Surgery and transplantation – Guidelines on Parenteral Nutrition, Chapter 18

Chirurgie und Transplantation – Leitlinie Parenterale Ernährung, Kapitel 18

Abstract

In surgery, indications for artificial nutrition comprise prevention and treatment of catabolism and malnutrition. Thus in general, food intake should not be interrupted postoperatively and the re-establishing of oral (e.g. after anastomosis of the colon and rectum, kidney transplantation) or enteral food intake (e.g. after an anastomosis in the upper gastrointestinal tract, liver transplantation) is recommended within 24 h post surgery. To avoid increased mortality an indication for an immediate postoperatively artificial nutrition (enteral or parenteral nutrition (PN)) also exists in patients with no signs of malnutrition, but who will not receive oral food intake for more than 7 days perioperatively or whose oral food intake does not meet their needs (e.g. less than 60–80%) for more than 14 days. In cases of absolute contraindication for enteral nutrition, there is an indication for total PN (TPN) such as in chronic intestinal obstruction with a relevant passage obstruction e.g. a peritoneal carcinoma. If energy and nutrient requirements cannot be met by oral and enteral intake alone, a combination of enteral and parenteral nutrition is indicated. Delaying surgery for a systematic nutrition therapy (enteral and parenteral) is only indicated if severe malnutrition is present. Preoperative nutrition therapy should preferably be conducted prior to hospital admission to lower the risk of nosocomial infections. The recommendations of early postoperative re-establishing oral feeding, generally apply also to paediatric patients. Standardised operative procedures should be established in order to guarantee an effective nutrition therapy.

Keywords: surgery, transplantation, fast track surgery, postoperative nutrition

Zusammenfassung

Die Indikationen für eine künstliche Ernährung sind auch in der Chirurgie die Prophylaxe und Behandlung von Katabolie und Mangelernährung. Generell sollte deshalb postoperativ die Nahrungszufuhr nicht unterbrochen werden. Ein oraler (z.B. nach Anastomosen an Kolon und Rektum, Nierentransplantation) bzw. enteraler Kostaufbau (z.B. nach Anastomosen am oberen Gastrointestinaltrakt, Lebertransplantation) wird binnen 24 h nach OP empfohlen. Zur Vermeidung einer erhöhten Letalität, besteht auch bei Patienten ohne Zeichen der Mangelernährung, die peroperativ voraussichtlich mehr als 7 Tage keine orale Nahrungszufuhr oder mehr als 14 Tage oral eine nicht bedarfsdeckende Kost (weniger als 60–80%) erhalten, die Indikation zu einer unverzüglichen postoperativen künstlichen Ernährung. Nur in Fällen einer absoluten Kontraindikation für eine entrale Ernährung wie bei einer chronischen Darmobstruktion mit relevanter Passagestörung, z.B. einer Peritonealalkinose, besteht die Indikation zur totalen parenteralen Ernährung (TPE). Wenn der Energie- und Nährstoffbedarf durch orale und entrale Zufuhr allein nicht gedeckt werden kann, ist eine kombinierte entrale
und parenterale Ernährung indiziert. Die Verschiebung einer Operation zur Durchführung einer gezielten Ernährungstherapie (enteral und parenteral) ist nur bei schwerer Mangelerährnung angezeigt. Bei mangelernährten Patienten sollte die präoperative Ernährungstherapie möglichst prästationär durchgeführt werden, um das Risiko nosokomialer Infektionen zu senken. Prinzipiell gelten die Empfehlungen des frühesten postoperativen Kostaufbaus auch für das Kindesalter. Zur Sicherung einer effektiven Ernährungstherapie sollten klinikintern standardisierte Schemata erstellt werden.

Schlüsselwörter: Operation, Transplantation, fast-track-Chirurgie, postoperative Ernährung

Introduction

In surgery, the importance of nutritional status for postoperative morbidity and mortality in various clinical conditions is demonstrated by both retrospective [1, 2, 3, 4, 5, 6] and prospective [7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21] studies. The presence of malnutrition is often an expression of the underlying disease i.e. a tumour or chronic organ insufficiency [22, 23, 24, 25, 26, 27, 28, 29, 30, 31] (cf. appropriate chapter). Malnutrition is particularly relevant for outcome after organ transplantation [32, 33, 34, 35, 36, 37, 38, 39, 40, 41]. Nutritional status also has a significant influence on morbidity of older patients [42].

