NUTRITIONAL SUPPORT OF THE SURGICAL PATIENT

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INTRODUCTION

While most patients undergoing elective operations easily tolerate a brief period of perioperative starvation, as many as 50 per cent of hospital patients may be nutritionally compromised, depending on the definition. Nutritional status directly impacts on patient care and adequate attention to nutritional issues can help to minimize morbidity and complications.

Steps to Optimal Nutrition Support

The five steps to optimal nutrition support are:

1) Begin when the benefits are likely to exceed the risk,
2) Set protein and calorie goals,
3) Choose and establish a method for administering the nutrients, enteral (site and route) or parenteral (peripheral or central),
4) Choose or design a formula suitable for the particular patient, and
5) Monitor the patient for adequacy of nutrient intake and to avoid or minimize complications.

NUTRITIONAL REQUIREMENTS

Protein

Protein is perhaps the most important nutrient. Although protein can be degraded and used for gluconeogenesis, this yields only one-fourth of the energy required for protein synthesis and is thus a wasteful process. A primary goal in nutritional support is to provide adequate non-protein sources of fuel so that protein catabolism is minimized.
Protein requirements

The average normal protein requirement of 'high biologic value protein' is 0.8 g/kg or 56 to 60 g/day. And may increase to 1-2g/kg/day in stressed patients.

Assuming an adequate non-protein energy supply, most amino acids can be recycled. In this fashion, only small amounts of essential amino acids are needed in order to maintain nitrogen equilibrium. In adults, 19 to 20 per cent of protein intake should be essential amino acids. This percentage should increase with depletion or injury.

Amino Acids

Humans cannot synthesize the essential amino acids. Thus, they must be obtained from the diet. In addition, several other amino acids are conditionally indispensable, as their low synthetic rates may be exceeded by increased requirements, especially in infants..

The semi-essential amino acid glutamine has recently received a great deal of attention. Glutamine is abundant in the circulation and serves as a precursor for other amino acids and proteins. Glutamine also serves as the major energy substrate for the intestinal mucosa, as a nitrogen transporter between organs, and as an important route of ammonia detoxification during acidemia. Enteral glutamine supplementation may promote small bowel adaptation and lead to increased intestinal mucosa villous height and enterocyte protein content, but this effect is not universally seen with parenteral glutamine

Nitrogen losses and balance

One gram of nitrogen equals 6.25 g of protein.

Obligate nitrogen losses are 56 to 57 mg/kg per day.

\[ N_{\text{loss}} = 24 \text{ h urinary urea nitrogen} + 4 \text{ g/day (fecal and non-urinaryloss)} \]

Calories

There are three major sources of energy: protein, fat, and carbohydrates. Of normal daily energy expenditure, 85 per cent is from fat and carbohydrates, and 15 per cent from protein.

Protein as an energy source

Of the 15 per cent of normal daily energy expenditure supplied by protein, approximately 50 per cent of this is through direct oxidation of branched chain amino acids to high-energy phosphate. The remainder is via gluconeogenesis. Protein breakdown yields 4 kcal/g
Carbohydrates as an energy source

Glucose yields about 4 kcal/g through glycolysis and the tricarboxylic acid cycle. Glycogen breakdown yields only 1 to 2 kcal/g. Most carbohydrates in parenteral nutrition are supplied in the form of dextrose, which provides 3.4 kcal/g.

Glycogen stores, however, are exhausted within 24 h of initiation of a fast, and the body then becomes dependent on gluconeogenesis as a source of glucose.

At least 400 cal/day in the form of exogenously administered glucose are required to minimize proteolysis.

Fat as an energy source

Fat about 9 kcal/g. After lipolysis, free fatty acids are released into the circulation. Free fatty acids actually circulate bound non-covalently to albumin. Nearly all tissues, with the notable exception of the brain, can utilize fatty acids as an energy source.

Determination of caloric needs

Caloric needs are related to the metabolic rate, which in turn is demonstrated by the formula:

\[ \text{metabolic rate} = 4.83 \times V_{o2} \]

where \( V_{o2} \) is oxygen consumption in liters per unit of time. Furthermore, the respiratory quotient (RQ), a ratio of carbon dioxide produced to oxygen consumed, can be used to estimate utilization of the various caloric sources by the following formula:

\[ \text{RQ} = \frac{V_{co2}}{V_{o2}} \]

An RQ of 1 is consistent with pure carbohydrate utilization.

An RQ of 0.7 is consistent with utilization of fat.

An RQ of less than 0.7 indicates ketogenesis.

In clinical practice, and RQ of greater than 1 is uncommon, but this may indicate overfeeding.

An RQ of between 0.8 and 1, indicating mixed substrate utilization, is desirable.

The basal energy expenditure (BEE) can be estimated from the
**Harris–Benedict equation:**

\[
\text{BEE (men)} = 66.47 + [13.75 \times W] + [5 \times H] - [6.76 \times A] \\
\text{BEE (women)} = 655.1 + [9.56 \times W] + [1.85 \times H] - [4.68 \times A]
\]

where \( W \) is weight in kilograms, \( H \) is height in centimetres, and \( A \) is age in years.

