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Total parenteral nutrition in pediatrics

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With 3 figures and 6 tables

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Parenteral nutrition in necessary whenever oral food intake is partly or completely disturbed. In these situations, the objective of this type of nutrition is to provide the organism with sufficient nutrients and maintain structure and growth. The supply of an optimum mixture of water, protein, carbohydrates, fats, minerals, vitamins, and trace elements is a prerequisite for this.

Even in the adult, any form of nutritional abstinence for more than 14 hours results in a catabolic metabolic state, i.e. a disturbed equilibrium of protein anabolism and catabolism. Here the catabolic rate is to the advantage of glucogenesis from amino acids. The so-called labile proteins (proteo-enzymes from the intestinal mucosa, pancreas, heart muscles, the lymphatic and hematopoietic system and the liver) are the first to be affected. The organism of the infant is even more seriously affected due to smaller energy reserves. Nutritional deficiency is most serious at this age (62) because brain growth is at a maximum during infancy (14, 15).

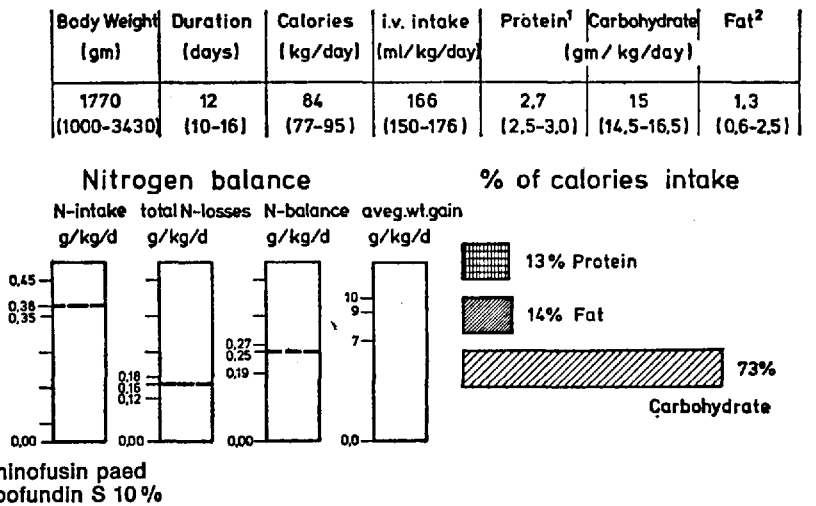
Fundamentals

The energy requirement (rest and growth requirement) is approx. 125 kcal/kg body weight per day in the first three months, approx. 120 in the second three months, approx. 100 in the second half year, approx. 80 for the infant and approx. 40 for children above this age. If this requirement is covered with an intravenous supply of 10 % glucose solution, then the calorie situation and metabolic efficiency of the disturbed organism improve, the desired calorie supply, however, is not achieved even with a higher supply of infusion solutions. The protein requirements are completely neglected although they should be at least 2.5–3.0 g/kg BW per day during the first weeks of life and 2.0–2.5 g/kg BW per day for infants (22, 28, 34). The administration of blood and plasma proteins (half-life 3 weeks) cannot cover the protein requirements. Although albumin can be used for short-term substitution of albumin losses, it cannot be used for "nutrition". If only amino acids are infused, however, they are wasted uneconomically instead of being utilized anabolically. Only the administration of all nutritional substrates together (table 1) results in an equilibrated energy and nitrogen balance (16, 17, 20, 21, 27, 30, 31, 32, 34, 36, 41, 52, 56, 63, 64).

Table 1. Approximate daily requirement of calories, water, and nutrients during total parenteral nutrition.

