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 perioperativ 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 enterale Ernährung wie bei einer chronischen Darmobstruktion mit relevanter Passagestörung, z.B. einer Peritonealkarzinose, besteht die Indikation zur totalen parenteralen Ernährung (TPE). Wenn der Energie- und Nährstoffbedarf durch orale und enterale Zufuhr allein nicht gedeckt werden kann, ist eine kombinierte enterale

A. Weimann[1]
Ch. Ebener[2]
S. Holland-Cunz[3]
K. W. Jauch[4]
L. Hausser[5]
M. Kemen[6]
L. Kraehenbuehl[7]
E. R. Kuse[8]
F. Laengle[9]
Working group for developing the guidelines for parenteral nutrition of The German Association for Nutritional Medicine

1 Dept. of General und Visceral Surgery, St. George's Hospital, Leipzig, Germany

2 Dept. of General, Visceral and Children's Surgery, Heinrich-Heine-University of Dusseldorf, Germany

3 Dept. of Paediatric Surgery, University of Tuebingen, Germany

4 Dept Surgery Grosshadern, University Hospital, Munich, Germany

5 Dept. of General and Visceral Surgery, Augsburg, Germany

6 Dept. Surgery, Lutheran Hospital Herne, Germany

7 Dept. of Surgery, Canton Hospital Fribourg, Switzerland

8 Central Clinic for Anaesthetics, Operative Intensive Medicine and Pain

und parenterale Ernährung indiziert. Die Verschiebung einer Operation zur Durchführung einer gezielten Ernährungstherapie (enteral und parenteral) ist nur bei schwerer Mangelernährung angezeigt. Bei mangelernährten Patienten sollte die präoperative Ernährungstherapie möglichst prästationär durchgeführt werden, um das Risiko nosokomialer Infektionen zu senken. Prinzipiell gelten die Empfehlungen des frühzeitigen 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

Therapy, Hospital of Salzgitter, Germany

9 Dept. General Surgery, University of Vienna, Austria

Introduction

In surgery, the importance of nutritional status for post-operative 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], [22] 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 post-operative 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] (IIa).

Food intake can be reintroduced immediately after a cholecystectomy, because a latency period or oesophagogastric 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 reintroduced should be guided by the gastrointestinal tract function and the patient’s tolerance [57] (Ia), ([63], [64], [65]) (Ib), ([66], [67], [68]) (IIa), ([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]) (IIa).

Perioperative (pre and postoperative) indications for artificial nutrition

General

- Insufficient food intake for more than 14 days is associated with increased mortality (Ib).
- 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 postoperatively.
- 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 (Ib) [76].

The current guidelines of the American Society for Parental and Enteral Nutrition (ASPEN) recommend postoperative 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 (Ib). 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] (Ib).

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 postoperative 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] (Ib). An adequate energy intake is better provided by PN when there is a limited gastrointestinal tolerance [99] (IIa).

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 malnourished 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-Sullam 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	Malnutritioned before laporotomy or non-cardiac thoractomy	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	At least 10 days with malnutrition (NI), nasogastr. or oral 150% BEE according to Harris & Benedict	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., TFN, 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	+ -

(Continued)

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, naso-jejunal	No significant difference in outcome	+ -
Hu et al. [96]	1998	40	Orthopaedics – spine	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	+ -
Bozzetti 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 bad burns 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] (Ib). The early postoperative release of cytokines such as IL-6 and IL-8 is, however, significantly higher when PN is administered [105] (Ib). 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] (Ib). 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 post-operatively the rate of complications is 30% lower and there is a reduction in mortality (Ib). 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 Braunschweig [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 (Ib) 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] (Ia). 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] (Ia). Significantly improved regeneration of the post-operative immune function was shown in two current studies with immunological end points [119], [120], [121], [122] (Ib).
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-

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. [108]	1998	28	Visceral – colorectal	0.3g/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 6 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	+
Karwow-ska 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	Viseral	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	0.4g/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

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 hyperbilirubinaemia (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-

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] (IIb). 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.

Table 3: Example for fast track

Body weight	OP day	1st post-operative day	2nd post-operative day
irrespective	1000 ml electrolyte solution	1000 ml electrolyte solution	as in day 1 in case of insufficient oral fluid intake

Table 4: Example for short-term hypocaloric PN

Body weight	OP day	1st post-operative day	as of 2nd post-operative day
irrespective	2500 ml electrolyte solution	1000 ml glucose (10–12%) 1000 ml amino acids (10%) + electrolytes 500 ml electrolyte solution	1000 ml glucose (10–12%) 1000 ml amino acids (10%) + electrolytes 500 ml electrolyte solution

Table 5: Example for PN to meet energy and nutritional requirements

Body weight	OP day	1st postoperative day	2nd postoperative day	as of 3rd postoperative day
irrespective	1000 ml electrolyte solution	2000 ml two-chamber bag 500 ml electrolyte solution	2000 ml two-chamber bag 500 ml electrolyte solution	2000 ml "all-in-one" three-chamber bag 500 ml electrolyte solution

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 post-operative stress in newborns. In infants, weight development and fluid balance should be observed to evaluate energy intake. Additionally CO_2 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

This article is part of the publication of the Guidelines on Parenteral Nutrition from the German Society for Nutritional Medicine (overview and corresponding address under http://www.egms.de/en/gms/2009-7/000086.shtml).
English version edited by Sabine Verwied-Jorky, Rashmi Mittal and Berthold Koletzko, Univ. of Munich Medical Centre, Munich, Germany.