Enhanced recovery after surgery (ERAS) is a prerequisite for the desirable reduction of length of hospital stay. This so-called “fast track” system has become a standard in post-operative management, especially after colon operations. The principles of the multimodal process are perioperative limited volume supply, adequate pain therapy (especially by means of epidural anaesthesia), and minimising the administration of opioids, antiemetics and peristaltics. The objective is the re-establishing of oral food intake and full mobilisation of the patient at the earliest possible time.

In surgery, the indications for artificial nutrition are prevention and treatment of catabolism and malnutrition. This mainly affects the perioperative maintenance of nutritional state to prevent malnutrition. Criteria for the success of the “therapeutic” indication for PN are the so-called “outcome” parameters of morbidity, length of hospital stay and mortality, while taking into consideration economic implications. The improvement of nutritional status and quality of life are most important in the postoperative period [43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55].

Postoperative re-establishing of food intake

• Generally, nutrient intake should not be interrupted post-operatively (A).
• The post-operative re-establishing of oral food intake should be adjusted according to the patient’s tolerance (C).
• The re-establishing of oral or enteral food intake is recommended within 24 h post surgery (A).
• Oral food intake can be reintroduced from the first postoperative day after an anastomosis of the colon and rectum (A).
• Enteral intake via a tube with the tip distal to the anastomosis site is recommended for the first few days after an anastomosis in the upper gastrointestinal tract (A).

Commentary

Early re-establishing of oral or enteral food intake lowers the risk of infection and reduces the length of the hospital stay ([56], [57], [58]) (Ia), ([59], [60]) (Ib), [61] (Ila). Food intake can be reintroduced immediately after a cholecystectomy, because a latency period or oesophageal decompression is of no advantage ([62], [63]) (Ib). Early re-establishing of oral food intake, by drinking from the first post operative day, after an anastomosis of the colon and rectum does not result in an increased insufficiency rate or interruption in the healing process ([56], [63], [64]) (Ib), [65] (Ia). The speed at which food is re-introduced should be guided by the gastrointestinal tract function and the patient’s tolerance [57] (Ia), ([63], [64], [65]) (Ib), ([66], [67], [68]) (Ila), ([59], [69]) (Iib).

No comparable data are available for patients with an upper gastrointestinal tract anastomosis e.g. after a gastrectomy or oesophageal resection. In these cases numerous controlled studies have shown the practicability of enteral nutrition via a tube distal to the anastomosis site [70], [71], [72], [73].

In comparison to conventional laparotomies, laparoscopic colonic surgery improves the tolerance to early re-establishing of oral food intake through faster establishment of peristalsis and intestinal passage [74] (Ib), ([68], [75]) (Ila).
Perioperative (pre and postoperative) indications for artificial nutrition

General

- Insufficient food intake for more than 14 days is associated with increased mortality (lb).
- Indications for artificial nutrition also exists in patients with no signs of malnutrition, but who will not receive oral food intake for more than 7 days perioperatively or whose oral food intake does not meet their needs (i.e. less than 60–80%) for more than 14 days. In these cases it is recommended that enteral nutrition and, if required, also PN (B) is started immediately post-operatively.
- Total PN (TPN) is indicated if there is an absolute contraindication for enteral nutrition, such as in chronic intestinal obstruction with a relevant passage obstruction e.g. a peritoneal carcinoma (A).
- If the energy and nutrient requirements cannot be met by oral and enteral intake alone, a combination of enteral and parenteral nutrition is indicated (C).
- Standardised operative procedures should be established to secure an effective nutrition therapy (C) (cf. Advice and examples for post-operative PN on general wards, below).

Commentary

The prognostic influence of nutritional state on morbidity, mortality and length of hospital stay (LOS) is prospectively documented for surgical patients, particularly after organ transplantation [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22]. Insufficient food intake over a period of more than 14 days is associated with increased mortality (lb) [76].