The additional caloric needs due to illness or other metabolic stress can then be calculated by multiplying the BEE by an injury factor:

- minor operation = 1.2 (20 per cent increase)
- skeletal trauma = 1.35 (35 per cent increase)
- major sepsis = 1.6 (60 per cent increase)
- severe thermal injury = 2.10 (110 per cent increase)

This estimate can be further refined to account for activity by multiplication by 1.2 if the patient is confined to bed and 1.3 if the patient is not confined to bed. Therefore, caloric needs equal:

\[
\text{BEE} \times \text{injury factor} \times \text{activity factor}
\]

**Calorie to nitrogen ratio**

Non protein energy is usually required at 30-35 kcal/kg/day
A non pretein energy : Nitrogen ratio of 100 – 200 is required to prevent protein breakdown for energy
NUTRITIONAL ASSESSMENT

PARAMETERS

1. Clinical:  General appearance (oedema, ascites, cachexia, obesity, skin changes)

2. Anthropometry

   - **Midarm muscle circumference**: $< 23\text{cm (male)}$ & $< 22\text{cm (female)}$ indicates malnutrition.
   - **Triceps skinfold thickness**: $< 10\text{mm (male)}$ & $< 13\text{mm (female)}$ indicates malnutrition.
   - **Handgrip dynometry**.

   Body Mass Index (kg/m²)
   
   - $= 18.5-25$ = normal
   - $< 15$ = significant increase in morbidity
   - $< 18.5$ = associated with longer hospital stay
   - $> 30$ = obesity, increased incidence of heart disease,

3. Biochemical Markers

   i) Plasma Proteins

   ![Diagram of Plasma Proteins](#)

   - Albumin
     - 20 day ½ life
   - Transferrin
     - 8 day ½ life
   - Transthyretin
     - Pre albumin
     - 2 day ½ life

   OPTICAL DENSITY

   MIGRATION DISTANCE
**Serum Albumin Concentration: Good Predictor of Outcome, Poor Marker for Nutrition Status**

Serum albumin is an exceedingly poor indicator of nutrition status because it is very insensitive and nonspecific. Infections and other inflammatory conditions which elevate inflammatory cytokines cause a decrease in albumin synthesis and also cause capillary leak resulting in an increased volume of distribution of albumin. Consequently, in sepsis and burns, serum albumin concentration may decrease, more than 1 g/dl in 24 hours. In contrast to its poor performance as an indicator of nutrition status, many studies have documented that serum albumin concentration is a good predictor of morbidity and mortality in many conditions.

**Serum Proteins and Nutrition Status**

Serum (visceral) proteins with a short half-life such as transferrin (8 days) and transthyretin (prealbumin) (2 days) respond more quickly to declining or improving nutrition status than does albumin, which has a half-life of 20 days. However, all three are negative acute phase reactants, that is, the serum levels decrease rapidly when catabolic inflammatory cytokines are released by infection or trauma. Also, the transferrin level is increased by iron deficiency while the transthyretin level is increased by renal failure and decreased by vitamin A deficiency. If these confounding factors are kept in mind, transthyretin measurements and to a lesser extent transferrin measurements, can be useful tools for assessing nutrition status. An undernourished patient with low serum transthyretin will show a significant increase in transthyretin concentration after as little as one week of adequate protein and calorie intake. Note: the quantity of transthyretin in normal serum is too small to produce a distinct protein peak on serum protein electrophoresis.

**Fibronectin:** opsonic glycoprotein (mw 440 000). Depletion correlates with reticuloendothelial phagocyte clearance depression.

**Creatinine - Height Index:** is the ratio of 24 hour urine creatinine excreted compared with height matched controls of the same sex. Expressed as a % and an index of 100% indicates normal muscle mass, provided there is normal excretion of creatinine.

**Immunological Markers:** Total lymphocyte count < 1500 cells/pJ associated with severe malnutrition. Clinical trials suggest that impaired delayed cutaneous hypersensitivity is present in severe malnutrition and with poor clinical outcome.

**Indirect Calorimetry and body composition analysis:** are helpful when nutritional requirements are difficult to estimate. Routine use cannot be advocated because they are expensive, technically demanding, and not demonstrated to effectively predict clinical outcome.
Multifactorial Prognostic Indices

a. Prognostic Nutritional Index: uses serum albumin and transferrin levels TSF and delayed hypersensitivity skin test reactivity to predict the risk of operative morbidity and mortality in relation to nutrition status. PNI 50% indicates high risk patients.

b. Prognostic Inflammatory & Nutritional Index: uses markers of inflammatory response ie a - 1 acid glycoprotein & c-reactive protein, in combination with nutrition assessment parameters (alb. & prealb.) to predict infectious complications and death.

c. Nutritional risk index: used in Veterans - Administration - cooperative group study of preoperative morbidity and mortality using serum albumin and the ratio of current weight to usual weight.

Dynamic Nutritional Assessment

Predictors of Poor Clinical Outcome

A number of measures initially designed and used to assess nutrition status correlate with outcome for patients in acute hospitals and chronic healthcare institutions. However, it remains unknown how much, if any, of the correlation between the measurements and outcomes is a result of nutrition status as opposed to severity of illness or other factors.

