A Review of Surgical Nutrition

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Critically Ill series:

1. ***"Peri-operative management of the surgical patient; Goal-Directed Therapy to the at-risk patient“***

2. ***"Sepsis & Critically ill patients, What do Surgeons need to know?“***

3. ***“Review of Surgical Nutrition”***

Background

- Malnutrition is still a significant problem in clinical practice in the Western world,
- with up to 40% of hospitalized patients classified as being malnourished.
- For example, in patients undergoing gastrointestinal surgery, the prevalence of
  - 'mild' approximately 50% and
  - 'moderate' 30%
- This is important because the consequences of malnutrition are a disturbance of cellular and organ function.

- The following can occur,
  - Muscle wasting and impairment of **skeletal muscle** function;
  - Impaired **respiratory** muscle function;
  - Impaired **cardiac** muscle function;
  - Atrophy of **smooth muscle** in the gastrointestinal tract;
  - Impaired **immune** function;
  - Impaired **healing**, e.g. wounds and anastomoses.

- **Fasting** (Variable periods of time)
- **Postoperative complications** (e.g. sepsis)

Exacerbation of the disturbances of cellular and organ function.

The Clinical outcome:

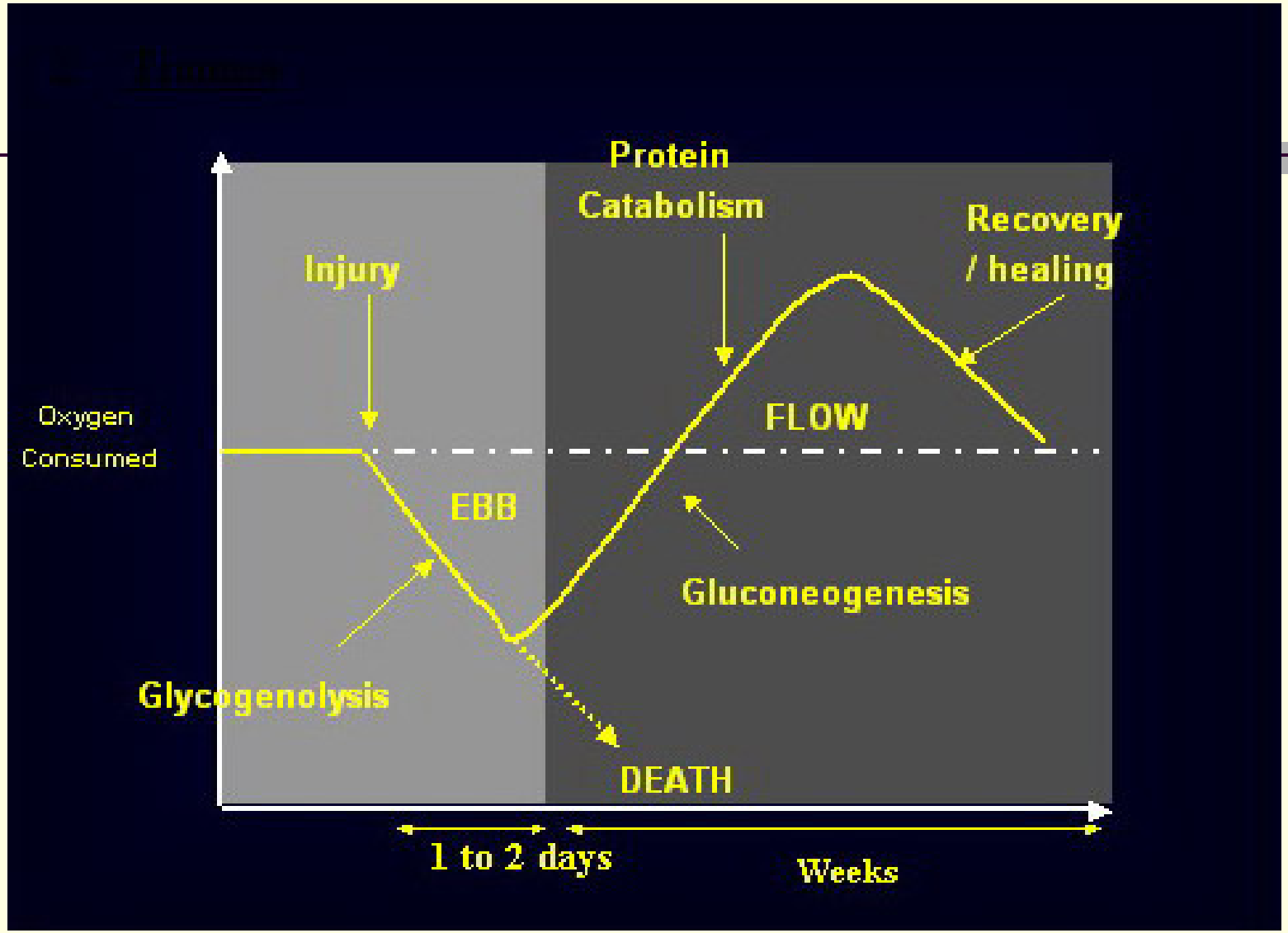
Increased risk of postoperative morbidity and mortality.