The current guidelines of the American Society for Parenteral and Enteral Nutrition (ASPEN) recommend post-operative PN for patients who cannot meet their energy needs orally within 7–10 days [77].

The effect of PN in comparison to oral/enteral standard nutrition with regards to the prognosis of surgical patients has been discussed controversially [72], [78], [79], [80], [81], [82], [83], [84], [85], [86], [87], [88], [89], [90], [91], [92], [93], [94], [95], [96], [97], [98], (Table 1). Twenty-one randomised studies of patients with abdominal surgery, including patients after liver transplantation and trauma patients, are known to the expert group. In these studies (total) PN was compared with enteral nutrition, or with crystalloid solutions or with a normal hospital diet.

Enteral and parenteral nutrition was compared in 15 studies, of which 6 showed studies significant benefits of enteral nutrition, mainly, a lower incidence of infectious complications, shorter length of stay, and lower costs (lb). No significant difference, was found in 8 of the 15 studies, which led most authors to favour enteral nutrition because of its lower costs [72], [92], [93], [95] (lb).

Several authors have pointed out the possible advantages of PN when there is a limited tolerance of enteral nutrition due to intestinal dysfunction especially in the early post-operative phase, which is associated with a lower energy intake [78]. Strict attention, therefore, must be paid to the tolerance of enteral intake especially in patients with severe polytrauma [88] (lb). An adequate energy intake is better provided by PN when there is a limited gastrointestinal tolerance [99] (Ila).

A meta-analysis by Braunschweig et al. [100] comparing enteral with parenteral nutrition incorporated the results of 27 studies with 1828 patients, (both surgical and non-surgical). It showed a significantly lower risk of infection with oral/enteral nutrition. In maldernourished patients, however, PN administration resulted in a significantly lower mortality with a tendency towards lower rates of infection. Heyland et al. [101] incorporated 27 studies in a meta-analysis of PN in surgical patients. Clinical trials comparing enteral versus parenteral nutrition were excluded. An influence of PN on the mortality of surgical patients was not shown. A lower complication rate, especially in those with malnutrition, was observed in the parenterally nourished patients.

These results lead to the recommendation not to enforce a dietary intake covering energy requirements during the first 7–10 post-operative days in well-nourished patients.

Combined enteral/parenteral nutrition

Indication

- Combined enteral/parenteral nutrition should always be carried out when artificial nutrition is indicated and the energy requirements cannot be adequately met because of limited enteral tolerance. This is particularly applicable when the energy intake amounts to <60% of the calculated caloric requirements and a central venous catheter for PN is already available (C).
- When insertion of a central venous catheter is required for the purpose of artificial nutrition, this indication must be critically considered in relation to the expected time period of PN. Combined nutrition is not necessary if expected time period of PN is <4 days. If the expected PN period is expected to last between 4–7 days, nutrition can be hypocaloric with 2 g carbohydrates and 1 g amino acids/kg body weight administered via a peripheral catheter, and if it is likely to last more than 7–10 days, it is recommended that a central venous catheter should be inserted (C).

Commentary

Combined enteral/parenteral nutrition has not yet been evaluated in prospectively controlled clinical trials with patients undergoing elective surgery. Heyland et al. [102]
Table 1: Randomised controlled studies on perioperative PN