The Prognostic Nutritional Index (PNI) % = 158 - 16.8 (ALB) - 0.78 (TSF)- 0.20 TFN - 5.8 DH where PNI is an estimate of postoperative risk of complication, ALB is serum albumin concentration (g/100 ml), TSF is triceps skinfold thickness (mm), TFN is serum transferrin concentration (g/100 ml) and DH is delayed cutaneous hypersensitivity to any of three recall antigens (0, nonreactive: 1, =5 mm induration: 2, > 5 mm induration).
**NUTRITIONAL SUPPORT**

**ROUTES TO DELIVER NUTRITIONAL SUPPORT**

Nutrition assessment

Decision to initiate specialised nutrition support

**FUNCTIONAL GI TRACT**

YES

**ENTERAL NUTRITION**

- Long term
  - Gastrostomy
  - Jejunostomy

- Short term
  - Nasogastric
  - Nasoduodenal
  - Nasojejunal

**GI Function**

- Normal
  - Intact Nutrients

- Compromised
  - Defined formula

**NUTRIENT TOLERANCE**

- Adequate
  - Progress to oral feedings
  - Progress to total Enteral feedings

- Inadequate
  - PN Supplementation

**PAARENTERAL NUTRITION**

Short term

Peripheral PN

- GI function returns

Long term or fluid restriction

Central; PN

NO (Obstruction, peritonitis, intractable vomiting, acute pancreatitis, short bowel syndrome, ileus)

Decision to initiate specialised nutrition support
Enteral vs. Parenteral

Compared to parenteral nutrition, enteral nutrition is less costly and has a more complete nutrient profile. The complication rate, including the likelihood of infection, is probably less for enteral than for parenteral nutrition although that is not well documented. On the other hand, parenteral nutrition is easier to administer, better accepted by patients, and provides more reliable delivery of nutrients. Taken together, the benefits of enteral nutrition outweigh those of parenteral when both are possible.

**ENTERAL NUTRITION**

**ADVANTAGES**
1. Maintains gut integrity and positive effect on immunity of small intestine
2. Enhanced utilization of nutrients
3. More efficient plasma insulin response
4. Ease and safety of administration
5. Less cost than TPN
6. Mechanical, infectious and metabolic complications less severe than with TPN.

**INDICATIONS**
Any condition which requires nutritional support and in which the GIT is functional.

**CONTRAINdications**
1. Generalized peritonitis
2. Shock
3. Complete intestinal obstruction
4. Intractable vomiting/severe diarrhoea
5. Paralytic ileus
6. Severe gut bleeding
7. High output fistula
8. Early stages of short bowel syndrome

**Short-term supplementation**

These are patients in whom the anticipated need for nutritional support is for a relatively short period, often less than 6 weeks. A variety of commercially available feeding tubes can be used to access the stomach or small intestine. For patient comfort, soft small bore (7 to 9 French) tubes should be used. These tubes may be placed nasogastrically if adequate gastric emptying and an intact gag reflex is present. They may also be placed nasoenterically in patients with a higher risk of aspiration.
Long-term supplementation

Patients in whom the anticipated need for nutritional support is greater than 6 weeks may benefit from more permanent enteral access.

Gastrostomy tubes may be placed either operatively or percutaneously with endoscopic guidance.

This route of feeding requires that gastric emptying is present and is contraindicated by evidence of gastroesophageal reflux and absence of a gag reflex. One advantage of a gastrostomy tube is that feedings may be administered either continuously or as intermittent boluses, thus potentially simplifying care, especially in the outpatient setting.

Jejunostomy tubes are commonly placed operatively, either via laparotomy or with laparoscopic assistance. They may either be permanent (end Roux-en-Y type) or temporary (Witzel).

In selected cases, a jejunostomy may be placed endoscopically or using the needle catheter technique. A small bore feeding tube may also be passed through an existing gastrostomy tube to create a functional jejunostomy. Jejunostomy feedings are given continuously, rather than as boluses.

Complications Of Enteral Nutrition

2. Metabolic: glucose intolerance, excess CO$_2$ production, electrolyte imbalances
3. Mechanical: Blocked tube, tube dislodgement, nasopharyngeal discomfort, nasal erosions and necrosis (esp. children)
   Complications of surgery (gastrostomy; jejunostomy)
   - Perforation
   - Haemorrhage
   - Wound infection
   - Bowel obstruction/necrosis
   - Stomal leakage
4. Infections: Aspiration pneumonia, contaminated feeds - gastroenteritis
Principles Of Administration

1. Choosing the appropriate feed.
2. Most patients tolerate a polymeric feed.
3. In the presence of malabsorption - semi elemental formula used. Single nutrient deficiencies - modular feed used.
4. Rate of administration: start slowly (approx. 20ml/hr) and increase to 80ml/hr within 48hrs. If poorly tolerated, reduce rate or discontinue feed and recommence slowly once mechanical obstruction excluded.
5. Early feeding (48 hrs) has shown to prevent gut mucosal atrophy, preserve mucosal integrity - reduced bacterial and endotoxin translocation, ensure maintenance of normal gut flora - reduces gram negative proliferation and improves the status of the gut immune system.