METABOLIC RESPONSE TO TRAUMA AND SEPSIS

The response to injury could be considered as occurring in two phases:

- **1. T**he ***'ebb'*** phase, which is a short-lived response
  - Associated with hypovolaemic shock,
  - Increased sympathetic nervous system activity
  - Reduced metabolic rate;

- **2. T**he ***'flow'*** phase, which follows
  - Associated with a loss of body nitrogen and
  - Resultant negative nitrogen balance.


Protein
Catabolism
Injury
Recovery
/ healing
Oxygen
Consumed
FLOW
EBB
Gluconeogenesis
Glycogenolysis
DEATH
1 to 2 days
Weeks

- These changes result in :
  - ↑ ↑ Resting **Energy** expenditure,
  - ↑ ↑ **Heat** production, pyrexia,
  - ↑ ↑ **Muscle catabolism** and wasting
  - ↑ ↑ Loss of body **Nitrogen**,
  - ↑ ↑ **Glucose** production, glucose intolerance,
  - ↑ ↑ Breakdown of **Fat** and reduced fat synthesis

- If these changes continue as part of the 'ebb phase',
  - Then despite advances in anesthetic and surgical technique, death is an inevitable outcome

- CNS, Hypothalamus
  - HRF & Hormones & Cytokines
  - Pituitary Glands
    - Prolactin,
    - Vasopressin,
    - Growth hormone and
    - Adrenocorticotrophic hormone (ACTH).
  - Stress hormones
    - (Adrenaline, Cortisol and Glucagon)

CHANGES IN PROTEIN METABOLISM:

The increased loss of nitrogen following trauma is due to

Protein breakdown occurring > synthesis,

- Whether the patient is fed or fasted. The magnitude of the nitrogen loss is proportional to the **degree of operative trauma**.
- A major site of protein breakdown is in the **skeletal muscle**:
  - Contains 80% of the body's free amino acid pool,
    - Of which 60% is glutamine.

The amino acids released can be used for:

- 1. **Fuel** by muscle;
- 2. Synthesis of proteins necessary for **structural repair** in the traumatized area;
- 3. Hepatic production of proteins with **immunological** or tissue repair functions;
- 4. Hepatic production of **glucose** from alanine (the latter being produced by a series of transamination reactions from other amino acids);
- 5. Energy substrates for the **gut, lymphocytes** and other rapidly proliferating tissues.

- *O'Kcefe S]D, Sender PM, lames WPT. Catabolic loss of body nitrogen in response to surgery. Lancet 1974; ii:1035-8.*
- *Bergstrom], Furst P, Noree L-O et a!. Intracellular free amino acid concentration in human muscle tissue. J Appl Physiol; 1973; 36:693-8 .*

CHANGES IN CARBOHYDRATE METABOLISM

- Glucose is the main fuel used for many different tissues.
- It is obtained by
  - Absorption from the gastrointestinal tract,
  - Endogenous production from glycogen (glycogenolysis) or
  - Other precursors such as amino acids.
- Glucose can be utilized for
  - Energy transduction or
  - Converted into glycogen or fat.

Following trauma:

- ↑ ↑ Hepatic glycogen breakdown (caused by increased sympathetic activity).

  These stores are substantially, but not completely, depleted within 24 hours.
- ↓ ↓ peripheral utilization of glucose.
- ↑ ↑ Insulin antagonists
- ↑ ↑ Resistance to insulin
- **In general**, the carbohydrate response is to **produce Hyperglycemia** both in the immediate 'shock' and later 'flow' phase

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- *Stoner HB. Studies on the mechanism of shock. The quantitative aspects of glycogen metabolism after limb ischaemia in the rat. Br J Exp Pathol 1958; 39:635-51. '*
- *Allsop]R, Wolfe RR, Burke JE Glucose kinetics and responsiveness to insulin in the rat injured by burn. Surg Gynecol Obstet 1978; 147:565-73.*

CHANGES IN FAT METABOLISM

- ↑ ↑ Turnover of fatty acids and glycerol.
  - Lipolysis of triacylglycerols with the production of free fatty acids and glycerol.
  - The glycerol can be used by the liver for gluconeogenesis and the
  - Fatty acids can also be used as a fuel source

Nordcnstrom], Carpentier YA, Askanazi] et al. 'Free fatty acid mobilisation and oxidarion during total parenteral nutrition in trauma and infection. Ann Surg 1983; 198:725-35.

