.
- Long-term follow-up of patients with burn injuries.

Certain questions were for instance *only* relevant to surgeons, dietitians and professional nurses and other questions were repeated amongst all three questionnaires. Other issues that were addressed in the questionnaire included statistics of different burns units, the period of involvement in the unit and the cooperation, communication between the health professionals and surgical practices such as excision of wounds and skin transplants.

The questions were mainly multiple choice questions, with open-end questions where more detail was required.

The validity of the questionnaires was tested during March 2005 by testing the face and content validity of each questionnaire. Due to the small size of the study population, one pre-selected burns unit that complied with the inclusion criteria was selected. The three separate questionnaires were completed by the dietitian, surgeon and professional nurse of that particular burns unit. They were excluded from the final study population. Thereafter, necessary changes were made. Changes were made mostly to the content of the questionnaire, where more options to certain multiple choice questions were added. Where questions asked about macronutrient distribution of feeds, the questions were changed to include ranges given in the literature rather than specific numbers. The questions regarding micronutrient supplementation were also changed to provide more details about the dosages. The validity of the questionnaire was only tested once, since the changes made included only addition of more options to answers. No new questions were added.

The final questionnaires (Figure 3.1) were sent via email and pre-paid envelops were sent via post to the involved dietitians in April 2005. The dietitians were requested to distribute the questionnaires to the relevant surgeons and professional nurses. The completed questionnaires were returned by post for the deadline of 29 April 2005.

ADSA advertisement was sent out to obtain names and contact information of dietitians working in burns units that complied to inclusion criteria

A database was compiled of all relevant burns units and dietitians working full-time in the units (n = 12)

Relevant dietitians were contacted and requested to participate in the study (n = 11); no consent (n = 1)

Relevant dietitians were also requested to distribute questionnaires to surgeons in charge of the units and professional nurses that act as unit managers
All units from the databases were included in the study (n= 10); used in pilot study (n = 1)

Health professionals that decided to participate in the study returned questionnaires and consent forms to the investigator.

Figure 3.1: The flow of data collection

3.6 DATA ANALYSIS AND STATISTICS

Data was captured electronically using Microsoft Excel® spreadsheets and the investigator controlled data transfer with regular cross-referencing. Descriptive statistics were used to describe the objectives of the study using averages and standard deviations. Where the questions were not answered by all, the total number was indicated in brackets. If data was missing through transfer, the investigator updated the data sheet. The investigator was responsible for data analysis with assistance from a statistician.

The data of the three questionnaires was processed separately, and the results are presented for the three groups of health professionals respectively. Where questions were repeated amongst the three health professionals' questionnaires, the author compared the answers between the health professionals and commented on them.

CHAPTER 4

RESULTS

4.1 SAMPLE DESCRIPTION

In South Africa, there are twelve (12) burns units revealed by the ADSA advertisement that complied with the inclusion criteria and all twelve units responded. Eleven (92%) of the burns units' relevant health professionals decided to participate in the study and gave informed consent. One unit was used for the pilot study and the responses of 10 units were used in the final study. All health institutions which participated were government institutions in 6 of the provinces in South Africa. Mpumalanga and Limpopo Province currently have no burns units that treat burned patients separately, but rather treat them as part of surgical or medical wards.

Unfortunately not all the health professionals from all the units returned the questionnaires even though they agreed to participate by completing the informed consent forms (Table 4.1)

Table 4.1: The number of health professionals who returned questionnaires:

Units that participated in the study	**Expected n=10**
Surgeons	n=8 (80%)
Dietitians	n=10 (100%)
Professional nurses	n=9 (90%)

All the respondents were experienced in burn wound management judging by the number of years working in the units (Figure 4.1).

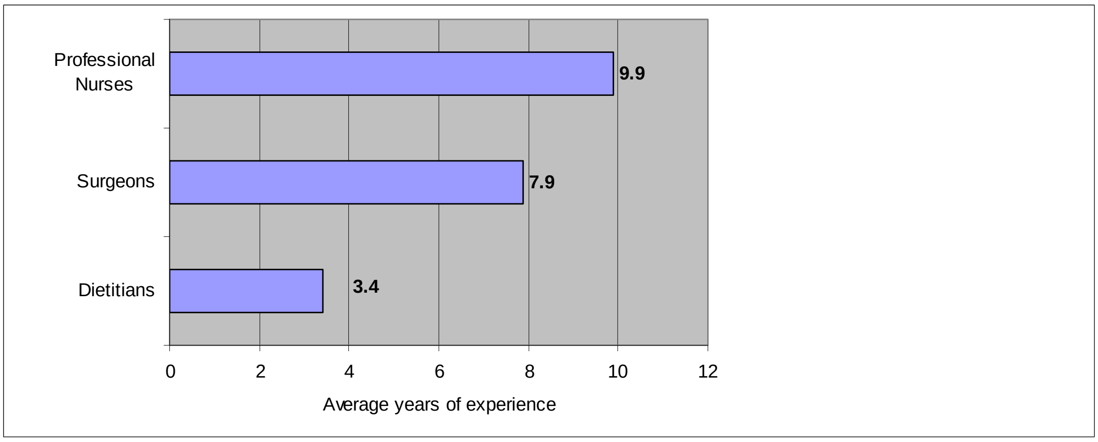

Figure 4.1 Experience of health professionals in burned patient management by the years of experience.

4.2 DESCRIPTION OF BURNS UNITS

The average South African burns unit could accommodate 20 adult burned patients and the units ranged from 12 beds in the smallest unit to 30 beds in the largest unit.

The average number of adult burned patients treated per year in the burns units in South Africa was 188 (range 58-350) and the mortality per year was 16% [Standard Deviation (SD) 6.4%]. The average length of hospital stay in the all burns units was 37 (28.2) days.

Severity of burned patients treated in burns units

Patients with smaller percentages TBSAB were treated more commonly than patients with for instance more than 50% TBSAB (Figure 4.2). The average number of patients treated decreased as the percentage TBSAB increased

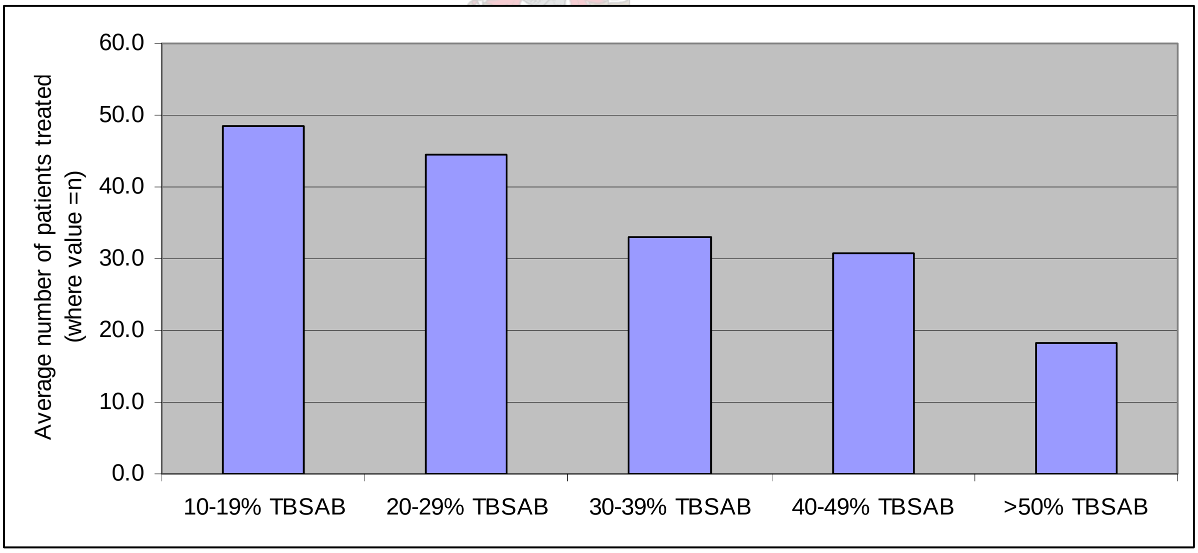

Figure 4.2 The average number of patients with various percentages total body surface area burns (TBSAB), treated in South Africa

*** TBSA = Total Body Surface Area**

The availability and use of nutritional protocols in burns units

Fifty percent of the surgeons (n=4), 33.3% (n=3) of the dietitians and 66.7% (n=6) of the professional nurses reported that their institution had a written protocol or policy for the nutritional management of burned patients. Of these health professionals that indicated that a protocol was present, all the surgeons and all the professional nurses indicated that the protocol was implemented in their institution. Interestingly, only 2 of the dietitians indicated that the protocols were implemented in their units.

Multi-disciplinary ward rounds in burns units

Multi-disciplinary ward rounds were routine in the burn institutions according to 100% of the surgeons and 88.9% of the professional nurses. There was, however, a discrepancy (Table 4.2) regarding the frequency of the multidisciplinary rounds in the data from the surgeons and the nurses respectively. The dietitians were not tested on this particular question.

Table 4.2: The frequency of multi-disciplinary ward rounds in burns units:

	Daily	Weekly	Twice weekly	Monthly	Less than monthly
Surgeons	12.5%	25%	50%	12.5%	0%
Professional nurses	0%	37.5%	37.5%	12.5%	12.5%

The role of the dietitian in burns units and communication between the health professionals

The role of the dietitian in the multi-disciplinary team was assessed. All the surgeons and the professional nurses indicated that a registered dietitian was actively involved in the management of burned patients in their institutions. All the surgeons and 77.8% of the nurses felt that there was a close relationship with the dietitians. A similar pattern was found in that 80% of the dietitians reported a close relationship with the nursing staff.

Communication between the dietitian and professional nurses was assessed separately. The majority of the dietitians felt that the communication was good, while most nurses indicated that there was excellent communication, which implied a discrepancy between the dietitians and the nurses' evaluation of the communication

(Figure 4.3). A consistently good agreement was found between dietitians and surgeons (Figure 4.4).

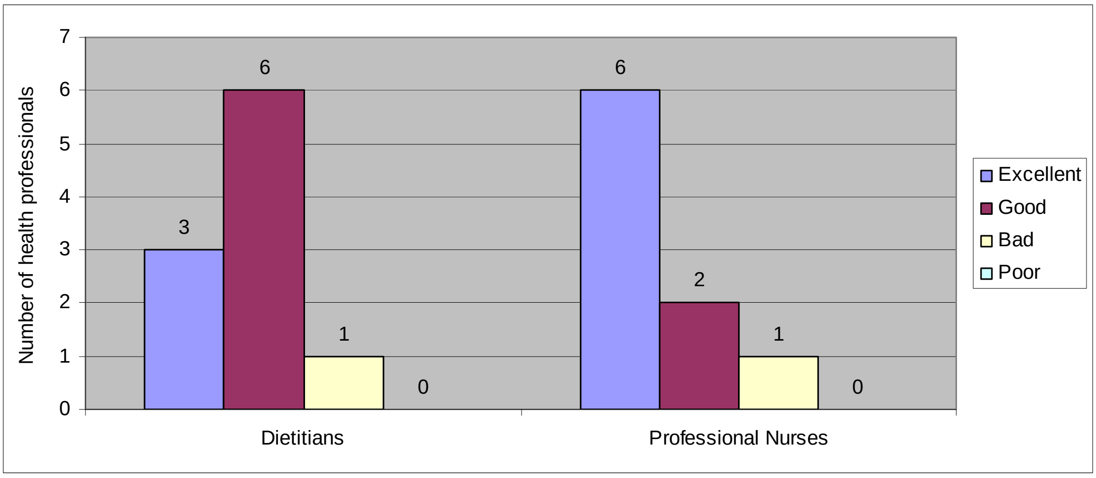

Figure 4.3 Communication between dietitians and professional nurses in burns units

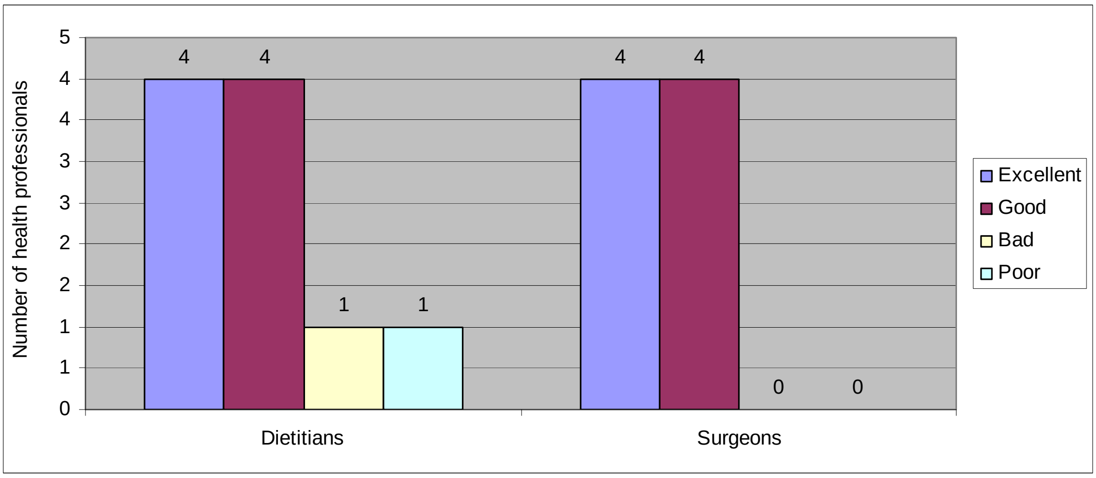

Figure 4.4 Communication between dietitians and surgeons in burns units

4.3 MANAGEMENT OF THE HYPERMETABOLIC RESPONSE

Surgery performed in burns units

The surgeons indicated that 87.5% of them performed early wound excisions, wound closures and skin transplants and they spend an average of 13 (4.8) hours in theatre per week.

The time between admission and surgery varied between patients and hospitals. The surgeons indicated that surgery was performed within 24 hours from admission (n=1), within 48-72 hours (n=1), after 72 hours (n=2) and anything between 1 and 10 days post burn (n=3). One surgeon indicated that it is individualised and that they performed surgery as soon as the wound was clean.

Choice of feeding routes for patients with various percentages TBSAB

The different feeding routes used in patients were influenced by the % TBSAB (Figure 4.5). It is clear that the oral (n=15), enteral (n=7) and a combination of the oral and enteral (n=9) options were used in most situations. A small percentage of dietitians used TPN only in patients with more than 40% TBSAB and no dietitians used a combination of oral nutrition and nocturnal tube feeds.