Products

Many formulas have been developed for enteral supplementation. These vary in osmolarity, caloric content, protein complexity and density, and fat content. Typical formulas contain 1 to 2 kcal/ml and between 30 and 60 g of protein per liter

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<th>Kcal</th>
<th>CHO (g)</th>
<th>FAT (g)</th>
<th>PROT (g)</th>
<th>Kcal: gN</th>
<th>OSM mosmol/kg</th>
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<td>162</td>
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**Early Enteral Feeding**

A compelling clinical and scientific rationale appears to support the use of enteral feeding as opposed to bowel rest or total parenteral nutrition (TPN) in patients after trauma, including major surgery.

1. Aggressive early enteral feeding has been shown to decrease sepsis and improve outcome in critically ill patients after major trauma.
2. In individual studies and in meta-analysis, patients fed via total enteral nutrition (TEN) after abdominal surgery for trauma experienced fewer septic complications than patients fed via the parenteral route.
3. Third, the use of perioperative TPN in the perioperative period is highly controversial, with several studies reporting an increase in infective complications in subsets of patients.
4. The cost of TEN is considerably less than TPN.

**Immuno modulating drugs**

(Discussed later under Management of the critically ill patient)

**OXEPA**

OXEPA is a low-carbohydrate, calorically dense enteral nutrition product designed for the dietary management of critically ill patients on mechanical ventilation. It contains eicosapentaenoic acid (EPA) (from sardine oil), gamma-linolenic acid (GLA) (from borage oil), and antioxidants. OXEPA can be used as a sole source of nutrition for tube feeding.

- For critically ill patients on mechanical ventilation
- For critically ill patients with LUNG INJURY, such as: pneumonia; sepsis; chest injury; multiple trauma; burns; shock and hypoperfusion; aspiration or near-drowning; cardiopulmonary bypass; or hyperfusion-associated lung injury.
Features:

- Complete, balanced nutrition for tube-feeding patients
- Unique patented oil blend—contains EPA from sardine oil and GLA from borage oil
- Contains 25% of fat as MCTs for improved fat absorption
- Fortified with elevated levels of the antioxidants all-natural vitamin E, beta-carotene, and vitamin C
- 1.5 Cal/mL, 355 Cal/8 fl oz, and a moderate osmolality of 493 mosm/kg H2O
- Caloric density is high to minimize the volume required to meet energy needs
- Meets 100% of RDI for 24 key vitamins and minerals in 1420 Calories (four 8-fl-oz cans)
- Lactose- and gluten-free

**PARENTERAL NUTRITION**

If enteral nutrition is not possible in the malnourished or at-risk patient, the parenteral route must be utilized. Parenteral nutrition may be used for either primary or supportive therapy.

**Indications for Parenteral Nutrition**

**Primary therapy**
- Gastrointestinal fistula
- Short bowel syndrome
- Acute renal failure
- Hepatic insufficiency
- Inflammatory bowel disease *Efficacy not established*

**Secondary therapy**
- Radiation enteritis/chemotherapy toxicity
- Hyperemesis gravidarum
- Prolonged ileus
  
  - Preoperative therapy *Efficacy not established*
  - Cardiac cachexia *Efficacy not established*
  - Pancreatitis insufficiency *Efficacy not established*
  
  - Cancer *Efficacy not established*
  - Sepsis *Efficacy not established*
TPN Formula Composition

Components of TPN include dextrose; lipids; amino acids; electrolytes including phosphorus, potassium, sodium, magnesium, calcium, chloride, and acetate; vitamins and trace elements.

Typical vitamin amounts administered daily in TPN are:
- vitamin A 3,300 IU, vitamin D 200 IU, ascorbic acid 100 mg, folic acid 400 mcg, niacin 40 mg, riboflavin 3.6 mg, thiamin 3 mg, pyridoxine 4 mg, cyanocobalamin 5 mcg, pantothenic acid 15 mg, biotin 60 mcg, and vitamin E 10 IU.

These approximate amounts are present in commercial mixtures. Vitamin K 1 mg daily or 5-10 mg weekly is often added separately.

A typical trace element cocktail provides approximately the following per day: zinc 5 mg, copper 1 mg, manganese 500 mcg, chromium 10 mcg, and selenium 60 mcg. Molybdenum may also be included.

NUTRIENT MIXTURES

Standard solutions

- Peripheral - Vamin 750 ml + 20 % intralipid + fluids
- Central - Synthamin 14 - 14g N2
- Intralipid 10% - soybean oil + egg yolk phospholipids + glycerol 500mls.
- Glucose 50% - 500mls.
- Maintelyte - 10% glucose + electrolytes - 1ℓ
- Soluvit - water soluble vitamins
- Vitalipid - fat soluble vitamins
- Addamel - essential micronutrients.

All mixed into 3ℓ bags.
**Routes**

**Peripheral**
- 800 mOsm/L range
  - 1. Needs good peripheral veins
  - 2. Limited to 2 major veins
  - 3. Sites have to be changed every 24 hrs.
  - 4. Prone to phlebitis if osmolarity >900 mOsm/L
  - 5. In order to provide adequate calories in a reasonable volume with a tolerable osmolality, lipid provides 50% to 70% of the nonprotein calories in peripheral TPN

**Central**
- 2,000 mOsm/L range
  - 1. Usually via the infraclavicular route (subclavian vein) using a silicone, double-lumen catheter.
  - 2. strict aseptic conditions.
  - 3. Occlusive hydrocolloide dressings are most suitable. The dressings and administration set must be changed every third day.