References

1. Velanovich V. The value of routine preoperative laboratory testing in predicting postoperative complications: a multivariate analysis. Surgery. 1991;109(3 Pt 1):236-43.
2. Engelman DT, Adams DH, Byrne JG, Aranki SF, Collins JJ Jr, Couper GS, Allred EN, Cohn LH, Rizzo RJ. Impact of body mass index and albumin on morbidity and mortality after cardiac surgery. J Thorac Cardiovasc Surg. 1999;118(5):866-73. DOI: 10.1016/S0022-5223(99)70056-5
3. Kama NA, Coskun T, Yuksek YN, Yazgan A. Factors affecting postoperative mortality in malignant biliary tract obstruction. Hepatogastroenterology. 1999;46(25):103-7.
4. Takagi K, Yamamori H, Toyoda Y, Nakajima N, Tashiro T. Modulating effects of the feeding route on stress response and endotoxin translocation in severely stressed patients receiving thoracic esophagectomy. Nutrition. 2000;16(5):355-60. DOI: 10.1016/S0899-9007(00)00231-8
5. Koval KJ, Maurer SG, Su ET, Aharonoff GB, Zuckerman JD. The effects of nutritional status on outcome after hip fracture. J Orthop Trauma. 1999;13(3):164-9. DOI: 10.1097/00005131-199903000-00003
6. Klein JD, Hey LA, Yu CS, et al. Perioperative nutrition and postoperative complications in patients undergoing spinal surgery. Spine. 1996;21(22):2676-82. DOI: 10.1097/00007632-199611150-00018
7. Dannhauser A, Van Zyl JM, Nel CJ. Preoperative nutritional status and prognostic nutritional index in patients with benign disease undergoing abdominal operations - Part I. J Am Coll Nutr. 1995;14(1):80-90.
8. Jagoe RT, Goodship TH, Gibson GJ. The influence of nutritional status on complications after operations for lung cancer. Ann Thorac Surg. 2001;71(3):936-43. DOI: 10.1016/S0003-4975(00)02006-3
9. Mazolewski P, Turner JF, Baker M, Kurtz T, Little AG. The impact of nutritional status on the outcome of lung volume reduction surgery: a prospective study. Chest. 1999;116:693-6. DOI: 10.1378/chest.116.3.693
10. van Bokhorst-de van der Schueren MA, van Leeuwen PA, Sauerwein HP, Kuik DJ, Snow GB, Quak JJ. Assessment of malnutrition parameters in head and neck cancer and their relation to postoperative complications. Head Neck. 1997;19(5):419-25.
11. van Bokhorst-de van der Schuer MA, van Leeuwen PA, Kuik DJ, et al. The impact of nutritional status on the prognoses of patients with advanced head and neck cancer. Cancer. 1999;86(3):519-27. DOI: 10.1002/(SICI)1097-0142(19990801)86:3<519::AID-CNCR22>3.0.CO;2-S
12. Lavernia CJ, Sierra RJ, Baerga L. Nutritional parameters and short term outcome in arthroplasty. J Am Coll Nutr. 1999;18(3):274-8.
13. Patterson BM, Cornell CN, Carbone B, Levine B, Chapman D. Protein depletion and metabolic stress in elderly patients who have a fracture of the hip. J Bone Joint Surg Am. 1992;74(2):251-60.
14. Rey-Ferro M, Castano R, Orozco O, Serna A, Moreno A. Nutritional and immunologic evaluation of patients with gastric cancer before and after surgery. Nutrition. 1997;13(10):878-81. DOI: 10.1016/S0899-9007(97)00269-4

15. Guo CB, Ma DQ, Zhang KH. Applicability of the general nutritional status score to patients with oral and maxillofacial malignancies. Int J Oral Maxillofac Surg. 1994;23(3):167-9. DOI: 10.1016/S0901-5027(05)80294-2

16. Guo CB, Zhang W, Ma DQ, Zhang KH, Huang JQ. Hand grip strength: an indicator of nutritional state and the mix of postoperative complications in patients with oral and maxillofacial cancers. Br J Oral Maxillofac Surg. 1996;34(4):325-7. DOI: 10.1016/S0266-4356(96)90012-1

17. Pedersen NW, Pedersen D. Nutrition as a prognostic indicator in amputations: A prospective study of 47 cases. Acta Orthop Scand. 1992;63(6):675-8.

18. Mohler JL, Flanigan RC. The effect of nutritional status and support on morbidity and mortality of bladder cancer patients treated by radical cystectomy. J Urol. 1987;137(3):404-7.

19. Saluja SS, Kaur N, Shrivastava UK. Enteral nutrition in surgical patients. Surg Today. 2002;32(8):672-8. DOI: 10.1007/s005950200125

20. Durkin MT, Mercer KG, McNulty MF, et al. Vascular surgical society of great britain and ireland: contribution of malnutrition to postoperative morbidity in vascular surgical patients. Br J Surg. 1999;86(5):702. DOI: 10.1046/j.1365-2168.1999.0702a.x

21. Nezu K, Yoshikawa M, Yoneda T, et al. The effect of nutritional status on morbidity in COPD patients undergoing bilateral lung reduction surgery. Thorac Cardiovasc Surg. 2001;49:216-20. DOI: 10.1055/s-2001-16110

22. Hulsewe KW, Meijerink WJ, Soeters PB, von Meyenfeldt MF. Assessment of outcome of perioperative nutritional interventions. Nutrition. 1997;13(11-12):996-8. DOI: 10.1016/S0899-9007(97)00376-6

23. Butters M, Straub M, Kraft K, Bittner R. Studies on nutritional status in general surgery patients by clinical, anthropometric, and laboratory parameters. Nutrition. 1996;12(6):405-10. DOI: 10.1016/S0899-9007(96)00094-9

24. Correia MI, Caiaffa WT, da Silva AL, Waitzberg DL. Risk factors for malnutrition in patients undergoing gastroenterological and hernia surgery: an analysis of 374 patients. Nutr Hosp. 2001;16(2):59-64.