NUTRITIONAL REQUIREMENTS:

- **Proteins & amino acids**
  - UK average daily intake of protein is approximately 80 g
  - Recommended daily intake of 0.8 *g/kg* body weight,
  - Nitrogen comprising approximately 16% of its weight.
  - However, it is of some interest to note that more than 50% of the world's population exist on less.
  - "Conventionally, amino acids have been classified as either 'essential' or 'non essential'.
    - Essential aa **cannot** be synthesized endogenously and are required in the diet,
    - Non-essential can be synthesized by human body.

- Both groups of amino acids however, are necessary for normal tissue growth and metabolism.

- Dietary intake and endogenous synthesis of amino acids in the body maintain the relevant pool of amino acids, replacing those that have been lost as a result, of:
  - Excretion in the urine,
  - Losses from the skin and
  - Gastrointestinal tract,
  - Utilization as precursors for non protein,
  - Synthetic pathways,
  - Irréversible modifcation and
  - Irreducible oxidation.

- It has become recognized that under certain circumstances (sepsis, trauma, growth) the endogenous synthesis of some of the amino acids normally considered to be 'non-essential' is **inadequate** for the body's nitrogen fluxes.

- Therefore, unless these amino acids are present in the diet abnormal tissue protein metabolism may occur.

- These amino acids are described as being **'conditionally essential'**
  - L-alanine,
  - L-glutamate and
  - L-aspartate,
- Which are produced by a simple Transamination reaction.

- **Energy requirements**
  - Energy transduction is accomplished by the down of carbohydrate, fat and proteins. The energy available from various common nutrients is as follows:
    - Fat 9.3 kcal/g (38.9 k]/g);
    - Glucose 4.1 kcallg (17.1 *kJ/g);*
    - Protein 4.1 kcallg (17.1 kJlg);
    - Alcohol 7.1 kcallg (29.7 kJlg).
- **The principal carbohydratcs in the diet are**
    - Polysaccharides (starch and dietary fibre),
    - Dextrins and
    - Free sugars (monosaccharides), disaccharides, oligosaccharides and sugar alcohols.
- **Dietary fat includes**
    - triacylglycerol, containing
      - Long-chain fatty acids
      - Medium-chain fatty acids .

- **If the energy intake > energy expenditure:**
  - Extra carbohydrate intake will be channeled into glycogen synthesis; when
  - Glycogen stores are replete, glucose is metabolized to fatty acids and fat synthesis occurs.
  - Additional fat intake will be stored in adipose tissue as triacylglycerol.

- **In contrast, if there is a negative energy balance:**
  - Then fat, glycogen and protein will be broken down to provide the required energy

- The **Total** daily energy expenditure (TEE) is composed of the following components:
  - •• **Resting** metabolic expenditure or RME (defined as the energy required for cardio-respiratory function plus that required for synthesis and maintenance of electrochemical gradients across cell membranes);
  - •• **Activity** energy expenditure (depends on physical work); Diet-induced energy expenditure.
- Under normal circumstances, approximately:
  - 25-30 kcal/kg (105-125 kJ/g) are required every day.

Micronutrients

- VITAMINS
  - Vitamins are organic compounds
  - Essential for normal growth and maintenance of body functions,
  - Playing key roles in many different metabolic processes in both health and disease.
- Vitamins are classified into those that are:
  - Fat soluble (A, D, E and K) and those that are
  - Water soluble C and the B vitamins (folic acid, Bn, Bh E2, E3, pantothenic acid, biotin and E6).
- The exact requirement for vitamins during trauma and sepsis is still unclear and may alter depending on the type of metabolic support provided.