| Author                  | Year | N  | OP            | Type              | Start           | Results                                      | Evaluation |
|-------------------------|------|----|---------------|-------------------|-----------------|----------------------------------------------|------------|
| Muggia-Sulliam et al. [78] | 1985 | 19 | Visceral      | EN vs. TPN        | 1–10 days, FNCJ | No difference                               | + -        |
| Adams et al. [79]       | 1986 | 46 | Trauma        | EN vs. TPN        | 1–14 days       | No difference in rate of complications and N-balance | + -        |
| Bower et al. [80]       | 1986 | 20 | Visceral      | EN vs. TPN        | 1–7 days, FNCJ  | Lower costs                                  | +          |
| Moore et al. [81]       | 1989 | 59 | Trauma        | EN vs. TPN        | 12h, FNCJ, 50ml/h isocaloric TPN, 1.3–1.5x BEE HB | Less severe infections, no difference in N-balance | +          |
| Reilly et al. [82]      | 1990 |    | Visceral – Liver transplantation | TPN+ - BCAA versus controls | | Better N-balance and shorter LOS in intensive care with TPN – no difference for enrichment with BCAA | +          |
| VA [83]                 | 1991 | 395 | Malnutrition before laparotomy or non-cardiac thoracotomy | 7 days preop. and 3 days postop. TPN versus controls | | Significantly less non-infectious complications in severe malnutrition – otherwise no difference | + -        |
| Kudsk et al. [84]       | 1992 | 98 | Trauma        | EN vs. TPN        | 24h FNCJ        | EN less infections                           | +          |
| Von Meyenfeldt et al. [85] | 1992 | 101 | Visceral      | Preop. EN versus TPN versus controls | | Less intraabdom. abscesses with weight loss >10% in comparison to the malnourished control group, however TEN versus TPN comparable | +          |
| Sandstrom et al. [76]   | 1993 | 300 | Visceral      | TPN versus glucose solution | | | |
| Iovinelli et al. [86]   | 1993 | 48 | Laryngectomy  | EN versus TPN     | PEG after 24h, energy: Harris & Benedict + 40% | Weight, TSF, MAC, alb., TPN, no difference, shorter LOS | +          |
| Brennan et al. [87]     | 1994 |    | Visceral – pancreas resection | TPN versus controls | | No benefit – significantly more complications in TPN | -          |
| Dunham et al. [88]      | 1994 | 37 | Severe polytrauma (ISS ≥15) | EN versus TPN versus PN/EN | approx. 24h | No difference in mortality, but increased mortality of enteral nutrition in intestinal dysfunction | -          |
| Fan et al. [89]         | 1994 | 124 | Visceral liver resection | Oral versus oral + PN | 1 day | Low rate of complications in PN | +          |
| Wicks et al. [90]       | 1994 | 24 | Visceral – liver transplantation | EN vs. TPN        | within 18h | No difference in anthropometric parameters, intestinal function and infection rate | + -        |
Table 1: Randomised controlled studies on perioperative PN

| Author       | Year | N | OP            | Type                           | Start | Results                                                                 | Evaluation |
|--------------|------|---|---------------|--------------------------------|-------|-------------------------------------------------------------------------|------------|
| Jauch et al. [91] | 1995 | 44 | Visceral      | Hypocal. glucose or xylite versus NaCl 0.9% | OP day | Hypocal. metabolically more favourable – No difference between glucose and xylite | +          |
| Baigrie et al. [92] | 1996 | 97 | Visceral      | EN versus TPN                  | 3 days, FNCJ | Tendency towards less complications                                     | + - safe  |
| Reynolds et al. [93] | 1997 | 67 | Visceral      | EN versus TPN                  | 1 day, FNCJ | No difference in complications                                           | + -       |
| Sand et al. [94] | 1997 | 29 | Gastrectomy   | EN versus TPN                  | 1 day, FNCJ | More economical                                                          | +         |
| Shirabe et al. [95] | 1997 | 26 | Liver resection | EN vs. TPN                     | 2 days, nasojejunal | No significant difference in outcome                                   | + -       |
| Hu et al. [96] | 1998 | 40 | Orthopaedics | TPN versus controls            | 1 day    | Significantly lower drop in albumin and prealbumin, lower albumin and prealbumin correlates with the increased risk of pneumonia and urinary tract infections, no significant difference in the rate of wound infections | +         |
| Pacelli et al. [72] | 2001 | 241 | Malnutrition – visceral | EE versus PN                   | FNCJ or nasojejunal on 1st day 30 ml/h | No difference in the rate of complication and mortality      | + -       |
| Bozetti et al. [73] | 2001 | 317 | Malnutrition – visceral | EE versus PN                   | FNCJ or nasojejunal on 1st day isocaloric | Enteral: significantly less complications and lower LOS | +         |
| Braga et al. [98] | 2001 | 257 | Visceral stomach (121) pancreas (110) oesophagus approx. (26) | EN versus PN                   | Target 25 kcal/kg/day | No difference in the rate of complications, LOS and mortality, EN 4x more economical | + -       |