25. Lumbers M, New SA, Gibson S, Murphy MC. Nutritional status in elderly female hip fracture patients: comparison with an age-matched home living group attending day centres. Br J Nutr. 2001;85:733-40. DOI: 10.1079/BJN2001350

26. Haugen M, Homme KA, Reigstad A, Teigland J. Assessment of nutritional status in patients with rheumatoid arthritis and osteoarthritis undergoing joint replacement surgery. Arthritis Care Res. 1999;12(1):26-32. DOI: 10.1002/1529-0131(199902)12:1<26::AID-ART5>3.0.CO;2-#

27. Saito T, Kuwahara A, Shigemitsu Y, Kinoshita T, Shimoda K, Miyahara M, Kobayashi M, Shimaoka A. Factors related to malnutrition in patients with esophageal cancer. Nutrition. 1991;7(2):117-21.

28. Weimann A, Meyer HJ, Müller MJ, et al. Bedeutung des präoperativen Gewichtsverlustes für die perioperative Stoffwechseladaptation und das Operationsrisiko bei Patienten mit Tumoren im oberen Gastrointestinaltrakt. Langenbecks Arch Chir. 1992;377(1):45-52. DOI: 10.1007/BF00186148

29. Bollschweiler E, Schröder W, Hölscher AH, Siewert JR. Preoperative risk analysis in patients with adenocarcinoma or squamous cell carcinoma of the oesophagus. Br J Surg. 2000;87(8):1106-10. DOI: 10.1046/j.1365-2168.2000.01474.x

30. Takagi K, Yamamori H, Morishima Y, Toyoda Y, Nakajima N, Tashiro T. Preoperative immunosuppression: its relationship with high morbidity and mortality in patients receiving thoracic esophagectomy. Nutrition. 2001;17(1):13-7. DOI: 10.1016/S0899-9007(00)00504-9

31. Padillo FJ, Andicoberry B, Muntane J, et al. Factors predicting nutritional derangements in patients with obstructive jaundice: multivariate analysis. World J Surg. 2001;25(4):413-8. DOI: 10.1007/s002680020043

32. Moukarzel AA, Najm I, Vargas J, McDiarmid SV, Busuttil RW, Ament ME. Effect of nutritional status on outcome of orthotopic liver transplantation in pediatric patients. Transplant Proc. 1990;22(4):1560-3.

33. Müller MJ, Lautz HU, Plogmann B, Bürger M, Körber J, Schmidt FW. Energy expenditure and substrate oxidation in patients with cirrhosis: the impact of cause, clinical staging and nutritional state. Hepatology. 1992;15(5):782-94. DOI: 10.1002/hep.1840150507

34. Pikul J, Sharpe MD, Lowndes R, Ghent CN. Degree of preoperative malnutrition is predictive of postoperative morbidity and mortality in liver transplant recipients. Transplantation. 1994;57(4):469-72. DOI: 10.1097/00007890-199402150-00030

35. Shaw BW Jr, Wood RP, Gordon RD, Iwatsuki S, Gillquist WP, Starzl TE. Influence of selected patient variables and operative blood loss on six-month survival following liver transplantation. Semin Liver Dis. 1985;5:385-93. DOI: 10.1055/s-2008-1040637

36. Selberg O, Böttcher J, Tusch G, Pichlmayr R, Henkel E, Müller MJ. Identification of high- and low-risk patients before liver transplantation: a prospective cohort study of nutritional and metabolic parameters in 150 patients. Hepatology. 1997;25(3):652-7. DOI: 10.1002/hep.510250327

37. Roggero P, Cataliotti E, Ulla L, Stuflesser S, Nebbia G, Bracaloni D, Lucianetti A, Gridelli B. Factors influencing malnutrition in children waiting for liver transplants. Am J Clin Nutr. 1997;65(6):1852-7.

38. Plöchl W, Pezawas L, Artemiou O, Grimm M, Klepetko W, Hiesmayr M. Nutritional status, ICU duration and ICU mortality in lung transplant recipients. Intensive Care Med. 1996;22(11):1179-85. DOI: 10.1007/BF01709333

39. Schwebel C, Pin I, Barnoud D, et al. Prevalence and consequences of nutritional depletion in lung transplant candidates. Eur Respir J. 2000;16(6):1050-5. DOI: 10.1034/j.1399-3003.2000.16f05.x

40. Figueiredo F, Dickson ER, Pasha T, et al. Impact of nutritional status on outcomes after liver transplantation. Transplantation. 2000;70(9):1347-52. DOI: 10.1097/00007890-200011150-00014

41. Stephenson GR, Moretti EW, El Moalem H, Clavien PA, Tuttle-Newhall JE. Malnutrition in liver transplant patients: preoperative subjective global assessment is predictive of outcome after liver transplantation. Transplantation. 2001;72(4):666-70. DOI: 10.1097/00007890-200108270-00018

42. Linn BS, Robinson DS, Klimas NG. Effects of age and nutritional status on surgical outcomes in head and neck cancer. Ann Surg. 1988;207(3):267-73. DOI: 10.1097/00000658-198803000-00008

43. Kornowski A, Cosnes J, Gendre JP, Quintrec Y. Enteral nutrition in malnutrition following gastric resection and cephalic pancreaticoduodenectomy. Hepatogastroenterology. 1992;39(1):9-13.