- **TRACE ELEMENTS**
  - inorganic elements that are also important in the regulation of many metabolic processes. For example,
    - **Zinc** : wound healing, being a cofactor in enzymes for protein and nucleic acid synthesis.
    - **Iron**: involved in energy transfer),
    - **Copper**: necessary for collagen synthesis) and
    - **Selenium** (important in synthesis of antioxidant enzyme systems, which protect against peroxidation).
- If given at high doses, could be toxic to tissues and organs.
- In particular, Excess vitamins A and D, iron, selenium, zinc and copper.
- Care must be taken when these micronutrients are provided for a prolonged period to patients.

IDENTIFICATION OF PATIENTS WHO ARE MALNOURISHED

- A reliable and reproducible assessment of nutritional status has proved difficult and, as yet, there is no definitive test for 'malnutrition'.

- However, assessments that have been used previously in clinical practice can be considered as falling into several categories:
  - Anthropometric measures
  - Biochemical assessments
  - Body composition measurements
  - Body function (skeletal and respiratory muscle function, immune responses).

Anthropometric measures

- **HEIGHT AND WEIGHT**
  - Body mass index (BMI), defined as **weight / the square of the height**,
  - The shorter the period of time over which weight is lost, is the most significant this is in predicting an increased risk of postoperative complications.
  - Malnutrition can be defined as a
    - BMI of < the 10th percentile with
    - A weight loss of 5% or more.

- *Metropolitan Life Assurance Company. StatisticalBulletin 19S9; 40:1.*
- *Pettigrew RA. Assessment of malnourished patients. In: Burns HG (ed.) Clinical gastroenterology. London: Baillicre Tindall, 1988; pp. 729-49.*

- **SUBCUTANEOUS FAT THICKNESS:**
  - 50% of total body fat is in the subcutaneous layer
  - Triceps skin fold thickness is most commonly
  - Multiple sites is better and has good correlation

- Regression equations for the estimation of total body fat from these measurements have been developed and can be used in clinical practice.

- However, measurements of skin-fold thickness are susceptible to intraobserver and interobserver variability, which limits their use clinically.

- *Durnin .JVGA, Womersley .I. Body-fat assessed from total body density and its estimation from skin-fold thickness: measurements on 481 men and women aged from 16 to 72 years. Br.J Nutr 1987; 32:77-97 .*

Biochemical Measures

- **SERUM PROTEINS**

  - Albumin is the **major protein** in serum and the relationship between serum protein concentration and protein-energy malnutrition was first recognized over 150 years ago.

  - Subsequently, studies have shown that low serum albumin levels-are associated with an increased risk of **complications** in patients undergoing surgery.

Rothschild MA, Oratz M, Schreiber SS. Albumin metabolism. Gastroenterology 1973; 64:324-37.

Ryan .IA, Taft DA. Preoperative nutritional assessmel1t does not. predict morbidity and mortality in abdominal operations. Surg Forum 1980; 31:96-8.

- Serum-albumin levels may not fall for several weeks because although synthesis decreases, :
  - Only 30% of the total exchangeable albumin is in the intravascular space, with the remainder- being in the extra-vascular compartment.
  - The flux of albumin between the intravascular and extra-vascular compartments is - about **ten times** the rate of albumin synthesis.
  - Albumin has a relatively long half-life of approximately 21 days.

- It has been suggested that- the extra-vascular compartments replenishes the intravascular-pool, which then only falls when this can no longer occur .

- **Morover**
  - Studies have shown that a 30% loss of body weight with long periods of semi starvation was associated with **an increase** in serum albumin concentration, thus confirming that albumin bears no relationship to nutritional status.
  - Serum albumin is lowered in malignancy, trauma and sepsis, despite an adequate intake,
  - And hence it should not be used as an assessment of nutritional state.

- **Alternatives** other serum protein concentrations have been evaluated, including:
  - Transferrin (half-life 7 days),
  - Retinol-binding protein (half-life 1-2 hours) and
  - Pre-albumin (half-life 2 days).

  The changes in their serum concentrations should therefore **more accurately** reflect acute changes in nutritional state than does albumin. The serum levels of these proteins are also altered in stress, sepsis and cancer

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- *Rothschild MA, Oratz M, Schreiber SS. Albumin metabolism. Gastroenterology 1973; 64:324-37.*
- *Fleck A, Raines G, Hawker F et al. Increased vascular perrneability: a major cause of hypoalbuminaemia in disease and injury. Lancet 1985; i:781-4.*

- **NITROGEN BALANCE**
  - Most of the nitrogen lost from the body is excreted in urine, mainly as urea (approximately 80% of total urinary nitrogen). Urea alone may be measured as an approximate indicator of losses.
  - Total urinary nitrogen may be measured, although this latter technique is less widely available. In addition, there are also losses of nitrogen from the skin and in stool of approximately 2-4 g per day.
  - One equation used for balance studies is:
    - Nitrogen balance = (dietary protein x 0.16) (urea nitrogen (urine) + 2 g stool + 2 g skin)
      - (Where urine urea nitrogen (g) = urine urea (mmol) x 28)
- Although nitrogen balance **has not been shown** to be a prognostic indicator, it is still an important way of assessing a **patient's nutritional** requirements and of assessing the response to the provision of nutritional support.

