Case Study: Nutritional management of a patient with an open abdomen

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Introduction

The use of the open abdomen as a technique in the management of complex surgery patients can be the result of a variety of contributing factors, including surgical or medical causes, as well as indications.[1] The early initiation of goal-directed enteral nutrition support improves wound healing, decreases intensive care unit (ICU) and hospital length of stay, and might improve survival following critical illness or injury.[1] The benefits of enteral nutrition in surgical and critical illness have been recognised since the early 1980s and are now well described.[2] Because of the nature of these patients, the establishment of sufficient enteral nutrition support can be challenging. Therefore, they might require parenteral nutrition (PN) support in the early postoperative phase until the physiological status has normalised.[2] The early use of PN is of particular importance in patients with pre-existing malnutrition.[2] Nutrition support in the patient discussed in this publication was complicated by haemodynamic instability, fluid restriction owing to renal failure and fistula formation in the open abdomen, which necessitated the long-term use of PN support.

Case study

A 30-year-old male with no significant past medical history was admitted to hospital with multiple gunshot wounds to the abdomen. On admission to hospital, he underwent damage control laparotomy, where he was found to have complete transection at the duodenojejunal (DJ) flexure, a transverse colon perforation, a splenic laceration, a left kidney injury, multiple small bowel perforations and arterial bleeding. The DJ flexure and colonic injuries were repaired primarily, a left nephrectomy was performed, the arterial bleed ligated and packed, and the small bowel tied off. The patient was transferred to the intensive care unit on ventilation and inotropic support, with an open abdomen. At the relook laparotomy, on day one post admission, there was no obvious bleeding and the packs were removed. The DJ flexure anastomosis was leaking and oversewn, and an end-to-end anastomosis performed on the small bowel 20 cm from the DJ flexure. The abdomen was left open with a vacuum dressing.

On nutritional assessment in the ICU, the patient's height and weight were estimated to be 1.75 m and 75 kg, respectively, with a normal body mass index (BMI) of 24.5 kg/m^2. He was started on PN support on day one post admission. The European Society for Clinical Nutrition and Metabolism (ESPEN) guidelines on PN with respect to intensive care were followed to calculate macronutrient requirements[1] (Table I). The biochemical blood variables on admission were essentially normal (Table II). Postoperatively, the patient developed worsening renal function and required dialysis. He was started on additional water-soluble vitamins and trace elements to provide twice the recommended dietary allowance to compensate for losses in the dialysate, as well as from the open abdomen.[2] The same PN regimen was continued.

The ESPEN guidelines for critical care recommend starting PN early in patients who are unlikely to tolerate enteral intake within the next three days.[1] The guidelines also suggest starting with a slightly lower than required energy intake (25 kCal/kg), and increasing it to target over the ensuing 2-3 days post initiation. The ESPEN PN surgical guidelines recommend 30 kCal/kg ideal body weight for the severely stressed patient as a goal in the absence of indirect calorimetry.[1,3] Similarly, the ICU guidelines recommend a range of protein requirements, 1.3-1.5 g/kg, while the surgical guidelines set the target slightly higher, providing at least 1.5 g/kg.[1,3] The ICU guideline recommends that critically ill patients requiring PN support should receive intravenous glutamine at a dose of 0.2-0.4 g/kg/day (a Grade A recommendation). The surgical guideline doesn't provide a specific recommendation.[1,3] Owing to the need for fluid restriction in this patient, it was difficult to meet his energy requirements at the higher end of the range, as suggested by the surgical guidelines.

Table I: Intravenous nutrient delivery during the course of treatment

Nutrient delivery	Parenteral nutrition			
	Day 1-Day 14	Day 15-Day 35	Day 36-Day 41	Day 42-Day 68
Volume (ml)	1 620	2 390	2 240	2 400
Non-protein energy (kCal/kg)	20	24	30	27
Protein (g/kg)	1.7	1.7	2.2	2.2
Glutamine (g/kg)	0.4	0.4	0.4	0.3
Lipid (g/kg)	0.67	1.3	1.6	0.8
Carboyhydrates	2.3 mg/kg/minute	1.9 mg/kg/minute	2.7 mg/kg/minute	3.3 mg/kg/minute
Na (mmol)	-	85.5	115.5	116.5
K (mmol)	-	40	60	52.5
Cl (mmol)	-	105.5	165.5	130.5
PO_4 (mmol)	-	21.5	21.5	21.25
Water-soluble vitamins	2 x RDA	2 x RDA	2 x RDA	2 x RDA
Fat-soluble vitamins	1 x RDA	1 x RDA	1 x RDA	1 x RDA
Trace elements	2 x RDA	2 x RDA	2 x RDA	2 x RDA