44. Velez JP, Lince LF, Restrepo JI. Early enteral nutrition in gastrointestinal surgery: a pilot study. Nutrition. 1997;13(5):442-5. DOI: 10.1016/S0899-9007(97)91283-1

45. Weimann A, Müller MJ, Adolph M, et al. Kriterien der Überwachung und des Erfolgs einer künstlichen Ernährung – Loccumer Gespräche 1997. Intensivmed. 1997;34(7):744-8. DOI: 10.1007/s003900050099

46. Hedberg AM, Lairson DR, Aday LA, et al. Economic implications of an early postoperative enteral feeding protocol. J Am Diet Assoc. 1999;99(7):802-7. DOI: 10.1016/S0002-8223(99)00191-1

47. Hamaoui E, Lefkowitz R, Olender L, et al. Enteral nutrition in the early postoperative period: a new semi-elemental formula versus total parenteral nutrition. JPEN J Parenter Enteral Nutr. 1990;14(5):501-7. DOI: 10.1177/0148607190014005501

48. Moore FA, Feliciano DV, Andrassy RJ, et al. Early enteral feeding, compared with parenteral, reduces postoperative septic complications: The results of a meta-analysis. Ann Surg. 1992;216(2):172-83. DOI: 10.1097/00000658-199208000-00008

49. Mochizuki H, Togo S, Tanaka K, Endo I, Shimada H. Early enteral nutrition after hepatectomy to prevent postoperative infection. Hepatogastroenterology. 2000;47(35):1407-10.

50. Shaw-Stiffel TA, Zarny LA, Pleban WE, Rosman DD, Rudolph RA, Bernstein LH. Effect of nutrition status and other factors on length of hospital stay after major gastrointestinal surgery. Nutrition. 1993;9(2):140-5.

51. Neumayer LA, Smout RJ, Horn HG, Horn SD. Early and sufficient feeding reduces length of stay and charges in surgical patients. J Surg Res. 2001;95(1):73-7. DOI: 10.1006/jsre.2000.6047

52. Weimann A, Müller MJ, von Herz U, et al. Lebensqualität als Kriterium des Erfolgs einer künstlichen Ernährung - Loccumer Gespräche 1998. Intensivmed. 1998;35(8):724-6. DOI: 10.1007/s003900050200

53. Bruning PF, Halling A, Hilgers FJ, et al. Postoperative nasogastric tube feeding in patients with head and neck cancer: a prospective assessment of nutritional status and well-being. Eur J Cancer Clin Oncol. 1988;24(2):181-8. DOI: 10.1016/0277-5379(88)90250-7

54. Hammerlid E, Wirblad B, Sandin C, et al. Malnutrition and food intake in relation to quality of life in head and neck cancer patients. Head Neck. 1998;20(6):540-8. DOI: 10.1002/(SICI)1097-0347(199809)20:6<540::AID-HED9>3.0.CO;2-J

55. Weimann A. Sinnvolle Ziele für eine Ernährungstherapie beim Tumorpatienten. Aktuel Ernaehr Med. 2001;26:167-9. DOI: 10.1055/s-2001-16667

56. Lewis SJ, Egger M, Sylvester PA, Thomas S. Early enteral feeding versus "nil by mouth" after gastrointestinal surgery: systematic review and meta-analysis of controlled trials. BMJ. 2001;323:773-6. DOI: 10.1136/bmj.323.7316.773

57. Marik PE, Zaloga GP. Early enteral nutrition in acutely ill patients: a systematic review. Crit Care Med. 2001;29(12):2264-70. DOI: 10.1097/00003246-200112000-00005

58. Weimann A, Jauch KW, Kemen M, et al. DGEM-Leitlinie Enterale Ernährung: Chirurgie und Transplantation. Aktuel Ernaehr Med. 2003;28:S51-S60. DOI: 10.1055/s-2003-36938

59. Schilder JM, Hurteau JA, Look KY, et al. A prospective controlled trial of early postoperative oral intake following major abdominal gynecologic surgery. Gynecol Oncol. 1997;67(3):235-40. DOI: 10.1006/gyno.1997.4860

60. Stewart BT, Woods RJ, Collopy BT, Fink RJ, Mackay JR, Keck JO. Early feeding after elective open colorectal resections: a prospective randomized trial. Aust N Z J Surg. 1998;68(2):125-8. DOI: 10.1111/j.1445-2197.1998.tb04721.x

61. Moiniche S, Bulow S, Hesselfeldt P, Hestbaek A, Kehlet H. Convalescence and hospital stay after colonic surgery with balanced analgesia, early oral feeding, and enforced mobilisation. Eur J Surg. 1995;161(4):283-8.

62. Bickel A, Shtamler B, Mizrahi S. Early oral feeding following removal of nasogastric tube in gastrointestinal operations: A randomized prospective study. Arch Surg. 1992;127:287-9.

63. Elmore MF, Gallagher SC, Jones JG, Koons KK, Schmalhausen AW, Strange PS. Esophagogastric decompression and enteral feeding following cholecystectomy: a controlled, randomized prospective trial. JPEN J Parenter Enteral Nutr. 1989;13(4):377-81. DOI: 10.1177/014860718901300437

64. Reissman P, Teoh TA, Cohen SM, Weiss EG, Nogueras JJ, Wexner SD. Is early oral feeding safe after elective colorectal surgery? A prospective randomized trial. Ann Surg. 1995;222(1):73-7. DOI: 10.1097/00000658-199507000-00012

65. Jeffery KM, Harkins B, Cresci GA, Martindale RG. The clear liquid diet is no longer a necessity in the routine postoperative management of surgical patients. Am Surg. 1996;62(3):167-70.

