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Review Article

Surgical and Nutritional Management in Gastro-Intestinal Surgery

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Introduction

In this paper, factors will be described determining and optimizing immediate postoperative surgical outcome and ways to improve the nutritional and metabolic condition of surgical patients in bad condition or with infection. Especially infection is the most frequent and much feared complication after surgery. Prevention of these complications does not only depend on technical skills but also on other more holistic aspects of treatment. Similarly, management of patients that present with acute abdominal infections should besides surgical technique also include non-surgical treatment aspects to achieve optimal results. These aspects play before, during and after surgery crucial roles in the healing process.

Preoperative Assessment

Nutritional assessment (Table 1)

Modern methods to assess nutritional state include an estimate of whether the patient can generate a healthy healing response, which should give guidance to the type and timing of surgery. In the presence of substantial pre-existing inflammatory activity, a less elaborate operation should be performed without performing extensive oncologic surgery or performing multiple anastomoses, which will heal less well during substantial inflammation. This is specifically relevant in its pro-inflammatory phase, implying that damaged tissue is not yet removed or infections are not yet successfully treated. In this situation, nutritional support does not inhibit loss of fat free (specifically muscle) mass but rather fat mass, which will however not preserve muscle function and immune response. Malnutrition is therefore defined as a "a subacute or chronic state of nutrition, in which a combination of varying degrees of undernutrition (negative nutrient balance) and inflammatory activity have led to changes in body composition, diminished function and worse clinical outcome". [1] (Table 1) Consequently, ideally nutrient balance, body composition, inflammatory activity and muscle, immune and cognitive function should be assessed. Pre-operative inflammatory activity diminishes the efficacy of the immune and healing responses to an additional trauma or infection, which is well known and described by Francis Moore [2] who was one of the founding fathers of surgical metabolism. The second hit phenomenon was modelled at a later stage. [3,4] The notion implies that when a patient is in an inflammatory state due to shock, trauma or infectious or non-infectious illnesses, the capacity to generate a renewed adequate host response is compromised. Not only is immune function diminished but also muscle force and cognition are decreased. Muscle function is not only decreased by diminished muscle mass due to undernutrition (an exclusively negative nutrient balance) but also by inflammation itself. This knowledge should be taken into account when treating for instance old and frail patients. Treatment should be right the first time, because when (infectious) complications occur, patients can often not be weaned from the respirator due to further deterioration of their ability to perform muscle work and from excess water (oedema) interfering with alveolar diffusion and exchange of oxygen and carbon dioxide. Even immediately after clean uncomplicated surgery the response to a second challenge (trauma, operation, infection) is mitigated and therefore often failing to achieve healing. [5] In addition, surgical trauma increases the virulence of Pseudomonas aeruginosa and other micro-organisms. [6,7] A similar mechanism prevails when operating in the presence of infectious inflammation already present and has an increased risk not to recover well. [5] Not only is the normal response to trauma dampened as outlined earlier but the risk to develop additional infections increases. The group of Alverdy has done much research elucidating mechanisms. [6,7]

Bacteria apparently are able to sense the host's stress and then can upregulate their virulence. If possible, infection should therefore be treated before performing surgery. When this is impossible and immediate surgery must be performed, it should be defensive, removing, treating or draining the septic focus without performing hazardous anastomoses. (See section Operation)

Nutritional Assessment/ Risk analysis

Undernutrition	**Inflammation**
Decreases FFM/muscle mass/FM	Causes catabolism peripheral tissues (muscle, bone, skin)
	Decreases function, wound, bone, anastomotic healing
Decreases Function	Muscle force/endurance, ADL
Wound, bone, anastomotic healing	Immune function (**Second hit)**
Immune function	Cognition
Muscle force/endurance, ADL	
Cognition	Dysfunction occurs even when nutritional intake is adequate
	Infectious inflammation increases risk more than non-infectious inflammation
When nutritional intake is inadequate	
Dysfunction depends on the degree of undernutrition and takes longer to develop than in the presence of inflammation. (significant when loss > 10% BW)	
Laboratory values	Laboratory values
Hb slowly decreasing	Hb quickly decreasing
Na normal	Na low unless Na administered
CrP low	CrP elevated
Albumin normal	Albumin decreased (dysfunction significant when < 35 g/L)
	Creat elevated
Creat low	Leucocytes elevated unless hypodynamic sepsis: leukopenia with left shift
Leucocytes normal unless cachectic	
Body composition	Body composition
Slowly decreasing fat free mass, normal water content	Rapidly decreasing fat free mass **solids.**
	Positive fluid balance, leading to increased water content.
Fat mass decreases	Fat mass only decreases when nutritional intake is insufficient
	BW may not decrease due to increased water content: oedema but body solids will decrease rapidly
BW and BW solids decrease slowly	

Table 1: Nutritional assessment defines function, body composition and causes of dysfunction.

