UNIT 5 NUTRITION DURING STRESS

Structure

5.1 INTRODUCTION

We all experience stress at some time or the other in life. Stress is the condition or stimulus that threatens the body's homeostasis. Stress may be physical and/or mental and may develop due to a number of reasons. Emotional stress results from feelings of ambition, divine and desire but is perceived as positive. However strain, tension and anxiety due to death of a dear one, financial problems, divorce, unemployment, sickness and injury, etc. are negative forms of emotional stress. Physical stress may occur in the form of starvation, illness, surgery, infection, injury, burns or trauma. We must also remember here that following a major stress, patients often exhibit a characteristic behaviour. These include immobility, when patients are fearful of moving or interacting; withdrawal, when patients may cease being aware of their environment and become incommunicative; and antagonism, when patients may resist interaction and display hostility to those around them. Altered cerebral blood flow may also be a reason for altered mental state.

In this unit, we shall be discussing the metabolic alterations and the importance of good nutrition in combating the ill effects of stress such as surgery, burns, trauma and sepsis. We shall first however, brief ourselves regarding the major physical/metabolic changes which may develop once the stress response has been activated.

Objectives

After studying this unit, you will be able to:

- define a stress response,
- enlist the various phases of a stress response,
- discuss the physiological, hormonal and metabolic changes during situations of stress such as surgery, burns, trauma and sepsis, and
- describe the nutritional support required for these stress conditions.

5.2 THE STRESS RESPONSE

The terms trauma, stress, shock are very often used interchangeably and encompass a variety of conditions such as sepsis (infection), burns, injury (accidents, wounds), surgery (elective/emergency) etc. Before we proceed towards understanding the physical and metabolic responses of the human system towards stress, it is important to remember that whether the event is in the form of sepsis (infection), trauma (including burns), or surgery, once the systemic response is activated, the physiologic and metabolic changes that follow are similar and may lead to shock and other outcomes. Variable responses relate to patient's age, previous state of health, pre-existing disease, type of infection and presence/absence of multiple organ dysfunction syndrome (MODS).

It has long been recognized that the physiological response of the patient to a stress or disease process will very largely determine the outcome. To an extent this will depend on the extent of the shock and injury; this tends to be minimal for minor surgery or injury and extensive for major accidental or surgical trauma. However, the physiological reserve of the individual is also important. Signals that are initiated in injured or ischaemic tissues communicate the extent of the injury systemically. These stress responses are necessary for the process of recovery from injury. However, when trauma is severe, the resultant physiological responses are extensive and sustained, such that the same responses may be detrimental and contribute to the progression to critical illness and even death. Stress response means major changes in metabolism that occur after severe injury, illness or infection. The nutrient needs of the body are greatly altered as a result of this response. There is accelerated catabolism of lean body or skeletal mass resulting in muscular wasting and a negative nitrogen balance. The metabolic responses to critical illness have been studied in a variety of critically ill patients, especially those with trauma, burns, or sepsis. The responses are often grouped into phases on the basis of their temporal relation to the injury or insult. The stress response is therefore referred to as a dynamic process that has an *ebb phase*, a *flow phase* and an *anabolic phase*. Let us discuss these phases one by one.

***Ebb-Phase*:** This occurs immediately following injury and lasts for approximately 24-hours. The so-called ebb phase, which is the early phase of the injury response, is characterized by:

- an elevated blood glucose level,
- normal glucose production,
- elevated free fatty acid levels,
- low insulin concentration,
- elevated levels of catecholamines and glucagon,
- an elevated blood lactate level,
- depressed oxygen consumption,
- below-normal cardiac output, and
- below-normal core temperature.

The ebb phase is dominated by cardiovascular instability, alterations in circulating blood volume, impairment of oxygen transport, and heightened autonomic activity. Emergency support of cardiopulmonary performance is of paramount therapeutic concern. Shock is the clinical manifestation of the ebb phase. After effective resuscitation has been accomplished and restoration of satisfactory oxygen transport has been achieved, the next phase i.e flow phase comes into play.

Flow Phase **:** This is a neuro-endocrine response to physiological stress following the ebb phase. This phase is characterized by:

- normal or slightly elevated blood glucose level,
- increased glucose production,
- normal or slightly elevated free fatty acid levels, with flux increased,
- a normal or elevated insulin concentration,
- normal or elevated levels of catecholamine and an elevated glucagon level,
- a normal blood lactate level,
- elevated oxygen consumption,
- increased cardiac output, and
- elevated core temperature.

It is characterized by hyper metabolism /catabolism. Increased cardiac output, urinary nitrogen losses, oxygen consumption, body temperature and energy expenditure occurs during the flow phase. There are also profound hormonal changes. As a result, there is breakdown of body protein stores to provide glucose and hence a rapid loss of nitrogen in the urine. Blood flow to the gastrointestinal tract is often reduced during this phase. This decreases the supply of oxygen and nutrients to the gastrointestinal tract. The secretion of mucus is decreased, whereas, gastric acid secretion is increased. This leads to wasting of the cells lining the gastrointestinal tract resulting in diarrhoea and bloating.

Recovery or Anabolic Phase **:** When wounds are closed and infection has resolved, repletion of lean tissue and fat stores along with restoration of strength and stamina can begin. This final, anabolic phase often begins near the time of hospital discharge and may persist for months before the patient fully recovers and is characterized by building up of body tissue and nutrient stores (anabolism). This phase is also marked by hormonal changes. There is an increase in the release of insulin and growth hormones. The patient's progress to the anabolic phase is important and depends on a number of factors. Age, severity and duration of the stress, as well as, the individual's prior nutritional status influence tissue growth and anabolism. Attempts to restore body mass and nutritional status rapidly may induce adverse metabolic consequences. Underweight and overweight patients and the elderly are particularly vulnerable to overfeeding, because of the difficulties in assessing true requirements.

Patients with ample nutrient stores to draw on during stress are better able to tolerate the negative effects of the stress, especially in case of emergency or unexpected stress. Having learnt about the stress response and its three phases, next let us move on to the study of the stress conditions, namely surgery, burns, trauma and infections, which have a great impact on metabolism

We shall first begin with surgery. We will learn about the changes in the metabolism of the body before and after surgery and how can an appropriate nutrition support minimize the stress/contraindications of surgery thereby promoting a speedy recovery.

5.3 SURGERY

Surgery ! Does the word itself not create a feeling of anxiety and bring our thoughts towards a debilitating state of health which would be accompanied by pain, inability to move and a high susceptibility for severe morbidity/mortality! Well, surgery, in fact, is one of the most stressful situations encountered in life. But have you ever focused your thoughts as to what exactly does the term surgery mean? or during which situations is surgery performed? What is the impact of a surgical procedure on our health and how can judicious utilization of medical and dietary services improve the ultimate outcome? Let us discuss these aspects one by one.

Well, surgery is that branch of medical science which has for its object the cure of local injuries or diseases, as wounds or fractures, traumas etc., whether by manual operation or by medicines along with constitutional treatment. A surgical procedure may be conducted in response to a sudden injury/trauma as you may have witnessed in case of road accidents/crush injuries. This is referred to *'Emergency Surgery'* during which the patient is in a variable state of resuscitation and the objective of treatment is to preserve as many organs and bodily functions as possible with minimum further trauma. Surgery however may not always be an outcome of an emergency. It may be undertaken as part of a well planned patient care process and involves removal or reconstruction of organs/body parts to promote treatment or for cosmetic purposes. Such surgical procedures are referred to as *'Elective Surgery'*. By-pass surgery of the heart, removal of organs, limb amputations, laproscopies are some common examples of elective surgery. The difference between elective and emergency surgery lies in the ability to prepare the patient for the injury and to control homeostasis/stress response in the elective surgical patient, while this is not possible in the traumatized patient. We must however remember here that whatever may be the form of surgery or its subsequent prognosis, the response of the human body to both forms of surgeries is quiet similar. In our subsequent discussions we will help you in understanding some of the key physiological/metabolic responses to surgery which in-turn affect the nutritional requirements of the patient.

5.3.1 Physiological Response to Surgery

Although advances in medicine and nutrition support have greatly reduced the morbidity and mortality associated with surgery, *debility* commonly accompanies surgical illness. It occurs in varying degrees after elective/emergency operations and other critical illnesses. Debility is caused by a variety of factors, including specific biochemical and physiologic alterations that usually occur in response to injury and disease, especially those that persist for a long time. Virtually all surgical patients experience some pain. Pain usually occurs in association with an incision or with a wound resulting from fracture, burn, contusion, or any other type of injury. In addition to creating an unpleasant subjective experience, pain often limits physical activities, such as turning in bed, deep breathing, coughing, and walking, and thereby directly interferes with recovery. Elevation of body temperature above normal, leukocytosis, and other signs of inflammation are common features of critical surgical illness and should be expected. The extent of temperature elevation is generally proportional to the severity of illness. In a patient with a major burn — an extreme example of critical surgical illness — body temperature may be as high as 39°C (102.2°F). The leukocyte count is also typically elevated and may be as high as 20,000 cells/ mm^3 during satisfactory recovery.

Food is commonly withheld from the patient before and during various diagnostic and therapeutic procedures. Patient is kept nil per oral (NPO) at least 6 hours prior to surgery. This restriction in diet before operation appears to be well tolerated by patients who were relatively well nourished before their critical illness. However, if food deprivation is prolonged, the complications of starvation will compound the effects of critical surgical illness. It is generally recommended that total starvation should usually be limited to a period no longer than 6-7 hours. However, patient is recommended to have liquitd or low residue diet one day prior to surgery.

