A major surgical procedure results in injury resulting in systemic response resulting in a negative nitrogen balance. The conventional management of a patient in the peri-operative period involves pre- and post-operative fasting, which potentiates the caloric deficit. Early feeding has been shown to result in a positive clinical outcome. However, the physiologic response to surgery impedes successful initiation of early enteral feeds. This article discusses the various strategies to improve tolerance to early enteral feeds in the immediate post-operative period.

Key words: Enteral feed, Parenteral feed, Surgery

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imize the surgery-induced catabolism and limit the disadvantages of a pre-existing malnutrition\textsuperscript{4,5}. It is an established fact that early oral or enteral nutrition following a major abdominal surgery is not associated with any increased complications\textsuperscript{4,7}.

The rationale of peri-operative nutritional support will be better appreciated by understanding the metabolic changes following surgery and the physiological changes that occur in intestinal permeability in all surgical patients. However early enteral or oral feeding tends to be unsuccessful due to gastrointestinal dysmotility, which occurs for the following reasons:

1. Surgical manipulation, anesthesia and hypotension increase leukocyte extravasation into the muscularis of the intestines, which increase the local inflammation. This in turn alters the electrical activity and reduces the contractile response.
2. Hyperglycemia increases dysmotility. Normal intestinal motility occurs at blood sugar of less than 150 mg/dl
3. Hypokalemia (less than 4 mmol/L)
4. Hypomagnesemia (less than 2 mmol/L)
5. pH of less than 7.27 affects the transporter activity
6. Pre-operative bowel preparation promotes inflammation within the bowel wall and delays return of normal gut function
7. Inadequate analgesia in the postoperative period will prolong the postoperative ileus
8. Opioids have a paralytic effect on the intestines and when used as analgesics in the perioperative period, will prolong dysmotility
9. Peri-operative and postoperative fluid administration is based on actual and perceived fluid losses after surgery, which in turn are based on three factors:
   i. Pre-operative overnight fasting
   ii. Pre-operative bowel preparation
   iii. Epidural analgesia

This article gives an overview of the metabolic changes that occur in surgical patients and focuses on the various strategies to increase tolerance to early oral or enteral feeds.

**Metabolic changes in surgical patients**

The stress of surgical trauma results in activation of the various neuro-endocrine and cytokine mediators. These in turn release stress hormones (catecholamines, cortisol and glucagon) which induce a catabolic response leading to negative nitrogen balance. Metabolic rate is increased by about 10% initially. If adequate nutritional support is not provided at this stage, then the body provides proteins from endogenous breakdown. 50% of the proteins are provided by the breakdown of skeletal muscles and the remaining from fat\textsuperscript{6}. This loss of muscle mass interferes with the muscle function and compromises the various host defenses. Activated inflammatory cells have high oxygen consumption and release a number of cytokines (TNF, IL1, IL6, etc). The effect of these cytokines is to cause tissue edema due to vasodilatation and increased capillary-leak, amongst other actions. This in turn is associated with increase in cardiac output and causes hyperthermia. These changes increase the energy expenditure, oxygen uptake and substrate utilization, which is provided by catabolism.

Surgery also causes a state of insulin resistance (IR) which is proportional to the magnitude of the procedure. This affects glucose metabolism similar to that of untreated diabetes. In addition, catecholamines, cortisol, glucagons, TNF, IL6 (all of which are increased in the post-operative period) can independently cause IR and can also potentiate each other to cause IR. This results in post-operative hyperglycemia. Because of ongoing surgery-induced IR, more protein is broken down by gluconeogenesis to provide glucose. This results in net protein catabolism.

However, not all organs are catabolic following surgery. Some organs like the wound, liver and the whole immune system are actually anabolic. Catabolism of the muscle proteins provides several grams of amino acids to the liver for synthesis of acute phase proteins. It has been calculated that 7 grams of muscle protein would have to be broken down to produce 1 gram of fibrinogen\textsuperscript{7}. Similarly there is an increased uptake of amino acids by the immune system and the wound for appropriate immune response and wound healing respectively.

Despite these catabolic and anabolic changes, the sum total of protein kinetics is negative and the body is in negative nitrogen balance. Without adequate nutritional intervention, patients undergoing major surgery lose 10% to 20% of proteins within the first week. Nutrients supplying energy and proteins thus represent an essential part of perioperative management.

**Advantages and contraindications to enteral feeding**

Post-operative feeding should be started in all normotensive patients, who have recovered from anesthesia and in patients who continue to be on ventilator in the post-operative period, if
hemodynamically stable. The following are advantages of early enteral feeding:

- It prevents mucosal atrophy by ensuring luminal supply of nutrients. This maintains the mucosal integrity of the gastrointestinal tract, and thereby limits the bacterial translocation.
- Gastrointestinal tract has the largest immune system in the body and enteral nutrition nourishes this enormous immune structure and improves immuno-competence. Early enteral feeding after surgery acts as prophylaxis against infection and sepsis and reduces the incidence of postoperative infections and hospital stay.
- Improves intestinal perfusion and stimulates peristalsis. Presence of bowel sounds and passage of flatus is not a pre-condition to commence enteral feeds. Trickle feeds can be commenced at very low volumes, which in turn stimulate peristalsis and improve immuno-competence.
- Reduces colonization by pathogenic micro-organisms and prevents bacterial overgrowth.
- Stimulates gastrointestinal hormones and maintains hepatopancreatic axis.
- Possible prophylactic measure against stress ulcers if fed into the stomach.
- Is less costly than parenteral nutrition.