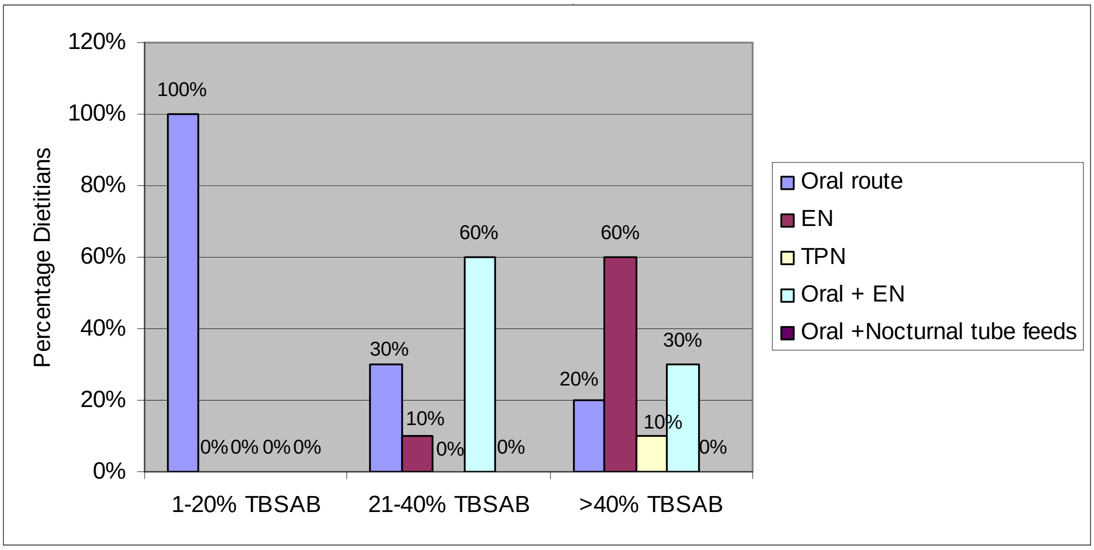

Figure 4.5 Choice of feedings route for patient with various percentages of TBSAB.

* TBSA = Total Body Surface Area; EN = enteral nutrition; TPN = total parenteral nutrition

The administration of feeds before or during surgery

According to the surgeons and dietitians, no patient received either enteral nutrition or total parenteral nutrition during surgery. The surgeons indicated that patients were kept nil per os (NPO) overnight (n=2); 6-8 hours before surgery (n=2), 6-10 hours before surgery (n=2) and one indicated that it was non-specific but would be as soon as possible before surgery.

Estimation of energy requirements

All dietitians indicated that they had taken the %TBSAB into consideration when calculating the patient's dietary requirements and the majority (80%) indicated that they adapted their regimen according to %TBSAB or associated complications e.g. respiratory impairment.

All dietitians (n=10) used predictive equations when calculating their patients' energy requirements and the most commonly used ones were identified (Figure 4.6). The Curreri formula was used in 70% of cases, followed by the Harris-Benedict equation that takes percentage TBSAB into consideration as a stress factor. The equations of 30-40 kcal/kg/day were also used, but to a lesser extent.

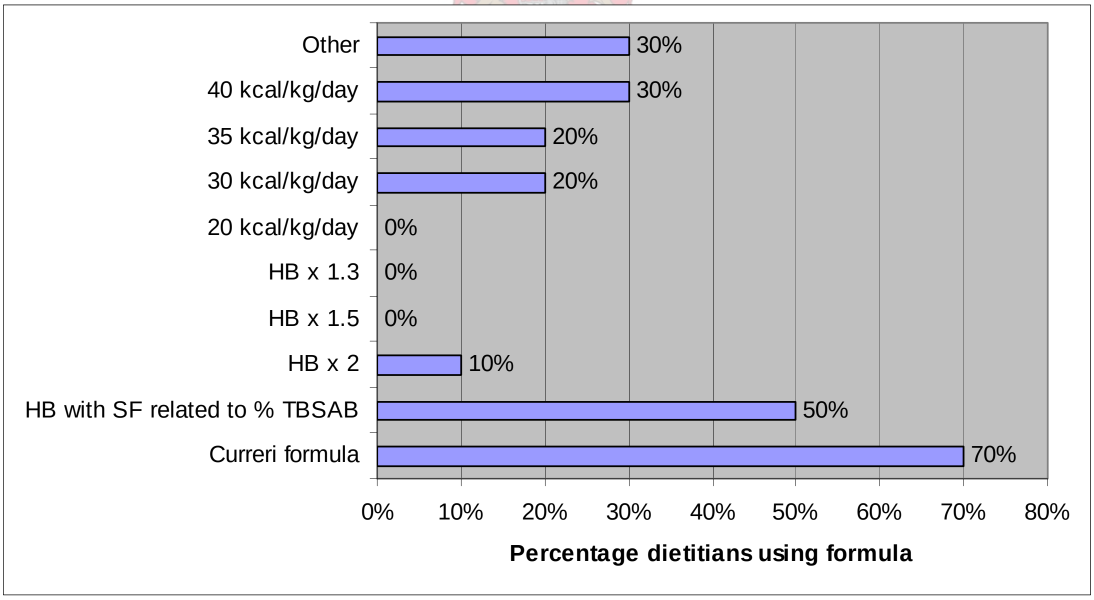

Figure 4.6 Predictive equations used for calculation of energy requirements in burned patients.

* kcal = kiloenergy; kg= kilogram; HB = Harri Benedict; SF = stress factor; TBSAB = total body surface area burn

The following other predictive equations were also used by the dietitians:

- 420-630 NPE kJ / g nitrogen
- Xie et al (1993): 1000 x m^2 + 25 x % TBSAB [33]

- Ireton Jones (1997) : [42]

  Energy requirement (v) = 1925 – 10 (A) + 5 (W) + 281 (S) = 292 (T) + 851 (B)

  Energy requirement (s) = 629 – 11(A) = 25(W)-609(O)

  v = ventilator dependant

  s = spontaneously breathing

  A= age (years), W = weight (kg), S = sex (male=1, female=0)

  Diagnosis of T = trauma, B = burn, O=obesity (if present = 1, absent = 0)

When a patient was ventilator dependant, a different predictive equation was used for calculating his/her energy requirements by 50% of the dietitians. They would mainly use the Ireton Jones Ventilator formula, [42] increase the fat content and reduce the carbohydrate content and also provided less energy than for patients who were not on a ventilator.

Ninety percent of the dietitians did not use a different predictive equation for patients who were recovering and undergoing wound healing. One dietitian indicated that she would provide less energy for a patient who was in recovery, than initially given.

Estimation of macronutrient requirements

All of the dietitians used predictive equations when calculating the protein requirements (Figure 4.7).

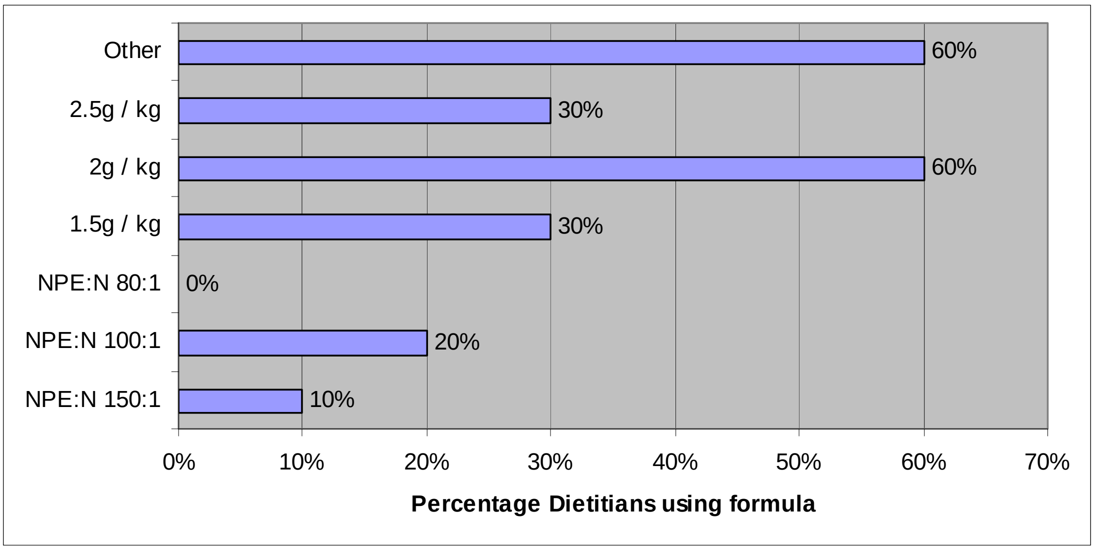

Figure 4.7 Predictive equations used for calculation of protein requirements in burned patients

* g = gram; kg= kilogram; NPE : N = non-protein energy to nitrogen ratio

The following other predictive equations for protein requirements were also used by the dietitians:

- 20-25% of total energy requirements
- Sutherland formula: 1g/kg + 3 g/ % TBSAB

The above-mentioned equations were very popular together with the equation of 2g/kg and were both used by 60% of dietitians. The equations of 1.5g/kg and 2.5g/kg were also both used by 30% of the dietitians respectively.

The non-protein energy (NPE) distribution most commonly used was 61-70% CHO: 30-39% fat (Figure 4.8). One dietitian responded that she used 41-50% CHO: 50-59% fat. Another NPE distribution that was given was 50-70% CHO, 20-30% fat and was used by one dietitian.

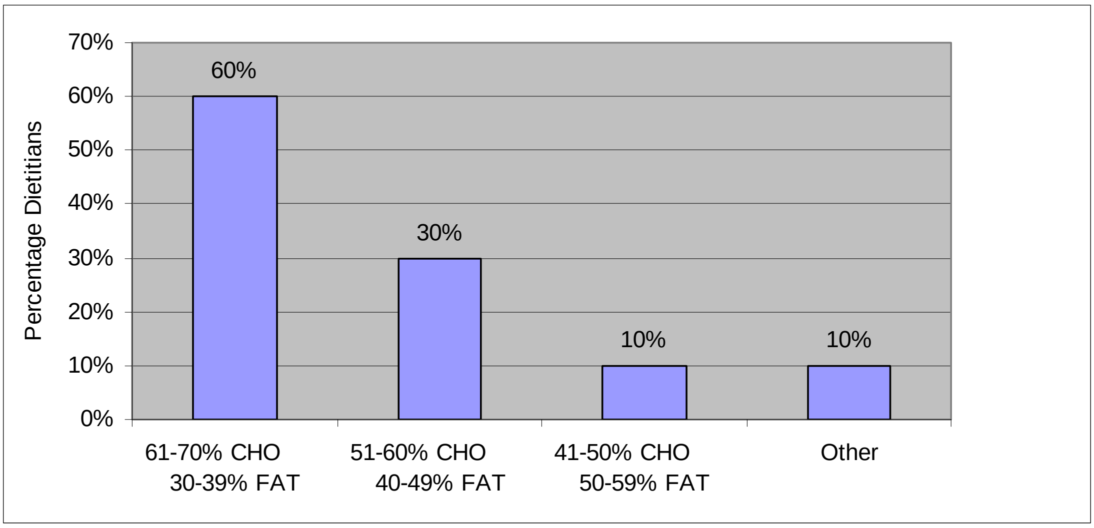

Figure 4.8 Estimation of non-protein energy requirements in burned patients

* CHO = carbohydrate

Most dietitians (60%) stated that they used the particular NPE distribution to reduce the amount of fat provided to the patients to prevent risk for infections and fatty livers.

The use of indirect calorimetry

All dietitians (100%) indicated that indirect calorimetry could not be performed at their institution and therefore it was not used in any of the adult burns units in South Africa.

Monitoring of over- and underfeeding

Monitoring for over- and underfeeding was reported by a large percentage of respondents. Eighty percent of the dietitians and 77.8% of the professional nurses indicated that they monitored patients for overfeeding. Ninety percent of the dietitians and 88.9% of the professional nurses indicated that they monitored patients for under-feeding.

The dietitians and professional nurses provided the following methods for monitoring for overfeeding:

- Biochemical values and blood results (no details provided).

- Clinical evaluation for overfeeding i.e. abdominal distension, vomiting, diarrhoea.
- Monitoring glucose infusion rate and monitoring blood glucose levels.
- Anthropometry in the form of weekly weights.
- Gastric aspirates.

The dietitians and professional nurses provided the following methods for monitoring for underfeeding:

- Biochemical values, especially total body protein, albumin and white blood cell counts.
- Enteral tubefeed protocols.
- Clinical evaluation i.e. inadequate wound healing.
- Anthropometry in the form of weekly weights.
- Subjective questioning (no details given).

Despite the clinical and biochemical monitoring for overfeeding, from a dietary point of view, there was no standard as to the maximum amount of energy and protein used to prevent overfeeding (Table 4.3). It appears as though the nutritional protocols followed, varied significantly between the units.

Table 4.3: The maximum amount of energy and protein provided as indicated by the burns units:

Unit	Maximum energy	Maximum protein
1.	50 kcal/kg/day	25% of TE
2.	3600 kcal/day	22g N2
3.	3000 kcal/day	25% of TE
4.	40 kcal/kg/day	2.5g/kg/day
5.	2800 kcal/day	2g/kg/day or 25% of TE
6.	Use the requirements of patients with 60% TBSAB if their TBSAB is >60%	2.5g/kg or 25% TE
7.	2 x REE	2.5-3g/kg/day
8.	2500-3000 kcal/day	2g/kg/day
9.	40 kcal/kg/day	No answer
10	40 kcal/kg/day	2g/kg

* kcal = kiloenergy; TBSAB = Total Body Surface Area Burn; REE = resting energy expenditure, N2 = nitrogen; TE = total energy; kg=kilogram; g=gram

Administration of various micronutrients in the burns units

The administration of a multi-vitamin and -mineral supplement in burned patients was routine practice, according to 85.7% (n=6) of the surgeons, 80% (n=8) of the dietitians and 100% (n=9) of the professional nurses. The following micronutrients were administered in the burns units according to the various health professionals (Table 4.4):

Table 4.4: The administration of various micronutrients in burns units:

Micronutrient	Surgeons (n)	Dietitians (n)	Professional nurses (n)
Vitamin A	3	4	4
Vitamin B-complex	6	7	8
Folic acid	5	5	7
Vitamin C	7	7	7
Vitamin D	1	0	1
Vitamin E	1	1	2
Vitamin K	1	0	0
Calcium	1	1	0
Magnesium	2	1	2
Phosphorus	2	1	1
Zinc	6	3	6
Iron	4	4	6
Selenium	0	0	0
Copper	0	0	0

The micronutrient regimens and the dosages varied significantly according to the information provided by the health professionals. This was also a difficult section to interpret since the data was incomplete; some health professionals for instance indicated the number of tablets without indicating what they contained. Others reported the micronutrients being used but failed to indicate the dosages.

4.4 ENTERAL NUTRITION

The indications and contra-indications for starting enteral nutrition

The surgeons and the dietitians were asked to select the indications and contra-indications for enteral nutrition used in their institution (Figures 4.9 and 4.10 respectively). The most common indications for enteral nutrition were unconscious patients, as well as artificial ventilation/tracheostomy patients.

Enteral nutrition was found most commonly to be contra-indicated in cases of prolonged ileus, small bowel obstruction and lack of enteral access. It can be seen that the dietitians felt stronger about the indications of small bowel obstruction and lack of enteral access than the surgeons. It is interesting to note the discrepancies between the responses of the dietitians and the surgeons (Figure 4.9).