Several metabolic changes also occur as a consequence of injury/surgery. For instance, injury caused by the operation initiates an inflammatory response resulting in the release of cytokines and acute phase proteins, along with the activation of stress hormones. The release of these mediators causes a change of metabolism into a catabolic state. There is a rise in the levels of circulating cortisol due to increased production of the adreno-corticotropic hormone from the pituitary gland. Cortisol mobilizes amino acids from skeletal muscle to provide the substrate for wound healing and for hepatic synthesis of new glucose. The excitement, pain, fear and hypovolemia that accompany surgery stimulate the sympathetic nervous system which leads to increased production of epinephrine by the adrenal medulla. Injury also initiates the release of aldosterone, (a corticosteroid that causes renal sodium retention, and of vasopressin (anti-diuretic hormone), which stimulates renal tubular water resorption. The action of these hormones results in conservation of water and electrolytes. Weight gain secondary to salt and water retention occurs due to changes in the response of pancreas. There is diminished secretion of insulin, whereas, glucagon production is increased. These responses are also a result of increased sympathetic nervous system activity. A rise in glucagon and fall in insulin levels are signals to accelerate glucose production and maintain gluconeogenesis. The postoperative hormonal responses are beneficial to the patient. Salt and water conservation support the circulating blood volume. Increased glucose production provides adequate fuel for the nervous system. Skeletal muscle protein breaks down at an accelerated rate after surgery resulting in the release of a variety of substances into the circulation, including creatinine, creatine, 3 methyl histidine, potassium, magnesium and amino-acids. The amino acids serve as precursors for protein synthesis in wound healing and in the liver. Lipid metabolism is also affected by critical illness. There is almost a two fold increase in glycerol turnover which is indicative of an accelerated rate of triglyceride hydrolysis to form free fatty acids and glycerol. There is also a high rate of free-fatty acid recyling.

Finally, a word about the convalescence stage.

Stages of Convalescence **:** This period of catabolism and alteration of the hormonal environment is known as the 'adrenergic – corticoid phase'. This is followed by a set of anabolism, which, in the absence of any postoperative complications, starts 3 to 5 days after a surgery. This 'turning point' from catabolism to anabolism is termed as 'corticoid – withdrawal phase' as there is spontaneous sodium and water diversion, and a reduction in nitrogen excretion. This phase lasts for 1 to 3 days. The patient then enters a period of early anabolism characterized by positive nitrogen balance and weight gain. Sustained feedings lead to protein synthesis and there is formation of lean mass and return of muscular strength. Then there is a final phase of late anabolism when there is much slower weight gain. There is deposition of body fat and nitrogen equilibrium is achieved.

Now that we are aware of the physiological response to surgery, let us in this context also understand dietary management of surgery.

5.3.2 Dietary Management during Surgery

Surgery increases the nutritional demands of the body and can lead to the elicitation of several nutritional deficiencies/imbalance. Malnutrition compounds the severity of complications as far as surgery is concerned and is associated with a high incidence of postoperative morbidity and mortality. The cellular processes involved in wound healing are critically dependent on adequate perfusion (delivery) of oxygen, glucose, and other essential nutrients. Inadequate perfusion may result in relative tissue ischemia (flow or flood restricted) and delayed wound healing. Nutritional support of critically ill patients is important both for promoting protein synthesis and other anabolic processes essential to recovery and for reducing the net drain on the patient's fuel and protein stores. Enteral nutrition is preferred, but the availability of effective intravenous techniques allows the clinician to provide appropriate nutrition to virtually all patients as you may recall reading in the last unit. Exercise and mobility have clear anti-catabolic effects and should be initiated as early as is practicable. A principal responsibility of the dietician is therefore to ensure adequate tissue perfusion during the entire period of wound healing. Thus, a complete nutrition and health assessment of the patient is essential to determine the macro-and micronutrient requirements before and after surgery. A complete assessment must include:

- Physical examination (anthropometric measurements such as ideal/usual body weight, skinfold thickness etc.);
- Clinical examination (presence/absence of oedema; abnormal changes in the skin, eyes, hair etc. cardio-pulmonary function, functional status of vital organs-kidney, pancreas, brain etc.);
- Bio-chemical examination (all important blood, urine, faecal components, as well as, enzymes/hormone levels that may be of immediate metabolic consequence)
- Medical and diet history.

A comprehensive dietary management regime of the patient should be based on the patient profile as gathered pre and post operatively and should be able to minimize the physiological and metabolic alterations associated with surgery. It should therefore be planned by keeping the following *objectives* in mind:

- To minimize/reduce the reasons of weight loss and depletion of tissue reserves
- To maintain an optimum energy and nitrogen ratio
- To achieve and maintain a healthy body weight
- To promote anabolism and hence wound healing
- To help in replenishing the depleted nutrient reserves

In view of the above mentioned objectives, we shall now discuss the nutritional management of patients before and after surgery. Let us start with the pre-operative nutritional care/patient preparation for an elective surgery.

A. Preoperative Nutritional Care

It can be provided only to prospective candidates of elective surgery and is not feasible for emergency cases. Preoperative malnutrition is often a cause of poor postoperative outcome. Nutritional support should be given for 7-14 days to moderately or severely malnourished patients undergoing a major surgery. Any nutritional deficiency should be corrected and nutritional reserves must be maintained for the surgery period as well as, for the immediate postoperative period to ensure proper rehabilitation.

Energy: The energy requirements of the patient should be based upon his present body weight which should be followed by a comparative assessment with his usual body weight (if data is available) or his ideal body weight. Adequate energy intake is important to build up weight deficit and build glycogen/adipose tissue reserves which are essential to provide energy to the body immediately after surgery when the nutrient intake may not be adequate enough to meet the increased requirements. Depending upon their nutritional status the energy requirements of the patients would be as follows:

Underweight: ~ 35 Kcal/kg ideal body weight per day

Normal weight: ~ 30 Kcal/kg ideal body weight per day

Overweight: ~ 20-25 Kcal/kg ideal body weight per day

Carbohydrates: Carbohydrates are needed to build up glycogen stores and spare the proteins for tissue synthesis. Around 60% of the total energy should be provided from carbohydrates. Maintaining blood glucose levels around 4.5-6.0 mmol/litre (with/without insulin) helps in marked reduction in septic episodes, renal failure, time on the ventilator, polynephropathy and mortality.

Protein: Negative nitrogen balance is the most common nutritional deficiency related to surgery. Reserves of protein in the tissues and plasma help to overcome blood losses during surgery and tissue catabolism in the postoperative period. The optimal protein requirements for critically ill patients in the absence of end stage renal/liver disease is 1.5-2.0 g/kg/day. Emphasis should be laid on the inclusion of foods rich in high biological value proteins such as eggs, milk, yoghurt, curd, cheese, flesh foods, legumes and pulses. Foods should be selected according to the age and pathophysiological condition of the patient. We must also keep a close watch on the liver and renal function tests while giving a high protein diet to terminally ill patients.

Vitamins and Minerals: Normal tissue stores of vitamins are required for the metabolism of carbohydrates and protein. Deficiency states like anaemia should be treated before a surgery, water and electrolyte balance should be maintained and dehydration, acidosis or alkalosis, if present, must be corrected. Inclusion of appropriate (disease specific) fresh fruits and vegetables, if on an oral intake/ selection of an appropriate enteral/parenteral formula can help in alleviating specific nutrient deficiencies.

Immediate Preoperative Period: Nothing should be given by mouth for at least 8 hours before a general surgery so that the stomach has no left over food at the time of surgery. In case of emergency surgery, gastric suction is used to remove the food if the patient has recently eaten a meal. This is important because food in the stomach may be vomited or aspirated during the surgery or during recovery soon after the surgery. It may also interfere with the surgery itself if it is related to the abdomen or gastrointestinal tract. In such cases a low residue or residue free diet is given several days before the surgery to clear the operative site. Elemental or chemically defined formulas are given either orally or through tube feeds.

Next, let us learn about the nutrient intake postoperatively.

B. Postoperative Nutritional Care

The therapeutic goal for the post-operative patient is rapid recovery to normal function and well being, minimum complications and early discharge. Nutrition plays an important role in minimizing the development of catabolism and returning the patient from the catabolic state to one of anabolism. As the nutrient losses due to catabolism during surgery are great, nutritional support is extremely important to aid recovery. In the post-operative period, nutrition support is used to reduce nutrition deficits that ordinarily develop in untreated patients during the period of NPO (nil orally) after surgery. we will now discuss the calorie and nutrient requirements during post-operative period. Let us start with energy.

Energy: Adequate calorie intake is critical for successful outcome of surgery and should be provided in the form of carbohydrates and fat. Energy requirements are generally high post operatively due to hyper-metabolism.

The energy requirement of the patient should be such as to be able to maintain a energy equilibrium or in other words stabilization of body weight at the pre-operative level. The energy requirement may be as high as 30-35 kcal/kg ideal body weight.