However, all post-operative patients may not be suitable candidates for early enteral nutrition. The following are absolute contraindications of enteral nutrition:

- Any state of shock
- Intestinal ischemia
- Intestinal obstruction
- Acute gastrointestinal bleeding
- Intestinal perforation
- Abdominal compartment syndrome
- Serum lactate > 3-4 mmol/L
- Hypoxia - \( pO_2 < 50 \text{ mmHg} \)
- Hypercapnia – \( pCO_2 \text{ mmHg} \)

**Minimal enteral nutrition or trickle feeds**

The rationale of commencing minimal enteral feeds is that, the presence of nutrients in the gut lumen, even at low volumes is sufficient to maintain gastrointestinal integrity and enhance mucosal defenses. Standard, high molecular weight, fat-free enteral formulas can be used to commence trickle feeds. Pure glucose or pure amino acid solutions are not recommended. Trickle feeds should be commenced at volumes of 10-15 ml/hour, continuously (which is the preferred method), by using an infusion pump. This provides about 240-350 ml in 24 hours. At times, it can be commenced as a bolus feed, into the stomach, at volumes of 50 ml, not more than six times in 24 hours. The tube should be clamped after administering the 50 ml feed. It should be opened after 1-2 hours and allowed to drain.

Minimal enteral feeds are safe to administer in the immediate post-operative period, within 12 to 24 hours. It does not disrupt the bowel anastomosis and has proven to be a safe clinical practice. Trickle feeds are also possible in presence of paralytic ileus, in patients with high gastric residuals of up to 500 ml/day. Trickle feeds can be increased every 12 hours by increments of 15 ml, till 60 ml per hour are reached. This takes about 2 to 3 days to achieve.

An important point to note is that these trickle feeds at low volumes, do not provide the required nutrient and energy needs. It only provides substrates to support the intestinal function. Supplementary parenteral nutrition should be utilized in appropriate cases.

**Strategies to improve tolerance to enteral feeding**

The following are the strategies to improve tolerance to early enteral or oral nutrition:

1. Provision and access to appetizing food
2. Nasogastric tube delays normal dietary intake, therefore avoid nasogastric tube in all elective abdominal procedures. Also by avoiding routine gastric decompression after abdominal surgery reduces the incidence of fever, atelectasis, pneumonia and prevents losses of trace elements (zinc and selenium), bile acids, bile salts, IgA and IgEA-F11.
3. Avoiding bowel preparation. Mechanical bowel preparation promotes inflammation in the bowel wall and delays return of normal gut function.
4. Epidural analgesia for postoperative analgesia. Catecholamines are released after surgery from adrenal medulla and also from local sympathetic nerves in response to apprehension, pain and due to tissue dissection of visceral peritoneum. Epidural analgesia at the mid-thoracic level will attenuate these responses and reduce postoperative ileus.
5. Control of postoperative nausea and vomiting is essential to resume normal dietary intake. Use of anti-emetics will enhance resumption of early dietary intake.
6. Adequate peri-operative fluid balance speeds up the return of bowel function and enhance enteral feeds tolerance. This can be achieved by...
i. A strict peri-operative fluid regime
ii. Avoiding overnight fasting
iii. Avoiding mechanical bowel preparation

7. Avoid opioids analgesia as they have a paralytic effect on the gut, which is about 4 times stronger than their analgesic effect! Non-steroidal anti-inflammatory drugs and paracetamol are better alternatives.

8. Appropriate surgical technique. The following practices will reduce the duration of ileus and enhance tolerance to enteral feeds:
   i. Minimal incisions, gentle manipulation and handling of tissues, especially stomach and intestines
   ii. Intra-operative warming
   iii. Minimal use of drains, tubes, catheters and their removal as soon as possible

9. Postoperative laxatives significantly speed up the time of return of bowel movement. Magnesium oxide 1200 mg per day, in divided doses is used routinely in all the enhanced recovery protocols. It is a safe and an effective laxative.

10. Optimization of patient factors. Correct hyperglycemia and electrolytes (potassium and magnesium), correction of blood pressure and optimization of co-morbidities.

11. Precautions against loose stools. The commonest cause of diarrhea in patients is medication, which should be reviewed in all cases of diarrhea. The hang time of enteral feed should not exceed 6 to 8 hours and strict hand hygiene should be maintained by the personnel preparing the feed.

12. Precautions against aspiration should be meticulously followed. They are:
   i. Always administer feeds with the head end elevated by 350. Maintain this position for an hour.
   ii. Minimize use of narcotics
   iii. Use smaller than 16 F tubes
   iv. Advocate continuous feeds
   v. Stop feeding if the patient develops abdominal distension or experiences abdominal discomfort, and if the residual volumes are increasing.
   vi. Feed into the small bowel (third part of duodenum or beyond) in patients with two or more risk factors. patients
   vii. Use sucralfate whenever possible
   viii. Use mouthwash and other measures to optimize oral health

Conclusion
Early and safe enteral or oral nutrition interventions in the post-operative period have evolved dramatically during the last few years. Like any other form of intervention, the practice of commencing early nutrition following surgery should be based on evidence based principles. However, early commencement of diet may not successful in view of gut dysmotility and hence the strategies to increase the tolerance should begin in the preoperative period. The strategies include pre-operative optimization of the patient, changing the traditional pre-operative practices and inculcating evidence-based intra-operative methods and adapting maneuvers to feed even in the presence of postoperative ileus.

Pre-operative patient education and counseling has shown to be beneficial in the post-operative recovery, including tolerance to early feeds. Enhanced recovery protocols combine several interventions. Their effect of post-operative gut function is impressive and ERAS protocols increases the tolerance to solid food and nutritional supplements very early after surgery.

This article reviews the various strategies to increase the tolerance to enteral feeds in the perioperative period.

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