**Complications Complications**
**Catheter related**
- (i) Mechanical: central vein thrombosis, catheter embolism, haemo-pneumothorax, haemopericardium, air-embolism, tracheal puncture, arterial laceration, brachial plexus injury.
- (ii) Sepsis: Staphylococcus epidermidis, candida albicans
- (iii) Blockage: Use of heparin and choice of catheter (silicone/polyurethane)

**Metabolic**
- Hyperglycaemia, electrolyte and acid base abnormalities, trace element and vitamin deficiencies.
- Electrolyte abnormalities
- Hypoglycaemia
- Hepatic function changes: Cholestasis, elevated liver enzymes and hepatomegaly
- GI changes: Atrophy of intestinal mucosa

**Preventing Hyperglycaemia**
- Begin the infusion at 40 ml/h of 25 per cent glucose based solution and increasing the infusion rate by 20 ml/h every 24 hrs, depending on glucose tolerance.

**Preventing TPN Associated Liver Disease**
- Decrease dextrose content < 40 kcal/kg/day
- Decrease fat content < 1 g/kg/day
- Adequate protein intake < 1-1.5g/kg/day
**PICC (Peripherally inserted central line)**

A cubital fossa PICC provides a safe effective means of administering intravenous therapy.
A PICC can be expected to last two months without complication.
Complications that do occur are most likely in the first week.
The most common complication resulting in line removal was phlebitis.
Line-related sepsis is a very rare event.
This means that the PICC compares favourably with any other means of venous access and is the method of choice for most intermediate or longer term intravenous therapy.

### NUTRITIONAL SUPPORT IN CLINICALLY RELEVANT SITUATIONS

#### A. BURNS
- Appropriate nutritional support contribute significantly to improve patients survival.
- Helps to maintain body weight, promote wound healing, combat infection, preserve body nutrient reserves and replace visceral and somatic proteins.
- Early enteral nutrition route unless non-functioning gut → then parenteral nutrition.
- Carbohydrates 50%, protein 20% and lipid 30%.
- Recent evidence that omega-3-fatty acids results in increased feeding tolerance.
- Arginine supplementation improves CMI and wound healing and is a conditionally indispensable a/acid for maintaining body protein homeostasis and nutrition in severely burned patients.

#### B. PANCREATITIS
Estimating the severity of pancreatitis is important.
Most acute pancreatitis is mild, self-limiting and resolves within 5-7 days, hence no need for nutritional support.
Severe pancreatitis induces a hypercatabolic state resulting in rapid weight loss and increased morbidity and mortality.
Chronic pancreatitis results in malnutrition. Therefore the aim is to treat the malnutrition and to avoid the development of malnutrition.
In severe pancreatitis the best route of nutrition is the nasojejunal feeding with a semi-elemental low triglyceride diet. The outcomes are similar than those patients receiving TPN. If enteral feeding increases pain. Ascites or fistula output then discontinue.

- Pancreatic fistula: Low output ----enteral feed
- High output ---TPN
- Pancreatic Ascites: TPN + somatostatin

#### C. ENTEROCUTANEOUS FISTULA
- TPN has been shown to have no effect on mortality but does influence closure as shown in local studies.
- high output > 500 ml - TPN + somatostatin
- definitive closure if no decrease in 6 weeks, patient afebrile.
- Low output < 500 ml - enteral feed.
D. CRITICALLY ILL PATIENT

Have increased metabolic demands (20-60% above basal needs). Goal is to maintain and not to replete. Initial calorie delivery 25 Kcal/kg/day and 1.5-2.0g protein/kg/day.

Associated complications
1. Hepatic dysfunction
   Aetiology: TPN, hepatic hypoperfusion, drug induced liver disease
   
   Appropriate nutrition (prevention of hepatic encephalopathy)
   Reducing the gastro-intestinal protein load by restricting dietary protein intake, preventing gastrointestinal bleeding, and encouraging intestinal emptying with agents such as lactulose. In stage I and II encephalopathy, protein intake should be restricted to fewer than 40 g/day, and this should be further reduced to fewer than 20 g/day in patients with stage III and IV encephalopathy. Caloric intake, preferably as dextrose, should be maintained in excess of 2000 cal (8.4 kJ)/day. Patients with liver damage may be lipid intolerant, and the presence of lipaemic serum requires a reduction of lipid intake.

2. Acute pancreatitis (discussed above)

3. Stress ulcer prophylaxis: Critically ill surgical patients are at risk from gastrointestinal stress ulceration. Ulcers are most often sited in the fundus of the stomach or the first part of the duodenum. They are small, multiple, superficial, well demarcated, and usually without surrounding oedema. Stress ulcer bleeding is less common in patients who are receiving enteral nutrition; this could reflect a lower severity of illness in view of the maintenance of gastrointestinal absorptive function or be a direct protective effect of nutrients in the stomach and gastrointestinal tract.

Immunonutrition:

Intended for critically ill patients at risk for infections and for use in the immediate postoperative period. They contain increased protein, immunostimulatory amino acids, and lipids, and may decrease infectious complications. Immune enhancing formulas include arginine, glutamine, nucleic acids and omega-3 fatty acids.