Protein: Increased catabolism leads to protein deficiency and hence negative nitrogen balance which amounts to loss of tissue proteins which can be as high as 1 lb per day. In addition, plasma proteins are lost through haemorrhage, wound bleeding and exudates. Metabolic losses also result from tissue inflammation, infection, trauma, immobilization and poor calorie intake. The protein deficit may cause serious complications, especially if the patient has some degree of previous malnutrition. Adequate intake of protein, is therefore, required to replace losses and meet the increased demand for the following reasons:

- *Tissue Synthesis for Wound Healing* : Tissue proteins are synthesized only by amino acids brought to the tissues by circulating blood. The necessary amino acids are provided either by ingested proteins or intravenous feeding. Concentrated liquid diets or commercial formulas may be used to overcome a poor appetite. The protein intake should be slowly increased according to the patients' tolerance.

- *Avoidance of Shock*: Loss of plasma proteins lead to decrease in blood volume (hypovolemia) and lowered red blood cell volume causing a potential danger of shock. Adequate intake of protein is, therefore, required as protein deficiency enhances the danger.
- *Control of Oedema*: Low levels of circulating proteins lead to oedema due to loss of colloidal osmotic pressure to maintain the normal fluid shift mechanism between the capillaries and the surrounding tissues prior to clinical oedema, considerable fluid collects in the interstitial spaces affecting heart and lung action. Local oedema at the site of surgery also delays closure of the wound and the healing process.
- *Bone Healing*: Protein is essential for callus formation, calcification and bone healing especially in cases of orthopaedic surgery. The protein matrix is required for mineral deposition in bone tissue.
- *Resistance to Infection*: Amino acids help to build the body's defense mechanisms like antibodies, blood cells, hormones and enzymes so as to prevent infection. Tissue integrity is the first line of defense against infection.
- *Lipid Transport*: Proteins provide the transport mechanism for lipids by forming lipoproteins. This helps to prevent fatty infiltration and hence protection of the liver which is the main site of fat metabolism.
- *Protein Deficiencies*: A depleted amino acid pool leads to poor wound healing (dehiscence), delayed healing of fractures, anaemia, depressed pulmonary and cardiac function, reduced resistance to infection, weight loss, liver damage and hence increased risk of mortality.

Carbohydrates: Carbohydrates ensure the use of protein for tissue synthesis and energy required for increased metabolic demands. With a high protein intake in extensive surgery or burns, the energy requirement may be as high about 35 kcal/kg ideal body weight. This will help to spare proteins for tissue repair and prevent them from being diverted to provide energy. Carbohydrates also provide glycogen reserves to avoid liver damage.

If oral intake can be resumed, emphasis should be laid on the inclusion of foods rich in simple carbohydrates which are easy to digest and can be used to prepare calorie dense dishes which have a small volume and hence facilitate an enhanced food intake. Glucose is the preferred form of energy in case of enteral or parenteral tube feeding.

Fat: Adequate amount of fat is needed to build up and maintain tissue fat reserves. Depending upon the existing health and nutrition status of the patient, fat may be incorporated in the diet to provide 15% to 30% of the total energy intake to prevent the deficiency of essential fatty acids and to meet the increased energy requirements particularly in the presence of glucose intolerance. Emulsified fats and medium chain triglycerides are generally well tolerated in the presence of sluggish gastrointestinal function.

Fluid: Extensive fluid losses may occur through vomiting, haemorrhage, diesis, excudate, fever and sweating after a surgery. An adequate fluid intake is, therefore, required to meet the increased needs. Fluids may be provided by intravenous therapy initially but oral intake should begin as soon as possible. The fluid intake should be sufficient to avoid dehydration on one hand and intoxication on the other.

Vitamins and Minerals: Vitamins are required for wound healing after a surgery. Vitamin C provides the cementing material of connective tissue, capillary walls and for building up of new tissues. Supplements of vitamin C are needed for aiding extensive tissue regeneration. With increase in energy and protein intake, intake of B group vitamins must also be increased as they are the coenzyme factors for energy and protein metabolism. Vitamin K helps in the blood clotting mechanism and is, therefore, essential for preventing blood loss. Potassium and phosphorus are lost during tissue catabolism. Electrolytes, accompany fluid losses. Overloading of patient with fluids and electrolytes can affect gastric function. Restricting postoperative maintenance fluids to 2000 ml and NaCl to 77 mmol/day has been shown to enhance substantially gastric motility and speed up the recovery. Iron deficiency occurs from blood loss or due to faulty iron absorption. Mineral intake, therefore, should be adequate to replace losses and correct deficiencies.

Nutrition Support: Aggressive nutritional support is important to avoid postoperative complications and mortality. Routine postoperative intravenous fluids are given to meet hydration needs and provide electrolytes but cannot meet the high nutritional needs. Majority of general surgery patients, therefore, should progress to oral feedings as soon as possible to provide adequate nutrition. In case of major tissue damage or trauma, or when a patient is unable to take sufficient oral feeds, parenteral feeding must be done. A high amount of glucose, amino acids, electrolytes, minerals and vitamins have to be provided.

As soon as intestinal peristalsis returns, water and clear fluids such as tea, coffee and juice may be given to supply fluids and electrolytes. These fluids help stimulate normal gastrointestinal function and return to a normal, nutritionally balaned diet. With improvement, milk and milk products, pudding, cream soups and high protein beverages should be started. Progression to solid foods in the form of soft or regular diets should be done with improved tolerance.

Having learnt about surgery, its nutritional implications and dietary management, we shall now proceed towards learning about another form of stress viz., burns. But let us first check our learning and understanding about surgery by answering the questions given in check your progress exercise 1.

Check Your Progress Exercise 1

1. What is the difference between the ebb and flow phase in a stress response?

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2. Explain giving examples the different types of surgeries?

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3. Enlist any five physiological consequences of a surgery?

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4. Discuss the importance of protein intake in postoperative nutritional care.

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5. "Oedema is a postoperative complication". Explain this statement.

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5.4 BURNS

Burns are injuries to tissues that result from heat, electricity, radiation or chemicals. They are usually caused by heat (thermal burns), such as fire, steam, tar or hot liquids. While burns caused by chemicals are similar to thermal burns those caused by radiation, sunlight and electricity tend to be different. Thermal and chemical burns usually occur because heat or chemicals come in contact with part of the body's surface, most often the skin. Thus, the skin usually sustains most of the damage. However, severe surface burns may penetrate to deeper body structures, such as fat, muscle, or bone.

When tissues are burned, fluid leaks into them from the blood vessels, causing swelling and pain. In addition, damaged skin and other body surfaces are easily infected because they can no longer act as a barrier against invading organisms.

The classification of burns is presented next.

5.4.1 Classification of Burns

Burns can be classified on the basis of the extent, depth, patient age and associated illness or injury. On the basis of depth, burns are usually classified by degree. *First degree burns or erythema,* i.e., redness of the skin produced by coagulation of the capillaries with cell destruction above the basal layer of epidermis. First degree burns are not blistered. *Second degree burns* is erythema and is characterized by blistering with necrosis within the dermis. *Third degree burns* lead to total loss of skin including the fat layer, hair follicles and sweat glands (refer to Figure 5.1).

First- and second-degree burns heal in days to weeks without scarring. Deep second-degree and small (less than 1 inch) third-degree burns take weeks to heal and usually cause scarring. Larger third-degree burns require skin grafting. Burns that involve more than 90% of the body surface, or more than 60% in an older person, usually are fatal.

First degree or partial thickness burns regenerate new skin tissue from the epithelial cells of the skin or hair follicles, sweat glands and sebaceous glands. Second and third degree or full thickness burns do not have sufficient skin for healing and therefore extensive burns require skin grafting.

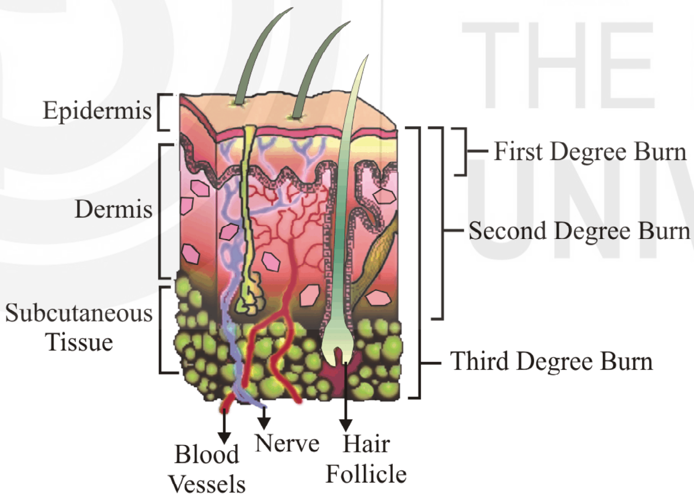

Figure 5.1: Diagramatic representation- categorization according to depth of burns

You have often heard or read about description of an individual who has got burnt being ascribed as '40% burns', ' 90% burns' etc. What does this mean? This is a method of assessing the total body surface area that is burnt. It is often spoken of as "rule of nines" as illustrated in the Figure 5.2 . Figure 5.2 shows the per cent of a particular area burnt, adding these would give the total body surface area burnt. This information as you will learn later in this unit is utilized for computing the energy and other nutrient requirements of the patient. Data on age of patient can help in predicting the prognosis of a burn's injury. The most accurate rule of thumb for predicting mortality after severe burn injury is the Baux Score (age + percent burn, e.g. age 50 years + 20% burns = 70% mortality).

A more recent revised baux formula is used in case of severe burn with inhalation injury.

Revised Baux Score = Age + Surface area burnt + 17.

(Here 17 accounts for inhalation injury, which is constant).