BCAA = Branched-chain Amino Acids, EN = Enteral Nutrition, FNCJ = Fine Needle Catheter jejunostomy, LOS = Length of Hospital Stay, QL = Quality of Life, PEG = Percutaneous Endoscopic Gastrostomy, PN = Parenteral Nutrition, TPN = Total Parenteral Nutrition

and Dhaliwal et al. [103] analysed the studies carried out on critically ill patients. Two of these studies from the 80’s came from the same study group, and were carried out on patients with burn wounds and severe trauma respectively. In the meta-analysis of these studies no advantage was found of combined nutrition regarding mortality, infection, LOS and length of artificial ventilation. Heyland et al. [102], therefore, recommend not to begin with combined enteral and parental nutrition in critically ill patients without signs of malnutrition. They further recommend to decide on parental substrate intake on an individual basis in case of poor tolerance to enteral nutrition. In major elective surgeries, placement of a central venous catheter is usually a routine. It is the opinion of this expert group that in the presence of a suitable indication this access should be used for PN, especially in malnourished patients, and if necessary also as a part of hypocaloric regime. A randomised controlled study has shown that a hypocaloric PN of 25 kcal/kg and 1.5 g/kg protein presents no increased risk of hyperglycaemia and infectious complications, but results in a significant improvement in nitrogen balance [104] (Ib). Insertion of a central venous catheter exclusively for artificial nutrition should be carefully considered. An increase in energy intake can be achieved in the short-term by lipid administration using peripheral venous access. An increase in enteral intake is the main objective in combined enteral/parenteral nutrition. A possible approach to combined PN and to tapering PN when reintroducing enteral feeding is shown in plan IV.
Preoperative indications for PN

- Delaying surgery for a systematic nutrition therapy (enteral and parenteral) is only indicated if severe malnutrition is present (A).
- Preoperative PN is indicated in patients where energy requirement cannot be adequately met by enteral nutrition (C).
- An intravenous administration of 200 g glucose preoperatively during the night is recommended in patients who cannot be enterally fed (B).
- In malnourished patients, preoperative nutrition therapy should preferably be conducted prior to hospital admission to lower the risk of nosocomial infections (C).

Commentary

Positive effects of PN for 7–10 days were observed postoperatively with regards to the rate of complications [83], [97] and the drop in mortality [83] (lb). The early postoperative release of cytokines such as IL-6 and IL-8 is, however, significantly higher when PN is administered [105] (lb). Furthermore, parenteral infusion involves the risk of expanding the extracellular space, thus lowering the albumin concentration and thereby, increasing the risk of pulmonary complications [106] (lb). Positive effects on postoperative stress adaption were reported after parenteral infusion of 1.5–2 g/kg glucose and 1 g/kg amino acids preoperatively (16–20 h) [107]. There is insufficient data available on the comparison of enteral and parenteral nutrition preoperatively. Therefore oral or enteral feeding should be preferred whenever possible. If parenteral nutrition is necessary to meet energy needs e.g. in stenosis of the upper gastrointestinal tract, it should be combined with oral nutrition (e.g. oral nutritional supplements) whenever possible. The benefits of preoperative PN over 7–10 days are only evident in patients with severe malnutrition (weight loss >15%) prior to major gastrointestinal surgery [83], [97]. When PN is continued for 9 days postoperatively the rate of complications is 30% lower and there is a reduction in mortality (lb). Questions regarding the type of preoperative nutritional intake have not been clearly resolved in malnourished patients. Preoperative parenteral and enteral nutrition has been compared in one prospective study. Clear advantage of preoperative PN could not be shown [85]. The results of the meta-analysis by Braunshweig [100], however, do favour PN. A significantly lower mortality with a tendency towards lower rates of infection was found in malnourished patients receiving PN.

Glutamine

Indication for glutamine administration

- Currently, there is only an indication for post-operative parenteral supplementation of glutamine dipeptide solutions in severely malnourished patients who cannot be adequately fed enterally and, therefore, require PN (C).
- A lack of sufficient evidence-based studies deter the expert group from making a general recommendation for parenteral use of glutamine in surgical patients (C).