Anaemia

Many patients with abdominal cancer, cardiovascular disease or benign inflammatory disease have anaemia, which has different causes. Low-grade long-standing inflammation and malnutrition may suppress bone marrow activity. In addition, anaemia has been found to be strongly correlated with hypoalbuminemia (see further) and may be caused by an inflammation related vasodilatation, leading to an increased vascular volume, in which haematocrit decreases while erythrocyte mass may be maintained. [8] In addition, the anaemia of malnutrition can be caused by overall depletion or/and specific deficiencies (iron and folic acid). Another cause of anaemia is blood loss, often accompanying benign or malignant conditions in the abdomen. Classification based on mean corpuscular volume is due to these different coinciding causes generally difficult to establish, especially in the elderly. [9] In recent decades transfusions (especially with whole blood or blood older than 3 weeks) to normalize haemoglobin levels before operation have become unpopular in view of negative effects on the immune response [10] and increased risk to develop postoperative complications. [11,12] According to the 2012 guidelines "Surviving sepsis" a transfusion indication exists at a Hb < 4.4 mmol/L (1B recommendation). In case of cardiovascular instability or a central-venous saturation ($ScvO_2$) < 70%, a Hb of at least 6 mmol is aimed for. [13] Preoperative anemia as an independent risk factor has been well established. [14] Blood transfusions have been shown to have negative effects on host response, unless anemia interferes with pre-existing marginal respiratory or cardiac function. Similarly oral iron supplementation does not appear to be beneficial, but intravenous iron supplementation may increase hemoglobin levels especially when anemia is caused by iron deficiency related to bleeding or lack of intake [15].

Intoxication

Smoking and substantial alcohol intake coincide with an increase in infectious complications and mortality after surgery. [3,16], although in plastic surgery smokers tend to have thinner and smaller scars but with lower tensile strength. Both addictions cause mild but chronic inflammation, which may explain a lower healing tendency after the "second hit" of the operation. It is not clearly proven, nor refuted that discontinuing smoking for a month or longer diminishes the risk of infectious complications and mortality although this seems very likely but depending on the duration of smoking, which parallels damage inflicted on the cardiorespiratory system. Although it was known since decades that non-steroidal anti-inflammatory agents increase the risk to develop heart failure, renal dysfunction and gastro-intestinal ulcer formation with all their sequelae, [17] it becomes also apparent that especially the non-specific NSAID's have harmful effects even more than the specific Cox-2 inhibitors, increasing the likelihood to develop anastomotic breakdown and disturbed wound healing. [18] Large prospective randomized studies should answer the question which drugs effectively treat pain without interfering with anastomotic and wound healing. The adage not to use opioids in view of their depressing effect on intestinal motility should be weighed against these harmful effects of NSAID's. Epidural anaesthesia during and after operation may effectively treat pain, but which metabolic effects are caused is not very well investigated. Cardiovascular instability may occur in patients with cardiac pump failure using NSAID's and receiving epidural anaesthesia, which interferes with adaptive vasoconstriction in the lower half of the body when correction of hypovolemia is required.

Many patients are operated while on steroids. Operation can be successful but when complications occur, they are often diagnosed late due to mitigation of symptoms of infection. This risks to lead to delayed intervention and a higher risk of mortality. Steroids should therefore preferably be discontinued at least a month before operation if possible. Nevertheless, steroids must be resumed shortly before and some days after operation depending on whether adrenal function has recovered. Neo-adjuvant chemotherapy is advocated and applied in colonic and other types of surgery. Care should be taken to exclude patients that are frail which by definition includes low functional capacity, who will lose even more fat free mass while on chemotherapy before operation.