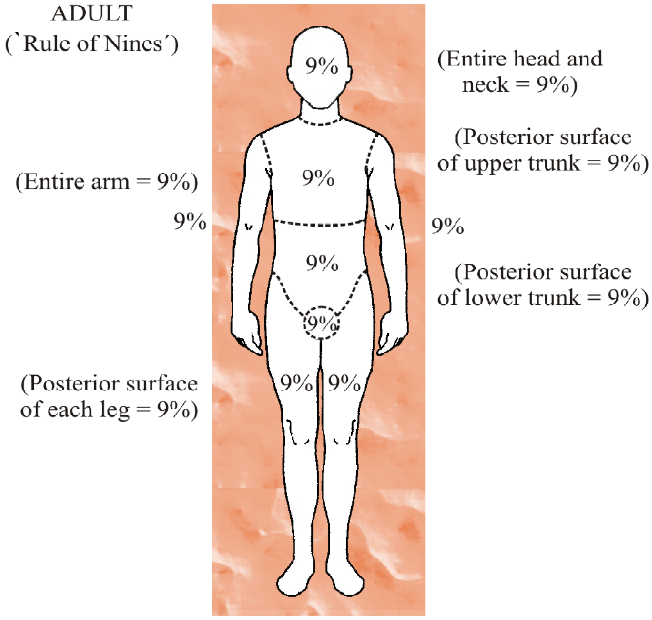

Figure 5.2: Diagramatic assessment of the total body surface area burnt – "Rule of Nines".

Source: Tierney LM, McPhee SJ and Papadakis MA. Current medical diganosis and treatment 42nd e (2003).

5.4.2 Complications of Burns

Most minor burns are superficial and do not cause complications. However, deep second-degree and third-degree burns swell and take more time to heal. In addition, deeper burns can form a scar tissue. This scar tissue shrinks (contracts) as it heals. If the scarring occurs at a joint, the resulting contracture may restrict movement.

Severe burns can result in serious complications due to extensive fluid loss and tissue damage. Complications from severe burns may take hours to develop. The longer the complication is present, the more severe are the problems it tends to cause. Young children and older adults tend to be more seriously affected by complications than other age groups.

Dehydration eventually develops in people with widespread burns, because fluid seeps from the blood to the burned tissues. Shock develops if dehydration is severe. Destruction of muscle tissue occurs in deep third-degree burns. The muscle tissue releases myoglobin, one of the muscle's proteins, into the blood. If present in high concentrations, myoglobin harms the kidneys.

Thick, crusty surfaces (eschars) are produced by deep third-degree burns. Eschars (a dry scab) can become too tight, cutting off blood supply to healthy tissues or impairing breathing.

The non-dietary treatment is emphasized in sub-section 5.4.5. This is additional information which is quite useful.

Treatment of burned patient is incomplete and often unsuccessful if proper nutritional care is not provided. Through our subsequent discussions we will learn about the dietary management of patients suffering from burns.

5.4.3 Dietary Management for Burns

Nutritional support is a major part of therapy for a patient with burns in view of the large catabolic losses, essential anabolic demands and to meet personal support needs.

Nutritional care plan and outcome is dependent on factors, like

- *Age* – Elderly people, very young children pregnant women and lactating mothers are highly vulnerable.

- *Health condition* – Presence of diabetes, cardiovascular or renal disease complicates the care process.
- *Severity of burns* – The location and severity of the burns and time lapse before treatment.

Nutritional support needs are calculated on the basis of body surface area burnt. Second and third degree burns covering 15-20% or more of body surface, or even 10% in children and elderly persons cause extensive fluid loss and therefore require intravenous fluid therapy. Severe burns covering more than 50% of the body surface area are often fatal. Nutritional care for a patient in the burns is adjusted to individual needs and is given in three stages:

Ebb or shock period: During the initial burns after injury, the focus is on counteracting the stress induced neurohormonal and physiologic responses that accelerate the body's metabolism by a series of events. Loss of skin on the burn site and exposure of extra cellular fluids lead to immediate loss of water and electrolytes, mainly sodium and also protein depletion. As a result, the body water shifts from extra cellular spaces in other parts of the body to the burn site adding to continuous loss of fluids and electrolytes. Due to this there are changes in the capillary fluid shift mechanism resulting in decreased volume hypotension, low haemo-concentration and diminished urine output. Intracellular water is also drawn out to balance extra cellular fluid losses leading to cellular dehydration. Patients with extensive burns need immediate fluid and electrolyte replacement during the first 12 to 24 hours after injury. A balanced salt solution such as *lactated Ringer's solution* is given to correct hypovolemia and prevent metabolic acidosis. Because the exact volume of fluid and infusion rate depend on the patient's response to fluid delivery, ongoing fluid replacement is based on close monitoring of the patient. The goal is to maintain an adequate blood pressure and haematocrit and a urine output of > 50 to 100 ml/hr (0.5 to 1 ml/kg/hr) in an adult or 1 ml/kg/hr in a child while avoiding circulatory overload. To maintain hydration status of patient parkland formula is used which is given below:

Total fluid requirement in 24 hours =

4 ml × (total burn surface area (%)) × (body weight (kg))

50% given in first 8 hours

50% given in next 16 hours

Children receive maintenance fluid in addition, at hourly rate

4 ml/kg for first 10 kg of body weight plus

2 ml/kg for second 10 kg of body weight plus

1 ml/kg for >20 kg of body weight

End point

Urine output of 0.5-1.0 ml/kg/hour in adults

Urine output of 1.0-1.5 ml/kg/hour in children

This ensures the hydration status of burn patient. Example of fluid management in burn patient is given in Box 5.1.

Box 5.1: Example of Flluid Management in Burn Patients

A 25 year old man weighing 70 Kg with 30% flame burn was admitted at 4 pm. His burn occurred at 3 pm and received 1000 ml in emergency services. Plan Fluid resuscitation regimen for an adult. Also pIan for a child weighing 24 kg.

FOR **ADULT**

1) *Total fluid requirement for first* 24 *hours*
   4ml * (30% total burn surface area) * (70 Kg) = 8400 ml in 24 hours
2) *Half to be given in first* 8 *hours and half over the next* 16 *hours.*
   Will receive 4200 ml during 0-8 hours and 4200 ml during 8-24 hours
3) Subtract any fluid already received from amount required for first 8 hours
   He has already received 1000 ml. Therefore, he needs 3200ml in first 8 hours after injury.

4) *Calculate hourly infusion rate for first 8 hours.*
Divide amount of fluid calculated by time left until it is 8 hours after burn.
Burn occurred at 3 pm, so 8 hour point is 11 pm. Patient was admitted at 4 pm. So, he needs 3200 ml over next 7 hours.
Therefore, 3200 ml/7 hours= 457 ml/hour from 4 pm to 11 pm.

5) *Calculate hourly infusion rate for next 16 hours.* Divide rest of the fluid with hours left.
4200ml/16 hours= 262.5 ml/hour from 11 pm to 3 pm next day.

FOR CHILD

Apart from above fluid requirement a child weighing 24 kg would need following maintenance fluid in addition on an hourly basis.
4ml/Kg/hour for first 10 kg weight < 40ml/hour *plus*
2ml/Kg/hour for next 10 kg weight = 20 ml/hour *plus*
1ml/Kg/hour for next 4 kg weight = 4 ml/hour
Total 64 ml/hour

During this initial period, nutritional requirements of protein and energy are not attempted to be met as the entire focus is on rapid and effective fluid and electrolyte therapy so as to prevent shock.

Flow or Recovery Period : After 48 to 72 hours, fluids and electrolytes are reabsorbed into the general circulation and excess fluid is excreted. Fluid balance is gradually reestablished and massive tissue loss is reversed. Fluid intake and output must be checked to prevent dehydration or over hydration. The patient usually returns to pre-injury weight by the end of first week and adequate bowel function returns. At this time, increased nutritional needs must be met for the following reasons:

- Replace losses of protein and electrolytes due to burn injury.
- Replace lean body mass due to extensive tissue breakdown.
- Meet increased metabolic needs for energy due to sepsis or fever, increasing the need for carbohydrates and B vitamins. Minerals and vitamins are also needed for tissue regeneration.
- Providing healthy tissue for subsequent successful skin grafting.

Anabolic Phase: During this period the patient is well hydrated and the reactions due to metabolic stress are under control. The patient may still be hypermetabolic and has depleted reserves of all nutrients. Rigorous nutrition support during this period is essential to promote fast recovery and proper rehabilitation. Proper nutritional care during this period can help in preparing patient physically for undergoing successful skin grafting/ any other surgery. Transplantation of organs or body parts is done much latter during the anabolic phase.

The nutrient requirement and dietary management during the flow and anabolic phase is discussed next.

Nutrient requirement and dietary management during the flow and anabolic phase

You must have understood by the discussion above that by the end of the flow phase, the patient usually is well hydrated and has body weight close to the pre-injury weight. The return of bowel movements is an indication that the patient can now be slowly introduced to nutrition support in the form of oral intake, enteral feeds or parenteral nutrition. A combination of any two alterations in these routes is required on a day-to-day basis depending upon the changing clinical parameters and the severity of burns. Dietary management should be such as to fulfill the following *objectives*:

– providing enough calories to prevent subsequent weight loss
– maintaining fluid and electrolyte balance
– minimizing stress response to pain and anxiety

– maintaining a positive nitrogen balance
– replenishing the depleted reserves of vitamins and minerals
– preventing curling's ulcers, ileus and other complications

As always we shall first discuss about the energy requirements of the patient during the flow and anabolic phase. Thereafter we shall learn about the contribution of various macronutrients for providing the required amount of calories.