L-arginine and L-glutamine:
- stimulates host defenses
- modulates tumour metabolism
- increases wound healing
- decreases nitrogen losses after trauma

**L-Glutamine:** maintains integrity of intestinal barrier function in preventing translocation of bacteria and endotoxins from bowel lumen into systemic circulation. Combination of nutrients have shown to enhance host defences significantly as reported by Cerr et al. Benefits of immunonutrition were reduction in hospital stay and decrease infections but has no effect on mortality as shown by Beale et al. In another study by Galban et al. has shown a significant reduction in mortality in patients on Immunonutrition.

**Essential Fatty Acids:** Acts as an intracellular messenger and plays a regulatory role in the metabolic process. Maintains cell structure and function. Administered enterally or parenterally via central or peripheral vein. Eg: Omega – 3 and Omega 6 fatty acids: enhances cell-mediated immunity and has shown to improve histological appearance of IBD. Improves immunocompetence, has antithrombotic effects which prolongs bleeding time.

**Long and Medium Chain Triglycerides:** a 50:50 mixture of LCT & MCT has shown to have greater physiochemical stability. Resulting in more oxygen radicals being produced LCT impairs the RES while MCT stimulates it. Has a trophic effect on the bowel, reducing bile output and decrease the risk of hepatic dysfunction.

**Branched Chain Amino Acids:** Leucine, isoleucine and valine metabolized in skeletal muscle and are important oxidative fuels. Leucine rich amino acid stimulates resting energy expenditure and thermogenesis by up to 20%.

### INTENSIVE INSULIN THERAPY

Hyperglycemia associated with insulin resistance is common in critically ill patients, even those who have not previously had diabetes.

In diabetic patients with acute myocardial infarction, therapy to maintain blood glucose at a level below 215 mg per deciliter (11.9 mmol per liter) improves the long-term outcome.

In nondiabetic patients with protracted critical illnesses, high serum levels of insulin-like growth factor–binding protein 1, which reflect an impaired response of hepatocytes to insulin, increase the risk of death.

In a study by *Van den Berghe et al*, 2001 showed that intensive insulin therapy to maintain blood glucose at or below 110 mg per deciliter reduces morbidity and mortality among critically ill patients in the surgical intensive care unit.
1. HEAD INJURY PATIENTS

- The metabolic response to trauma is usually a sustained hypermetabolic state with a peak hormonometabolic response at 3 - 5 days.
- The exact mechanisms involved are unknown with the following postulates:
  a. Damage to the cardioregulatory pons with autonomic hyperactivity and increased catecholamines release.
  b. Damage to the blood brain barrier with resultant catecholamine accumulation.
  c. Steroid therapy.
  d. Raised intracranial pressure may result in gastric hypersecretion.

This effectively leads to a basal metabolic rate that may be up to 140% of normal. Nitrogen excretion may be increased up to 7 times which depends on intake, muscle mass, muscle use and steroid therapy. Hyperglycaemia develops due to the mechanisms mentioned and the overall response to trauma. This tends to produce and worsen intracellular lactic acidosis, may result in increased pCO2 with further increase in intracranial pressure.

Requirements:

i) 40 - 50 kcal/kg/day, indirect calorimetry is the standard for determining the requirements.

ii) protein 1.5 - 2.0 g/kg/day although levels of 2 - 2.5 g/kg/day are now being given.

iii) The caloric needs are the basal energy expenditure multiplied by 1.4

iv) Non protein energy: nitrogen is 80 : 1 initially then up to 130 : 1.

Route: enteral feeds should be aimed for early on ie within 48 hrs.

Other options include percutaneous endoscopic jejunstomy or gastrostomy with long term requirements.

The standard indications for parenteral therapy apply.

SHORT BOWEL SYNDROME

A number of conditions require surgical resection or bypass of intestine resulting in a short bowel. The pathophysiologic consequence of a short bowel is malabsorption.

Malabsorption due to a short bowel and its clinical consequences is referred to as the short bowel syndrome. Severity is determined by the amount of intestine resected, the site resected and the ability of the intestine to undergo adaptive hyperplasia. A short bowel is one of the causes of intestinal failure.

Other causes of intestinal failure include motility disorders (visceral myopathy, visceral neuropathy, scleroderma, amyloidosis), refractory celiac disease and radiation enteritis.

In adults, the length of the small intestine when measured at autopsies is on average 600 cm (20 feet). The length of the colon is about 150 cm (5 feet). There is no anatomic distinction that demarcates jejunum from ileum. The proximal 2/5 of small intestine is
usually accepted as jejunum and the distal 3/5 as ileum. Most dietary carbohydrates, fats, proteins, vitamins, minerals, and trace elements are absorbed within the first 2/3 of the small intestine.

Most iron is absorbed in the duodenum; folate in the proximal jejunum. Vitamin B12 (cobalamin) and bile salts are only absorbed in the distal ileum. Water and electrolytes are absorbed throughout the small intestine and colon. A small amount of carbohydrate escapes absorption in the small bowel and enters the colon. This is important for colonic health. Bacteria in the colon metabolize carbohydrate, soluble fiber and some unabsorbed fats to short chain fatty acids which are the preferred energy source for colonocytes. Short chain fatty acids are absorbed in the colon along with sodium and water, thus promoting caloric salvage and fluid absorption.