Isolated Organ Failure

Patients with severe cardiorespiratory comorbidity, liver failure or renal failure, are all at risk to recover less well from major surgery, even more so when complications arise. Depending on the severity of the trauma, infection or illness, treatment should be defensive, including dealing with the primary illness/trauma/infection/cancer as far as these illnesses cause life threatening obstruction, sepsis etc without for instance performing extensive curative surgery. The complication risk during true liver failure (Child 2-3) or a MELD score above 15 increases several fold. [19] The liver is our most important immune and metabolic organ, harbouring immune cells, producing acute phase proteins and a multitude of other proteins with important roles in host defence. In addition, the liver plays an important role in intermediary metabolism, including the production of substrate mixes, serving as building blocks in the immune system, the wound and potential anastomoses made after resection of bowel segments or cancer of other intra-abdominal organs. Ref Surgery should therefore be defensive or not performed at all. Chronic renal failure patients are generally malnourished, almost always suffer from low grade inflammation and cardiovascular disease, and are prone to develop postoperative complications. [20] Defensive surgery is indicated.

Preoperative Indication and Preparation for Operation

Indications for Elective Surgery

Self-evidently indications for elective surgery should follow well-accepted surgical guidelines in oncology, inflammatory bowel disease, biliary stones, diverticular disease, functional disturbances of the gastro-intestinal tract (hiatus hernia, faecal incontinence, rectocele etc.), obesity and more rare abnormalities of the gastro-intestinal tract. In the presence of a solid indication for operation the risk to develop complications after surgery should be taken into account. In the presence of an increased risk, a defensive approach should be followed and less extensive surgery performed e.g. constructing a protective proximal diverting stomata when a distal resection for sigmoid diverticulitis or cancer has been performed or even in patients in very bad condition only constructing this diverting stoma without resecting the diseased distal colon to ensure intestinal passage of food or to soften complaints to improve quality of life, despite knowing that life expectancy may be shorter. In frail old (and sometimes young) patients one may decide to refrain from surgical treatment and to institute other types of palliative treatment. Precise guidelines are difficult to define, but cachexia (low fat free mass and fat mass), which per definition is caused by chronic inflammation together with low nutritional intake, is associated with a strongly elevated risk of treatment failure and therefore may lead to refrain from surgery even more because in this situation full preoperative nutritional support yields little or only modest benefit.

Preoperative Nutritional and Other Support

In the absence of severe infection/inflammation even patients with malignancies and severe undernutrition benefit from preoperative nutritional support unless the malignancy has a strong inflammatory character. Depending on the accessibility of the gut this may consist of enteral supplements, tube feeding or parenteral nutritional support. In the presence of body weight loss of 5 kg in 3 months or 10 kg in 6 months even 7-10 days of preoperative nutritional support improves clinical outcome despite the fact that in this short period changes in body composition are difficult to demonstrate. [21-23] When weight losses are even higher, longer preoperative feeding is required. In [23] it was found that benefit is only achieved in previously malnourished patients. Some evidence has been suggested to show that even in well-nourished patients perioperative administration of "immunonutrition" consisting of an enteral supplement with extra Arginine, Omega-3 fatty acids and RNA, has beneficial effects on postoperative infectious complications. [24] However after several PRCT's and meta-analyses, this has not been convincingly demonstrated, precluding clear conclusions. [25] In patients that have lost more than 10% of their body weight (especially fat free mass) preferably longer courses of nutritional support should be instituted together with physiotherapy, provided that there is no severe infection with major systemic effects, or intestinal obstruction, which would require urgent intervention. Secondary infections in Crohn's disease develop gradually. Transmural non-infectious inflammation leads to slowly progressing perforations that therefore in the majority of cases allow walling off by surrounding tissues forming abscesses rather than leading to generalized peritonitis. These abscesses often perforate to other hollow organs (intestine, bladder, cutaneous scars of earlier operations) or are surgically drained. In the majority of these cases, an internal (to other organs) or enterocutaneous fistula develops (to the skin), because the fistula arises from diseased tissue, not always able to close spontaneously. In such situations, artificial enteral or parenteral nutrition is indicated during 4-6 weeks allowing the fistula to mature, close spontaneously or become accessible for surgery. [26] Surgery is almost always necessary because the local segment of bowel affected by Crohn's disease and leading to fistula formation, is always strictured or/and aperistaltic due to slowly progressing scarring and narrowing of the afflicted bowel segment. This occurs because Crohn's disease is, in contradistinction with ulcerative colitis, a transmural inflammatory illness.