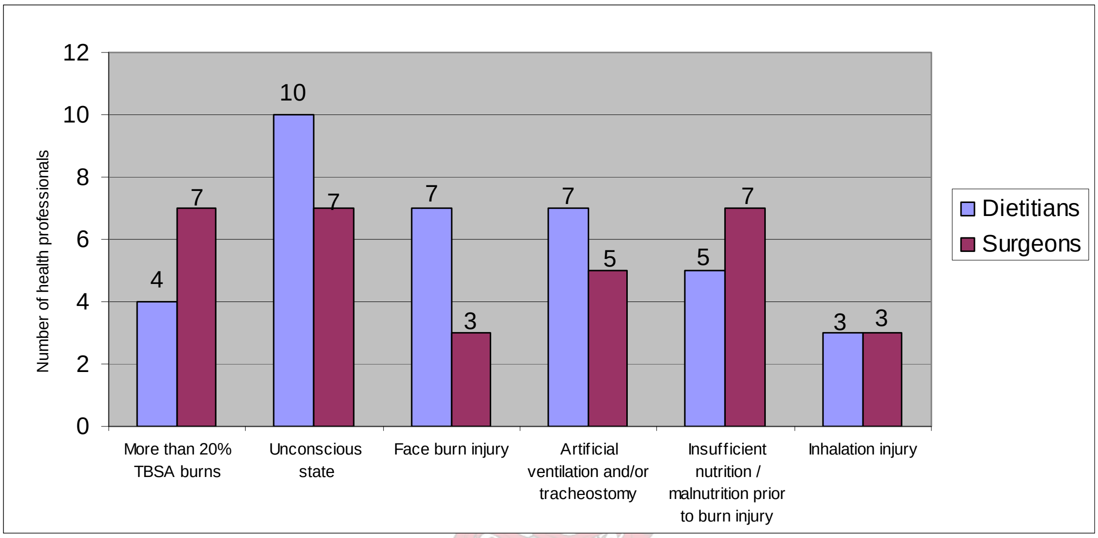

Figure 4.9 Indications for the use of enteral nutrition

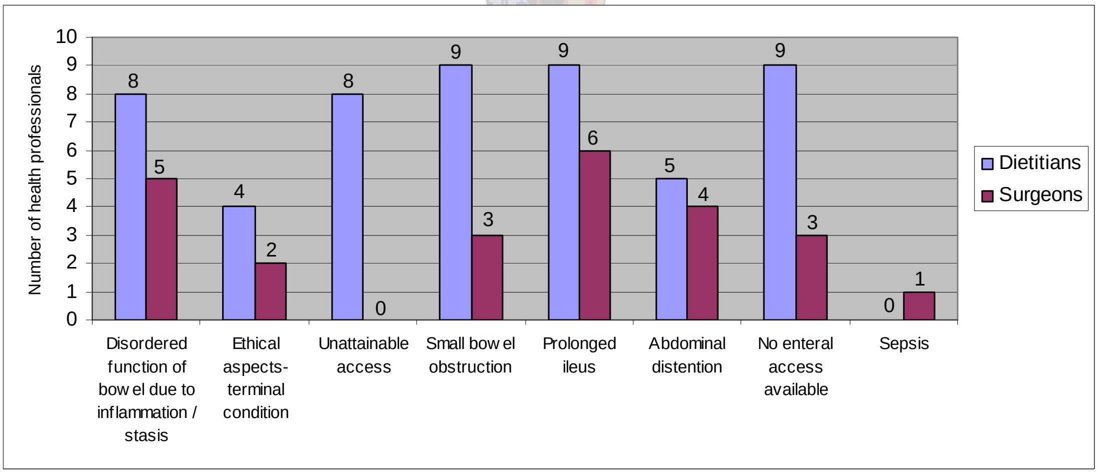

Figure 4.10 Contra-indications for the use of enteral nutrition

Other indications that were given for enteral nutrition were poor intake, severe depression therefore loss of appetite and continuous weight loss. Another contra-indication that was reported was vomiting (n=1) and the presence of tracheo-oesophageal fistulae (n=1).

The time of feeding initiation

When asked how soon feeding was initiated in their institution 42.9% (n=3) of the surgeons indicated within 0-12 hours after insult, 28.6% (n=2) indicated within 24 hours and 28.6% (n=2) within 72 hours. Of those who responded to the question, no institution starts enteral nutrition later than 72 hours after the insult.

The preferred route for enteral nutrition

All surgeons who responded to the question (n=7) preferred the nasogastric route for enteral nutrition over the post-pyloric or the percutaneous gastrostomy route. If nasogastric feeding should fail, only one surgeon indicated that he/she would use post-pyloric feeding as a next option. The rest (n=5) would rather opt for TPN. Two surgeons did not respond to the particular question. The one institution that used post-pyloric feeding used an endoscopist when placing the tube and confirmed its placement with a routine X-ray.

The reasons provided for "failure" of nasogastric tube feeding include gastric stasis, persistent vomiting, displacement of feeding tube, pulmonary aspiration and uncontrollable diarrhoea (Table 4.5).

Table 4.5: The reasons for "failure" of nasogastric tubefeed:

Setting	n
Gastric stasis	3
Persistent vomiting	2
Displacement of nasogastric tube	3
Pulmonary aspiration	1
Uncontrollable diarrhoea	2

The method of enteral feeding

Seventy percent of the dietitians (n=7) and 75% (n=6) of the professional nurses, indicated that they administered continuous infusion to deliver the enteral nutrition and the starting volume for enteral nutrition of 20 ml/hour was commonly used (Figure 4.11). One professional nurse did not respond to the question.

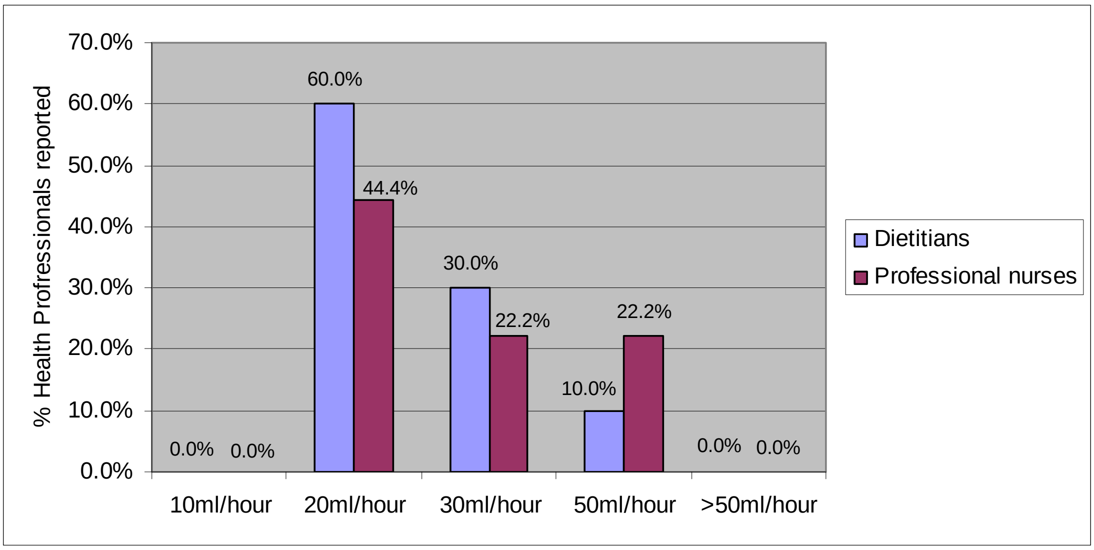

Figure 4.11 Starting volumes for initiating enteral nutrition

* ml = mililitre

The majority of the dietitians (50%) reported that they reached at least 50% of their requirements within 48 hours and full energy goals were achieved after 72 hours (Figure 4.12).

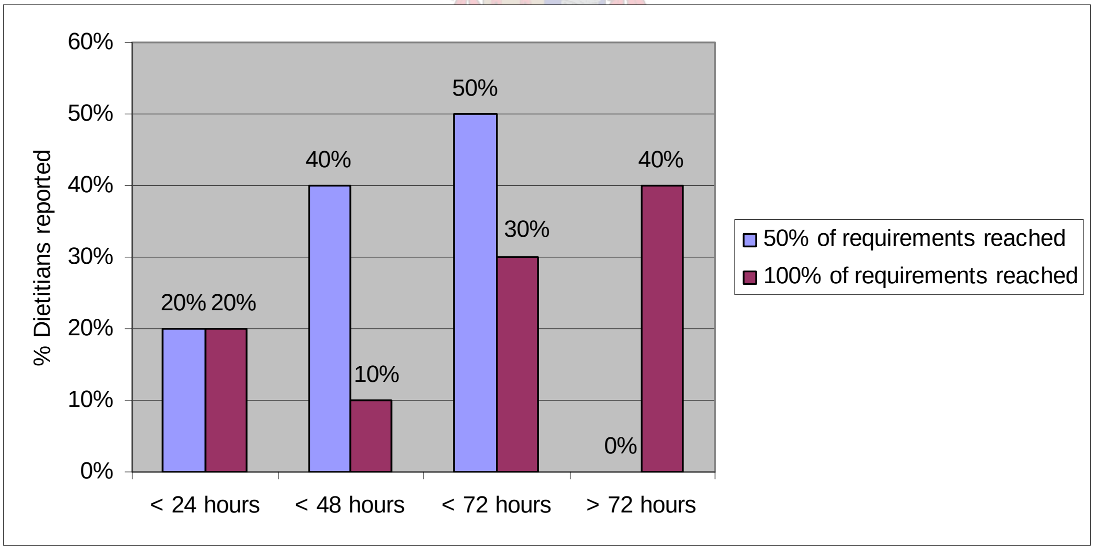

Figure 4.12 The time taken to reach nutritional requirements with enteral nutrition

The administration of medication via the tubefeed and flushing of feeding tubes

The flushing of the feeding tube was done by using different protocols. The nurses indicated that they flushed the tubes with the exchange of tube feeds (n=3), after the

administration of medication (n=1), every 24 hours (n=1) and when the feed had stopped or when the infusion pump alarm was activated (n=1).
However, 88.9% of the professional nurses indicated that they administered medication via the nasogastric-tubes, after which the tubes are flushed, with either tap water (87.5%, n=7) or sterile water (12.5%; n=1).

The charting of enteral nutrition intake

The intake of enteral nutrition was charted in the patient's file according to 90% of the dietitians and 87.5% of the professional nurses.

The replacement of enteral feeds

When asked how often the tubefeed is replaced many professional nurses did not respond to the question. The dietitians reported that not many institutions kept their feeds for longer than 24 hours (Table 4.6).

Table 4.6: The frequency of replacement of enteral feeds:

	Dietitians (n)	**Professional nurses (n)**
6 hourly	3	1
12 hourly	1	0
24 hourly	3	2
36 hourly	1	0
48 hourly	1	1
> 48 hourly	0	1

The type of enteral products prescribed

The dietitians were asked to name the enteral feeding products being used in their unit (Table 4.7). Ten different enteral products from the three leading enteral manufacturers were listed.

Table 4.7: Enteral products used in the burns units:

Enteral product	Number of units using
Product used when feeding was initiated.	
Fresubin Energy Fibre (Fresenius Kabi)	**1**
Fresubin HP Energy (Fresenius Kabi)	**2**
Jevity Plus (Abbott Laboratories)	**1**
Peptamen (Nestle)	**1**
Perative (Abbott Laboratories)	**3**
Supportan (Fresenius Kabi)	**1**
Survimed (Fresenius Kabi)	**3**
Products used as follow-up formulae	
Ensure (Abbott Laboratories)	**1**
Fresubin Energy Fibre (Fresenius Kabi)	**1**
Fresubin HP Energy (Fresenius Kabi)	**3**
Fresubin Original (Fresenius Kabi)	**1**
Jevity Plus (Abbott Laboratories)	**4**
Nutren Fibre (Nestle)	**3**
Peptamen (Nestle)	**3**
Survimed (Fresenius Kabi)	**1**

For the initiation of feeds the most popular products were Perative (Abbott Laboratories) and Survimed (Fresenius Kabi). Both products are semi-elemental feeds. For follow-up feed Jevity Plus (Abbott Laboratories) was the most popular and overall Jevity Plus and Fresubin High Protein Energy (Fresenius Kabi), Peptamen (Nestle) and Nutren Fibre (Nestle) featured the highest in the burns units. The dietitians were also asked to provide the compositions of the various feeds (Table 4.8).

All dietitians indicated that they used more than one enteral product in the nutritional prescription of burned patients.

The indications for use of various enteral products

Dietitians would change the type of enteral products for various reasons (Table 4.9). Sixty percent of dietitians reported that they would start a patient on a semi-elemental feed due to malabsorption initially or a low albumin value. The fibre containing feeds were used as the initial feed (n=2) or the follow-up feed (n=6).

Table 4.8: The composition of enteral products used in burns units:

Product	Energy (kcal/ml)	Protein (%TE)	CHO (%TE)	Fat (%TE)	Fibre (g/1000 ml)	Immuno-nutrition
Ensure (Abbott Laboratories)	1	14.2	54	31.8	0	NO
Fresubin Energy Fibre (Fresenius Kabi)	1.5	15	50	35	2	NO
Fresubin HP Energy (Fresenius Kabi)	1.5	20	45	35	0	NO
Fresubin Original (Fresenius Kabi)	1	15	30	55	0	NO
Jevity Plus (Abbott Laboratories)	1.2	18.5	52.5	29	12	NO
Nutren Fibre (Nestle)	1	16	51	34	15	NO
Peptamen (Nestle)	1	16	50	35	0	NO
Perative (Abbott Laboratories)	1.3	20.5	54.5	25	0	YES, Arginine
Supportan (Fresenius Kabi)	1.3	18	32	50	1.33g	YES Omega 3 & 6 Fish oil and Nucleotides
Survimed (Fresenius Kabi)	1	18	60	22		NO

*kcal = kiloenergy; ml = millilitre; TE= total energy

Table 4.9: The indications for changing the enteral product

Indication for changing the product	Number of dietitians (n)
Development of infections / sepsis	2
Tolerance of the semi-elemental feed	4
Intolerance of the polymeric feed	1
Ventilation	1
Availability of feeds	1
Constipation / Diarrhoea	2
Increased energy requirements	1

When asked whether they used open- or closed system feeding, 65% of dietitians reported closed systems and 35% of the dietitians reported open-systems. One dietitian indicated that they used both systems.

The use of immuno-nutrition

Sixty percent of the dietitians reported that they did not incorporate immuno-modulators into the nutritional care for burn wound patients. Of the 40% who did incorporate it, two dietitians supplemented glutamine separately as part of routine care. The names of the products used were Glutamine 10 (Fresenius Kabi) which was administered enterally and Dipeptivan (Fresenius Kabi) parenterally. The typical dose of glutamine was 20-30g/day or 0.3-0.5g/kg.

Seventy percent of the dietitians felt it was necessary to use products with an immuno-nutrition "mix" and 44.4% (n=4) reported that they used those products. Two dietitians used products with glutamine, one used products with arginine and two used essential fatty acids.

4.5 MANAGEMENT OF PATIENTS WITH INHALATION INJURY

Dietitians reported that 60% of them treated patients with inhalation injury differently than other patients. Different treatment methods included supplementation with Vitamin E (n=2), increasing of nutritional requirements (n=3) and enteral nutrition prescribed (n=3).