Commentary

The parenteral supplementation of glutamine dipeptide in 9 controlled randomised trials (lb) with non-enterally fed surgical patients was reviewed by the working group with regards to the end-points morbidity and outcome (two as abstracts, see Table 2 [108], [109], [110], [111], [112], [113], [114], [115], [116]). In eight of these studies, the patients were to undergo elective surgery and in one after emergency visceral surgery. All studies showed significant benefits of glutamine supplementation, seven with respect to post-operative LOS and two with respect to post-operative morbidity. This correlates with the results of an earlier meta-analysis examining elective surgical patients [117] (la). A systematic analysis of European and Asian non-enterally nourished surgical patients resulted in 10 studies with the end point of infectious complications and 8 studies of post-operative LOS. Significant benefits of glutamine supplementation were also seen [118] (la). Significantly improved regeneration of the post-operative immune function was shown in two current studies with immunological end points [119], [120], [121], [122] (lb).

Based on the current understanding, exclusive PN over 5–7 days is not indicated in surgical patients particularly after elective colorectal surgery with an uncomplicated course [58], [123]. To what extent does parenteral glutamine intake, with oral/enteral nutrition, may have a positive effect, cannot be answered at present due to lack of available data. The possible significance of a short-term perioperative glutamine infusion for a total duration of 72 hours, beginning 24 hours before elective surgery, needs to be further clarified [119].

Specific aspects in paediatric surgery

- The recommendations on early post-operative re-establishing of oral feeding generally apply also to infants, children and adolescents (C).

Commentary

In neonates and premature infants, early re-establishing of food (even with the smallest amounts of EN) result in a lower risk of sepsis due to an increase in immune competence [124]. Numerous studies have shown that post-operative energy expenditure increases in newborns after major surgery by 20%, and is normal again within the first 12 to 24 hours [125]. Post-operatively, infants tend to retain water during the first 24 hours due to in-
creased ADH levels and, therefore, fluid intake should be restricted whereas sodium should be given in higher doses [126], [127].

No benefits have been observed when PN is supplemented with glutamine in newborns and children undergoing gastrointestinal surgery [128] (Ib).

Children with short bowel syndrome due to genetic or acquired loss of resorptive surface are dependent on long-term PN. Liver damage and complications like thromboses, embolism and sepsis associated with intravenous nutrition determine the prognosis [129]. An assessment by an intestinal transplantation centre should be considered for PN-dependent paediatric patients with short bowel syndrome who suffer from hyperbilirubinemia (total bilirubin >3 mg/dl) for more than three months despite adequate therapy [130]. A formula is available to calculate the anticipated duration of PN-dependency in order to determine an early indication of transplantation [131]. An isolated small intestine transplantation is strived for in children with reversible liver damage. PN may usually be terminated over medium-

### Table 2: Randomised controlled studies on glutamine supplementation in the PN of surgical patients

| Author          | Year | N  | Patients                          | Glutamine dosage                                                                 | Results                                                                 | Evaluation |
|-----------------|------|----|-----------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------|------------|
| Morlion et al. [106] | 1998 | 28 | Visceral – colorectal             | 0.3 g/kg/day alanine-glutamine versus standard isonitrogen, isocaloric for 5 days postop. | Significantly shorter LOS, improved N-balance and regeneration of immune defence | +          |
| Fürst et al. [109,110]* | 1999 | 126 | Multicenter visceral, thorax      | 0.5 g/kg d alanine-glutamine versus standard isonitrogen for 5 days postop.       | Significantly lower LOS, no difference in rate of complications        | +          |
| Jacobi et al. [110] | 1999 | 34 | Visceral (oesophagus, stomach)    | 0.4 g/kg/day for 5 days postop.                                                   | Lower rate of complications, no clear advantage in postop. immune function | +          |
| Jiang et al. [111] | 1999 | 120 | Multicenter visceral              | 0.5 g/kg/day alanine-glutamine versus standard isonitrogen, isocaloric for 5 days postop. | Significantly lower LOS                                                | +          |
| Powell-Tuck et al. [112] | 1999 | 168 | Mixed – also visceral             | Suppl. of 20 g/day versus standard for the whole period of PN                     | Significantly lower LOS only in surgical patients                      | +          |
| Mertes et al. [113] | 2000 | 37 | Visceral                          | 0.5 g/kg/day alanine-glutamine versus standard isonitrogen, isocaloric for 5 days postop. | Significantly lower LOS                                                | +          |
| Karwowska et al. [114]* | 2000 | 30 | Abdominal aorta surgery          | 0.202 g/kg/day alanine-glutamine versus standard isonitrogen, isocaloric for 10 days postop. | Significantly shorter LOS, significantly better N-balance, improved regeneration of immune function | +          |
| Neri et al. [115] | 2001 | 33 | Visceral                          | 0.3 g/kg/day alanine-glutamine versus standard isonitrogen, isocaloric for 10 days postop. | Significantly shorter LOS, significantly better N-balance              | +          |
| Fuentes Orozco et al. [116] | 2004 | 33 | Visceral – secondary peritonitis  | 0.4 g/kg/day alanine-glutamine versus standard isonitrogen, isocaloric for 10 days postop. | Significantly less infectious complications                             | +          |
| Albers et al. [128] | 2005 | 80 | Newborns and children with OP on intestinal tract | 0.4 g/kg/d L-glutamine in 2.5% solution, isonitrogen, isocaloric | No significant difference in intestinal permeability, N-balance and outcome | +          |