Na: sodium, K: potassium, Cl: chloride, PO_4: phosphate, RDA: recommended dietary allowance

Table II: Blood values of the monitored variables during the course of treatment

Days post admission	Normal value	Day 1	Day 36	Day 42	Day 50	Day 63
Sodium (mmol/l)	135-147	139	132	146	135	131
Potassium (mmol/l)	3.3-5.3	5	4	3.9	3.3	5.2
Urea (mmol/l)	2.6-7.0	5.7	11.2	19.6	12.2	7.2
Creatinine (μmol/l)	64-104	92	129	100	110	83
Calcium (corrected) (mmol/l)	2.05-2.56	2.08	2.39	2.48	2.44	2.46
Magnesium (mmol/l)	0.65-1.10	0.63	0.42	0.87	0.81	0.72
Phosphate (mmol/l)	0.8-1.4	1.27	1.12	1.08	1.27	1.32
Total bilirubin (μmol/l)	0-21	-	8	8	-	15
Conjugated bilirubin (μmol/l)	0-6	-	5	4	-	8
Alkaline phosphatase (U/L)	40-120	25	132	170	-	122
γ-glutamyl transferase (U/L)	0-60	22	94	-	-	86
Alanine transaminase (U/L)	5-40	19	6	32	-	30
Aspartate transaminase (U/L)	5-40	31	24	18	-	30
Albumin (g/l)	35-52	20	20	22	25	22

On day four post admission, the patient underwent a second relook laparotomy, during which a feeding jejenostomy was placed. The DJ flexure repair was leaking and an omentopexy was performed. The abdomen remained open with a vacuum dressing. The patient continued dialysis and the same PN regimen. Because of haemodynamic instability, enteral feeds were not started via the jejenostomy.

On day seven, the patient was discharged to the trauma ward, but required readmission to ICU within 24 hours. He underwent three more relook laparotomies with abdominal washouts in the following nine days. PN support continued according to the same regimen, but the patient's requirements could not be met because of the need for fluid restriction. The jejenostomy was kept open with 5% dextrose infusion, but because of haemodynamic instability, enteral feeding could still not commence.

On day 15 post admission, the PN regimen was increased to a higher volume, with an energy content of 24 kCal/kg non-protein energy (NPE), which was more in line with the ESPEN guidelines on PN with respect to surgery.[3] A semi-elemental tube feed was commenced at 10 ml/hour via the feeding jejenostomy. The patient continued dialysis for an acute kidney injury.

On day 17 post injury, he developed worsening sepsis with enteral feeds draining from the abdominal vacuum dressing. On relook laparotomy, the feeding jejenostomy was found to be intact. However, there was a necrotic patch of small bowel 10 cm distal to the feeding jejenostomy. The necrotic patch was debrided and repaired. As a result of extensive adhesiolysis, it was impossible to gain enough length to bring the jejenostomy out as an enterostomy. Therefore, the feeding jejenostomy was wrapped with omentum and advanced to 10 cm distal to the necrotic patch. The PN regimen remained the same. At this stage, the patient was weaned off inotropes and was haemodynamically stable. Therefore, the surgeons and clinicians