Small feedings should be started as soon as possible because nutrients are important in stimulating adaptive hyperplasia in the intestine. Only a small amount of calories (about 500-750 kcal of a soft normal diet) should be given orally to start and then increased as tolerated. Oral fluids should be limited and given separately from food. Feeding stimulates digestive juices and may increase intestinal fluid losses. Intestinal fluid and electrolyte losses should be measured and replaced daily.

There are a number of ways to enhance calorie absorption for optimal weight in those with a short bowel. Frequent small meals and slowing transit enhances absorption by maximizing the contact time for nutrient absorption. Medium chain triglycerides (MCTs) are water soluble and can diffuse across the epithelium intact or as medium chain fatty acids. Administration of excess amounts of MCTs should be avoided because unabsorbed MCTs in the intestinal lumen cause an osmotic diarrhea. In those with >100 cm of ileum resected, exogenous bile salts (e.g. ox bile, cholylsarcosine) improves fat absorption; ursodeoxycholic acid does not.

**CONCLUSION**

Nutritional support of the surgical patient is an extremely important part of the total care of the patient, unfortunately in our hospital setting it is given little importance to the average patient and only reserved for the acutely ill patient. Early assessment of the patient and initiation of nutritional support will yield excellent results and reduce morbidity and mortality.
REFERENCES

10. ASPEN Board of Directors. Rationale of Adult nutritional support guidelines. JPEN 1993 ; 17 ( 4 ) : 58 - 68.
## APPENDIX

### KING EDWARD VIII HOSPITAL (ICU) ENTERAL FEEDING PROTOCOL

<table>
<thead>
<tr>
<th>Protocol 1</th>
<th>Protocol 2</th>
<th>Protocol 3</th>
<th>Protocol 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemodynamically stable</td>
<td>Hypoalbinaemia</td>
<td>Diarrhoea / intolerance</td>
<td>Diabetic/ glucose intolerance</td>
</tr>
</tbody>
</table>

#### Day 1

<table>
<thead>
<tr>
<th>Jevity (500 ml) 20ml/hr</th>
<th>Jevity (500ml) 20ml/hr</th>
<th>Jevity (500ml) 20ml/hr</th>
<th>Jevity (500ml) 20ml/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein = 22,2g</td>
<td>Protein = 22,2g</td>
<td>Protein = 22,2g</td>
<td>Protein = 22,2g</td>
</tr>
<tr>
<td>energy = 530Kcal</td>
<td>energy = 1060 Kcal</td>
<td>energy = 1060 Kcal</td>
<td>energy = 1060 Kcal</td>
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</tbody>
</table>

#### Day 2

<table>
<thead>
<tr>
<th>Jevity (1000ml) 40ml/hr</th>
<th>Jevity (1000ml) 40ml/hr</th>
<th>Jevity (1000ml) 40ml/hr</th>
<th>Jevity (1000ml) 40ml/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein = 44,3g</td>
<td>Protein = 44,3g</td>
<td>Protein = 44,3g</td>
<td>Protein = 44,3g</td>
</tr>
<tr>
<td>Energy 1060Kcal</td>
<td>Energy 1060 Kcal</td>
<td>Energy 1060 Kcal</td>
<td>Energy 1060 Kcal</td>
</tr>
</tbody>
</table>

#### Day 3

<table>
<thead>
<tr>
<th>Jevity (1500ml) 60ml/hr</th>
<th>Jevity (1500ml) 60ml/hr</th>
<th>Jevity (1500ml) 60ml/hr</th>
<th>Jevity (1500ml) 60ml/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein = 66,5g</td>
<td>Protein = 66,5g</td>
<td>Protein = 66,5g</td>
<td>Protein = 66,5g</td>
</tr>
</tbody>
</table>

#### Day 4

<table>
<thead>
<tr>
<th>Jevity (2000 ml) 80 ml / hr</th>
<th>IL Jevity + IL Jevity plus 80ml/hr</th>
<th>Jevity (2000 ml) 80 ml / hr</th>
<th>Jevity (2000 ml) 80 ml / hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein = 88,6g</td>
<td>Protein = 99,8g</td>
<td>Protein = 88,6g</td>
<td>Protein = 88,6g</td>
</tr>
<tr>
<td>Energy 2120Kcal</td>
<td>Energy 2260 Kcal</td>
<td>Energy 2120Kcal</td>
<td>Energy 2120Kcal</td>
</tr>
</tbody>
</table>

or for poor wound healing operative 60 ml/hr
Protein = 99,9g
Energy = 1950 Kcal

#### Long term

<table>
<thead>
<tr>
<th>As above</th>
<th>Once nutritionally repleted, return to jevity 2L/day (80ml/hr)</th>
<th>If still poor tolerance, try pepttsorb (semi-elemental feed)</th>
<th>As above</th>
</tr>
</thead>
</table>