Body composition

- Complicated techniques for assessing the body's different compartments (e.g. fat, fat-free mass, total body nitrogen and total body mineral contents) have become available but:
- these often require specialized equipment and may not be readily applicable to clinical practice.
- Relatively simple techniques, such as bioelectrical impedance, can be used in clinical practice.

BIOELECTRICAL IMPEDANCE

- This entails the passage of an alternating electrical current between electrodes attached to the head and foot. The current passes through the water and electrolyte compartment of lean tissues and the drop in voltage 'phase-shift' between the two electrodes is measured

- Although bioelectrical impedance is an accurate measure of body composition in stable subjects, it becomes less reliable in patients with oedema and electrolyte shifts.

- Its value in critically ill patients is unclear.

Kushner RE, Kunigk A, Alspaugh J'vl et al. Validation of bioelectrical-impedance analysis as a measurement of change in body composition in obesity. Am .I Clin Nur' 1990; 52:219-23.

IMMUNE COMPETENCE

- Reduction in the total circulating lymphocyte count and impairment in a wide variety of immune functions, e.g. decreased skin reactivity to mumps, *Candida* and tuberculin

- these alterations in immune function are nonspecific and can be affected by trauma, surgery, anesthetic and sedative drugs, pain and psychological stress (all important in the surgical patient) and therefore are not generally applicable to clinical practice.

- *Eremin 0, Broom J. Nutrition and the immune response. In: Eremin 0, Sewell HF (eds) The immunological basis of surgical science and ·practic. Oxford: Oxford University Press, 1992; 133-44.*
- *Bistri.an BR, Blackburn GL, Scrimshaw NJ et al. Cellular immunity in semi starved hospitalized adults. Am J Clin Nutr 1975; 28:1148-55.*
- *Seltzer MH, Bastidas JA, Cooper DM et al. Instant nutritional' assessment. J Parenteral Enteral Nutr 1979; 3:157-9*
- *Heys SD, Khan AL, Eremin O. Immune suppression in surgery. Postgrad Surg 1995; 5:62-7.*

- **MUSCLE FUNCTION**
  - Skeletal muscle
  - Respiratory muscle
- However, may be influenced by other factors such as the patient's motivation and, cooperation,
- Furthermore, such tests may be difficult to apply to patients who are critically ill
- Alternatively, 'stimulation of the ulnar nerve

Lopes J, Russke DM, Whitwell J et al. Skeletal muscle function in malnutrition. Am J Clin Nutr 1982; 36:602-10.

- **NUTRITION RISK INDEX**
  - A nutritional risk index is an index of nutritional status, based on a combination of variables.
  - Although several indices exist, one that is commonly used depends on serum albumin, current weight and the patient's usual weight.
  - **Nutrition risk index = 1.519 x serum albumin (g/L), + 0.417 x (current weight/ usual weight) x 100**
  - The score obtained is used to categorizes the patient's nutritional state:
    - < 83,S, 'severely' malnourished;
    - 97.5-100, 'borderline' malnourished
    - 83.5-97.5, 'mildly' malnourished

How should nutritional status be assessed in clinical 'practice?

- **No one reliable technique for assessing nutritional status.**

- Hill and Windso have suggested useful indicators for the bedside' assessment of nutritional status that are readily' applicable to clinical practice, include:
  - Estimation of protein and energy balance,
  - Assessment of body composition and,
  - Evaluation of physiological function

- *Hill G, Windsor JA. Nutritional assessment in clinical practice. Nutrition 1995; 11(suppl.):198-201.*

Coming Soon

- **NUTRITIONAL SUPPORT IN SURGICAL PRACTICE**
  - **Access / Solutions / Complications / Monitoring**
- **NUTRITIONAL SUPPORT IN DEFINED CLINICAL SITUATIONS:**
  - **Perioperative period**
  - **Acute pancreatitis**
  - **Inflammatory bowel disease**
  - **Enterocutaneous fistulas**
  - **Burns**

Any Questions ?!!

Thank You !