Table III: Patient's course of treatment summary

Day		Surgical intervention		Clinical aspects		Oral diet		Enteral feeding		Parenteral nutrition
0	→	Damage control laparotomy	→	Small intestine tied off	→	NPO	→	NGT on free drainage	→	Start of PN and IV glutamine
1	→	Relook laparotomy	→	AKI requiring dialysis Required inotropic support					→	Started additional IV water soluble vitamins and trace elements
4	→	Second relook and feeding jejenostomy	→	AKI requiring dialysis Required inotropic support						
8	→	Third relook								
10	→	Fourth relook								
15			→	Haemodynamic instability improved Dialysis discontinued			→	NGT on free drainage Semi-elemental feed at 10 ml/hour via feeding jejenostomy	→	PN regimen changed to higher volume and calories
17	→	Fifth relook	→	Worsening sepsis Enteral feed draining from abdominal dressing						
20	→	Sixth relook								
23	→	Seventh relook								
25	→	Eighth relook								
28	→	Ninth relook	→	Feeding jejenostomy removed secondary to necrosis Frozen abdomen			→	NGT on free drainage Jejenostomy feed stopped		
36			→	Deteriorating liver function tests and hypoalbuminaemia					→	PN regimen changed to provide more calories
42			→	Ongoing deterioration in liver function tests High output from abdominal dressing and NGT					→	PN regimen changed to provide less fat, fish oil lipid emulsion and more protein

AKI: acute kidney injury, NPO: *nil per os,* NGT: nasogastric tube, PN: parenteral nutrition, IV: intravenous

involved deemed it safe to attempt enteral feeds. Because of the 17-day delay in starting enteral nutrition, a decision was taken to start semi-elemental enteral feeds again at 10 ml/hour via the feeding jejenostomy.

The patient underwent an additional three relook laparotomies. On day 28, during his tenth laparotomy, the feeding jejenostomy was removed, secondary to necrosis. One small bowel perforation was noted at the site of the feeding jejenostomy and repaired. Interloop collections were washed out. He had now developed a "frozen abdomen" which was left open with a vacuum dressing.

On day 36, the PN regimen was revised and changed to provide more energy and protein (Table I). His liver function tests were deteriorating, presumably secondary to prolonged PN support and sepsis.[4] His albumin remained at 20 g/l and the alkaline phosphatase and γ-glutamyl transferase were raised (Table II).

Table III summarises the patient's course of treatment up to this point of his hospital stay

After 38 days in ICU, the patient was weighed on a bed scale. A weight of 64 kg was recorded, equating to a BMI of 21, still within the normal range. On average, the drainage from the open abdomen and nasogastric tube were 730 ml/day and 250 ml/day, respectively. Because of his high protein requirements to compensate for the abdominal losses and dialysis, as well as the deteriorating liver function tests, the PN regimen was changed to a non-standard PN regimen on day 42 post injury (Table I and Table II). The aim of this regimen was to reduce the amount of lipid provided, to provide lipid in the form of a fish oil-containing lipid emulsion and to optimise his protein intake.[4,5]

Energy requirements were calculated with the aim of providing 25-35 kCal/kg NPE and 1.5-2.5 g/kg protein, as well as taking the protein losses from the open abdomen into consideration.[5] Protein losses from an open abdomen are estimated to be approximately 29 g/l.[5] An average output of 730 ml/day from the open abdomen in this patient equated to 21 g of protein being lost therefrom.[5] Therefore, his PN regimen would have to provide 96-160 g of protein (1.5-2.5 g/kg), plus an additional 21 g/kg to compensate for the losses, i.e. 117-181 g protein/day. The patient received 140 g protein per day, which included 20 g of glutamine (Table I). Biochemistry, performed on day 42, showed an increased urea and borderline high serum sodium, while the creatinine remained within the normal range, indicative of possible dehydration. The raised urea was not thought to relate to his protein intake. Furthermore, the urea decreased to within the normal range on subsequent days, despite the higher protein PN regimen, while the albumin improved to 25 g/l (Table II).

The patient was discharged to the intestinal failure unit on day 65 post admission to ICU. He was managed nutritionally in the intestinal failure unit on a combination of PN and fistuloclysis. He underwent surgery on day 157 post injury, during which a 40 cm segment of small bowel with multiple perforations was resected and a double-barrel stoma fashioned 80 cm from the DJ flexure, with 40 cm of remaining small bowel distally. The ileocaecal valve and colon were in situ. He continued PN support for 15 days postoperatively, after which he was successfully weaned onto EN and fistuloclysis. At this point, he had received 139 days of PN support in total. He underwent definitive surgery with closure of the double barrel stoma on day 247, and was discharged home five days later on oral supplementation. He regained nutritional autonomy and his weight improved to 67 kg at the five month follow-up.