Energy: The energy needs of the burned patient vary according to the depth and size of the burn. The requirements of course would be highest in third degree burns Although several formulas have been developed to determine the energy needs; Currie formula is most commonly utilized and is mentioned below:

Calories needed per day = 24 Kcal × kg usual body weight
+ 40 Kcal × % total body surface area (TBSA) burned
(using a maximum of 50% burn).

The energy requirements thus calculated may be slightly higher than the actual needs in lieu of the improved medical facilities now available. At times therefore the *Ireteon-Jones Equation* is utilized which is based on assessment of total energy expenditure

Estimated energy expenditure = 1784 – 11 (A) + 5 (W) + 244 (G)
(Kcal/day) + 239 (T) + 804 (B)

Wherein, A : Age; W : Weight (kg); G : Gender (female = 0; male = 1); T : Diagnosis of trauma (absent = 0; present =1); B : Diagnosis of burn (absent = 0, present = 1).

Some additional calories may be added to this for supporting energy expenditure due to fever, sepsis, multiple trauma or stress of surgery.

For assessing the energy requirements of pediatric patients; *Galveston formula* may be utilized i.e. :

Energy requirements for 24 hrs. = 1800 Kcal/m^2 + 2200 Kcal/m^2 of burns.

For children below 3 years of age the *Mayes and colleagues formula* may be utilized i.e

Energy requirements for 24 hrs = 1008 + (68 × Kg weight) + 3.9 × % body surface area burnt)

We shall do some exercises to help you in using these formulas in the check your progress exercise section.

It must be evident from these formulas that the energy requirement of burnt patients are much higher than those for their healthy counter parts.

Let us now learn about the contribution towards the total energy through various macronutrients viz; carbohydrates, proteins and fat.

Carbohydrates : Liberal amounts of carbohydrates should be given i.e. around 60% to 65% of the total energy. However, care must be taken regarding the maximum rate of administration feasible keeping in mind the fact that the maximum tolerance level is about 7 mg/kg/min above which glucose is not oxidized to release energy but is converted to fat. Blood glucose levels should be closely monitored to prevent hyperglycemia and its associated complications such as dehydration, coma, respiratory problems etc. During the anabolic phase when the patient can eat orally and has normal defecation process, a combination of simple and complex carbohydrates may be given. Providing good amounts of foods rich in mono and di saccharides, as well as, starches help in preparing meals which are nutrient dense, have small volume and are easy to digest. Thus, rice, refined wheat flour, semolina, sago, arrowroot, rice, rice flakes, murmura, pastas, dextrose, glucose, honey, potato should be incorporated liberally in the diet.

Fat : As we have learnt earlier in the Unit 4 on enteral and parenteral feedings; administration of lipids should be carried out carefully in all critically ill patients. A careful monitoring of immune function, feeding tolerance and serum triglycerides is required during lipid administration. Most of the patients are able to tolerate around 12-15% of the total calories in the form of lipids. Structured lipids and medium chain triglycerides are currently being preferred. A low fat diet is preferred during the initial phases of recovery in view of its association with improved respiratory function, reduced incidence of pneumonia, faster recovery. During the later phases of anabolism (near discharge) the fat intake may be normalized. In view of the impaired gastro-intestinal function among many patients it is advisable to lay emphasis on foods rich in emulsified fat and medium chain triglycerides (MCT's).

Protein: It is one of the most crucial nutrient which determines the ultimate outcome of burns. Amino acid requirements are high due to increased losses through wounds and urine, increased requirement for promoting synthesis of blood proteins and wounds. Fluid loss from a burn wound may be considerable and can contain 4-6 g protein/100 ml, representing 25-50% of total nitrogen loss. Nitrogen losses via faeces have been estimated to be around 1-3g N/day. Thus, adult patients should be given 20-25% of the increased energy from protein. Among children the requirements are still higher i.e. 2.5 to 3.0 g per kg usual body weight per day. Protein intake beyond this level is not recommended in view of the increased burden on the kidneys. Blood urea nitrogen, serum creatinine and level of hydration must be monitored carefully. The protein intake may need to be curtailed if the burnt area has involved the kidney / excretory system. High biological value protein food sources such as eggs, milk, cheese, yoghurt, marine food, meat, poultry, legumes and pulses should be included liberally but in an easy to digest form. Hospital based tube feeds may be prepared by using soya milk, milk proteins (casein, whey protein, lactalbumin), eggs and flour of pulses particularly soyabean.

Vitamins and Minerals : Although the exact requirements are not known, it is generally recommended to give plenty of fresh fruits and vegetables if an oral intake is feasible. When the patient is on tube feeds it is suggested to provide around 500 mg (twice daily) vitamin C and 5000 I.U of vitamin A per 1000 Kcals of energy being provided. Hyponatremia which is frequently observed due to fluid losses during change of dressings/ application of grafts, can be corrected by restricting the oral consumption of sodium-free fluids /water. Supplements of calcium, phosphate, zinc and iron are generally required. Anaemia may need to be treated with administration of red packed blood cells.

Other considerations

- oral intake is generally feasible only during the anabolic phase wherein the patient should be given a high-energy, high protein, micronutrient rich diet. The diet should have a small volume, it should be nutrient dense and easy to digest. A two hourly feeding schedule or a 6-7 meals/ day pattern should be adopted.
- Oral feeding may be supplemented with enteral nutrition to be able to replenish the depleted nutrient reserves.
- Most of the patients are depressed and may need encouragement by family and medical team to promote adequate food consumption.
- Anabolic steroids such as oxandrolone are often combined with a high protein diet to promote weight gain and enhance anabolism at the site of wound.

Now that we are aware of the nutrient requirement let us take a closer look on the methods we can use to feed burn patients.

5.4.4 Mode of Feeding/ Nutrition Support

Do you recall studying about the nutrition support methods, namely enteral and perenteral feeding, discussed earlier in Unit 4 of this course. These two methods form the common nutrition support strategy for burns patients. Let us review these methods in the context of burn patients.

Oral feeding is desirable if tolerated by the patient. Concentrated oral liquids with protein hydrosylates or amino acids must be given to ensure adequate intake. Solid food should be gradually introduced according to food preferences. Support and encouragement help the patient to eat better. Food should be attractive and appetizing and individual like and dislikes must be considered.

Enteral nutrition can be utilized judiciously alone or in combination with other forms of feeding during various stages and purposes during the course of treatment for instance some patients may initially require tube feeding, low bulk defined formula solutions may be given. Commercial high protein formulas may also be used.

Parenteral Feeding is required for some patients to provide extra nutritional support if oral intake and tube feedings are inadequate to meet the high nutritional needs. This form of feeding is more commonly used during the ebb and flow phase.

Continuous nutritional support is important to maintain tissue integrity for successful skin grafting or plastic reconstructive surgery. Persistent supportive care – medical, nutritional and nursing helps the patient to cope with the stress situation.

5.4.5 Non-Dietary Treatment of Burns

While good nutritional care should be provided to the patient as soon as feasible it is equally imperative and at times critical to provide efficient and appropriate physical care to the patient to minimize trauma, pain and ensure re-habilitation. Some important aspects of non-dietary treatment are being briefed below.

The most immediate step is removal of the burning agent from the patient to prevent further damage. For example, fires are extinguished. Clothing — especially any that is smoldering (such as melted synthetic shirts), covered with hot tar, or soaked with chemicals should be immediately removed.

Hospitalization is sometimes necessary for optimal care of burn injuries. For example, elevating a severely burned arm or leg above the level of the heart to prevent swelling is more easily accommodated in a hospital. In addition, burns that prevent a person from performing essential daily functions, such as walking or eating, make hospitalization necessary. Severe burns, deep second- and third-degree burns, burns occurring in the very young or the very old, and burns involving the hands, feet, face, or genitals are usually best treated at burn centers. Burn centers are hospitals or wards in a hospital that are specially equipped and staffed to care for burn victims.

***Superficial Minor Burns*:** Superficial minor burns are immersed immediately in cool water if possible. The burn is carefully cleaned to prevent infection. If dirt is deeply embedded, a doctor can give analgesics or numb the area by injecting a local anesthetic and then scrub the burn with a brush. Often, the only treatment required is application of an antibiotic cream, such as silver sulfadiazine which prevents infection and forms a seal to prevent further bacteria from entering the wound. A sterile bandage is then applied to protect the burned area from dirt and further injury. A tetanus vaccination is given if needed. Care at home includes keeping the burn clean to prevent infection. The burn can be covered with a nonstick bandage or with sterile gauze. The gauze can be removed without sticking by first being soaked in water.

***Severe Burns* :** Severe, life-threatening burns require immediate care. Dehydration is treated with large amounts of fluids given intravenously. A person who has gone into shock as a result of dehydration is also given oxygen through a face mask.

Destruction of muscle tissue is also treated with large amounts of fluids given intravenously. The fluids dilute the myoglobin in the blood, preventing extensive damage to the kidneys. Sometimes a chemical, sodium bicarbonate, is given intravenously to help dissolve myoglobin and thus also prevent further damage to the kidneys.

Eschars that cut off blood supply to an extremity or that impair breathing are cut open in a surgical procedure called escharotomy. Escharotomy usually causes some bleeding, but because the burn causing the eschar has destroyed the nerve endings in the skin, there is little pain.