<table>
<thead>
<tr>
<th>Day</th>
<th>Renal failure (Acute/Chronic) On haemo-or peritoneal dialysis</th>
<th>Renal failure (acute/chronic) Not on haemo or peritoneal dialysis</th>
<th>Hepatic failure (C) Encephalopathy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Urine output &gt; 1000ml/day = 2L osmolite (80ml/hr) Protein = 74g Energy = 2124Kcal</td>
<td>Suplena (1175ml/dy) 40ml/hr (max rate) Protein = 35,3g Energy = 2350Kcal</td>
<td>Osmolite (500 ml) 20ml/hr Protein = 18,5g Energy = 531Kcal</td>
</tr>
<tr>
<td>Day 2</td>
<td>As Above</td>
<td>As Above</td>
<td>Osmolite (1000 ml) 40ml/hr Protein = 37g Energy = 1062Kcal</td>
</tr>
<tr>
<td>Day 3</td>
<td>As Above</td>
<td>As Above</td>
<td>Osmolite (1500 ml) 60ml/hr Protein = 55,5g Energy = 1593Kcal</td>
</tr>
<tr>
<td>Day 4</td>
<td>As Above</td>
<td>As Above</td>
<td>Osmolite (2000 ml) 80ml/hr Protein = 74g Energy = 2124Kcal</td>
</tr>
<tr>
<td>Long-term</td>
<td>As Above</td>
<td>As Above</td>
<td></td>
</tr>
</tbody>
</table>

**NB 1.** Periative and Stresson Multifibre are contraindicated for hypotensive and severe head patients (both products are rich in arginine which forms nitric oxide which is a vasodilator, however arginine is very good for wound healing. Ideally 80 ml/hr should be achieved in 3 days, but otherwise by day 5. if a patient does not tolerate > 40ml/hr, consider supplementing the nutritional intake with peripheral TPN. Peptic (semi-elemental feed) is very high in carbohydrate (carb = 352g) – need to monitor Dm and glucose intolerant pts. (2L Pepti = protein = 80g; Energy = 2000 Kcal)
# COMMERCIALLY AVAILABLE PRODUCTS

<table>
<thead>
<tr>
<th>Formulae (1000 ml)</th>
<th>Kcal</th>
<th>CHO (g)</th>
<th>FAT (g)</th>
<th>PROT (g)</th>
<th>Kcal: gN</th>
<th>OSM mosmol/kg</th>
<th>R cost</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure</td>
<td>1100</td>
<td>162</td>
<td>37,2</td>
<td>39,7</td>
<td>150:1</td>
<td>480</td>
<td>10,7</td>
<td>5</td>
</tr>
<tr>
<td>Osmolite</td>
<td>1060</td>
<td>145</td>
<td>37,6</td>
<td>37,2</td>
<td>178:1</td>
<td>300</td>
<td>22,3</td>
<td>5</td>
</tr>
<tr>
<td>Nutrison</td>
<td>1000</td>
<td>122,5</td>
<td>38,9</td>
<td>40</td>
<td>131:1</td>
<td>290</td>
<td>17,6</td>
<td>8</td>
</tr>
<tr>
<td>Alitraq</td>
<td>1000</td>
<td>165</td>
<td>15,5</td>
<td>52,5</td>
<td>120:1</td>
<td>575</td>
<td>18,5</td>
<td>5</td>
</tr>
<tr>
<td>Jevity</td>
<td>1060</td>
<td>151,7</td>
<td>35,9</td>
<td>44,4</td>
<td>150:1</td>
<td>300</td>
<td>24,6</td>
<td>5</td>
</tr>
<tr>
<td>Paediasure</td>
<td>1000</td>
<td>109,7</td>
<td>49,7</td>
<td>30</td>
<td>208:1</td>
<td>310</td>
<td>24,3</td>
<td>0</td>
</tr>
<tr>
<td>Peptison</td>
<td>1000</td>
<td>187,5</td>
<td>10</td>
<td>40</td>
<td>131:1</td>
<td>470</td>
<td>44,4</td>
<td>5</td>
</tr>
<tr>
<td>Glucerna</td>
<td>1000</td>
<td>33,3</td>
<td>50</td>
<td>16,7</td>
<td>150:1</td>
<td>375</td>
<td>7,98</td>
<td></td>
</tr>
<tr>
<td>Suplena</td>
<td>2000</td>
<td>255,2</td>
<td>95,6</td>
<td>30</td>
<td>418:1</td>
<td>600</td>
<td>7,98</td>
<td></td>
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<tr>
<td>Advera</td>
<td>1280</td>
<td>215,8</td>
<td>22,8</td>
<td>60</td>
<td>133:1</td>
<td>680</td>
<td>9,35</td>
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</tr>
</tbody>
</table>

### Examples of immunofeeds

<table>
<thead>
<tr>
<th></th>
<th>IMPACT</th>
<th>IMMUNO-AID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories (kcal)</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>56</td>
<td>37</td>
</tr>
<tr>
<td>Arginine (g)</td>
<td>12.5</td>
<td>14</td>
</tr>
<tr>
<td>Glutamine</td>
<td>9.0</td>
<td></td>
</tr>
<tr>
<td>Branch-chain amino acids (g)</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Nucleic acids (g)</td>
<td>1.23</td>
<td>1.0</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>27.8</td>
<td>22.0</td>
</tr>
<tr>
<td>Omega-3 polyunsaturated fatty acids (%)</td>
<td>10.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Osmolality (mosm/kg)</td>
<td>300</td>
<td>460</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>67</td>
<td>60</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>15</td>
<td>26</td>
</tr>
<tr>
<td>Selenium (µg)</td>
<td>46</td>
<td>100</td>
</tr>
<tr>
<td>Copper (mg)</td>
<td>1.7</td>
<td>2</td>
</tr>
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</table>