* Abstract; LOS = Length of Hospital Stay

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term after the small intestine transplantation has been successful.

Organ transplantation

PN in patients after organ transplants

- An early re-establishing of oral feeding should be strived for after successful, uncomplicated heart, liver, and kidney transplantation procedures (C).
- Early EN, combined with PN if necessary, is recommended within 24 hours after liver or pancreas transplantations (C).
- EN should be increased very carefully within the first week of a small intestine transplantation. Enteral/parenteral nutrition should be combined as well (C).
- No recommendation can be made for parenteral supplementation of immune-modulatory substrates due to the lack of data available (C).
- No recommendation can be made regarding the parenteral supplementation of glutamine and arginine to precondition against ischemia/reperfusion damage (C).

Commentary

Early oral or enteral feeding should also be strived for transplantation patients [132], [133]. Absorption and blood levels from tacrolism are not impaired by EN [134] (IIb). EN and PN are equally important in patients after liver transplantations [90] (Ib). Benefits have been reported with administration of MCT/LCT lipid emulsions compared to LCT emulsions, with more favourable regeneration of the function of the reticuloendothelial system after liver transplantation [135]. The metabolism of both lipid solutions shows no difference [136] (Ib). Advantages of EN are evident when the incidence of viral infections is considered [137] (Ib). In comparison to a standard enteral diet in combination with selective intestinal contamination, a significant drop in the rate of infection was also shown through the use of a high-fibre diet enriched with Lactobacillus plantarum [138] (Ib). The placement of a fine needle catheter jejunostomy is also feasible in liver transplanted patients [139] (Ib). After small intestine transplantation EN is more difficult because of increased intestinal secretion [140]. The role of pre-conditioning the organ donor or the donor organ i.e. through high-dosage arginine intake for the production of NO and its conversion into glutamine and glutathione is a still open-ended question. There are no clinical trials on parenteral immunonutrition. Data resulting from animal experiments on parenteral supplementation with glutamine after transplantation of the small intestine show beneficial trophic effects with low mucosa permeability and a low rate of bacterial translocation [141].

Attachment

Advice and examples for post-operative PN on general wards

See also “Safe Practices of PN” [126]

- Multi-chamber bags must be mixed according to instructions prior to administration.
- Attention should be paid to expiry date, precipitation etc.
- Careful labelling of infusion bags (admixtures, patient’s name)
- Solutions with high osmolarity (>800 mosm/l) should only be infused via central venous access.
- The infusion is administered via infusion pumps when feeding paediatric patients and when using hypercaloric nutrition.
- Regular checks of the infused solutions should be made during every shift in order to recognise and correct irregularities.
- Replacement of the whole infusion system including the three-way valve should take place every 3rd day.
- For drug infusion via piggy-bag a separate intravenous line should be used.
- Attention should be paid to hygiene rules when injecting admixtures, penetrating a vein or changing the infusion system, or during manipulations at the access etc.
- Replacement of additional fluid losses (fever, drainages, diarrhoea, vomiting, stomach tube, etc.).
- Exact documentation in the chart (length of infusion, signature)
- Regular laboratory tests.