Keeping the burned area clean is important, because the damaged skin is easily infected. Cleaning may be accomplished by gently running water over the burns periodically. Wounds are cleaned and bandages are usually changed 1 to 3 times per day.

Let us now make an attempt to answer the questions mentioned in the check your progress exercise 2 to find out our level of understanding. You may need to read the details discussed above to recapitulate and answer these questions.

Check Your Progress Exercise 2

1. Define and classify burns on the basis of their depth.

   ....

   ....

   ....

2. What is lactated Ringer's solution?

   ....

   ....

   ....

3. Mrs. Asha is a 57 years old women who has suffered from second degree burns with 33% total body surface area burned. Calculate her energy requirements by using the Currie formula.

   ....

   ....

   ....

4. What is the significance of protein in the diet of burn patients during the anabolic phase?

   ....

   ....

   ....

5. What are the benefits of vitamin A and C for promoting recovery during anabolic phase?

   ....

   ....

   ....

So far we have learnt about the physiologic/ metabolic effects and dietary management of two forms of stress viz. surgery and burns. We shall now discuss about the physiology and nutritional care during trauma.

5.5 TRAUMA

The term "trauma" comes from a Greek word which means "a wound" (and or damage or defect). Trauma is a form of shock to the human body which may occur in the form of crush injuries, diving/ air compression or specific wounds on body part/ organs such as head/spinal cord. Accidental or crush injury – a form of acute trauma is a major cause of death and disability. Crush injuries generally result from serious road accidents, industrial mishaps, explosions etc. It may involve several fractured bones, profuse multiple external bleeding, internal bleeding, shock and deterioration into unconsciousness. Optimal care of the injured patient is often intensive and prolonged. Survival rate is low and may be followed by years of rehabilitation. Metabolic and nutritional support of the injured patient is a major component of overall care. Let us first discuss about the physiological response of the body towards a crush/ sudden injury to the body-a form of trauma.

5.5.1 Physiological Response to Injury

The physiological events are related to the severity of injury that is, greater the insult, the more pronounced is the response. Two distinct periods of post-traumatic responses have been identified:

Early ebb or shock phase: This is usually brief in duration lasting 12 to 24 hours and occurs immediately following injury. Blood pressure, cardiac output, body temperature and oxygen consumption are reduced. These are often associated with haemorrhage and result in hypo perfusion and lactic acidosis. As the blood volume is restored, more accelerated responses occur.

Flow Phase: It is characterized by hyper metabolism, increased cardiac output, increased urinary nitrogen losses, altered glucose metabolism and accelerated tissue catabolism. These flow phase responses to injury are similar to those following surgery but are usually more intensive and extend over a longer period of time. This phase is characterized by hyper metabolism and alterations in the metabolism of glucose, protein and fat.

Next, let us learn about the metabolic aberrations developing during and after a trauma.

5.5.2 Metabolic Response to Injury

There is an increase in the basal metabolic rate above the normal. The degree of hyper metabolism is related to the severity of the injury. Long-time fracture usually result in a 15 to 25 % increase in metabolic rate, multiple injuries increase metabolic rates by 50% and severe burn patients have metabolic rates raised by 100%. The body temperature of a trauma patient rises by 1-2^{O}C due to an upward shift in the thermoregulatory set point of the brain. The changes in glucose, protein and fat metabolism are being discussed below.

– *Altered Glucose Metabolism*: Following injury, hypoglycemia commonly occurs and is related to the severity of the stress. In the ebb phase, insulin levels are low and glucose production is slightly elevated. During the flow phase, hyperglycemia persists although insulin levels are normal or even high. Hepatic glucose production and gluconeogenesis are increased.

– *Altered Protein Metabolism*: Urinary nitrogen loss is extensive following injury. Trauma accelerates nitrogen turnover. In unfed patients, tissue breakdown rates exceed synthesis and a negative balance occurs. Providing exogenous calories and increase in nitrogen synthesis and thus helps in restoring the nitrogen balance.

– *Altered Fat Metabolism*: The stored fat deposits are mobilized and oxidized at a high rate in order to support hyper metabolism and increased gluconeogenesis. Severely injured patients, if unfed, deplete their fat and protein stores rapidly.

The resulting malnutrition increases their susceptibility to haemorrhage, infections, organ system failure, sepsis and death.

Next, after metabolic aberrations we move on to the hormonal responses, specific to trauma viz./injury..

5.5.3 Hormonal Responses to Injury

A number of hormonal changes take place in patients following injury. There is a marked rise in the counter regulatory hormones, viz., glucagon, glucocorticoids and catecholamine. Glucagon has glycogenolytic and gluconeogenic effects the liver, Cortical mobilizes amino acids from skeletal muscle, increases hepatic gluconegenesis and maintains body fat stores. The catecholamine also stimulates hepatic gluconegenesis and glycolysis and increase lactate production from skeletal muscles. They also increase metabolic rate and lipolysis. Growth hormone is elevated while thyroid levels are reduced.

Now that we are familiar with the physiological, metabolic and hormonal changes specific to trauma, you will find yourself better equipped to understand dietary management of this stress response. Since the dietary considerations/requirements are quite similar to that in the post operative period in surgery, which has aleady been discussed in greater detail in section 5.2 earlier. The dietary management of trauma/ injury dealt here in this section is brief.

5.5.4 Dietary Management – Trauma

As a result of metabolic responses to injury, there is an increase in the energy expenditure. Oxidation of body fat stores takes place causing loss of weight. Most injured patients can tolerate a loss of 10% of their pre-injury body weight prior to injury. If weight loss exceeds 10% body weight, under nutrition increases the morbidity and mortality rates. The patients are exposed to a variety of infectious agents in the hospital, due to use of catheters and nasogastric tubes. Under nutrition increases the likelihood of sepsis, multiple organ system failure and death. It also delays wound healing. The purpose of nutrition support for a trauma patient is to aid in the defense mechanisms of the body. Adequate nutrition allows normal responses that optimize wound healing and recovery. Nutritional support should be provided before significant weight loss occurs. Intravenous administration of hypertonic nutrient solutions, use of peripheral vein feedings with fat emulsions and use of specific diets provide effective nutrition support to injured patients.

Nutrient Requirements during Trauma

Nutritional assessment of the trauma patient is done to determine energy and protein requirements. Basal energy requirements are determined from standard tables based on age, sex and body surface area. These requirements are adjusted for increase in metabolic rate due to injury or disease. Dietary protein is required in greater amounts to achieve nitrogen balance. Approximately, 15 to 20% of calorie intake should be from protein. Carbohydrates (glucose) should provide 60% of caloric needs and the rest of energy needs should be met by fat. Multivitamins are given daily along with supplements of vitamin C, which is required in increased amounts after injury. Electrolytes may be added to feed formulas so as to maintain normal serum levels. Potassium, magnesium and phosphate supplements are added to parenteral fluids. Zinc supplements should be given to severely malnourished patients or those with a history of poor nutrient intake, e.g. alcoholics.

The routes of nutrition support are oral, enteral and parenteral. Oral and enteral routes are generally preferred over the parenteral (intravenous) administration. Oral liquid supplements should be administered to increase the nutrient intake. The patient's injuries may interfere with oral feedings. Patients with facial and head injuries, disorders of the jaw, mouth or oesophagus and those receiving artificial ventilation are not able to take feeds orally. Such patients have to be fed by use of tubes. Enteral or parenteral tube feed formulas are usually balanced mixtures of fat, carbohydrate and protein. Intravenous or parenteral feedings may be necessary to supplement enteral feedings or when enteral feeds cannot be tolerated.

With nutritional requirements, we end our study on trauma. Next, let us get to know about sepsis-a complication which may arise on its own or as a consequence of any long-term stress.

5.6 SEPSIS

Sepsis is defined as the presence of an infection due to an identifiable organism. Bacteria and their toxins lead to a strong inflammatory response. Viruses, fungi and parasites also cause infection and inflammation. The Systemic Inflammatory Response Syndrome (SIRS) is the term used to describe the inflammation that occurs in infections, burns, multiple trauma, shock and organ injury. The inflammation is usually present in areas much away from the primary site of injury and affects healthy tissues. The association between the terms sepsis and SIRS can be better understood by the diagnostic criteria given in Box 5.2. SIRS commonly leads to development of Multiple Organ Dysfunction Syndrome (MODS). It generally begins with lung failure followed by failure of the liver, intestines and kidney.

Multiple hypothesis have been proposed to explain the development of SIRS or MODS. The progression of SIRS to MODS appears to be mediated by excessive production of pro-inflammatory cytokines and other mediators of inflammation. According to the "gut hypothesis" disruption of the gut barrier function results in translocation of enteric bacteria into the mesentery lymph nodes, liver and other organs.

Box 5.2 Diagnostic Criteria for Sepsis/SIRS

Sepsis can be diagnosed if infection is proven by means of a positive blood culture and two or more of the following:

- Heart rate > 90 beats per minute
- Body temperature < 36 (98.6°F) or > 38°C (100.4°F)
- Hyperventilation (high respiratory rate) > 20 breaths per minute or, on blood gas, a $PaCO_2$ less than 32 mm Hg
- White blood cell count < 4000 cells/mm^3 or > 12000 cells/mm^3 ($< 4 \times 10^9$ or $> 12 \times 10^9$ cells/L), or greater than 10% band forms (immature white blood cells).

When two or more of these clinical parameters are met without confirmation of infection it is called systemic inflammatory response syndrome.