66. Choi J, O'Connell TX. Safe and effective early postoperative feeding and hospital discharge after open colon resection. Am Surg. 1996;62(10):853-6.

67. Detry R, Ciccarelli O, Komlan A, Claeys N. Early feeding after colorectal surgery. Preliminary results. Acta Chir Belg. 1999;99(6):292-4.

68. Chen HH, Wexner SD, Iroatulam AJ, et al. Laparoscopic colectomy compares favorably with colectomy by laparotomy for reduction of postoperative ileus. Dis Colon Rectum. 2000;43(1):61-5. DOI: 10.1007/BF02237245

69. Brönnimann S, Studer M, Wagner HE. Frühpostoperative Ernährung nach elektiver Kolonchirurgie [Early postoperative nutrition after elective colonic surgery]. Langenbecks Arch Chir Suppl Kongressbd. 1998;115:1094-5.

70. Daly JM, Bonau R, Stofberg P, Bloch A, Jeevanandam M, Morse M. Immediate postoperative jejunostomy feeding: Clinical and metabolic results in a prospective trial. Am J Surg. 1987;153(2):198-206. DOI: 10.1016/0002-9610(87)90815-4

71. Kemen M, Senkal M, Homann HH, et al. Early postoperative enteral nutrition with arginine-omega-3 fatty acids and ribonucleic acid-supplemented diet versus placebo in cancer patients: an immunologic evaluation of Impact. Crit Care Med. 1995;23(4):652-9. DOI: 10.1097/00003246-199504000-00012

72. Pacelli F, Bossola M, Papa V, et al. Enteral vs parenteral nutrition after major abdominal surgery: an even match. Arch Surg. 2001;136:933-6. DOI: 10.1001/archsurg.136.8.933

73. Bozzetti F, Braga M, Gianotti L, Gavazzi C, Mariani L. Postoperative enteral versus parenteral nutrition in malnourished patients with gastrointestinal cancer: a randomised multicentre trial. Lancet. 2001;358(9292):1487-92. DOI: 10.1016/S0140-6736(01)06578-3

74. Schwenk W, Böhm B, Haase O, Junghans T, Müller JM. Laparoscopic versus conventional colorectal resection: a prospective randomised study of postoperative ileus and early postoperative feeding. Langenbecks Arch Surg. 1998;383(1):49-55. DOI: 10.1007/s004230050091

75. Bardram L, Funch-Jensen P, Kehlet H. Rapid rehabilitation in elderly patients after laparoscopic colonic resection. Br J Surg. 2000;87(11):1540-5. DOI: 10.1046/j.1365-2168.2000.01559.x

76. Sandström R, Drott C, Hyltander A, Arfvidsson B, Scherstén T, Wickström I, Lundholm K. The effect of postoperative intravenous feeding (TPN) on outcome following major surgery evaluated in a randomized study. Ann Surg. 1993;217(2):185-95.

77. ASPEN Board of Directors and the Clinical Guidelines Task Force. Guidelines for the use of parenteral and enteral nutrition in adult and pediatric patients. JPEN J Parenter Enteral Nutr. 2002;26(1 Suppl):1SA-138SA.

78. Muggia-Sullam M, Bower RH, Murphy RF, Joffe SN, Fischer JE. Postoperative enteral versus parenteral nutritional support in gastrointestinal surgery: A matched prospective study. Am J Surg. 1985;149(1):106-12. DOI: 10.1016/S0002-9610(85)80018-0

79. Adams S, Dellinger EP, Wertz MJ, Oreskovich MR, Simonowitz D, Johansen K. Enteral versus parenteral nutritional support following laparotomy for trauma: a randomized prospective trial. J Trauma. 1986;26(10):882-91. DOI: 10.1097/00005373-198610000-00004

80. Bower RH, Talamini MA, Sax HC, Hamilton F, Fischer JE. Postoperative enteral vs parenteral nutrition: A randomized controlled trial. Arch Surg. 1986;121:1040-5.

81. Moore FA, Moore EE, Jones TN, McCroskey BL, Peterson VM. TEN versus TPN following major abdominal trauma - reduced septic morbidity. J Trauma. 1989;29(7):916-22. DOI: 10.1097/00005373-198907000-00003

82. Reilly J, Mehta R, Teperman L, et al. Nutritional support after liver transplantation: a randomized prospective study. JPEN J Parenter Enteral Nutr. 1990;14(4):386-91. DOI: 10.1177/014860719001400438 6

83. The Veterans Affairs Total Parenteral Nutrition Cooperative Study Group. Perioperative total parenteral nutrition in surgical patients. N Engl J Med. 1991;325(8):525-32.