Deviation of Protocol in Frail Patients Undergoing Elective Surgery

When steroids, used for instance to treat inflammatory bowel disease or COPD, have not been beneficial (in inflammatory bowel disease) and an operation is judged to be necessary, discontinuation is advisable for weeks or longer before operation. Ideally this should also be done in patients with cancer. When steroids are discontinued only for one or two weeks, short term perioperative re-institution of steroids may still be required because secretory capacity of the adrenals will still not be optimal. Frail especially elderly patients without significant infection/inflammation, may still fail to overcome major surgery, when complications arise. In truly malnourished patients, preoperative nutritional support may improve nutritional state and host response, but nevertheless a defensive surgical approach is warranted. This implies that not all elements of the protocol and all criteria of oncologic surgery should necessarily be followed. Critical anastomoses should not be performed or they should be protected by temporary proximal diverting stomata even when this requires additional surgery later to close the stoma. Neo-adjuvant chemotherapy or radiotherapy may be omitted because they will further deteriorate the clinical condition of a frail patient and lead to surgical treatment failure, complications and mortality. In younger patients in good condition more risk can be taken, because even when, in rare cases, infectious complications occur (anastomotic breakdown, abscess formation), in the majority of cases these patients survive a septic episode if properly managed. The advantage of this approach is that the

majority of patients requires only one operative procedure. Findings during elective operation also dictate the type of procedure to be performed. Abdominal spread of tumour or perforating tumour, opening the gastrointestinal tract and contaminating the intra-abdominal cavity with intestinal contents may lead to tailoring the extent and art of the operation to diminish the risk to develop even more serious infectious complications. However, there is an old German adage that contamination of the abdominal cavity with "healthy stools" will not lead to postoperative infectious complications if carefully cleaned and nevertheless immediately performing anastomoses.

Emergency Operation

In acute abdominal sepsis, leading to a symptomatology suggesting generalized peritonitis, measures should be taken quickly to improve the cardiovascular and respiratory condition of the patient and subsequently to intervene without delay (i.e. within 24 hrs) radiologically or surgically. Early intervention has been proven to increase the chances of cure. [27] Theoretically, rapid intervention within the pro-inflammatory phase of acute abdominal sepsis, dealing with harmed or infected tissue leads to an optimal host response, whereas delaying intervention will significantly decrease the success of treatment and increases the risk of mortality. Only when this approach is successful, nutritional support is effective. Radiology is only diagnostic when enteral and parenteral contrast are administered, which delays the intervention but is, in addition to potentially causing renal damage, also stressful for the intestine due to the hyperosmolarity of the contrast medium. At present intervention radiologists nevertheless contribute significantly to treatment via radiological imaging and drainage of abscesses in a less traumatic manner than when performing mini-invasive surgery, which however sometimes must be performed to remove sources of sepsis. Mini-invasive (laparoscopic) techniques have limited the extent of trauma and the risk of wound dehiscence because allowing smaller incisions or wounds to enter the abdomen.

Reoperative surgery and GI fistula treatment

SOWATS protocol (management of bowel fistulas). [28] The following management priorities should be followed in chronological order when treating intestinal fistulas:

Sepsis treatment

Optimization of nutritional state and muscle function

Wound care

(**A**natomy of the fistula)

Timing of surgery

Surgical technique

The SOWATS protocol includes the order of treatment steps in patients after acute infectious abdominal infections with or without bowel fistulas. The first urgent steps include dealing with infection and optimization of nutritional state. This phase requires minimally 6-12 weeks and aims to improve the condition of the patient, allowing to perform definitive treatment generally but not always requiring surgery, in view of some fistulas closing spontaneously, which depends on the anatomy of the fistula: lateral, persisting passage, healthy surrounding tissue. When sepsis is treated successfully, physiotherapy should be started.

After operations or drainage procedures for abdominal sepsis, ileus, ischemia and in situations with an open abdomen (with or without fistulas) due to abdominal compartment syndrome or abdominal wall dehiscence (rare in view of mini-invasive surgery), at a later stage reoperative surgery is often required. Such an operation can be performed when the patient is in a good condition after a recovery period of at least 6-12 weeks, allowing physical recovery, improved nutritional state and improved accessibility of the abdomen to be achieved. After for instance 2-4 weeks the patient is still not fully recovered and is still in an inflammatory condition, during which a "second hit" (early reoperation) cannot be adequately dealt with. At this time the abdomen is not surgically accessible without risk because of the bowel still being oedematous, fragile and sticking together. This makes dissection hazardous because leading to lacerations even in the best of surgical hands. Consequently, reoperation should be postponed at least 6 weeks after the primary infectious or obstructive event, for which "damage control" surgery has been performed. [29] Normalization of plasma albumin levels and a number of other plasma constituents are valid indicators of recovery and abatement of the inflammatory state. In the presence of persistent inflammation, the organism recovers less well from an operation (second hit). The SOWATS protocol includes the order of urgent treatment steps in patients after generalized peritonitis with or without bowel fistulas.