Fifty seven percent (n=4) of the surgeons and 90% of the dietitians reported that not all patients with inhalation injury were necessarily on enteral nutrition.

4.6 MONITORING OF PATIENTS

Biochemical monitoring

The health professionals were consistent as to which biochemical parameters were monitored in their units (Figure 4.13). Blood glucose levels, serum electrolytes, liver function tests, albumin and full blood counts were commonly measured in the units. Very few units monitored gastric aspirates, pre-albumin, and CRP as biochemical parameters. No units monitored nitrogen balance in burned patients.

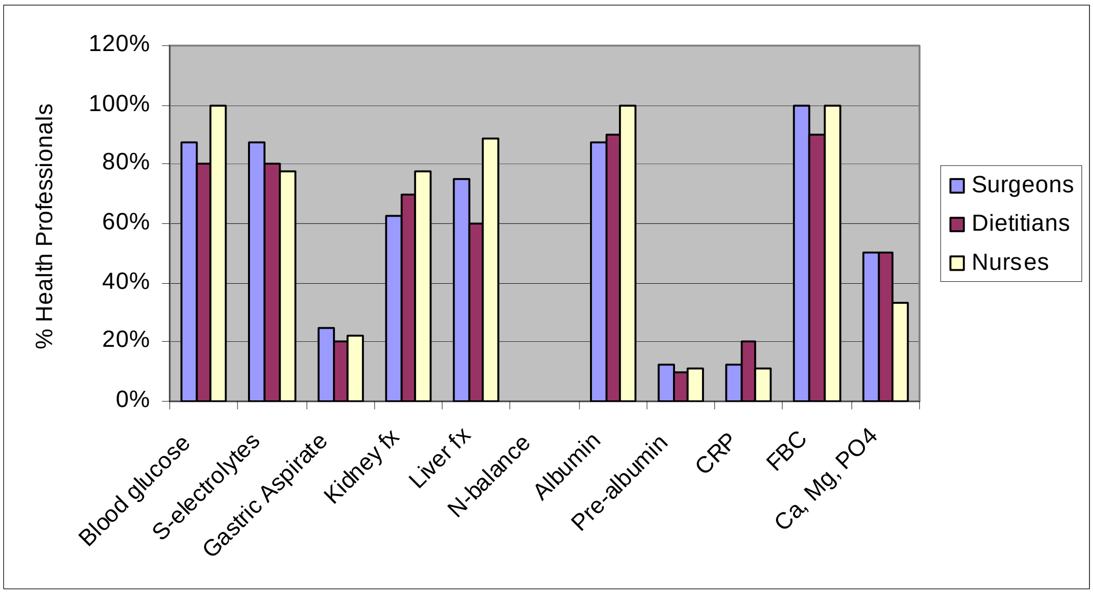

Figure 4.13 The monitoring of biochemical parameters according to health professionals

S = serum; fx = function; N = nitrogen; CRP = C-Reactive Protein; FBC = full blood count; Ca = calcium; Mg = magnesium; PO4 = phosphorus

Although most professionals were clear on which parameters to measure, there appeared to be inconsistency among the various health professionals and various burns units about the frequency of monitoring biochemical parameters. (Figure 4.14 and 4.15 respectively). It was clear that no standard protocol existed in South African burns units regarding the type and frequency of measurement of biochemical parameters. The dietitians were not tested on this particular issue.

The monitoring of protein losses

When asked if protein losses were monitored in burned patients, a third of the surgeons and dietitians reported that they monitored protein losses in burned patients. The method for monitoring protein losses included albumin levels, total protein levels, urea and creatinine and one dietitian indicated that such losses were through the monitoring of pre-albumin levels.

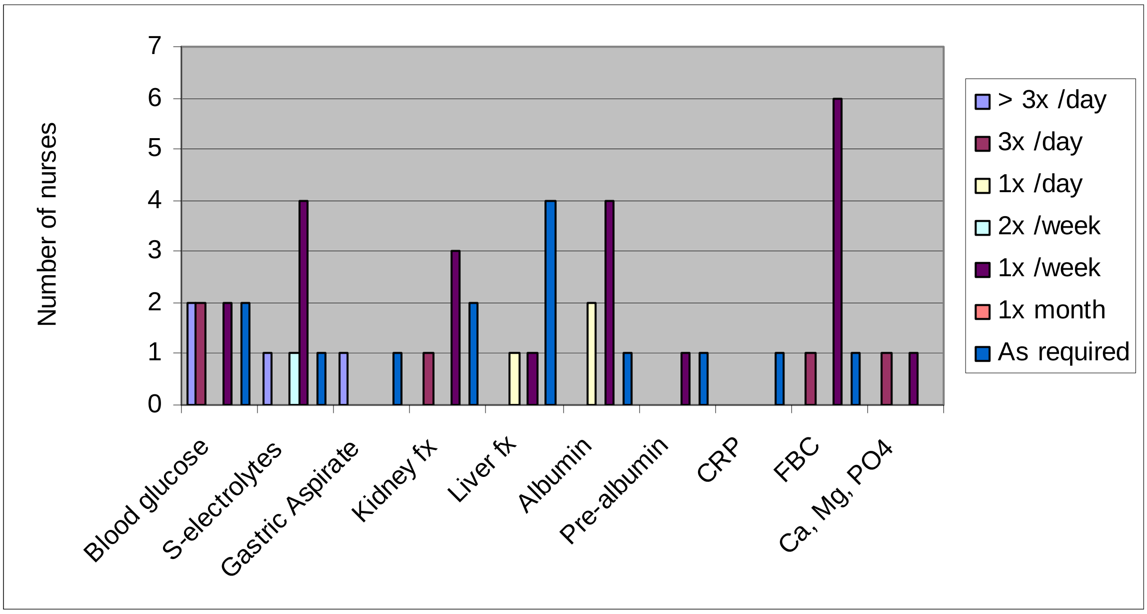

Figure 4.14 The frequency of biochemical parameters monitored according to the nurses

S = serum; fx = function; N = nitrogen; CRP = C-Reactive Protein; FBC = full blood count; Ca = calcium; Mg = magnesium; PO4 = phosphorus

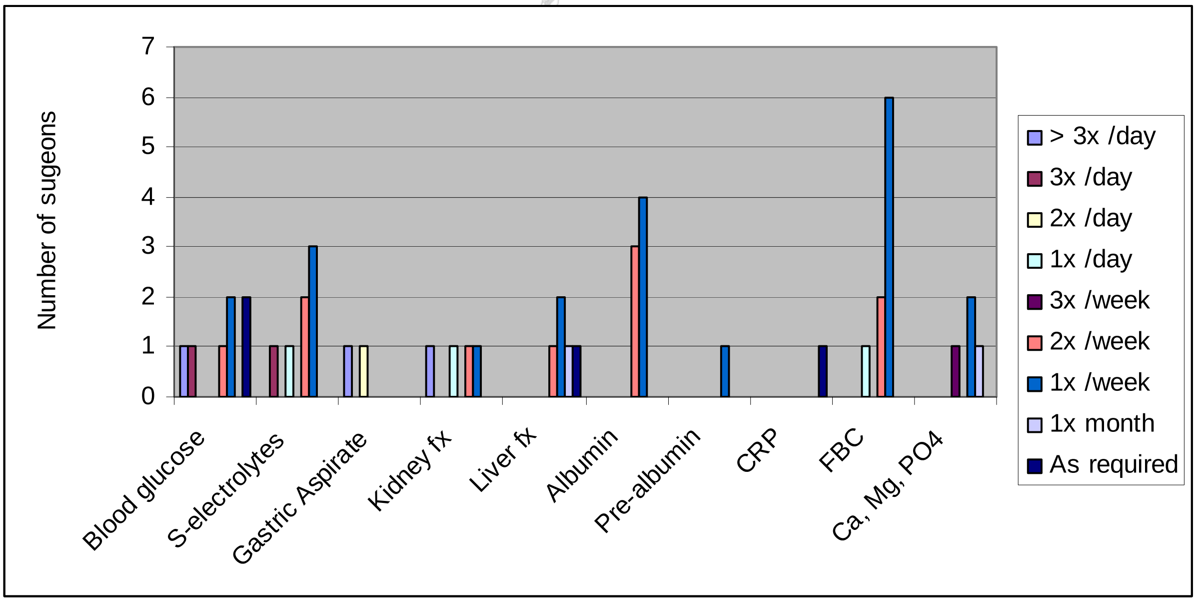

Figure 4.15 The frequency of biochemical parameters monitored according to the surgeons

S = serum; fx = function; N = nitrogen; CRP = C-Reactive Protein; FBC = full blood count; Ca = calcium; Mg = magnesium; PO4 = phosphorus

The use of prokinetic agents in burned patients

Four (50%) of the surgeons used prokinetic agents in their patients. Erythromycin, Metaclopromide and Neostigmine were mainly used in South Africa. Reasons for using pro-kinetic agents included nausea and vomiting as well as patients on enteral nutrition.

The use of anthropometry

The weight of most of the less critically ill patients was obtained on admission, while height was measured to a lesser extent (Figure 4.16).

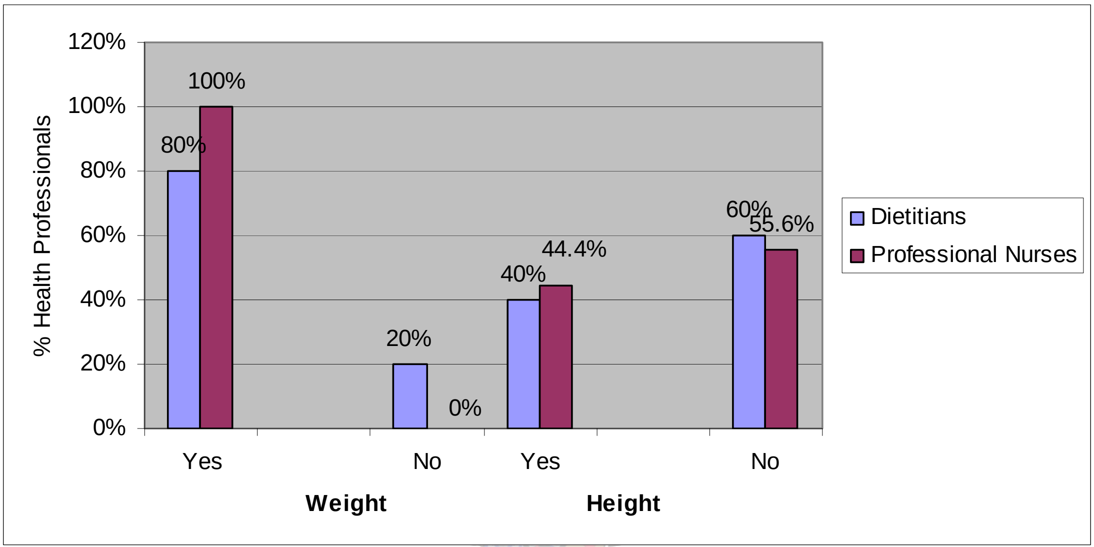

Figure 4.16 Weight and height measurements obtained on admission

Follow-up weight measurements are mostly done weekly (Table 4.10).

Table 4.10: The frequency of the weight measurements in the burns units:

Frequency	Dietitians (n)	Professional nurses (n)
Daily	0	0
Weekly	6	9
Monthly	1	0
Only on admission	0	0
Not routinely done	3	0

The ideal body weight was used by five dietitians to calculate dietary requirements, and four dietitians used weight on admission. Three dietitians reported that they would use the current body weight of the patient. All dietitians did take oedema into consideration and BMI was calculated according to 60% of the dietitians.

Of those who calculated BMI, 71.4% (n=5) dietitians reported they changed their nutritional regimens for malnourished patients and obesity. Of those who responded to the question, three dietitians indicated that they calculated the ideal body weight of their patients to compensate for malnourished or obese patients. Only one dietitian reported that they used other anthropometric measurements (i.e. triceps skin fold, sub scapular skin fold, waist and hip measurements) in their institution.

4.7 ORAL DIETS

Supplementary enteral nutrition was maintained until the patients were able to meet their nutritional requirements orally according to 60% of the dietitians and 100% of the professional nurses. High protein diets were most frequently prescribed in burns units (Table 4.11). The average high protein diet contained 11008 kJ, 113g protein (17% TE), 332g carbohydrates (51% TE) and 94g of fat (33% TE).

Table 4.11: The types of oral diets provided to burned patients:

Type of oral diet	Dietitians (n)	Professional nurses (n)
Normal ward diet	2	1
Normal soft diet	1	0
High protein diet	8	6
High protein soft diet	1	0
High protein fluid diet	1	1
High fibre diet	0	0
Light diet	1	2
Puree diet	0	1

The person responsible for prescription of oral diets

All of the dietitians reported that they were responsible for the prescription of oral diets in their institution, while 77, 8% of the professional nurses reported that it was the dietitian’s responsibility. Two professional nurses reported that the doctor decided on the oral diet and two or more reported that all three health professionals were responsible for the prescription of oral diets. Two dietitians also reported the same result.

The interventions used for refusal to eat

Various interventions were used in cases where patients refused to eat due to pain and depression (Table 4.12).

Table 4.12: Interventions taken when patients refuse to eat:

	Dietitians (n)	Professional nurses (n)
Motivation to eat	4	6
Enteral feeding initiated	7	5
Social worker / Psychologist consulted	1	1
Consistency changes to oral diet	1	0
Supplemental drinks provided	1	1
Pain medication prescribed	2	3

Ninety percent of the dietitians reported that they provided patients with supplemental drinks additional to the oral diet as part of routine dietetic care.

The use of supplemental drinks

The supplementation drinks used were commercial (57%) or hospital-made products (20%) or a combination of the two (20%). The types of commercial drinks used frequently were Ensure (Abbott) and Fresubin Energy Fibre (Fresenius Kabi) (Table 4.13).

Table 4.13: Commercial drinks used for burned patients:

Product	Dietitians (n)
B-Immune- Fresenius Kabi	2
Ensure –Abbott	3
Ensure Plus – Abbott	1
Ensure with FOS –Abbott	1
Fresubin Energy Fibre- Fresenius Kabi	3
Fresubin High Energy Drink- Fresenius Kabi	2
Jevity Plus - Abbott	1
Nutren Active (previously known as Build-Up) – Nestle	2
Nutren Fibre- Nestle	1
Provide Xtra- Fresenius Kabi	1
Supportan Drink- Fresenius Kabi	1

Commercial drinks (Ensure, Nutrimil, Nutren Active, Promod, Polycose) were also part of the typical ingredients used for hospital-made supplemental drinks. Other ingredients included full cream milk, full cream and skimmed milk powder, evaporated milk, yogurt, apple juice and eggs.

4.8 ANABOLIC AGENTS

Anabolic agents were used in only one institution. They used a testosterone derivative Deca-Durabolin (100 mg, once every three weeks) and an Insulin sliding scale. The anabolic agent was administered only once while the patient was in hospital.