Discussion

An open abdomen occurs as a consequence of complicated surgery and refers to an inability to close the fascia or skin post surgery.[5-8] Three indications give rise to the need to manage a patient with an open abdomen: damage control laparotomy, the prevention and/or treatment of abdominal compartment syndrome, and management of severe intraabdominal sepsis.[8,9]

Damage control laparotomy refers to a procedure during which the primary goal is to attend to life-threatening injuries and to control bleeding and contamination.[5,6,8-10] Overall, 10-15% of trauma laparotomies are managed with damage control laparotomy and require an open abdomen approach.[9]

Intra-abdominal hypertension and abdominal compartment syndrome can occur in both surgical and non-surgical patients.[9] Normal intra-abdominal pressure (IAP) in most critically ill patients is 5-7 mmHg.[9,10] IAP of 10-15 mmHg is associated with decreased visceral organ perfusion.[9] Intra-abdominal hypertension (IAH) is defined as an increased and sustained IAP ≥ 12 mmHg, while abdominal compartment syndrome (ACS) refers to a condition with an increased and sustained IAP ≥ 20 mmHg, associated with new-onset organ dysfunction or failure.[9,10] Clinical conditions that might lead to increased abdominal pressure include peritonitis, acute pancreatitis, ascites, ruptured abdominal aortic aneurysm, mesenteric ischaemia and bowel oedema from sepsis or intensive fluid resusitation.[6,7,9] IAH or ACS could also be a consequence of abdominal closure.[9] Decompressive laparotomy is indicated in patients with intractable IAH or ACS.[9]

In all of these cases, the abdomen is normally closed once the patient has achieved haemodynamic and physiological stability.[6] Patients might require repeated laparotomies prior to closure.[6,7]

Although maintaining an open abdomen can be life-saving in these conditions, the management strategy places the patient at a significantly increased risk of developing other complications.[6,9] Complications arising from open abdomen management include increased transfusion requirements, increased infectious morbidity, fistula formation, abdominal hernia and significant electrolyte, fluid and protein losses from the exposed viscera, as well as increased ICU and hospital charges.[6,9] In order to minimise these complications, closure of the abdomen within a week of the first intervention remains a major surgical goal.[6,9,10] The incidence of fistula formation, wound infection and abscesses increases significantly if the abdomen remains open for longer than eight days after the initial intervention.[6]

Trauma and surgery lead to an intense inflammatory response and possible organ dysfunction, and although leaving the abdomen open in an attempt to lessen the inflammatory response, it also creates a "hostile" high-risk environment.[8] An open abdomen might be characterised by intestinal oedema, abdominal wall oedema, inflamed friable tissue, infection, the accumulation of ascites and vulnerable exposed intestines.[8] During the first week post surgery, fibrin begins to form in the wound exudate. Granulation tissue covers the intestine by days 10-15 following the first intervention.[8] During this period, dense adhesion may and usually does start to form between the bowel loops, and the abdominal contents may adhere to the abdominal wall.[8] These changes can eventually lead to a frozen abdomen, whereby immediate surgical closure is impossible.[8] It can take 6-12 months for the scar tissue and adhesions to soften, and allow for definitive surgical intervention.[8]

After injuries such as shock, trauma, burns and sepsis, the inflammatory response is characterised by the release of proinflammatory mediators.[6] This is associated with a hypermetabolic state, characterised by muscle breakdown, acute protein malnutrition, impaired immune function and multi-organ failure.[6] Therefore, appropriate nutrition therapy in these patients becomes vitally important, but at the same time challenging. The presence of inflammation often limits the effectiveness of nutrition support, and the resulting malnutrition frequently limits the effectiveness of medical therapy.[6] Patients with an open abdomen are thought to be among the most hypermetabolic of all surgical patients.[6] In itself, the large open wound associated with an open abdomen creates a significant catabolic stimulus, and the exposed bowel is extremely vulnerable to injury and fistula formation.[6] The underlying illness or injury further increases resting energy expenditure and protein requirements.[6] The hypermetabolic condition present in patients with an open abdomen remains until the abdomen is successfully closed.[6]

Meeting requirements in these patients is very challenging, and even if achieved, only partly reverses or prevents muscle breakdown in the acute inflammatory state.[6] A negative nitrogen balance is a common occurrence in these patients.[6] Studies have demonstrated significant electrolyte, fluid and protein losses associated with an open abdomen.[6] Failure to compensate for these losses leads to underfeeding and inadequate nutrition support, associated with decreased wound healing, increased infectious morbidity and ultimately decreased survival.[6]

There is ongoing debate on the management of critically ill patients with regard to the feed, when to feed, how to feed and how much to feed.[6] Options for providing nutrition support include enteral nutrition, PN or combination feeding.[6] Each of these modes is associated with positive or negative effects and present unique challenges.