Postoperative Management

In the last decade many dogmas have been challenged, existing in perioperative care. The so called ERAS program (Enhanced Recovery After Surgery) has rationalized measures that have been taken since a century.[30] Fasting before surgery is shortened and it is recommended to eat normally before surgery and use carbohydrate drinks the night before and 2 h before surgery with the intent to diminish insulin resistance. However, it should be appreciated that insulin resistance is a normal adaptive response to fasting as well as during building tissue or dealing with oxidative stress. [31] Therefore, implementing nutritional support before and early after surgery rather than the effect of glucose drinks on insulin resistance are important and effective elements of the ERAS approach. Patients are encouraged to resume eating

and to mobilize early after operation. Opiates are minimized not to diminish intestinal motility, while epidural anaesthesia is recommended. Drains, stomach tubes and bladder catheters are removed early after operation or not given at all. Altogether these measures are intended to remove unnecessary stress and to limit the stress/inflammatory response after operation to the part that is required for healing. [30] The ERAS program has made life after operation more agreeable, shortened hospital stay and associated costs. However, no influence on postoperative infectious complications and mortality has been demonstrated. [32] In the same study it was found that laparoscopically executed surgery was associated with fewer infectious complications.

The stress response inevitably leads to increased permeability and increased capillary escape of fluid into the interstitium. As a consequence, to maintain cardiac output and blood pressure during and immediately after major surgery, substantial infusion/ingestion of balanced salt solutions in combination with no electrolyte containing fluids is required leading to weight gain, amounting to accumulation of 4-6 litres of fluid, which are lost in the week after operation when recovery is uneventful and the required inflammatory activity abates. Efforts to diminish the infused volume during and in the first 2 days after surgery, may lead to decreasing the amount of fluid accumulating and subsequent weight gain and oedema formation, but care should be taken to maintain hemodynamic stability. Nonetheless, during and after major abdominal surgery in adults with average body length and weight a positive fluid balance of at least 4-5 L during the first two days is necessary to maintain cardiovascular stability and urine production. Measures to limit a positive fluid balance to not more than 5 litres have been found to improve gastro-intestinal motility. [33] This finding has not been confirmed by other authors. Nevertheless, a balance between too much and too little fluid should be carefully maintained. Careful monitoring is required especially in patients with cardiac failure. In this situation, the amount of fluid infused should be tapered and in rare cases diuretics administered for one or two days after surgery to promote urinary excretion of the surplus of fluid required during and in the three days after operation, if recovery is uneventful.

At this moment there is a "tipping point", including increased urine production leading to a negative fluid balance and a decrease in plasma volume and interstitial volume. This is associated with a rise of haematocrit and the concentration of plasma solutes, among others vitamins, trace-elements, electrolytes and plasma proteins like albumin. At this stage nutritional support becomes beneficial. Similarly, in critically ill patients, a spontaneous rise in plasma albumin heralds recovery of disease. Complete normalization may take months up to 6-9 months. Importantly, this type of evolution indicates that dealing with harm has been successful and that nutritional support will successfully support the anti-inflammatory response. Additional information regarding the healing response after surgery or critically illness is given in Table 2 [34,35].

Postop. day	**day 1 Uncomplic**	**day 2-3 Uncomplic**	**day 4-6 Uncomplic**	**day 40 Uncomplic**	**day 1 Complic**	**day 2-3 Complic**	**day 4-6 Complic**
Clinical state							
Cardiovasc.	5-7 L ↑	6-8 L ↑↑	1-3 L ↑	1-3L ↓	7-10 L ↑	10-12L	12-14L ↑
Cognition	↓↓↓	↓↓	↓	Normal	↓↓↓	↓↓↓	↓↓↓↓
Strength	↓↓↓	↓↓	↓↓	↓	↓↓↓	↓↓↓	↓↓↓↓
Body composition							
Body weight	↑↑	↑↑↑	↑	↓	↑↑↑	↑↑↑	↑↑↑
FFM	↑↑	↑↑↑	↑↑	↓	↑↑↑	↑↑↑	↑↑↑
FFM solids	↓	↓↓	↓↓↓	↑	↓↓	↓↓↓	↓↓↓↓
Total fluids	↑↑	↑↑↑	↓	↓↓	↑↑↑	↑↑↑	↑↑↑
Laboratory values							
Plasma Albumin	↓↓	↓↓↓	↓↓	↓-Normal	↓↓	↓↓↓↓	↓↓↓↓↓
CrP%	↑↑	↑↑	↑↑↑=	Normal	↑↑	↑↑↑	↑↑↑↑
Na^+	↓↓	↓	↓	Normal	↓↓	↓↓↓	↓↓↓
Leucocytes*	↑	↑	↑-N	Normal	↑↑↑	↑↑↑	↑↑↑