4.9 SPECIFIC DISEASE STATES

Diabetes Mellitus

The dietitians reported that they mainly treated diabetic patients with diabetic diets, according to their energy requirements and added diabetic supplemental drinks if needed. They monitored the carbohydrate distribution, included fibre in the diet and used low fat foods. Blood glucose was managed with insulin sliding scales. When enteral nutrition was required, enteral products indicated for diabetic patients were used. When only blood glucose was increased without the diagnosis of diabetes mellitus, the glucose was monitored more frequently, insulin was administered and they would consider a diabetic diet or an enteral product when the problem persisted.

Renal failure

In cases of renal failure in burn wound patients, the dietitians intervened with protein, sodium, potassium and phosphate restricted diets. Fluid was also restricted. The protein requirements given for kidney failure ranged from 1- 1.7g protein per kilogram body mass. Some dietitians reported that they would try to motivate for the patients to get dialysed and increase the protein requirements accordingly. When on enteral nutrition, disease specific products were used, and they were low in protein and electrolytes. Urea and Creatinine were monitored frequently.

4.10 FOLLOW-UP

Eighty eight percent of the surgeons and 10% of the dietitians indicated that they reviewed burned patients as part of an out-patient department. The frequency of the follow-ups varied between the institutions and ranged from twice a week initially to every 6 weeks, depending on the patient’s progress.

CHAPTER 5

DISCUSSION

The nutritional management of burned patients was described in ten burns units in South Africa. The surgeons, dietitians and nursing managers in the units had good experience in the management of burned patients and full-time dietitians were employed in all units and were involved in the nutritional management of these patients. Patients with total body surface area burn (TBSAB) of 10-30% were most frequently treated in South Africa. There was some confusion regarding the availability and the implementation of a written nutritional protocol between the different health professionals and this may be suggestive of a lack of communication between the health professional with regards to the nutritional management of burned patients. The literature clearly highlights the importance of a nutritional protocol in units, especially in the critically ill patient. A study by McClave et al, [96] showed that the development of strict protocols and education of health care professionals may be required to maximize the delivery of nutrition in the critical care setting. [96] In the absence of a feeding protocol, significant periods of time can pass because decisions about restarting or increasing the rate of feedings are often left until ward rounds. Feeding protocols can reduce the time to when feedings are initiated and how quickly patients achieve tolerance. [97]

There also was a certain degree of differences in the opinion of the health professionals' on the implementation and frequency of multi-disciplinary ward rounds between the professionals, which, by definition, should include all the members of a health care team. The definition may have been misinterpreted, hence the difference in response by the health professionals. Nevertheless, it was interesting to note that the health professionals in the burns units felt that there was a close relationship among them and communication among them was mostly described as good or even excellent. However, when studying the response of some of the questions it was clear that there was, in fact, a degree of miscommunication between all the professionals, in that the health professionals of the same unit would respond differently to certain questions stated in the questionnaire.

Even though the majority of the units perform early wound excisions, wound closures and skin transplants on a regular basis, it was of concern that very few units (n=2) were able to perform wound excisions within 72 hours post-burn despite the fact that the literature states that a patient's metabolic rate will be 40% less if the excisions are performed 2-3 days after the injury .[11] There are definite advantages of early burn excision and wound closure and although the health care teams in South Africa may be faced with a shortage of medical staff and theatre hours, which is a challenge in itself, it is recommended that wound excisions and wound closure should be done within 72 hours, where possible.

The popular Curreri formula was still frequently used in South Africa, as in other parts of the world. [13, 30] The Harris-Benedict equations with injury related stress factors [31] was also used in 50% of the cases. It is clear that dietitians used many different predictive equations and, in certain cases, even more than one equation per patient. This may be due to the fact that there is no standard as to which is the most appropriate formulae to use for our patient population and dietitians may have felt uncertain as to which formulae to use. The literature indicates that caution must prevail when using the Curreri formula, since it markedly overestimates measured energy expenditure (MEE). [13, 29, 32] It may seem logical to use the most precise, unbiased methods for estimating REE in the burned patient according to a study done by Dickerson et al. Unfortunately, the patient demographics and body sizes in which those formulae were tested differ from our South African population and the formulae are also not always practical to implement in a clinical environment. Studies to determine whether these formulae are accurate for the typical South African burned patient are desperately needed. Meanwhile it may seem prudent to use the Harris-Benedict equation with injury factors [31] since it takes all possible variables into consideration (including % TBSAB and age) and energy is not over-estimated to the same extent as the Curreri formula. This is particularly importance since none of the units in the present study made use of indirect calorimetry, in spite of its accuracy, probably due to the cost and difficulty of implementation of such a method in the every day clinical environment.

In spite of the fact that the literature highlights the importance of nutritional calculations to be repeated frequently to ensure that needs are met and over- or under-feeding do not occur, the majority of the dietitians did not use different predictive equations for patients who were recovering and undergoing wound healing, and the same energy requirements were used throughout the patient's hospital stay.

Another cause for concern is the fact that there were no standards in the units studied as to the maximum amount of energy that can be administered and the dietitians used many different methods. Less than half of the dietitians used the recommended maximum of 30-40 kcal/kg/day, [14] or twice the BEE. [13, 21, 39] Once again this is a reflection on the confusion that exists regarding the management of burned patients, since no such standards exist in South Africa. The detrimental effects of overfeeding are well-known and this issues thus need to be addressed.

The dietitians were more accurate with the estimation of protein requirements when compared with the available literature and the majority used 2 g protein/kg body weight per day, or 20-25%. It must be remembered that factors such as pre-existing malnutrition and HIV/AIDS that is common in South Africa, and should also be taken into consideration when determining a patient's protein requirements. Most dietitians used the carbohydrate-fat ratio of 61-70%: 30-39% and they used the particular NPE distribution to reduce the amount of fat given to the patients to prevent risk of infections and hepatic steatosis. This seems to be a prudent guideline for burned patients to prevent excess CHO and fat intake.

Nutritional support of the critically ill patient includes the daily provision of vitamins, minerals and trace elements [46] and vitamin- and mineral supplementation is an extremely important component of the therapeutic nutrition care plan for the patient with burns. [47] Unfortunately, it would appear that no standard regimen exists in South Africa for the supplementation of micronutrients, and micronutrient regimens vary significantly between units and health professionals. Most of the health professionals did however indicate that micronutrient supplementation was routine practice in their units. The information provided by the health professionals on the use of micronutrients was unfortunately not sufficient to make a conclusion on the use thereof in South Africa. Health professionals working with burned patients, therefore, need to develop a standard regimen that is practical, feasible, safe and sufficient for our patients.

The feeding route (oral diets vs. enteral nutrition vs. TPN) was the next important step in the nutritional management of a burned patient. The results of this study indicate that patients with between 21-40% TBSAB would mostly receive oral diets in combination with enteral nutrition, which is in agreement with the literature recommending that more aggressive nutrition is warranted when patients with more that 20% TBSA burns are unable to meet dietary intake goals orally. [29] Another important measure to implement is not to stop supplementary enteral nutrition until adequate oral intake is maintained. The majority (60%) of the health professionals stated that they did, in fact, wait until oral diets were tolerated sufficiently before enteral nutrition was stopped.

Different opinions existed as to who was responsible for the decision on and and prescription for oral diets, and currently doctors, dietitians and professional nurses all prescribed oral diets. It is important for burns units to decide whose responsibility this should be, so that confusion and inappropriate nutrition prescription does not take place.

It was interesting to note that TPN was prescribed to only 10% of the study population, primarily in patients with more than >40% TBSAB, since there is overwhelming evidence that the enteral route for nutrition delivery is far superior to the parenteral route. [6, 8, 9, 14, 20, 22, 29, 38, 45, 54.] Total parenteral nutrition should only be considered when enteral access cannot be obtained; enteral feeding fails to the meet the nutritional requirements of the patient or the use of the gastrointestinal tract is contra-indicated by injury or a disease. [6] Other reasons why TPN may be considered include: the need for high-dose vasoactive intravenous medication, [6] unattainable gastro-intestinal access, [6] delayed gastric emptying, [6] intolerance to enteral feeding, [11] prolonged ileus or when all other routes of enteral nutrition have failed. [6, 11, 57]

Most dietitians reported that lack of enteral access was a contra-indication for enteral nutrition. If nasogastric feeding fails, other means of enteral nutrition, i.e. PEG, or nasoduodenal feeding should be considered before nutrition is withheld or TPN is initiated.

Aspects that contribute to interruption of feeding included the withholding of feeds for several hours before, during and after surgery. Because burned patients often undergo several surgerical interventions during a short period, this disruption of feeds often occurs. Our study population indicated that the burned patient was kept NPO for any period from the previous night to 6 hours before surgery. Substantial amount of nutritional support is lost through these measures. This procedure has long been believed to be necessary to decrease the chance of gastric reflux and vomiting, which can result in aspiration. [62, 63] However, the literature indicates that when enteral feedings were introduced beyond the pylorus and careful attention was given to the peri-operative procedures designed to decrease the reflux and to monitor for its occurrence, peri-operative feeding was a safe strategy. It is suggested in the literature that facilities that discontinue feeding during surgical procedures should reconsider this practice, since more than about 30% of the patient's calculated energy needs were not met due to interruption of feeding. [96] Clearly, further studies are needed to determine the feasibility of peri-operative feeding and the impact of nutrient losses during surgical interventions on the recovery and outcome of burned patients. [62] Until then, enteral nutrition should not be withheld for more than 6 hours pre-operative, and initiated as soon as possible after surgery.

In South Africa the nasogastric route for enteral nutrition was still the most popular route. Unfortunately, very few units made use of other feeding routes, and they would rather opt for TPN when nasogastric feeding failed. Even though nasojejunal feeding in South Africa has not been extensively investigated, this option may be safer and less expensive and may become a better option than TPN in the future. The disadvantage of post-pyloric feeding includes skilled health care personnel (radiologists/endoscopists) [8, 53] and equipment for the correct placement of the tube which further increases expense. [8] The alternative, especially when planning long-term nutrition may be percutaneous gastrostomy. Previous studies concerning burned patients all concluded that gastrostomy, when feasible, offers a safe, effective and more comfortable access for prolonged enteral feeding than nasogastric tubes.

Enteral nutrition was typically commenced at 20 ml/hour, and half of the study population indicated that energy requirements are met after only 72 hours of feeding initiation. Once again variation of opinion existed amongst dietitians, as to the volume at which nutrition should be started and how soon feeds should be increased. Available literature recommends that feeds should be typically started (when the patient is haemodynamically stable) at more or less 25 ml/hour and increased by 25 ml every 12 hours, or slower if the patient is at risk of re-feeding syndrome. [8, 14, 56] Re-feeding may be a greater risk in a country such as South Africa where pre-existing malnutrition in individuals is common. The patient's condition should be carefully assessed before deciding on what volume to begin with. [56] On the other hand, no time should be wasted when working with burn injured patients. Whether enteral feeds should be delivered using a continuous or intermittent regimen, remains controversial. [56] Continuous infusions are more popular in South Africa, probably because of convenience of the method in short-staffed, busy hospitals.

A very wide range of enteral products were used in the units studied. It is recommended to begin a critically ill burned patient on a semi-elemental feed to increase absorption that may be impaired due to hypo-perfusion of the gut. The feed can later be changed to a high energy, high protein, low fat feed that preferably contains fibre. The most popular feeds used for burned patients were Jevity Plus (Abbott Laboratories) and Fresubin High Protein Energy (Fresenius Kabi). Both have the above-mentioned characteristics.

It is very important that enteral tubes should be flushed four hourly with sterile water, to prevent obstruction of the feeding tube and unnecessary cessation of feeding. [8] In South Africa it appears that tubes were not flushed often enough and sometimes only once a day when tubes were exchanged. The question of how often feeds are exchanged in the units were poorly answered which may indicate confusion or misunderstanding. The literature recommends 24-hour hang-time for closed feeding systems and 6 hour hang time for open feeding systems. [64]

Most experts agree that feeding should begin as soon as possible, ideally within the first 24-48 hours after injury, [6, 8, 14, 17, 54, 56] presuming that the patient is haemodynamically stable. [19] This may be especially necessary when the patient is malnourished, prior to the insult. [14, 17] It is interesting to note that in South African burns units, feeds were commenced within 72 hours after admission and almost two thirds of the study population indicated that feeds are commenced within 48 hours after the insult. It is clear that the advantages of early enteral nutrition may not be realised in South Africa.

From the results is appears that dietitians were confused and less confident regarding the use of immuno-nutrition in burned patients, in spite of the overwhelming available literature regarding this issue. Only two dietitians indicated that they used glutamine supplementation in their patients. It is clear from the available evidence that glutamine should be considered in burned patients. [54] High dosage glutamine supplementation (>0.2-0.3 g/kg/day) has been reported to be more effective than low dose glutamine supplementation [72-74] and up to 0.5g/kg/day has been shown to be safe. [72] With regards to other immuno-nutrients, the verdict is less clear. Dietitians should abstain from using products which contain large dosages of immuno-nutrients until further research can prove their effectiveness and safety in the burn wound population.

The nutritional prescription should change when a patient is ventilator dependant, especially when suffering from severe inhalation injury. During paralysis the REE is significantly decreased by 24-33% [67] and overfeeding should be avoided. The predictive equation used for obese patients, may also be used for patients on mechanical ventilation. [40]

Currently the only formulae available for determining the energy requirements of a ventilated patient are the Ireton-Jones energy equations. [42] Our dietitians made use of these energy equations, but also reduced the carbohydrate content of the feed to reduce the amount of carbon-dioxide produced by the body.

Weight and height were the only anthropometric measurements used in 90% of the burns units. The measurement of body weight is one of the recommended assessment methods in burned patients. [14, 29] Care should, however, be exercised when interpreting the results, since fluid shifts and oedema are very common occurrences in burned patients, and could influence measurements. After hospital admission, daily weights without dressings and splints are recommended. [29] In this study, variation existed about the measuring of weight of patients, since 80% of dietitians reported weight measurements on admission as compared with 100% of the nurses. Weight measurements are thereafter done mostly once a week, rather than daily as recommended. Oedema that might occur frequently in burned patients, should always be taken into consideration when interpreting weight or calculating energy needs. In cases of overweight and underweight, ideal body weight should mainly used.

Tolerance to enteral nutrition should be constantly observed. [14] High gastric residual volumes after a period of rest from feeding are used as a marker of gastric intolerance. In general, a range of 50-150 ml has been suggested. The frequency at which residual volumes should be measured varies from 4-hourly to 6-hourly daily. [56]

Routine laboratory analysis should be carried out: blood glucose levels, electrolyte values, measures of kidney and liver function and measures of protein metabolism. [14] There was, once again, no standard on the type and frequency of biochemical measurements that needs to be done in burned patients and this varied significantly between burns units and health professionals. A protocol that gives guidance on type and frequency of measurements is desperately needed in South African burns units.

Albumin levels correlate poorly with nutritional status and should not be used to determine the adequacy of nutritional support. [9, 29] Pre-albumin is considered to be the most suitable indicator of nutrition in burned patients. [9, 14, 29] Pre-albumin has a much shorter half-life of only 2-3 days. Pre-albumin and transferrin correlate well with negative nitrogen balance. [38] One burns unit made use of pre-albumin and CRP when monitoring the nutritional status of a patient. It is however important to note that the measurement of pre-albumin is more costly than that of albumin and this should be taken into consideration when deciding whether to use pre-albumin.