84. Kudsk KA, Croce MA, Fabian TC, et al. Enteral versus parenteral feeding: Effects on septic morbidity after blunt and penetrating abdominal trauma. Ann Surg. 1992;215(5):503-11. DOI: 10.1097/00000658-199205000-00013

85. von Meyenfeldt MF, Meijerink WJ, Rouflart MM, Builmaassen MT, Soeters PB. Perioperative nutritional support: a randomised clinical trial. Clin Nutr. 1992;11(4):180-6. DOI: 10.1016/0261-5614(92)90026-M

86. Iovinelli G, Marsili I, Varrassi G. Nutrition support after total laryngectomy. JPEN J Parenter Enteral Nutr. 1993;17(5):445-8. DOI: 10.1177/014860719301700544 5

87. Brennan MF, Pisters PW, Posner M, Quesada O, Shike M. A prospective randomized trial of total parenteral nutrition after major pancreatic resection for malignancy. Ann Surg. 1994;220(4):436-41. DOI: 10.1097/00000658-199410000-00003

88. Dunham CM, Frankenfield D, Belzberg H, Wiles C, Cushing B, Grant Z. Gut failure – predictor of or contributor to mortality in mechanically ventilated blunt trauma patients? J Trauma. 1994;37(1):30-4. DOI: 10.1097/00005373-199407000-00007

89. Fan ST, Lo CM, Lai EC, Chu KM, Liu CL, Wong J. Perioperative nutritional support in patients undergoing hepatectomy for hepatocellular carcinoma. N Engl J Med. 1994;331(23):1547-52. DOI: 10.1056/NEJM199412083312303

90. Wicks C, Somasundaram S, Bjarnason I, et al. Comparison of enteral feeding and total parenteral nutrition after liver transplantation. Lancet. 1994;344(8926):837-40. DOI: 10.1016/S0140-6736(94)92824-X

91. Jauch KW, Kroner G, Hermann A, Inthorn D, Hartl W, Günther B. Postoperative Infusionstherapie: Elektrolytlosung im Vergleich zu hypokalorischen Glukose- bzw. Zuckeraustausch-Aminosäurenlösungen [Postoperative infusion therapy: electrolyte solution in comparison with hypocaloric glucose and carbohydrate exchange-amino acid solutions]. Zentralbl Chir. 1995;120(9):682-8.

92. Baigrie RJ, Devitt PG, Watkin DS. Enteral versus parenteral nutrition after oesophagogastric surgery: a prospective randomized comparison. Aust N Z J Surg. 1996;66(10):668-70. DOI: 10.1111/j.1445-2197.1996.tb00714.x

93. Reynolds JV, Kanwar S, Welsh FK, et al. 1997 Harry M. Vars Research Award. Does the route of feeding modify gut barrier function and clinical outcome in patients after major upper gastrointestinal surgery? JPEN J Parenter Enteral Nutr. 1997;21(4):196-201. DOI: 10.1177/014860719702100419 6

94. Sand J, Luostarinen M, Matikainen M. Enteral or parenteral feeding after total gastrectomy: prospective randomised pilot study. Eur J Surg. 1997;163(10):761-6.

95. Shirabe K, Matsumata T, Shimada M, Takenaka K, Kawahara N, Yamamoto K, Nishizaki T, Sugimachi K. A comparison of parenteral hyperalimentation and early enteral feeding regarding systemic immunity after major hepatic resection - the results of a randomized prospective study. Hepatogastroenterology. 1997;44(13):205-9.

96. Hu SS, Fontaine F, Kelly B, Bradford DS. Nutritional depletion in staged spinal reconstructive surgery: The effect of total parenteral nutrition. Spine. 1998;23(12):1401-5. DOI: 10.1097/00007632-199806150-00019

97. Bozzetti F, Gavazzi C, Miceli R, et al. Perioperative total parenteral nutrition in malnourished, gastrointestinal cancer patients: a randomized, clinical trial. JPEN J Parenter Enteral Nutr. 2000;24(1):7-14. DOI: 10.1177/014860710002400107

98. Braga M, Gianotti L, Gentilini O, Parisi V, Salis C, Di C, V. Early postoperative enteral nutrition improves gut oxygenation and reduces costs compared with total parenteral nutrition. Crit Care Med. 2001;29(2):242-8. DOI: 10.1097/00003246-200102000-00003

99. Woodcock NP, Zeigler D, Palmer MD, Buckley P, Mitchell CJ, MacFie J. Enteral versus parenteral nutrition: a pragmatic study. Nutrition. 2001;17(1):1-12. DOI: 10.1016/S0899-9007(00)00576-1

100. Braunschweig CL, Levy P, Sheean PM, Wang X. Enteral compared with parenteral nutrition: a meta-analysis. Am J Clin Nutr. 2001;74(4):534-42.

101. Heyland DK, Montalvo M, MacDonald S, Keefe L, Su XY, Drover JW. Total parenteral nutrition in the surgical patient: a meta-analysis. Can J Surg. 2001;44(2):102-11.

102. Heyland DK, Dhaliwal R, Drover JW, Gramlich L, Dodek P. Canadian clinical practice guidelines for nutrition support in mechanically ventilated, critically ill adult patients. JPEN J Parenter Enteral Nutr. 2003;27(5):355-73. DOI: 10.1177/014860710302700535 5

103. Dhaliwal R, Jurewitsch B, Harrietha D, Heyland DK. Combination enteral and parenteral nutrition in critically ill patients: harmful or beneficial? A systematic review of the evidence. Intensive Care Med. 2004;30(8):1666-71. DOI: 10.1007/s00134-004-2345-y

104. McCowen KC, Friel C, Sternberg J, et al. Hypocaloric total parenteral nutrition: effectiveness in prevention of hyperglycemia and infectious complications - a randomized clinical trial. Crit Care Med. 2000;28(11):3606-11. DOI: 10.1097/00003246-200011000-00007

105. Lin MT, Saito H, Fukushima R, et al. Preoperative total parenteral nutrition influences postoperative systemic cytokine responses after colorectal surgery. Nutrition. 1997;13(1):8-12. DOI: 10.1016/S0899-9007(97)90871-6

106. Gil MJ, Franch G, Guirao X, et al. Response of severely malnourished patients to preoperative parenteral nutrition: a randomized clinical trial of water and sodium restriction. Nutrition. 1997;13(1):26-31. DOI: 10.1016/S0899-9007(97)90875-3

107. Bolder U, Ebers M, Tacke J, Löhlein D. Effekte einer unmittelbaren präoperativen Substratzufuhr auf das postoperative Stoffwechselverhalten. Aktuel Ernaehr Med. 1995;20:98-103.