Age	Calories kcal/kg BW	Water ml/kg BW	Protein g/kg BW	Carbohydrates g/kg BW	Fat g/kg BW
Prematures	130	160	3.5–2.5	10–20	1–3
Newborns	120	160	3.0–2.5	10–20	1–3
Infants	110	150	2.5–2.0	10–20	1–3
1– 3 years	100	125	2.0–1.5	10–20	2–1
4– 6 years	90	100	1.5–1.0	10–15	2–1
7– 9 years	80	80	1.0	10–15	2–1
10–12 years	70	75	1.0	8–12	1
13–15 years	60	55	1.0–0.75	8–10	1
16–19 years	50	50	1.0–0.75	8–10	1

Amino acids (AA), carbohydrates (CH) and fat are regarded as a calorie source for the infant in a percent distribution corresponding to oral nutrition (10–20 % protein, 40–50 % carbohydrates, and 30–40 % fat). In practice, these proportions cannot be realized for the infant in every case of parenteral nutrition (fig. 1). Once the infant is older, the internationally recommended proportion of 20 % amino acids, 30 % fat and 50 % carbohydrates should be observed (19). Alcohols are not used as an energy source in pediatrics.



¹ Aminofusin paed
² Lipofundin S 10 %

Fig. 1. Infusion program, average daily nitrogen balance and average daily gain in body weight in 30 premature and newborn infants under total parenteral nutrition.

Amino acids

The free L-amino acids are the physiological form of nutritional protein transport in the organism, from which *all* endogenous proteins and peptides are synthesized. In addition, they are the physiological substrate that provides the nitrogen required under the conditions of parenteral nutrition. Amino acid solutions for parenteral nutrition (p. n.) of children should contain nitrogen exclusively in the form of physiological structural amino acids. The knowledge gained during oral as well as parenteral nutrition is used as a basis for the composition of L-amino acid mixtures (5, 22, 23, 24, 26, 36, 45, 46, 59). Protein hydrolysates (1, 60, 63) and L-amino acid solutions (36, 41, 54, 59) are available for parenteral nutrition. Protein hydrolysates are produced from protein (casein, fibrin) through enzyme action or acid hydrolysis and contain, in addition to the L-amino acids, at least 30 % of the peptide bound amino acids which induce side-effects – large peptides – (23, 25, 39) and are excreted to a high percentage inutilized via the kidney.

Today, synthetically produced crystalline L-amino acid mixtures are used for parenteral nutrition. As a nitrogen source, such preparations must contain the nine amino acids essential for the infant (isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine, histidine), the semi-essential amino acids (arginine, proline, tyrosine) and the non-essential amino acids (alanine, glycine, glutamic acid, serine, aspartic acid). Due to its essential character, histidine is most important for patients with uraemia and for children. There are indications that tyrosine is essential for prematures and young newborns and cystine for the fetus and premature infants (55). Glycine is also essential for premature infants.

Experimental studies showed a drastic improvement of the nitrogen balance through addition of nitrogen sources to amino acid mixtures (35). According to our studies (46) under the conditions of total parenteral nutrition, a similar improvement of the nitrogen balance is achieved in premature and newborn infants with an adequate supply of glutamic and aspartic acid. A nitrogen retention of 65 % was achieved, whereas only 57 % was achieved in a similar infusion program without the two dicarbonic acids. The requirement figures of dicarbonic acids established by us correspond closely to the amounts contained in mother's milk. As expected, a supply of 0.4 mg of free dicarbonic acids/kg BW per min. caused neither clinical nor metabolic disturbances (40, 41, 45, 46).

A supply of L-tyrosine and L-cystine (7) in excess of 60 mg/kg BW per day is difficult in parenteral nutrition because they are still insoluble in amino acid solutions.

L-arginine decreases the toxicity of free amino acids and their mixtures and is thus an essential ingredient of solutions supplying free amino acids. According to studies of adults under total parenteral nutrition (35), L-proline is an essential amino acid for the adult and most probably also for the child.

Taurine is not contained in any amino acid mixture because its function in parenteral nutrition is still unclear. Within the first days of life a significant decrease of the high values ($\bar{x}$ = 5.18 mg/100 ml, SD = 1.33) in the blood of the umbilical cord is evident, at the end of newborn

Table 2. Amino acid requirements under the conditions of parenteral nutrition using synthetic L-amino acids.