Anabolic agents were not very commonly used in South Africa, probably due to their high cost. This practice may be worth investigating since the treatment of burned patients with an oral dose of oxandrolone at 0.1 mg/kg twice daily or 20 mg/day improved muscle protein metabolism by enhanced efficiency of protein synthesis according to recent studies. [11] Testosterone derivates are less expensive than for example hGH and safe to use at recommended dosages.

According to the results the dietitians were aiming to keep strict blood glucose control in burned diabetic patients as recommended in the literature. [95] Blood glucose was monitored regularly, diabetic diets were provided according to energy requirements and fibre and low fat foods were incorporated into the meal plan. The use of diabetic supplemental drinks and enteral products was common.

Renal burned patients were also closely monitored and dietary goals were also within current recommendations. Burned patients with renal failure should receive approximately 1.7g protein / kg body weight per day, when dialyzed and electrolytes should be restricted. [93] South African dietitians concentrated on diets which were electrolyte and protein restricted according to patients' needs, and fluid needs were kept into consideration.

Patients were, however, not followed-up regularly by dietitians. This is another area where improvements should be considered, since it is clear from the literature that hypermetabolism persist for months after the insult and patients may still continue losing weight and have impaired nutritional status. No recommendations are available in the literature as to how often patients should be followed-up by the dietitian.

The main limitation of the research was the small number of burns units that were used in the study to obtain the results. However, these were the only units available in the country. Future research could possibly focus more on “informal” management of burned patients in smaller units or where patients are managed as part of the surgical units.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

The pivotal role of nutrition in hypermetabolic, catabolic patients with burn injury is clear from recent data and literature. [8] So far we have seen that supporting the stress response to injury, preventing infection, and encouraging wound healing are the primary factors influencing the burned patient's need for aggressive nutritional management. [6]

The results of this study indicate that despite the use of correct recommendations in certain instances there remains a definite degree of variation and uncertainty amongst health professionals regarding the nutritional management of burned patients. Another fact that is a cause of concern is that there appears to be poor communication between health professionals that deal with burn injured patients and their nutrition on a daily basis. The burns units in South Africa and other units caring for patients with major burn injury should use set standards for nutritional management, obtain and implement strict feeding protocols and improve communication with means such as multi-disciplinary ward rounds. Protocols for the nutritional management of burn injured patients can assist in communication between health professionals, prevent over- or underfeeding and avoid unnecessary interruptions of feeds or prescription of wrong diets or products. Standardized methods for the estimation of macronutrient requirements are desperately needed and further studies to investigate these matters should be performed.

In the meanwhile, dietitians actively involved in the management of burned patients should study peer reviewed literature and come up with acceptable methods which should form a standard throughout South Africa. Ongoing education and provision of the latest data will enable South African surgeons, dietitians and professional nurses to appropriately to treat burned patients in South Africa.

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APPENDICES

RESEARCH PROTOCOL

Marlene Ellmer

13099477

Masters in Nutrition

Department of Human Nutrition

University of Stellenbosch

October 2004

TABLE OF CONTENTS

1. TITLE

A study to determine the nutritional management of adult burn wounds patients in South Africa.

2. INVESTIGATORS:

Marlene Ellmer

Study-leader: Dr. Renee Blaauw

Co-study leader: Mrs. Sulene van der Merwe

3. INTRODUCTION:

The role of nutrition in hypermetabolic, catabolic patients with burn injury is well known and well described in the literature and nutritional support is an important part of the management of these critically ill patients [1].

Supporting the stress response to injury, preventing infection, and encouraging wound healing are the primary factors influencing the burned patient's need for aggressive nutritional management. [2]

It is accepted that nutritional support may improve morbidity and mortality after severe thermal injury. However it is also known that energy intake cannot overcome the catabolic response to critical illness, and the detrimental effects of over-feeding are well established. [3] But do we in South Africa realize the importance of nutrition in the outcome of our terminally injured patients and do we have registered dietitians, surgeons and chief professional nurses that are actively involved of the determination of requirements, administration and monitoring of nutritional support?

Success of the nutrition management may depend on how well this burn-related change in energy expenditure can be estimated and then matched by an appropriate level and mixture of macronutrients and micronutrients. [3]

As a result attempts have been made to improve methods for estimating energy requirements in thermally injured patients. Unfortunately the abundance of predictive methods used for estimating energy expenditure may have led to further confusion rather than clarity. [3] More specific, which are most commonly used in South Africa, are they valid for our particular population or are we over- or underfeeding our patients? There is currently no literature in South Africa available on population specific methods that differentiate our population from our neighbours in more western and developed countries.

Enteral nutrition is the preferred route of providing nutrition to the acutely injured burned patient. The multiple benefits associated with enteral feeding have been well documented, [4] Total parenteral nutrition (TPN) has been shown to be ineffective in preventing the catabolic response after burn injury. TPN enhanced the stress response, increases endotoxin translocation and leads to an impairment of mucosal immunity. [4] In burned patients supplemental TPN leads to a significant increase in mortality. [4]
Contra-indications for enteral nutrition in burned patients practically does not exist; there are only very few, rare, contra-indications for enteral nutrition. These include disordered function of bowels due to inflammation or stasis, no technical possibilities for administration and ethical aspects (terminal condition). [5] In the first two situations TPN could be considered.
Total enteral nutrition should start as early as possible and can be increased very rapidly. [4] In fact it has been shown that early aggressive enteral feeding improve clinical outcomes. [4]
Specific formulae of enteral nutrition for specific metabolic abnormalities are currently under evaluation Do we have products and formulae available in South Africa and can we afford them, and do we have the knowledge to use them, for us to be able to treat our patients optimally. Are we using the correct methods, route and amounts with regards to the administration of enteral nutrition and TPN?

It is very important to evaluate efficiency of nutritional support for the consequence of insufficient nutrition is slower and ineffective wound healing. Evaluation of the nutritional status of the patient should be started from clinical analysis. Tolerance to enteral nutrition should be constantly observed; remaining volume of stomach should be measured and intestine transit should be observed. Routine laboratory test should also be carried out for the monitoring of the patients. [5] Do we have these facilities and resources available to implement the measures in South Africa and are they being used optimally?

Anabolic hormones that are suppressed by the acute response are clinically available exogenously and have been shown to be efficacious in increasing protein synthesis. [2]

Are they available in South Africa, and do we use them?

In South Africa, we are currently dealing with obstacles on a daily basis that could influence our management of our burn wound patients. Can we compare our developing country with developed countries that have sufficient staff, resources and funds? How does issues like HIV/AIDS, TB, under- and over nutrition, household food insecurity, economy influences our treatment of burn wound patients and can we apply recommendations from developed countries?

To our knowledge there have not been any studies conducted in South Africa that address or answer the above-mentioned questions. A study exploring this field is thus necessary and a great need exists. It must be determined whether we are implementing the correct practices, do we have the resources do implement it optimally and is it applicable to our unique population in South Africa?

The results of this study could be used to be used to determine whether our patients are managed optimally in terms of nutritional support and to make recommendations that will improve nutritional
practices and protocols in our burn wound patients.

4. OBJECTIVES:

4.1 RESEARCH PROBLEM

An investigation into the nutritional and other treatment-related practices of doctors, dietitians and chief professional nurses in burn wound patients in South Africa.

4.2 RESEARCH OBJECTIVES

1. To determine the nutritional practices and aspects that determine and affect the nutritional support of burn wound patients in South Africa.

Nutritional practices for the purposes of this study would include:

- Involvement of the registered dietitian in burned patients
- Use of predictive equations in SA to determine nutritional requirements
- Use of enteral and / or parenteral nutrition
- Timing and amount of nutritional support
- Application of immuno-nutrition
- Type of products and / or diets used.
- Monitoring of nutritional status and - support
- Nutritional follow-up of burned patients after discharge
- Use of agents / methods to reduce hypermetabolic response
- Working relationship of staff working with burn wound patients.

2. To compare practices to latest available literature and make subsequent recommendations.

5. STUDY PLAN

5.1 STUDY DESIGN

A descriptive study will be used.

5.2 STUDY POPULATION

5.2.1 Selection of sample

Non-random sampling will be used and the names and contact information of all institutions treating burn wound patients in South Africa that comply to the inclusion criteria will be obtained through an email request via the Association of Dietetics of South Africa's (ADSA) mailing list. All surgeons in charge of burns units, dietitians actively involved in burned patients and chief professional nurses that serve as unit managers of burns units working in hospitals that responded to the request will be included in the study.

5.2.2 Inclusion criteria

All institutions in South Africa with burn wound units that comprise of the following, will be included in the study:

- Six or more beds specifically intended for the treatment of burn wound patients (with or without ICU for burn wounds)
- One or more registered dietitians employed on a full basis in the particular institution.
- Patients treated for burn wounds, 18 years and older (adults) from both sexes (males and females).

5.2.3. METHODS OF DATA COLLECTION

Three different questionnaires (see Addenda 1-3) were compiled by the investigator in order to determine the current nutritional practices of burn wound patients in South Africa. The three questionnaires are intended for surgeons in charge of units, dietitians actively involved in nutritional care for burn wound patients and chief professional nurses that serve as unit managers of the units, respectively.
The three questionnaires will comprise of questions relating to the involvement of each health professional in the nutrition of burn wound patients. (See Addendum 1-3) The data of the three questionnaires will be processed separately, and the results would be presented for the three groups of health professionals.

The validity of the questionnaires will be tested during February 2005. The questionnaire will be completed by the staff of one pre-selected burns unit that complies with the inclusion criteria. They will be excluded from the final study population. Thereafter, any necessary changes will be made.

The final questionnaires will be sent via email and pre-paid envelopes will be sent via post to the involved dietitians in January 2005. The dietitians will be requested to distribute the questionnaires to the relevant health care professionals. The questionnaires could either be returned via email or by post.

A reminder email will be sent to all individuals who have not responded to the questionnaires during the beginning of February 2005. All returned questionnaires and participants would be kept anonymous.

6. DATA ANALYSIS

The investigator will be responsible for the processing and analysis of the data. Descriptive statistics will be used to discuss the objectives of the study.

The researched will also be responsible for the statistical procedures with the assistance of a qualified statistician.

7. RESOURCES AND BUDGET

7.1 FINANCIAL EXPENSES:

The research project will have the minimal financial expenses since all questionnaires will be emailed to the study population with the relevant letters and questionnaires attached to it as Microsoft Word documents.

The investigator will be responsible for the expenses of the research project.

7.2 STAFF

The research team consists of one qualified dietitian, undertaking her Master degree with assistance from two study-leaders from the Department of Human Nutrition and a statistician from the University of Stellenbosch.

7.3 EQUIPMENT:

Computer programs will be used for the processing of the data.

8. ETHICAL CONSIDERATION:

The study will be submitted for approval at the Committee for Human Research, Faculty of Health Sciences of the University of Stellenbosch.

All questionnaires and study participants will be kept anonymous throughout the study and thereafter.

Participation of the study is voluntary and each study participant will give written informed consent.

9. TIME SCHEDULE:

29 October 2004:	Submission of final protocol and relevant documentation to the Committee for Human Research at the US for final approval.
February 2004:	Pilot study to test questionnaires.
March 2005:	Distribution of final questionnaires to the study population.
1 April 2005:	Closing date for final questionnaires.
April 2005:	Reminder will be sent to those who have not returned questionnaires.
April 2005:	Processing of the data.
May 2005:	Writing of thesis
June 2005:	Hand in final research project to the department.

10. RESULTS REPORTING:

Data will be presented on national and international conferences and published in peer-reviewed literature.

11. REFERENCES:

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WRITTEN INFORMED CONSENT

INFORMATION AND INFORMED CONSENT DOCUMENT

TITLE OF THE RESEARCH PROJECT:
A STUDY TO DETERMIINE THE NUTRITIONAL MANAGEMENT OF BURN WOUND PATIENTS IN SOUTH AFRICA.

PRINCIPAL INVESTIGATOR: **MARLENE ELLMER**
Address: **MAYSTREET 53, ADAMAYVIEW, KLERKSDORP, 2571**
PO BOX 1871, KLERKSDORP, 2570
EMAIL: mellmer@lantic.net

DECLARATION BY OF PARTICIPANT:
I, THE UNDERSIGNED, ____*(name)*
[ID No_______________________] the participant of_____________________________ *(Address).*

A. HEREBY CONFIRM AS FOLLOWS:

1. I, the participant was invited to participate in the above mentioned research project, which is being undertaken by a Master's student of the Department of Human Nutrition, Faculty of Health Sciences, Stellenbosch University.
2. I understand the following information on the details of the study:

2.1 **Aim:**

- To determine the nutritional practices and aspects that determine and affect the nutritional support of burn wound patients in South Africa.
- To compare practices to latest available literature and make subsequent recommendations.

2.2 **Procedures:**
Please complete the attached questionnaire as complete and honestly as possible and return it to the investigator via post before 29 April 2005.

2.3 **Possible benefits:**
The results of this study would be used to be used to determine whether patients are managed optimally in terms of nutritional support and to make recommendations that will improve nutritional practices and protocols for our burn wound patients in South Africa.

2.4 **Confidentiality:**
The information collected will be treated as confidential; it will be included in a thesis, a publication in a professional journal, and be presented on international and national conferences, without disclosing the identity of the person or the institution.

2.5 **Voluntary participation/refusal/discontinuation:**
Participation is voluntary and the participant may consequently refuse to participate and such refusal would not influence the participant in any negative way.

B. HEREBY CONSENT VOLUNTARILY TO PARTICIPATE IN THE ABOVE MENTIONED PROJECT.

Signed/confirmed at _______________________(place) on ___________________________(date)

_______________________________________ _______________________________

Signature or right thumbprint of Participant *Signature of witness*

MEllmer
____

Signature of investigator

IMPORTANT MESSAGE TO PARTICIPANT:

Dear participant,

Thank you for your participation in this study. Should you, at any time during the study, require any further information with regard to the study, or have any uncertainties or questions regarding the study / questionnaires, kindly contact **MARLENE ELLMER** at telephone number **082 338 0123**

INFORMASIE EN TOESTEMMINGSDOKUMENT

TITLE VAN DIE NAVORSKINGS PROJEK:
'N STUDIE OM DIE VOEDINGSBEHANDELING VAN BRANDWONDPASIËNTE IN SUID-AFRIKA TE BEPAAL.

HOOF NAVORSER: **MARLENE ELLMER**
Adres: **MAYSTRAAT 53, ADAMAYVIEW, KLERKSDORP 2571**
POSBUS 1871, KLERKSDORP 2570
EPOS: mellmer@lantic.net

VERKLARING VAN DIE DEELNEMER:
EK, DIE ONDERTEKENDE ______________________________(*NAAM*)
[ID No__________] die deelnemer van……………………………………. *(Adres).*

A. BEVESTIG HIERMEE AS VOLG:

1. Ek, die deelnemer is uitgenooi om deel te neem aan die bogenoemde navorsingsprojek, wat uitgevoer word deur 'n Magister student van die Department Menslike Voeding, Fakulteit Gesondheidswetenskappe, Universiteit van Stellenbosch.
2. Ek verstaan die volgende aspekte aangaande die navorsingsprojek:

Doel:

- Om te bepaal watter voedingspraktyke en aspekte die voedingsorg van brandwondpasiënte in Suid-Afrika, beïnvloed.
- Om die praktyke te vergelyk met die nuutste beskikbare literatuur, en vervolgens aanbevelings te maak.