108. Morlion BJ, Stehle P, Wachtler P, et al. Total parenteral nutrition with glutamine dipeptide after major abdominal surgery: a randomized, double-blind, controlled study. Ann Surg. 1998;227(2):302-8. DOI: 10.1097/00000658-199802000-00022

109. Fürst P. Effects of supplemental parenteral L-alanyl-L-glutamine (Ala-Gln) following elective operation - a European multicentre study. Clin Nutr. 1999;18:16.

110. Jacobi CA, Ordemann J, Zuckermann H, Docke W, Volk HD, Müller JM. Einfluss von Alanyl-Glutamin bei der postoperativen totalen parenteralen Ernährung auf die Morbidität unter besonderer Berücksichtigung der Immunfunktion: erste Ergebnisse einer prospektiv randomisierten Studie [The influence of alanyl-glutamine on immunologic functions and morbidity in postoperative total parenteral nutrition: preliminary results of a prospective randomized trial]. Zentralbl Chir. 1999;124(3):199-205.

111. Jiang ZM, Cao JD, Zhu XG, et al. The impact of alanyl-glutamine on clinical safety, nitrogen balance, intestinal permeability, and clinical outcome in postoperative patients: a randomized, double-blind, controlled study of 120 patients. JPEN J Parenter Enteral Nutr. 1999;23(5):S62-6. DOI: 10.1177/014860719902300516

112. Powell-Tuck J. Total parenteral nutrition with glutamine dipeptide shortened hospital stays and improved immune status and nitrogen economy after major abdominal surgery. Gut. 1999;44(2):155.

113. Mertes N, Schulzki C, Goeters C, et al. Cost containment through L-alanyl-L-glutamine supplemented total parenteral nutrition after major abdominal surgery: a prospective randomized double-blind controlled study. Clin Nutr. 2000;19(6):395-401. DOI: 10.1054/clnu.2000.0142

114. Karwowska KA, Szulc R, Dworacki G, Zeromski J. Influence of glutamine-enriched parenteral nutrition on nitrogen balance and immunologic status in patients undergoing elective aortic aneurysm repair. Clin Nutr. 2000;19:22.

115. Neri A, Mariani F, Piccolomini A, Testa M, Vuolo G, Di Cosmo L. Glutamine-supplemented total parenteral nutrition in major abdominal surgery. Nutrition. 2001;17(11-12):968-9. DOI: 10.1016/S0899-9007(01)00693-1

116. Fuentes-Orozco C, Anaya-Prado R, Gonzalez-Ojeda A, et al. L-alanyl-L-glutamine-supplemented parenteral nutrition improves infectious morbidity in secondary peritonitis. Clin Nutr. 2004;23(1):13-21. DOI: 10.1016/S0261-5614(03)00055-4

117. Novak F, Heyland DK, Avenell A, Drover JW, Su X. Glutamine supplementation in serious illness: a systematic review of the evidence. Crit Care Med. 2002;30(9):2022-9. DOI: 10.1097/00003246-200209000-00011

118. Jiang ZM, Jiang H, Fürst P. The impact of glutamine dipeptides on outcome of surgical patients: systematic review of randomized controlled trials from Europe and Asia. Clin Nutr Suppl. 2004;1(1):17-23. DOI: 10.1016/j.clnu.2004.07.009

119. Exner R, Tamandl D, Goetzinger P, et al. Perioperative GLY-GLN infusion diminishes the surgery-induced period of immunosuppression: accelerated restoration of the lipopolysaccharide-stimulated tumor necrosis factor-alpha response. Ann Surg. 2003;237(1):110-5. DOI: 10.1097/00000658-200301000-00015

120. Jing-Xiang S, Xiao-Huang T, Lie W, Chen-Jing L. Glutamine dipeptide-supplemented parenteral nutrition in patients with colorectal cancer. Clin Nutr Suppl. 2004;1(1):49-53. DOI: 10.1016/j.clnu.2004.07.010

121. Yao GX, Xue XB, Jiang ZM, Yang NF, Wilmore DW. Effects of perioperative parenteral glutamine-dipeptide supplementation on plasma endotoxin level, plasma endotoxin inactivation capacity and clinical outcome. Clin Nutr. 2005;24(4):510-5. DOI: 10.1016/j.clnu.2005.04.002

122. Lin MT, Kung SP, Yeh SL, Liaw KY, Wang MY, Kuo ML, Lee PH, Chen WJ. Glutamine-supplemented total parenteral nutrition attenuates plasma interleukin-6 in surgical patients with lower disease severity. World J Gastroenterol. 2005;11(39):6197-201.