Despite a number of advances in the treatment of infections and a better understanding of its path physiology, the mortality and morbidity rates from septicemia are high. Unlike elective surgery and trauma, the response patterns following major infection are unpredictable. The variability in metabolic and physiological response is relied partly to the patient's age, previous health status, preexisting disease, previous stress, site of infection and the infective agent. Moreover, the organ system failure may mask the manifestation of systemic infection. Based on cardiac output, two physiological responses have been described. The first is characterized by an increased cardiac output and high systemic perfusion. The second response is characterized by cardiac decomposition, inadequate tissue perfusion and acidosis, and is described as low flow sepsis. Both these responses reflect the body's reaction to systemic infection and are modified by the underlying disease and physiologic reserves of the patient. The invasion of the body by infective agents initiates host responses. There is mobilization of phagocytes and inflammation at the local site. As the infection progresses, fever, tachycardia and other responses occur.

5.6.1 Systemic Metabolic Responses

Many of the metabolic responses to infection are similar to those following injury. The key changes include:

Hyper metabolism: Oxygen consumption is elevated in the infected patient. It may be 50-60% higher than normal and is related to the severity of the infection ($PaCO_2$ of < 32 mmHg-hyperventilation). In the pre-operative and post injury period, such a response often occurs secondary to severe pneumonia, abdominal infection or wound infection. Increased metabolism is related to fever – being 10-13% for every $1^{O}C$ elevation in temperature. The metabolic rate returns to normal as the infection resolves.

Altered Glucose Metabolism: Blood glucose levels are generally elevated in the infected patient but plasma insulin levels are normal or even higher in previously healthy patients who develop infection. Increased glucose production in infected patients is in addition to the increased gluconegenesis following injury. Glucose metabolism following infection is, however, complex as hypoglycemia and diminished hepatic glucose production has also been seen in patients.

Altered Protein Metabolism: There is increased proteolysis and nitrogen excretion resulting in negative nitrogen balance following an infection. Amino acids flow from skeletal muscle is accelerated in patients with sepsis.

Altered Fat Metabolism: Fat is the major fuel oxidized in infected patients. If nutrition support is inadequate, the peripheral fat stores are mobilized. Increase in the sympathetic nervous system activity mediates the increase in lipolysis.

Changes in Trace Minerals: Changes in the balance of magnesium, phosphate, zinc and potassium follows alterations in nitrogen balance. Iron and zinc level in the blood are decreased. This is not only due to body losses of these minerals but due to accumulation of these within the liver as a part of the lost defense mechanism. We will now move on to the catabolic responses to sepsis

5.6.2 Catabolic Responses

Hormonal responses during the hyper metabolic phase of infection are same as in case of injury. Serum cortisol levels are elevated, glycogen is incurred and insulin levels may be normal or higher. The levels of catecholamine, growth hormone, antidiuretic hormone (ADH) and aldosterone are also elevated. The growth hormone level remains elevated during convalescence, to promote anabolism.

Interleukin-1 is an endogenously produced pyrogen which produces fever and has direct effects on the liver; it promotes hepatic repletion of zinc and iron, increases plasma copper levels and stimulates hepatic synthesis of plasma amino acids.

The metabolic and hormonal changes discussed above can result in reversible or irreverisble alteration in the structure and/or function of one or more organs over a period of time. This is often referred to as multiple system organ failure and is being discussed below.

Multiple Organ Dysfunction Syndrome (MODS)

Failure of essential organs is the most severe complication of sepsis and may result in death. The treatment of systemic infection, therefore, consists of use of antibiotics, support of cardiovascular and respiratory function, supportive therapy of specific organs and vigorous nutrition support. Septic shock may lead to a decrease in peripheral resistance and cause pulmonary insufficiency. Patients often require ventilator support. Inadequate cardiac output may lead to impairment and malfunction of the kidney. The resulting uremia superimposed on the sepsis further impairs the hyper catabolic infected host. Sepsis causes marked changes in the structure/ function of gastrointestinal tract and may lead to stress ulcers and bleeding. Septicemia also commonly leads to hepatic dysfunction causing jaundice, hyperbilirubinemia and liver failure. Multi-system organ failure or MODS is associated with a high incidence of death.

5.6.3 Dietary Management of Sepsis with or without MODS

Before we begin with the dietary management of patients suffering from sepsis with or without MODS let us read a case below.

Mr. Sunder a 71 years old man was admitted to the ICU of a multi-speciality hospital suffering from moderate urinary tract infection and difficulty in breathing due to aspiration pneumonia. He was immediately put on ventilator to facilitate breathing. His medical history indicated that he was an old case of non-insulin dependent diabetes mellitus. Due to aspiration pneumonia and resultant intubations; the patient had to be fed through external tube feeds. Presence of infection however exacerbated hyperglycemia and there was a marked reduction in WBC count. Gradually, the patient had to fed through the parenteral route. Due to persistent infection there was considerable wasting and under-nourishment. On one hand the infection entered the blood stream and affected other organs whereas on the other hand feeding through parenteral route resulted in atrophy of the small intestine. The patient ultimately expired after three months due to the septic shock, renal failure and diabetic coma.

This is an example of the most common pathways which develop in critically ill patients. Keeping these complications in mind let us briefly discuss the nutrient requirements and the various forms of nutritional support which can be provided to such patients.

Dietary Management of Sepsis and MODS

Patients suffering from sepsis and/or resultant multiple system organ dysfunction are critically ill and admitted in the intensive care unit of the hospital. They usually have an impaired immune function and compromised cardiopulmonary functional capacity. Such patients may also have reduced functional and regulatory capacities of renal and/or gastrointestinal tract and impaired immune function along with compromised cardiopulmonary function capacity. They generally have altered blood/ urine indices (abnormal serum albumin) and are hypermetabolic. The Urine Urea Nitrogen (UUN) excretion in grams per day has been used to evaluate the degree of hypermetabolism. The UUN can be used to interpret the level of hypermetabolism as follows:

Urine Urea Nitrogen

$\leq$ 5 gm/24 hrs.	=	No stress
5 to 10 gm/ 24 hr	=	mild hypermetabolism or level 1 stress
10 to 15 gm/24 hrs	=	moderate hypermetabolism or level 2 stress
< 15 gm/ 24 hrs	=	severe hypermetabolism or level 3 stress

Meeting the nutritional requirements of such patients can be a challenging issue as they suffer from not one but several metabolic/ physiological abnormalities. For example, a diabetic patient may be suffering from urinary tract infection and end-stage renal disease wherein; the dietary management of one may be contradictory for the other form of illness. Further, these patients may be on life-support system (such as ventilator, catheters, dialysis) and oral intake may not be feasible. Multiple abnormalities may appear in the metabolism of energy, protein, carbohydrates, fat and several vitamins/ minerals. While meeting the nutrient requirements may not be always feasible; our endeavour should be to help the patient in maintaining a good nutritional status and prevent the progression of the disease. It is important to remember here that the nutritional care process undergoes several modifications over a small period of time and may require immediate implementation. However, the major/broad objectives of nutritional care are:

– to minimize the development of nutrient imbalance.

– to maintain fluid and electrolyte homeostasis

– to promote energy equilibrium

– to help in achieving and maintaining normal/ safe levels of all macro - and micro-nutrients.

The nutrition care plan for meeting the above mentioned objectives can come into play only when the patient is haemodynomically stable. We shall now proceed towards learning about the dietary management during sepsis/MODS. It is important to note that over-enthusiastic feeding of the patient would only worsen his disease condition. Patients suffering from sepsis and / or MODS should not be expected to gain weight/ body mass or strength until the source of hypermetabolism is treated.

So, let us first discuss about the energy requirements during sepsis.

Energy: Patients suffering from septicemia with or without MODS are generally hypermetabolic which results in weight loss. Critically ill patients are generally able to tolerate around 25-30 Kcals per kg usual body weight. Although adequate energy is essential for metabolically stressed patients excess calories intake may elicit complications such as hyperglycemia, excess carbon-dioxide production, which can exacerbate respiratory insufficiency or prolong weaning from mechanical ventilator. Whatever may be the amount of calories given to the patient, our objective should be to maintain blood glucose levels $\leq$ 100 mg/dl, if required by the help of insulin.

Proper choice of enteral/ parenteral tube feeds along with insulin infusions is advocated. A combination of two or three types of feed formulas may be required to meet the individualistic requirements of a patient. However, in isolated cases if oral intake is feasible; it is usually in the form of full-fluid/semi-liquid diets (mild sepsis/ MODS).

Protein: Adequate amount of protein is required by these patients to improve immunity against infections, promote recovery, spare lean body mass and reduce the amount of endogenous protein catabolism for glyconeogenesis. The requirements may vary from 1.2 gm to 2.0 gm per kg usual body weight per day.

During mild sepsis with adequate organ function, the protein intake can be maintained at 1.0-1.2 gm/kg usual body weight per day. Intact protein or protein rich foods can be included in the form of enteral tube feeds or as liquid or semi-soft diets. However, if the patient is having complications particularly of liver or kidneys, it is advisable to give specific amino-acids according to the underlying disease condition.

Carbohydrates and Fat: Carbohydrates should constitute nearly 60% to 70% of the total energy. Glucose is the primary calorie substrate in a parenteral nutrition formulation. Parenteral nutrition should be initiated with a low dextrose infusion rate.

Fats may provide 20% to 30% of the total calories depending on the underlying complications. Fat helps in preventing the deficiency in the presence of hyperglycemia. However, intravenous fat emulsions may create problems in patients having severe infection, liver or gall bladder disorders.