EN is associated with an attenuation of acute protein malnutrition, modulation of the inflammatory response, the promotion or maintenance of gastrointestinal structure and function, improvement in wound healing, a decrease in infectious morbidity, a decrease in the length of hospital stay and a decrease in mortality in the appropriate clinical setting.[5,6] Compared to PN, EN results in better blood glucose control, improved gut barrier function and less cost.[6] EN is considered to be safe in patients with an open abdomen, and may show benefit in terms of earlier fascial closure and less fistula formation.[6,11] It is recommended that once resuscitation is complete and the patient is stable, EN should be considered in all critically ill patients.[11] In the Western Trauma Association study, patients without bowel injuries who were fed via the enteral route had a significant increase in the number of successful fascial closures, as well as decreased morbidity and mortality rates.[11] The initiation of EN in patients with bowel injury did not seem to alter fascial closure rates, and morbidity or mortality, but the role of EN requires further investigation.[11]

Several factors contribute to suboptimal nutrition delivery via the enteral route, including gastrointestinal intolerance, the elective interruption of feeding for radiological procedures, surgeries, tube dislodgement or blocked tubes, as well as lack of appropriate feeding protocol for the timely advancement of enteral feeds to achieve the goal rate.[6] Persistent hypocaloric feeding and negative nitrogen balance is associated with poor a outcome, and might necessitate the use of PN in combination with EN, to achieve the nutrition goals.[6] The feasibility of post-pyloric feedings should be considered in patients when EN is complicated by high nasogastric drainage.[5]

Early EN might not be possible in patients with an open abdomen because of the physiological compromise that may be associated with the initial insult.[5] Early focus in the medical management of these patients is primarily aimed at controlling infection, the reversal of shock and the repair of the injuries.[5] PN might be required in the early phase post injury until the physiological status returns to normal, especially in patients with pre-existing malnutrition.[5]

A nutrition assessment should be carried out with respect to patients with an open abdomen.[5] An estimation of the requirements can be performed using one of the many predictive equations, or by means of indirect calorimetry.[5] In general, most patients can be managed with an energy intake of 25-35 kCal/kg/day NPE and 1.5-2.5 g/kg/day protein.[5]

Protein losses from the open abdomen depend on the daily volume of exudate, and this should be taken into account when calculating protein requirements.[5] Estimated losses are approximately 29 g protein/l of wound exudate (4.6 g N_2/l) for patients with an open abdomen and 2 g/l protein for those with fistula losses.[5] Some studies have demonstrated values as high as 30 g nitrogen/l of abdominal fluid output.[6] Protein supplementation should be given, even in the presence of renal dysfunction.[5]

Patients with an open abdomen and associated fistulae present a unique challenge in terms of nutritional management, meeting the nutrient requirements and replacing fluids and electrolytes (Figure 2).[5] Documentation of the gastrointestinal anatomy and the location of each fistula, as well as the length of the remaining gut, are important in deciding the likelihood of complications arising from short bowel syndrome, as well as in evaluating the patient for possible distal feeding via fistuloclysis.[5] Fistuloclysis refers to feeding via the fistula, and can include the fistula effluent or enteral feed, or a combination of the two.[8] To ensure successful implementation of fistuloclysis, the distal fistula opening must be suitable for intubation with a balloon-retained gastrostomy tube, there must be no evidence of distal intestinal obstruction and there should be at least 75 cm of intact intestine distal to the fistula.[8] Fistuloclysis will improve fluid and electrolyte disturbances and increase enteral energy delivery, and could be considered in these patients.[5]