123. Weimann A, Braga M, Harsanyi L, Laviano A, Ljungqvist O, Soeters P, Jauch KW, Kemen M, Hiesmayr JM, Horbach T, Kuse ER, Vestweber KH. ESPEN Guidelines on Enteral Nutrition: Surgery including Organ Transplantation. Clin Nutr. 2006;25(2):224-44. DOI: 10.1016/j.clnu.2006.01.015

124. Marin VB, Rebollo MG, Castillo-Duran CD, et al. Controlled study of early postoperative parenteral nutrition in children. J Pediatr Surg. 1999;34(9):1330-5. DOI: 10.1016/S0022-3468(99)90005-2

125. Shulman RJ, Phillips S. Parenteral nutrition in infants and children. J Pediatr Gastroenterol Nutr. 2003;36(5):587-607. DOI: 10.1097/00005176-200305000-00002

126. Mirtallo J, Canada T, Johnson D, et al. Safe practices for parenteral nutrition. JPEN J Parenter Enteral Nutr. 2004;28(6):S39-S70. DOI: 10.1177/0148607104028006S39

127. Deutsche Arbeitsgemeinschaft für künstliche Ernährung (DAKE), Österreichische Arbeitsgemeinschaft für künstliche Ernährung (AKE). Empfehlungen zur parenteralen Infusions- und Ernährungstherapie im Kindesalter. Klin Padiatr. 1987;199(4):315-7.

128. Albers MJ, Steyerberg EW, Hazebroek FW, et al. Glutamine supplementation of parenteral nutrition does not improve intestinal permeability, nitrogen balance, or outcome in newborns and infants undergoing digestive-tract surgery: results from a double-blind, randomized, controlled trial. Ann Surg. 2005;241(4):599-606. DOI: 10.1097/01.sla.0000157270.24991.71

129. Amii LA, Moss RL. Nutritional support of the pediatric surgical patient. Curr Opin Pediatr. 1999;11:237-40. DOI: 10.1097/00008480-199906000-00012

130. Kaufman SS. Prevention of parenteral nutrition-associated liver disease in children. Pediatr Transplant. 2002;6:37-42.

131. Sondheimer JM, Cadnapaphornchai M, Sontag M, Zerbe GO. Predicting the duration of dependence on parenteral nutrition after neonatal intestinal resection. J Pediatr. 1998;132(1):80-4. DOI: 10.1016/S0022-3476(98)70489-5

132. Weimann A, Kuse ER, Bechstein WO, Neuberger JM, Plauth M, Pichlmayr R. Perioperative parenteral and enteral nutrition for patients undergoing orthotopic liver transplantation: Results of a questionnaire from 16 European transplant units. Transpl Int. 1998;11 Suppl 1:S289-91.

133. Plauth M, Merli M, Kondrup J, et al. ESPEN guidelines for nutrition in liver disease and transplantation. Clin Nutr. 1997;16(2):43-55. DOI: 10.1016/S0261-5614(97)80022-2

134. Murray M, Grogan TA, Lever J, Warty VS, Fung J, Venkataramanan R. Comparison of tacrolimus absorption in transplant patients receiving continuous versus interrupted enteral nutritional feeding. Ann Pharmacother. 1998;32(6):633-6. DOI: 10.1345/aph.17181

135. Kuse ER, Kotzerke J, Muller S, Nashan B, Luck R, Jaeger K. Hepatic reticuloendothelial function during parenteral nutrition including an MCT/LCT or LCT emulsion after liver transplantation - a double-blind study. Transpl Int. 2002;15(6):272-7. DOI: 10.1111/j.1432-2277.2002.tb00165.x

136. Delafosse B, Viale JP, Pachiaudi C, Normand S, Goudable J, Bouffard Y, Annat G, Bertrand O. Long- and medium-chain triglycerides during parenteral nutrition in critically ill patients. Am J Physiol. 1997;272(4 Pt 1):E550-5.

137. Hasse JM, Blue LS, Liepa GU, et al. Early enteral nutrition support in patients undergoing liver transplantation. JPEN J Parenter Enteral Nutr. 1995;19(6):437-43. DOI: 10.1177/0148607195019006437

138. Rayes N, Seehofer D, Theruvath T, et al. Supply of pre- and probiotics reduces bacterial infection rates after liver transplantation – a randomized, double-blind trial. Am J Transplant. 2005;5(1):125-30. DOI: 10.1111/j.1600-6143.2004.00649.x

139. Pescovitz MD, Mehta PL, Leapman SB, Milgrom ML, Jindal RM, Filo RS. Tube jejunostomy in liver transplant recipients. Surgery. 1995;117(6):642-7. DOI: 10.1016/S0039-6060(95)80007-7

140. Rovera GM, Graham TO, Hutson WR, et al. Nutritional management of intestinal allograft recipients. Transplant Proc. 1998;30(6):2517-8. DOI: 10.1016/S0041-1345(98)00706-4

141. Li YS, Li JS, Jiang JW, et al. Glycyl-glutamine-enriched long-term total parenteral nutrition attenuates bacterial translocation following small bowel transplantation in the pig. J Surg Res. 1999;82(1):106-11. DOI: 10.1006/jsre.1998.5525

142. Jaksic T, Shew SB, Keshen TH, Dzakovic A, Jahoor F. Do critically ill surgical neonates have increased energy expenditure? J Pediatr Surg. 2001;36(1):63-7. DOI: 10.1053/jpsu.2001.20007

Please cite as
Weimann A, Ebener C, Holland-Cunz S, Jauch KW, Hausser L, Kemen M, Kraehenbuehl L, Kuse ER, Laengle F, Working group for developing the guidelines for parenteral nutrition of The German Association for Nutritional Medicine. Surgery and transplantation – Guidelines on Parenteral Nutrition, Chapter 18. GMS Ger Med Sci. 2009;7:Doc10.

This article is freely available from
http://www.egms.de/en/gms/2009-7/000069.shtml

Received: *2009-01-14*
Published: *2009-11-18*