Amino acids	mg/kg BW/day (2.4–2.6 g/kg BW/day)	As a 5% amino acid solution (g/l)
Leucine	140–150	3.0
Isoleucine	120–130	2.6
Lysine	160–170	3.4
Methionine	70– 90	1.6
Phenylalanine	90–100	1.9
Threonine	80– 90	1.7
Tryptophan	40– 40	0.8
Valine	100–110	2.2
Histidine	50– 60	1.2
Tyrosine	40– 45	0.9
Cystine	25– 25	0.5
Arginine	180–200	3.8
Alanine	350–360	7.0
Glycine	180–200	3.8
Serine	60– 70	1.2
Proline	210–220	4.2
Aspartic acid	170–200	3.6
Glutamic acid	300–350	6.6
Total	2365–2610	50.0

period these values are $\bar{x} = 2.56$ mg/100 ml and SD = 0.7. Further studies regarding clarification will be conducted by us (is taurine essential?).

Table 2 shows the amino acid requirement determined by us under the conditions of parenteral nutrition. Amino acid solutions composed accordingly cause optimum nitrogen retention and little disturbance of the amino acid homeostasis (36, 45, 46). This requirement pattern within the physiological regulating range of ± 10 % maximum should therefore be the necessary basis for children.

The following nitrogen supply is desirable: 0.4–0.5 g of N/kg BW/day for infants, 0.3–0.4 g of N/kg BW/day for small children, and 0.2–0.4 g of N/kg BW/day for older children (5, 23, 41, 46).

Carbohydrates

Carbohydrates belong to the main sources of energy metabolism; their calories are utilized to meet the energy requirements. Glucose as well as the sugar substitutes fructose, sorbitol and xylitol may be used as substrates. The body has a high turnover capacity for these substances. The best utilization, however, is achieved with glucose, which is metabolized in all organs (including the brain), whereas fructose, sorbitol and xylitol are converted mainly into glucose in the liver.

The use of sugar substitutes in parenteral nutrition has raised recent controversy due to the known side-effects (lactate formation, increased bilirubin and uric acid levels, decreased ATP-content, oxalate deposits). These side-effects, however, are dose-dependent and do not occur when the dosage guidelines are observed. No side-effects were observed with the

recommended dosage of 0.1 g/kg BW per hour (0.25 g/kg BW per hour for adults) even in the newborn infant, provided that fructose intolerance did not exist (fructose-1,6-diphosphatase deficiency), in which case fructose infusions might be lethal (hepatic coma, liver necroses). The use of fructose (and sorbitol) for infants is therefore problematic without the respective anamnesis. Under the above-mentioned conditions, our studies of the lactate and uric acid level during parenteral nutrition indicated normal values. Presently (2), a combination of fructose : glucose : xylitol in a ratio of 2 : 1 : 1 is recommended for adults in a total dosage of 0.5 g/kg per hour. The advantages of fructose, sorbitol and xylitol (so-called glucose precursors) compared to glucose become evident in diabetes mellitus and in stress situations. Glucose tolerance during stress and sepsis is low. In postoperative stress, up to 40 % of the amounts infused are again excreted.

Maltose is not suited as a nutrient for parenteral nutrition. It produces osmotic diuresis (due to glucosuria) without raising the blood sugar level.

Fat

Fat as a nutrient fulfills two important requirements: it is a calorie source and a carrier of essential fatty acids. The use of fat in parenteral nutrition supplies higher calorie amounts in small fluid volumes than would be possible with carbohydrates and amino acids. Essential fatty acids in the form of phospholipids are an important part of the cell membrane structure and are found in many organs of the human body, especially the brain and the liver (38, 47). Two fatty acids, linoleic and linolenic acid, are now considered to be essential. Linoleic acid is biologically more active, but both are very important in the intermediary metabolism of the fatty acids as initial substances for many secondary products.