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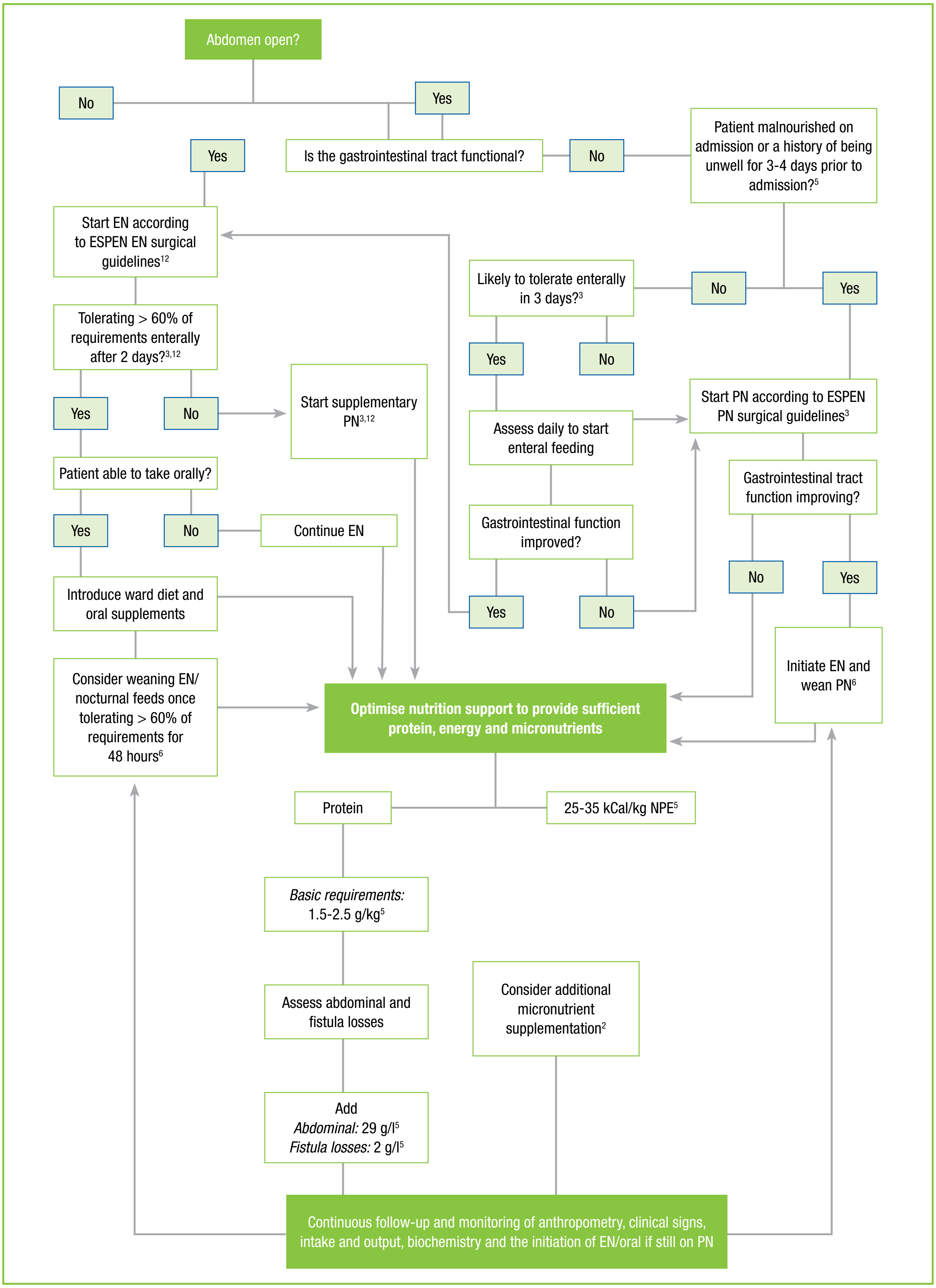
Algorithm for the nutritional management of a patient with an open abdomen



EN: enteral nutrition, ESPEN: The **European Society** for Clinical **Nutrition** and Metabolism, NPE: non-protein energy, PN: parenteral nutrition

Figure 2: Algorithm for the nutritional management of a patient with an open abdomen