2.1 **Prosedures:**
Voltooi asb.die aangehegte vraelys so eerlik en volledig as moontlik en stuur met pos terug aan die navorsers voor 29 April 2005.

2.2 **Moontlike voordele:**
Die resultate van die studie sal gebruik word om te bepaal of pasiënte optimaal behandel word in terme van voedingsorg, en aanbevelings te maak wat die voedingspraktyke en protokolle vir brandwond pasiënte in Suid-Afrika, sal verbeter.

2.3 **Vertroulikheid:**
Die inligting wat versamel word, sal te alle tye vertroulik hanteer word. Dit sal ingesluit word in 'n tesis, 'n publikasie in 'n professionele tydskrif en voorgedra word op nasionale en internasionale konferensies, sonder om die identiteit van die deelnemers of instansies bekend te maak.

2.4 **Vrywillige deelname of weiering:**
Deelname is vrywillig en die deelnemer mag weier om aan die studie deel te neem. Weiering sal nie die deelnemer op enige wyse negatief beïnvloed nie.

B. HIERMEE TOESTEMMING OM VRYWILLIG DEEL TE NEEM AAN DIE BOGENOEMDE STUDIE.

Onderteken/bevestig ______(*plek*) ____________op__________*(datum)*

____________________ ____________________
Hndtekening van die deelnemer *Handtekening van getuie*

____
Handtekening van die navorser

BELANGRIKE BOODSKAP AAN DEELNEMER :
Beste deelnemer,
Dankie vir u deelname in hierdie studie. Sou u, enige tyd tydens die studie enige verdere informasie benodig of enige onsekerhede of vrae het aangaande die studie / vraelyste, kontak asseblief vir **MARLENE ELLMER** by telefoonnommer **082 338 0123.**

QUESTIONNAIRE
SURGEONS

Please mark the appropriate block with an "X".
Abbreviations: % TBSAB = percentage total body surface area burns

STATISTICS:

If available, please complete the following statistics:

Number of burn wound patients seen in your institution per year: ________________
Number of patients treated with 10 – 19% TBSA burns per year: _________________
Number of patients treated with 20 – 29% TBSA burns per year: _________________
Number of patients treated with 30 – 39% TBSA burns per year: _________________
Number of patients treated with 40 – 49% TBSA burns per year: _________________
Number of patients treated with >50% TBSA burns per year: ___________________
Percentage mortality from burns per year: ___________________________________
Average number of hospital days for burned patients: __________________________

INTRODUCTION:

88. Please indicate the size of the burn wound unit in your institution.

____

89. How long have you been working with burn wound patients in your institution?

____

90. Is a registered dietitian actively involved in burn wound patients in your institution (i.e. daily ward rounds etc)?

90.1	YES	
90.2	NO	

91. Are multi-disciplinary ward rounds routine in your institution?

91.1	YES	
91.2	NO	

92. If yes, how often?

92.1	DAILY	
92.2	TWICE WEEKLY	
92.3	MONTHLY	
92.4	LESS THAN MONTHLY	

93. Do you feel there is a close relationship / cooperation between doctors and dietitians in your institution?

93.1	YES	
93.2	NO	

94. How would you describe the communication with the dietitian and the medical doctors in your institution?

94.1	EXCELLENT	
94.2	GOOD	
94.3	BAD	
94.4	POOR	

95. Does your institution have a standard written policy or protocol for the nutritional management of burn wound patients?

95.1	YES	
95.2	NO	

96. Is the protocol / policy followed in your institution?

96.1	YES	
96.2	NO	

97. Are early burn wound excisions; wound closures and skin transplants performed at your institution?

97.1	YES	
97.2	NO	

98. If yes, how many hours in theatre per week?

____

99. How soon after admission is surgery performed in theatre in your institution?

____

100. Does the patient receive enteral feeding or TPN during surgery?

____

101. If no, how long before surgery is the patient kept nil per mouth?

____

ENTERAL NUTRITION

102. Please indicate the **indications** for enteral nutrition used in your institution. (Please indicate all relevant options):

102.1	More than 20% TBSA burns	
102.2	Natural nutrition impossible because of state of consciousness	
102.3	Face burn injury	
102.4	Artificial ventilation and/or tracheostomy	
102.5	Insufficient nutrition / malnutrition prior to burn injury	
102.6	Inhalation injury	
102.7	OTHER	

If "other", please specify:

____

103. Please indicate the **contra-indications** for enteral nutrition used in your institution (Please indicate all relevant options):

103.1 Disordered function of bowel due to inflammation / stasis
103.2 Ethical aspects-terminal condition
103.3 Unattainable access
103.4 Small bowel obstruction
103.5 Prolonged ileus
103.6 Abdominal distension
103.7 No enteral access available
103.8 Sepsis
103.9 OTHER

If "other", please specify:

____

104. When is enteral feeding initiated in your institution?

104.1 Within 0-12 hours after insult?
104.2 Within 24 hours after insult?
104.3 Within 72 hours after insult?
104.4 After 72 hours after insult?

105. Please indicate the preferred route for enteral nutrition:

105.1 Nasogastric tube
105.2 Post-pyloric tube
105.3 Percutaneous gastrostomy

106. Please indicate the contra-indications or reasons for "failure" of nasogastric feeding in your institution (Please indicate all relevant options):

106.1 Gastric stasis
106.2 Persistent vomiting
106.3 NG-tube could not be maintained in position
106.4 Pulmonary aspiration
106.5 Uncontrollable diarrhoea

107. If contra-indications /failure exists for nasogastric tube feeding what would your next choice be?

107.1 Total parenteral nutrition
107.2 Post-pyloric tube
107.3 Percutaneous gastrostomy

108. Is a radiologist used when placing the post-pyloric tube?

108.1 YES
108.2 NO

109. Is an endoscopists used when placing the post-pyloric tube?

109.1 YES
109.2 NO

110. Is it routine to X-ray patients after insertion of a post-pyloric tube?

110.1 YES
110.2 NO

111. Do all patients with inhalation injury receive enteral nutrition?

111.1 YES
111.2 NO

MICRONUTRIENTS

112. Is the administration of a multi-vitamin supplement to burn wound patients part of routine care in your institution?

112.1	YES	
112.2	NO	

113. Does the supplement also contain minerals and / or trace elements?

113.1	YES		113.3	MINERALS	
113.2	NO		113.4	TRACE ELEMENTS	

114. Please indicate (tick) the micronutrients as well as their daily dosages that are routinely prescribed in burn wound patients in your institution:
(Supplementation in addition to standard nutrition therapy)

Micronutrient		**Daily dosage**
Vitamin A		
Vitamin B-Complex		
Folic acid		
Vitamin C		
Vitamin D		
Vitamin E		
Vitamin K		
Calcium		
Magnesium		
Phosphorus		
Zinc		
Iron		
Selenium		
Copper		

MONITORING:

115. Which of the following are monitored in your institution, and how often?

	3 X PER DAY	**2 X PER DAY**	**1 X PER DAY**	**3 X PER WEEK**	**2 X PER WEEK**	**1 X PER WEEK**	**2 X PER MONTH**	**1 X PER MONTH**	**NEVER**
Blood glucose levels									
S-electrolytes									
Gastric aspirate/residual volume									
Kidney function tests									
Liver function tests									
Nitrogen balance									
Albumin									
Pre-albumin									
C-reactive protein (CRP)									
Full blood count									
Calcium, Magnesium, Phosphorus									
OTHER									

If "other", please specify:

116. Are protein losses monitored in burn wound patients?

116.1	YES	
116.2	NO	

If yes, how is it done?

117. Are prokinetic agents used in your institution?

117.1	YES	
117.2	NO	

118. If yes, in which instances?

119. Please indicate the type and dosages of prokinetic agent used.

ANABOLIC AGENTS

120. Are anabolic agents used in your institution for suppression of the hypermetabolic response?

120.1	YES	
120.2	NO	

121. If yes, please indicate the type and dosage:

			Dosage
121.1	Human Growth Hormone (hGH)		
121.2	Testosterone		
121.3	Oxandrolone		
121.4	Insulin-like-growth-factor 1 (IGF-1)		
121.5	Insulin		
121.6	Beta-blocking agents		
121.7	OTHER		

If, "other" please specify:

122. If Beta-Blocking agents are used; please indicate the types and dosages:

123. Please indicate the timing of anabolic agent administration and provide reasons for the regimen (i.e. after 5 or 10 days).

124. Are the anabolic agents administered once or repeatedly?

124.1	ONLY ONCE	
124.2	REPEATEDLY	

125. If repeatedly, how often?

___

FOLLOW-UP:

126. Do the doctors follow up burned patients after discharge as part of an outpatient department?

126.1	YES	
126.2	NO	

If yes, how often are the followed-up?

___

___

___

THANK YOU FOR YOUR TIME AND COOPERATION!

QUESTIONNAIRE
DIETITIANS

Please mark the appropriate block with an "X".
Abbreviations: % TBSA = percentage total body surface area burns

INTRODUCTION:

1. How long have you been working with burn wound patients in your institution?

____

2. Does your institution have a standard written policy or protocol for the nutritional management of burn wound patients?

2.1	YES	
2.2	NO	

3. Is the protocol / policy followed in your institution?

3.1	YES	
3.2	NO	

4. How would you describe the communication with the dietitian and the medical doctors in your institution?

4.1	EXCELLENT	
4.2	GOOD	
4.3	BAD	
4.4	POOR	

5. Is there, in your opinion, a close relationship / cooperation between nursing staff and dietitians in your institution?

5.1	YES	
5.2	NO	

6. How would you describe the communication with the dietitian and the nursing staff?

6.1	EXCELLENT	
6.2	GOOD	
6.3	BAD	
6.4	POOR	

7. What is the preferred feeding route / first choice for patients with 1-20 % Total Body Surface area (TBSA) burns?

7.1	ORAL ROUTE	
7.2	ENTERAL NUTRITION	
7.3	TOTAL PARENTERAL NUTRITION (TPN)	
7.4	ORAL ROUTE + NOCTURNAL TUBE FEEDS	
7.5	OTHER	

If "other", please give details:

____

8. What is the preferred feeding route / first choice for patients with 21-40% TBSA burns?

8.1	ORAL ROUTE	
8.2	ENTERAL NUTRITION	
8.3	TOTAL PARENTERAL NUTRITION (TPN)	
8.4	ORAL ROUTE + ENTERAL NUTRITION OVER 24 HOURS	
8.5	ORAL ROUTE + NOCTURNAL TUBE FEEDS	
8.6	OTHER	

If "other", please give details:

---

9. What is the preferred feeding route / first choice for patients with > 40% TBSA burns?

9.1	ORAL ROUTE	
9.2	ENTERAL NUTRITION	
9.3	TOTAL PARENTERAL NUTRITION (TPN)	
9.4	ORAL ROUTE + ENTERAL NUTRITION OVER 24 HOURS	
9.5	ORAL ROUTE + NOCTURNAL TUBE FEEDS	
9.6	OTHER	

If "other", please give details:

---

10. Does the patient receive enteral feeding or TPN during surgery?

10.1	YES	
10.2	NO	

ESTIMATION OF DIETARY REQUIREMENTS:

11. Do you take the percentage total body surface area burns (%TBSAB) into consideration when calculating your patient's dietary requirements?

11.1	YES	
11.2	NO	

12. Does your nutritional regimen change when the % TBSAB is above / under a certain number?

12.1	YES	
12.2	NO	

13. When calculating energy needs, is a metabolic formula used?

13.1	YES	
13.2	NO	

14. If yes, please indicate which metabolic formula / formulae are used?

14.1	CURRERI FORMULA (25 X body weight) + (40 X % TBSAB)	
14.2	HARRIS-BENEDICT WITH STRESS FACTORS RELATED TO **% TBSA BURNS**	
14.3	HARRIS-BENEDICT X **2**	
14.4	HARRIS-BENEDICT X **1.5**	
14.5	HARRIS-BENEDICT X **1.3**	
14.6	20 kcal / kg / day	
14.7	30 kcal / kg / day	
14.8	35 kcal / kg / day	
14.9	40 kcal / kg / day	
14.10	OTHER	

If "OTHER", please specify (if possible, please include the reference / source used for the "other" formula used):

____

15. Are different metabolic formulaes used for calculating the energy needs for patients that are ventilator dependent compared to patients that are not on a ventilator?

15.1	YES	
15.2	NO	

If yes, please give details:

____
____

16. Are different metabolic formulae used for calculating the energy needs for patients that are recovering and undergoing wound healing?

16.1	YES	
16.2	NO	

If yes, please give details:

____

17. To prevent overfeeding, what is the maximum amount of energy used in burn wound patients in your institution? Please motivate your answer.

____

18. When calculating protein needs, is a metabolic formulae used?

18.1	YES	
18.2	NO	

19. If yes, please indicate which metabolic formula / formulae are used?

19.1	Kcal Non-protein Energy (NPE) to Nitrogen (N) in gram ratio: 150:1	
19.2	Kcal Non-protein Energy (NPE) to Nitrogen (N) in gram ratio: 100:1	
19.3	Kcal Non-protein Energy (NPE) to Nitrogen (N) in gram ratio: 80:1	
19.4	1.5 gram protein / kg body weight per day	
19.5	2 gram protein / kg body weight per day	
19.6	2.5 gram protein / kg body weight per day	
19.7	OTHER	

If “OTHER”, please specify (if possible, please include the reference / source used for the formula used):

---

20. To prevent overfeeding, what is the maximum amount of proteins used in burn wound patients in your institution? Please motivate your answer.

---

21. Please choose the non-protein energy distribution calculated for burned patients in your institution.

21.1	61-70% CHO 30-39% FAT	
21.2	51-60% CHO 40-49% FAT	
21.3	41-50% CHO 50-59% FAT	
21.4	OTHER	

If “other”, please specify:

Please give reasons for your answer in 21:

---

22. Is it possible to perform indirect calorimetry in your institution?

22.1	YES	
22.2	NO	

23. If yes, is indirect calorimetry routinely performed in your institution to estimate energy needs?

23.1	YES	
23.2	NO	

24. If yes, how often?

24.1	DAILY	
24.2	THREE TIMES A WEEK	
24.3	TWICE A WEEK	
24.4	ONCE A WEEK	
24.5	EVERY TWO WEEKS	
24.6	ONCE A MONTH	
24.7	ONLY ONCE	

25. Are patients monitored for overfeeding?

25.1	YES	
25.2	NO	

If yes, please state how.

---

26. Are patients monitored for underfeeding?

26.1	YES	
26.2	NO	

If yes, please state how.