Diff.	Left shift	Normal	Normal	Normal	Left shift	Left shift	Left shift
Zn[@]	↓↓	↓↓↓	↓↓	Normal	↓↓	↓↓↓↓	↓↓↓↓
Fe[#]	↓↓	↓↓↓	↓↓		↓↓↓	↓↓↓↓	↓↓↓↓
Transferrin[#]	↓↓	↓↓↓	↓↓	Normal	↓↓	↓↓↓↓	↓↓↓↓
Fe binding cap[#]	↓↓	↓↓↓	↓↓	Normal	↓↓	↓↓↓	↓↓↓
Lactate mmol[$]	1.5-2.5	1.5-2.5	1.5-2.5	< 1.0	2.5 or >	2.5 or >	2.5 or >
Blood gas							
pO_2	↓-N	↓-N	Normal	Normal	↓	↓↓	↓↓↓
pCO_2	↓-N	↓-N	Normal	Normal	↓-N	↓	↓↓ - ↑↑
pH[&]	↑-N	↑-N	Normal	Normal	↑-N	Varying	Varying

[%] CrP increases within a day after trauma and to higher levels when infection is superimposed. After a few days it is not an accurate reflection of the severity of infection and the success of healing. A rapid decrease will signify that damage or infection is cleared.

* Leucocytes are generally increased after trauma and further increase as a consequence of infection, accompanied by a left shift. In frail patients a hypodynamic form of sepsis can develop, including neutropenia with left shift, hypothermia, somnolence. This state constitutes a high mortality risk.

[@] Zinc levels drop parallel with albumin levels because Zn is largely bound to albumin.

[#] Iron drops because its binding protein Transferrin, to which iron is bound, is a constitutional protein, its plasma concentration decreasing in inflammatory states.

[$] Lactate levels are slightly elevated after trauma and increase even more in hyperdynamic inflammatory (septic) states to between 2.5 and 4 mmol. This reflects Cori-cycling. Only after true shock periods or in the presence of organ ischemia much higher levels are attained.

[&] pH is variable in these conditions and may range from respiratory alkalosis due to hyperventilation in hypoxia or pain, metabolic acidosis after shock periods and renal failure, or respiratory acidosis due to muscle weakness or opiate use. Combinations may lead to normal pH (for instance metabolic acidosis compensated by hyperventilation leading to hypocapnia).

Table 2: Schematic representation of commonly occurring changes in clinical state, body composition, laboratory values and blood gas values. The difference in normal healing and a continuous septic course consists of an unrelenting progression of inflammation induced capillary leakage, leading to fluid accumulation and hypoalbuminemia and related disorders. This is accompanied by a rapid loss of cell mass (muscle, skin, bone), cognitive, immune and muscular disturbances and increased mortality risk.

Conclusions

Successful elective or acute surgical treatment of severe sepsis due to peritonitis and its prevention or in elective surgery for malnourished patients, does not only depend on surgical "cutting" skills but also on non-cutting management skills when dealing with cancer, inflammatory bowel disease, trauma or infectious complications in the abdomen. There is not one superior way of preventing or dealing with these conditions. One should adhere to the principle that infection should be early and adequately treated and damaged tissue removed. Both conditions interfere with the benefit of nutritional support, including healthy wound healing and rebuilding tissue (especially muscle) mass. To achieve optimal results, the capacity of the patient to heal well should be weighed against the metabolic burden of treatment of these conditions. This relies on estimates rather than a precise calculation. Recovery from inflammatory conditions includes "drying up". Increased vascular volume and oedema disappear, which is highlighted by increasing plasma solutes like albumin and vitamins, trace-elements and electrolytes like sodium. In elective cases without (major) pre-existing infectious inflammation but with malnutrition, preoperative refeeding and physical exercise are feasible and have been shown to improve outcome especially by decreasing postoperative infectious complications. When dealing with old, frail or malnourished patients, the surgeon should try to tailor the extent of surgery to the ability of the patient to generate adequate healing.

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