Micronutrients: The requirement of almost all vitamins and certain mineral increases due to infection and inflammation. In the absence of underlying complications adequate intake of all minerals and trace-elements like iron, calcium, zinc, sodium, potassium and magnesium is suggested. However, if the patient is suffering from complications of liver, kidney or oedema then the sodium and potassium intake should be regulated. Liberal amounts of foods rich in B-group vitamins, vitamin A and C should be included in the diet. Adequate amount of fluids should also be provided to prevent complications arising due to dehydration or hypovolemia.

Other Feeding Considerations/Nutrition Support

The preferred route for feeding the patient should be oral intake/ via the utilization of gastrointestinal tract. If oral intake is feasible, natural foods may be given in the form of semi-soft/ full-fluid diets. However, if oral intake is not possible then we should opt for enteral feedings which can be prepared from natural foods (absence of MODS/ complications) Commercially available foods (intact, hydrolyzed or semi-hydrolized formulas) parenteral nutrition should be provided if other forms of feeding can not be provided.

From the above discussion it must be clear to you that the dietary management of septic patients, especially those suffering from MODS is complex and needs to be altered after every few hours depending on the clinical parameters which are analyzed atleast 24 hourly.

In this section we learnt about sepsis and MODS which are among the most critical and life threatening conditions for human beings. Let us attempt the check your progress exercise 3 to recapitulate the concepts learnt so far.

Check Your Progress Exercise 3

1. What is trauma? Enlist the key features of the Ebb and shock period during trauma.

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2. Describe the term "sepsis" and its association with SIRS and MODS.

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3. Enumerate the energy and protein requirements of patients suffering from sepsis with or without MODS.

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4. What is the significance of providing feeding support during trauma and MODS.

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5.7 LET US SUM UP

In this unit we studied about the physiological and metabolic consequences of stress in its various forms viz. surgery, burns, injuries, sepsis and multiple organ dysfunction syndrome. We learnt that stress is a psycho-physiological response to a non-conducive environment within or outside the body which results in excessive or inappropriate activation of the body's defense mechanism.

In the first section we briefed ourselves regarding the stress response in the form of ebb and flow phase which is followed by the anabolic phase. The ebb phase is the most critical period with respect to survival of the patient. Efficient and prompt emergency treatment (first-aid) during this stage can help in reducing the incidence of mortality to a great extent. The flow phase which develops thereafter is characterized by elevated O_2 requirements, increased cardiac output, and marked catabolism. The dietician plays an important role in providing judicious and prompt care to manage the fluctuations in the nutrition status during the three phases.

The second section discussed about elective and emergency surgeries. The importance of a pro-active approach both pre - and post-operatively was discussed with regards to nutritional care.

We also learnt about a critical form of stress viz. burns which can be described as injuries to the tissues due to heat, electricity, radiation or chemicals. A briefing on classification of burns as per the common methods employed in the hospitals (rule of nines, degree/depth of burn etc.) was followed by overall treatment of superficial/ severe burns. The importance of adequate resuscitation during the ebb/ shock period was also explained. The nutrient requirements and mode of feeding during the flow and anabolic phase is also critical for ensuring proper treatment and rehabilitation of the patient.

This unit finally dealt with the most critical forms of illness viz. trauma related to injuries due to cold, radiations, altitude, accidents etc. Sepsis may result on its own or as a consequence to surgery, burns, injuries etc. Sepsis can result in multiple organ dysfunction syndrome which is often difficult to handle as it involves structural/ functional changes in not one but several organs. Such patients are usually referred to as those suffering from terminal illness and their nutritional care generally involves utilizaton of specialized formula foods through enteral or parenteral route.

5.8 GLOSSARY

Adreno-corticoid : a hormone secreted by the adrenal cortex.

Cortisol : a gluco-corticoid produced by the adrenal cortex.

Homeostasis : A balanced, normal state of the body's metabolic and physiological functioning.

Hypermetabolism : metabolism at an increased or excessive rate.

Hypovolemia : decrease in volume of blood.

Hypoxia : lack of oxygen.

Sepsis : a systematic response typically to a serious usually localized infection (abdomen/lungs) especially of bacterial origin.

SIRS : a severe systemic response to a condition that provokes an acute inflammatory reaction.

5.9 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

EBB Phase	Flow Phase
1. Develops immediately after injury and lasts for about 24 hours	1. It occurs within 24-48 hours of injury and may last for several days or weeks
2. Normal glucose production	2. Increased glucose production
3. Low insulin concentrations	3. Normal or elevated insulin concentrations
4. Elevated blood lactate level	4. Normal blood lactate level
5. Below-normal cardiac output	5. Increased cardiac output

2. Surgeries are generally categorized as elective or emergency. Elective surgery is a well planned form of medical treatment and involves removal or reconstruction of body parts/ organs. An emergency surgery is usually a life saving strategy with the major objective of preserving the body organs/ functions to the best possible extent. These are usually conducted for instance after an accident/ crush injury. By-pass surgery, removal of a tumor, organ transplants are examples of elective surgery.

3. Several physiological changes occur during and after a surgery such as: elevated body temperature; high leukocyte count; inflammation resulting in the release of cytokines, acute phase proteins and stress hormones; changes in carbohydrate metabolism characterized by rise in glucagon and fall in insulin levels, and changes in lipid metabolism in the form of increased glycerol turnover and enhanced free fatty acid recycling.

4. A high protein diet is suggested to promote wound healing and prevent wound dehiscence, to avoid hypovolemia which may develop due to low levels of circulating blood cell, to provide resistance to infection particularly at the site of surgery; to control/ prevent oedema and promote bone healing and to prevent the development of protein deficiency.

5. Negative nitrogen balance frequently develops post-operatively. This results in low levels of serum proteins especially albumin which leads to reduction in intravascular oncotic pressure and outflow of fluids/ water into the extra vascular space. This results in oedema in the interstitial spaces which affects the working capacity of heart and lungs.

Check Your Progress Exercise 2

1. Burns are injuries that are caused by heat, friction, electricity, radiation or chemicals. Burns are categorized by degree, based on the severity or depth of tissue damage as first, second or third degree burns. Read sub-section 5.4.1 for details.

2. Lactated ringers solution is used during the Ebb or Shock period to provide fluids and electrolytes as an emergency measure to prevent death due to burns. It is used in combination with colloid solution during the resuscitation period.

3. According to the Currie formula:

   Calories needed per day = 24 Kcal × kg usual body weight
   + 40 Kcal × % TBSA burned .

   Putting the patient values in this formula:

   $$24 \text{ Kcal} \times 62.5 + 40 \text{ Kcal} \times 33 = 1500 \text{ Kcal} + 1320 = 2820 \text{ Kcal} / 24 \text{ hrs.}$$

4. Burn Patients should be given a high protein diet during the anabolic phase to maintain a positive nitrogen balance for promoting healing of wounds, to resplenish amino acid stores in the liver for synthesis of blood proteins, to maintain normal blood picture, to facilitate successful skin grafting etc. and to prevent infections.

5. Vitamin C is involved in collagen synthesis and immune function and may be required in increased amounts (500 mg twice daily) for wound healing. Vitamin A is an important nutrient with respect to maintenance of immune function and epithelialization. Provision of 5000 I U of Vitamin A per 100 Kcal of enteral nutrition is often recommended.

Check Your Progress Exercise 3

1. Trauma refers to any physical injury or emotional stress inflicted on the human body. Medically trauma refers to a serious or critical bodily injury, wound or shock. Some characteristic features of the Ebb and Shock period include:

Ebb Phase	Flow Phase
– Low blood volume – Cardiogenic shock – Hypotension – Hyperventilation – Weak rapid pulse – Oliguria	– Increased cardiac output – Increased urinary nitrogen loss – Alterations in metabolism of carbohydrates, proteins and fat – Hypermetabolism

2. Sepsis is commonly referred to as a "blood stream infection". It is a severe form of infection in an organ wherein the causative organism is known and can result in septic shock or septicemia (infection in the blood). If a proven source of infection is lacking but the other criteria of sepsis are met, the condition typically meets the criteria for SIRS. SIRS leads to widespread activation of inflammation and co-agulation pathways. This may progress to dysfunction of the circulatory system and even under optimal treatment results in the development of multiple organ dysfunction syndrome (MODS) and eventually death.

3. Nutrient requirements during sepsis with or without MODS:

   – Majority of the patients being hyper-metabolic and usually malnourished need to be given adequate amount of calories i.e. around 25-30 Kcal per kg usual body weight per day.

   – The protein requirements are generally high varying from 0.8 to 2.0 g/kg usual body weight per day depending upon the status of organ efficiency particularly of liver and kidneys..

   – Principal source of carbohydrate is glucose which needs to provide 60% to 70% of the modified requirements of energy. The requirement is generally governed by maximum rate of glucose oxidation (5-7 mg/kg/minute) and the insulin infusion feasible for the patient.

   – Depending upon the presence/ absence of diseases associated with the gastro-intestinal tract and associated organs; the fat requirements/ intake may vary from 20% to 30% of total calories.

   – Micronutrient intake should be governed by the medical reports (biochemical tests) and mode of feeding (oral, enteral or parenteral).

4. The feeding support particularly the time, type and composition of nutrition support (enteral or/ and parenteral feeds) has a direct impact on the future morbidities and eventual mortality of the patient. Refer section 5.6.3 for details.