ENTERAL NUTRITION:

27. Please indicate the **indications** for enteral nutrition used in your institution (Please indicate all relevant options):

27.1	More than 20% TBSA burns	
27.2	Natural nutrition impossible because of state of consciousness	
27.3	Face burn injury	
27.4	Artificial ventilation and/or tracheostomy	
27.5	Insufficient nutrition / malnutrition prior to burn injury	
27.6	Inhalation injury	
27.7	OTHER	

28. If "other", please specify:

____

29. Please indicate the **contra-indications** for enteral nutrition used in your institution (Please indicate all relevant options):

29.1	Disordered function of bowel due to inflammation / stasis	
29.2	Ethical aspects-terminal condition	
29.3	Unattainable access	
29.4	Small bowel obstruction	
29.5	Prolonged ileus	
29.6	Abdominal distension	
29.7	No enteral access available	
29.8	Sepsis	
29.9	OTHER	

If "other", please specify:

____

30. Please indicate the method of enteral feeding:

30.1	Bolus feeding		30.2	Continuous feeding	

31. What is the starting volume for initiating enteral nutrition at your institution?

31.1	10 ml / hour	
31.2	20ml / hour	
31.3	30ml / hour	
31.4	40ml / hour	
31.5	50ml / hour	
31.6	More then 50ml / hour	

32. How fast are at least 50% of energy goals achieved?

32.1	Within 24 hours	
32.2	Within 48 hours	
32.3	Within 72 hours	
32.4	After 72 hours	

33. How fast are the full energy goals achieved?

33.1	Within 24 hours	
33.2	Within 48 hours	
33.3	Within 72 hours	
33.4	After 72 hours	

34. Please name the enteral product (as well as the company that manufactures it) most frequently prescribed for burn wound patients in your institution when feeding is **initiated**?

____

35. Please indicate the energy content of the product in kcal / ml:

35.1	1 kcal / ml	
35.2	1.5 kcal / ml	
35.3	2 kcal / ml	
35.4	> 2 kcal / ml	

36. Please indicate the percentage (%) of total energy that the macronutrient composition of the product is comprised of.

CARBOHYDRATES	
PROTEIN	
FAT	

37. Does the above-mentioned product contain fibre?

37.1	YES	
37.2	NO	

38. Is the above-mentioned product a closed-system product or open-system feeding?

38.1	CLOSED	
38.2	OPEN	

39. Are more than one enteral products used in the routine nutritional treatment of your patients?

39.1	YES	
39.2	NO	

40. If yes, please state the indications for changing to a different product:

____

41. If yes, to question 39, please name the enteral product (as well as the company that manufactures it)

____

____

42. Please indicate the energy content of the product in kcal / ml:

42.1	1 kcal / ml	
42.2	1.5 kcal / ml	
42.3	2 kcal / ml	
42.4	> 2 kcal / ml	

43. Please indicate the percentage (%) of total energy that the macronutrient composition of the product is comprised of.

CARBOHYDRATES	
PROTEIN	
FAT	

44. Does the above-mentioned product contain fibre?

44.1 YES ☐
44.2 NO ☐

45. Is the above-mentioned product a closed-system product or open-system feeding?

45.1 CLOSED ☐
45.2 OPEN ☐

46. Is the intake of enteral nutrition charted in the patients file?

46.1 YES ☐
46.2 NO ☐

47. How often are tubefeeds exchanged?

47.1 6 HOURLY ☐
47.2 12 HOURLY ☐
47.3 24 HOURLY ☐
47.4 36 HOURLY ☐
47.5 48 HOURLY ☐
47.6 > 48 HOURLY ☐

IMMUNONUTRITION:

48. Do you incorporate immunomodulators into your nutritional care for burn wound patients?

48.1 YES ☐
48.2 NO ☐

49. If yes, do you supplement glutamine separately as part of routine care?

49.1 YES ☐
49.2 NO ☐

50. If yes to question 49, please state the name of the product used for glutamine supplementation.

____

51. Is the glutamine supplement administered parenterally or enterally?

51.1 ENTERALLY ☐
51.2 PARENTERALLY ☐

52. Please indicate the dose of glutamine supplemented:

52.1 0.2 g / kg / day ☐
52.2 0.5 g / kg /day ☐
52.3 20 – 30g / day ☐
52.4 OTHER ☐

If "other", please specify:

____

53. Do you feel it is necessary to use enteral products that contain the so-called immuno-nutrition "mix"?

53.1	YES	
53.2	NO	

54. Do you ***use*** enteral products that contain the so-called immuno-nutrition "mix"? (I.e. a combination of immunomodulators?)

54.1	YES	
54.2	NO	

55. Please provide reasons for your answer in question 54.

____

56. Which of the following immuno-modulators does the product contain?
(Mark more than one, if applicable.)

56.1	GLUTAMINE	
56.2	ARGININE	
56.3	OMEGA 3 FATTY ACIDS	
56.4	OTHER	

MICRONUTRIENTS

57. Is the administration of a multi-vitamin supplement to burn wound patients part of routine care in your institution?

57.1	YES	
57.2	NO	

58. Does the supplement also contain minerals and / or trace elements?

58.1	YES		58.3	MINERALS	
58.2	NO		58.4	TRACE ELEMENTS	

59. Please indicate (tick) the micronutrients as well as their daily dosages that are routinely prescribed in burn wound patients in your institution:
(Supplementation in addition to standard nutrition therapy)

Micronutrient		**Daily dosage**
Vitamin A		
Vitamin B-Complex		
Folic acid		
Vitamin C		
Vitamin D		
Vitamin E		
Vitamin K		
Calcium		
Magnesium		
Phosphorus		
Zinc		
Iron		
Selenium		
Copper		

<u>PATIENTS WITH INHALATION INJURY</u>

60. Are patients with inhalation injury treated differently (in terms of nutrition) than patients without inhalation injury?

60.1	YES	
60.2	NO	

If yes, please explain:

____

61. Do all patients with inhalation injury receive enteral nutrition?

61.1	YES	
61.2	NO	

MONITORING OF NUTRITIONAL STATUS:

62. Is the weight of all less critical burned patients (i.e. non-ICU patients and patients with less % TBSA burns) obtained on admission?

62.1	YES	
62.2	NO	

63. Is the height of all less critical burned patients (i.e. non-ICU patients and patients with less % TBSA burns) obtained on admission?

63.1	YES	
63.2	NO	

64. How often are burned patients, in the recovery phase, weighed in your institution?

64.1	DAILY	
64.2	WEEKLY	
64.3	MONTHLY	
64.4	ONLY ON ADMISSION	
64.5	NOT ROUTINELY DONE	

65. What weight is used for calculations of dietary requirements?

65.1	CURRENT BODY WEIGHT	
65.2	ADMISSION BODY WEIGHT	
65.3	IDEAL BODY WEIGHT	

66. Is oedema taken into consideration, i.e. do you subtract a certain weight if oedema is present?

66.1	YES	
66.2	NO	

67. Is BMI calculated for all burn wound patients?

67.1	YES	
67.2	NO	

68. If yes, does the nutritional regimen change for patients with under-nutrition, over nutrition of obesity? (i.e. BMI < 18.5, >25, > 30).

68.1	YES	
68.2	NO	

69. If yes to question 68, please specify:

---

70. Are any other anthropometric measurements (i.e. triceps skin fold, sub scapular skin fold, waist and hip measurements, upper arm circumference etc.) routinely performed in your institution?

70.1	YES	
70.2	NO	

71. How is the nutritional status of the patient monitored? (Indicate more than one if applicable)

71.1	Blood glucose levels	
71.2	S-electrolytes	
71.3	Gastric aspirate/residual volume	
71.4	Kidney function tests	
71.5	Liver function tests	
71.6	Nitrogen balance	
71.7	Albumin	
71.8	Pre-albumin	
71.9	C-reactive protein (CRP)	
71.10	Full blood count	
71.11	Calcium, Magnesium, Phosphorus	
71.12	Other	

If "other", please specify:

---

72. Are protein losses monitored in burn wound patients?

72.1	YES	
72.2	NO	

73. If yes, how?

ORAL DIET

74. Is supplementary enteral nutrition maintained until the patients are able to meet their estimated requirements orally?

74.1	YES	
74.2	NO	

75. Please indicate the type of oral diet that is introduced to burn wound patients (either initially or after enteral nutrition).

75.1	NORMAL WARD DIET	
75.2	HIGH PROTEIN DIET	
75.3	HIGH FIBRE DIET	
75.4	LIGHT DIET	
75.5	OTHER	

If “other”, please specify:

____

76. If available, please indicate the macronutrient compositions of the oral diets used for burn wound patients in your institution:

TYPE OF DIET					
ENERGY					
CARBOHYDRATES					
PROTEIN					
FAT					
FIBER					

77. Is the oral intake of the patient charted in the patients file?

77.1	YES	
77.2	NO	

78. Who decides on the type of oral diet in your institution?

78.1	NURSING STAFF	
78.2	DIETITIAN	
78.3	DOCTOR	

80. Are any supplemental oral drinks provided to patients in addition to oral diet as part of routine care in your institution?

80.1	YES	
80.2	NO	

81. If yes, are the supplemental drinks commercial or hospital-made?

81.1	COMMERCIAL	
81.2	HOSPITAL-MADE	
81.3	BOTH	

82. If commercial, please state the name of the product/s.

____

83. If hospital-made, please indicate the type of ingredients and volumes used.

____

SPECIFIC DISEASE STATES:

Please indicate how the following patients are nutritionally treated (if different) in the burn wound unit:

84. **Diabetes Mellitus:**

____
____
____

85. **Increased blood glucose:**

____
____
____

86. **Kidney failure:**

____
____
____

FOLLOW-UP:

87. Does the dietitian follow up burned patients after discharge as part of the outpatient department?

87.1	YES	
87.2	NO	

THANK YOU FOR YOUR TIME AND COOPERATION

QUESTIONNAIRE
CHIEF PROFESSIONAL NURSES
UNIT MANAGERS

Please mark the appropriate block with an "X".

INTRODUCTION:

127. How long have you been working with burn wound patients in your institution?

____

128. Is a registered dietitian actively involved in burn wound patients in your institution (i.e. daily ward rounds etc)?

128.1 YES ☐
128.2 NO ☐

129. Are multi-disciplinary ward rounds routine in your institution?

129.1 YES ☐
129.2 NO ☐

130. If yes, how often?

130.1 DAILY ☐
130.2 TWICE WEEKLY ☐
130.3 MONTHLY ☐
130.4 LESS THAN MONTHLY ☐

131. Does your institution have a standard written policy or protocol for the nutritional management of burn wound patients?

131.1 YES ☐
131.2 NO ☐

132. Is the protocol / policy followed in your institution?

132.1 YES ☐
132.2 NO ☐

133. Is there, in your opinion, a close relationship / cooperation between nursing staff and dietitians in your institution?

133.1 YES ☐
133.2 NO ☐

134. How would you describe the communication with the dietitian and the nursing-staff?

134.1 EXCELLENT ☐
134.2 GOOD ☐
134.3 BAD ☐
134.4 POOR ☐
134.5 ABSENT ☐

ENTERAL NUTRITION

135. Please indicate the method of enteral feeding:

135.1 Bolus feeding ☐ 135.2 Continuous feeding ☐

136. What is the starting volume for initiating enteral nutrition at your institution?

136.1	10 ml / hour	
136.2	20ml / hour	
136.3	30ml / hour	
136.4	50 ml / hour	
136.5	More then 50ml / hour	

137. Do you administer medication via the NG-tube in your institution?

137.1	YES	
137.2	NO	

138. Are the tubes flushed with sterile – or tap water?

138.1	YES		138.3	TAP WATER	
138.2	NO		138.4	STERILE WATER	

139. If yes, how often?

---

140. Are patients monitored for over-feeding?

140.1	YES	
140.2	NO	

If yes, please state how.

---

141. Are patients monitored for underfeeding?

141.1	YES	
141.2	NO	

If yes, please state how.

---

142. Is the intake of enteral nutrition charted in the patient's file?

142.1	YES	
142.2	NO	

143. How often are tubefeeds exchanged?

143.1	12 HOURLY	
143.2	24 HOURLY	
143.3	36 HOURLY	
143.4	48 HOURLY	
143.5	> 48 HOURLY	

MICRONUTRIENTS

144. Is the administration of a multi-vitamin supplement to burn wound patients part of routine care in your institution?

144.1	YES	
144.2	NO	

145. Does the supplement also contain minerals and / or trace elements?

145.1	YES		145.3	MINERALS	
145.2	NO		145.4	TRACE ELEMENTS	

146. Please indicate (tick) the micronutrients as well as their daily dosages that are routinely prescribed in burn wound patients in your institution:
(Supplementation in addition to standard nutrition therapy)

Micronutrient		**Daily dosage**
Vitamin A		
Vitamin B-Complex		
Folic acid		
Vitamin C		
Vitamin D		
Vitamin E		
Vitamin K		
Calcium		
Magnesium		
Phosphorus		
Zinc		
Iron		
Selenium		
Copper		

MONITORING:

147. Which of the following are monitored in your institution, and how often?

	3 X PER DAY	**2 X PER DAY**	**1 X PER DAY**	**3 X PER WEEK**	**2 X PER WEEK**	**1 X PER WEEK**	**2 X PER MONTH**	**1 X PER MONTH**	**NEVER**
Blood glucose levels									
S-electrolytes									
Gastric aspirate/residual volume									
Kidney function tests									
Liver function tests									
Nitrogen balance									
Albumin									
Pre-albumin									
C-reactive protein (CRP)									
Full blood count									
Calcium, Magnesium, Phosphorus									
OTHER									

If “other”, please specify:

____

ORAL DIET

148. Is the oral intake of the patient charted in the patient’s file?

148.1 YES ☐
148.2 NO ☐

149. Who decides on the type of oral diet in your institution?

149.1 NURSING STAFF ☐
149.2 DIETITIAN ☐
149.3 DOCTOR ☐

150. Please indicate the type of oral diet that is introduced to burn wound patients (either initially or after enteral nutrition).

150.1 NORMAL WARD DIET ☐
150.2 HIGH PROTEIN DIET ☐
150.3 HIGH FIBRE DIET ☐
150.4 LIGHT DIET ☐
150.5 OTHER ☐

151. If “other”, please specify:

____

152. Is supplementary enteral nutrition maintained until patients are able to meet their estimated requirements orally?

152.1 YES ☐
152.2 NO ☐

153. Please indicate what is done in cases where patients refuse to eat due to pain, depression etc.

____

MONITORING OF NUTRITIONAL STATUS:

154. Is the weight of all less critical burned patients (i.e. non-ICU patients and patients with less % TBSA burns) obtained on admission?

154.1 YES ☐
154.2 NO ☐

155. Is the height of all less critical burned patients (i.e. non-ICU patients and patients with less % TBSA burns) obtained on admission?

155.1 YES ☐
155.2 NO ☐

156. How often are burned patients, in the recovery phase, weighed in your institution?

156.1 DAILY ☐
156.2 WEEKLY ☐
156.3 MONTHLY ☐
156.4 ONLY ON ADMISSION ☐

THANK YOU FOR YOUR TIME AND CO-OPERATION!