A decrease of essential fatty acids in the organism leads to deficiency symptoms such as dermatoses, growth retardation and thrombocytopenia (9, 10, 50, 51). They occur only after a long period of deficient linoleic acid supply; in the adult after about 6–8 weeks or later. Newborn and young infants, receiving fat-free parenteral nutrition, may develop such a deficiency more quickly because of their rapid growth and their small essential fatty acid depots. Our studies of premature and newborn infants receiving fat-free parenteral nutrition revealed that the essential linoleic acid decreases rapidly (48). Already on the 4th day of life there is a decrease to less than 50 % of the initial value. Similar results were found in the subsequent metabolic product, the arachidonic acid (48). 0.1 g linoleic acid/kg BW/day is required for the adult (10) to avoid deficiency symptoms. The linoleic acid supply of the infant and small child should be 4 % of the total calorie amount (61); this is equivalent to 0.4 g linoleic acid/kg BW/day. Our studies of newborns and infants receiving oral nutrition revealed an average linoleic acid requirement of 5–6 % of the total calories (47, 49). In subsequent studies we calculated the requirement of the young infant receiving parenteral nutrition to be 0.4–0.5 g linoleic acid/kg BW/day (42). This amount is contained in 8–10 ml of a 10 % fat solution (fig. 2).

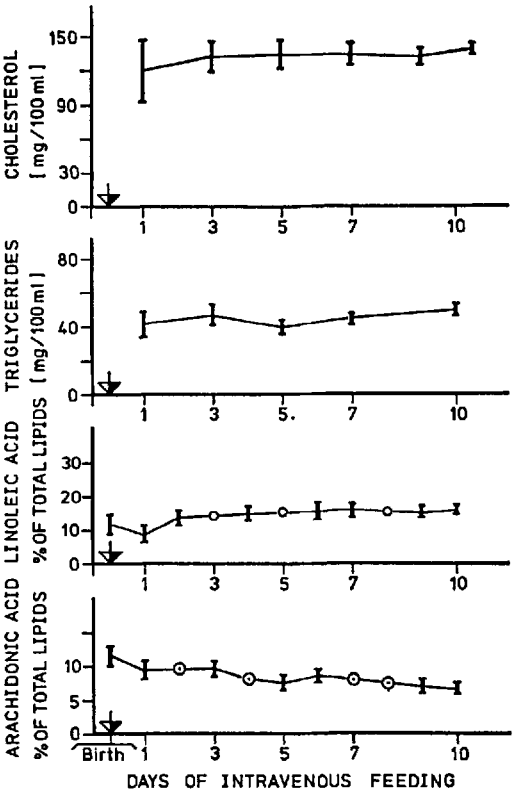


Fig. 2. Serum lipid profile (linoleic acid portion of total serum lipids, triglycerides, arachidonic acid and cholesterol) in 6 premature and newborn infants with TPN. Mean values and standard deviation.

The best results were obtained with fractioned soy bean oil due to greater tolerance. It contains approx. 85 % triglycerides of unsaturated fatty acids – mother's milk contains approx. 50 % – which are made up of 53.6 % linoleic acid, 8.0 % linolenic acid and 21.7 % oleic acid.

If the dosage given in table 1. the maximum infusion rate and the contraindications are observed, then side-effects are minor.

Indication for parenteral nutrition

Total parenteral nutrition over a longer period may become necessary in the following cases: a) premature and newborn infants with respiratory insufficiency, pronounced immaturity, malformation of the gastrointestinal tract, b) infants and small children with protracted diarrhea, malabsorption, severe burns, c) older children in unconscious states of various geneses, esophageal acid burns, after severe trauma, severe ulcerative colitis and after major abdominal surgery.

A partial short-term parenteral nutrition is necessary in: transitory hypoglycemia of newborns, hypotrophy of newborns, postpartal mal-

Table 3. Infusion solutions for parenteral nutrition.

Carbohydrate solutions
Glucose 5%, 10%, 20%, 50%
Levulose 5%, 10%, 40%
Xylitol 5%, 10%, 20%
Sorbitol 5%, 10%
Triofusin® 12%, 20%, 24%
Amino acid solutions
Aminofusin® paed 600, Aminofusin® paed 5% without carbohydrates; Aminoplasmal® L-5 without carbohydrates; Aminosol®-Glucose 3.3% (casein hydrolysate); Aminomel® LX 400; Vaminaco® 7%; Aminovenös® päd 6% without carbohydrates. (Except Aminosol crystalline L-amino acid preparations.)
Fat emulsions
Lipofundin® S 10%, 20%; Intralipid® 10%, 20%
Protein preparations
Human albumin 5%, 20%; Biseko® 5%

adaption, states of dehydration in infants and small children, the pre- and postoperative period, severe craniocerebral trauma, diabetic metabolic disturbances.