Post-operative infusion and nutrition therapy

Plan I: Fast track with immediate re-establishing of oral food

Indication: Patients who are not suffering from malnutrition and who may receive sufficient oral or enteral nutrition within 4 days, do not require PN irrespective of the type and size of surgery.

Principle: Exclusively electrolyte, fluids and glucose administration irrespective of body weight. Peripheral venous administration is possible. The electrolyte solution can serve as a carrier solution for drugs. Simultaneous increase in oral fluid intake and gradual re-establishing of food.

Application: Peripheral venous, crystalloids – preferred solution: balanced electrolyte solution, NaCl 0.9% in case of increase in serum potassium (dialysis patients). See example in Table 3.
Plan II: Short-term hypocaloric PN

**Indication:** Patients who are not malnourished and who probably will not be able to receive sufficient oral or enteral nutrition within 4 days of surgery.

**Principle:** Hypocaloric PN, i.e. adequate amino acid substitution with limited carbohydrate infusion, only meeting the basic requirements.

**Application:** Peripheral venous administration is possible. However, it could lead to vein irritation especially with the additional administration of electrolytes, drugs (i.e. antibiotic infusion etc.), complete solutions or two-chamber bags.

See example in Table 4.

Plan III: PN to meet energy and nutritional requirements

**Indications:** All patients who are suffering from malnutrition, and those who are not suffering from malnutrition but will not be able to receive sufficient oral or enteral nutrition within 7 days, or those who are not suffering from malnutrition but where it is not anticipated that adequate oral or enteral nutrition can be administered within 14 days.

**Principle:** Required calorie intake taking into account all substrates as well as adequate substitutions of vitamins and trace elements (total PN). Lipid intake is started on the third day. There is marked interindividual variance in energy needs for newborns and infants under severe post-operative conditions. Jaksic et al. [142] was not able to detect any increased energy expenditure as a result of massive postoperative stress in newborns. In infants, weight development and fluid balance should be observed to evaluate energy intake. Additionally CO₂ production may be measured.

**Application:** Central venous (catheter via the vena jugularis or vena subclavia), mixed or two-chamber and three-chamber bags. The electrolyte solution can serve as a carrier solution for drugs.

See example in Table 5.

Plan IV: Combined enteral and parenteral nutrition

**Indications:** All patients, with indications for artificial nutrition, who are unlikely to meet caloric requirements through EN.

**Principle:** The parenteral substrate intake is adjusted as enteral intake is tolerated with the objective of gradually meeting caloric requirements enterally.

**Application:** Enteral tube/needle catheter jejunostomy or peripheral venous access, two and three-chamber bags.

See example in Table 6.
Table 6: Example for combined enteral and parenteral nutrition

| Level * | Enteral | Parenteral |
|---------|---------|------------|
| 1a      | 10–25 ml/h over 20–24h approx. 200–500 kcal | 1000 ml glucose 10–12% (100–120 g = 400–480 kcal) + electrolytes 500 ml amino acids 10% (50 g)** |
| 1b      | 10–25 ml/h over 20–24h approx. 200–500 kcal | 1000 ml glucose 20–25% (200–250 g = 800–1000 kcal) + electrolytes 1000 ml amino acids 10% (100 g)** possibly 250 ml lipids 20% (50 g approx. 500 kcal) |
| 2       | 50 ml/h over 20h approx. 1000 kcal | 1000 ml glucose 20–25% (200–250 g = 800–1000 kcal) + electrolytes 1000 ml amino acids 10% (100 g)** |
| 3       | 75 ml/h over 20h approx. 1500 kcal | 500 ml glucose 10–12% (100–120 g = 400–480 kcal) + electrolytes 500 ml amino acids 10% (100 g)** |
| 4       | 100–125 ml/h over 20h approx. 2000–2500 kcal |

*The increase in levels is according to the enteral tolerance of the patient. Substitution with water-soluble and fat-soluble vitamins and trace elements is recommended, provided that Level 1 cannot be exceeded for several days.

**Amino acids are not included in this example for the calculation of the calorie intake.

Notes

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