In disturbed renal function, the supply of amino acids must be reduced to 0.4 g/kg/day to meet the endogenous protein requirements.

Infusion program

As listed in table 1, the calorie requirement necessitates $1^1/_2$ to 2 times the basal metabolic rate.

Fluid losses due to severe *perspiration, low humidity, exsiccosis, fistulae, drainages, burns* and *fever* must be added to the calculation. The caloric requirement increase after major surgery, burns and traumas. With fever, an increased fluid requirement of 5–10 % per day is calculated per degree of temperature increase, up to 30 % per day after major operations, and 50–150 % per day in burns. Fluid deficit due to exsiccosis is determined at 50–150 ml/kg BW per day according to severity. The secretions from wounds, tubes, drainages, and fistulae can normally be exactly measured with the aid of affixed plastic bags, or by weighing the bandaging material. 10 ml/kg BW are calculated in hyperventilation (*Kussmaul*'s respiration, artificial respiration). Under normal conditions, the insensible perspiration is 600 ml/m² per day or 40 ml/kg BW per day on the average.

Table 3 shows the most important solutions for parenteral nutrition. Most amino acid solutions (Aminofusion paed and Aminovenös paed excluded) are conceived for the adult and can be used without a metabolic risk. "Aminofusin paed" is conceived for the infant and can be administered without disturbing the amino acid homeostasis (6, 36, 45, 54). Some of the

Table 4. Mineral and trace element requirements under long-term parenteral nutrition.

Minerals (mEq/kg BW/day)		Trace elements (μg/kg BW/day)	
Na	2–3	Iron	50–110
K	2–3	Zinc	20– 60
Cl	2–3	Copper	20– 30
PO_4	2–5	Manganese	10– 40
Ca	0.5–2	Chromium	1– 8
Mg	0.2–0,8	Fluorine	10– 20
		Iodine	2– 5

amino acid solutions listed here contain xylitol and/or sorbitol as carbohydrate components.

For short-term parenteral nutrition or if fat emulsions are excluded, amino acids and carbohydrates alone would suffice. The use of high-percent glucose requires a gradual glucose increase (adaptation process). In long-term parenteral nutrition, however, the use of fat emulsions is inevitable. The total daily amount of fat should be administered in 4 single doses, each within 1 1/2 to 2 hours, via a by-pass to the infusion (Y-piece).

The infusion program in short-term parenteral nutrition can be administered via the peripheral veins (11), the head, brachial or foot veins, and in long-term parenteral nutrition through the central veins (cava catheter). The access to the caval vein is made percutaneously (8, 13, 18) through the subclavian vein, external or internal jugular vein or the basilical vein.

In most solutions, the amount of some *minerals* is sufficient. Substitution should be made according to the requirements (table 4) and the serum levels. Increased amounts of potassium for protein synthesis in the cell and of calcium and phosphorus for rapid growth are necessary. Calcium should be administered in 3 separate portions.

Amino acid mixtures contain *vitamins* in sufficient amounts, nevertheless, the additional supply of a multi-vitamin preparation is desirable. Vitamin K should be administered twice a week (2–3 mg), vitamin D_3 (250–500 IU/day) and folic acid (0.5 mg/day) daily and vitamin B_{12} (100 μg) once a month.

Trace elements (table 4) are not added to the solutions; they are, however, present in small amounts due to "impurities". Our studies of various infusion solutions yielded the following values: zinc 1.2–4.2 mg/l, copper 0.05–0.2 mg/l, manganese 0.05–0.07 mg/l, iron 0.5–4.5 mg/l. These amounts do not suffice for the given indication and for long-term parenteral nutrition (33, 43, 44) and must be supplied separately in the form of plasma or whole blood transfusions (10–20 ml/kg, once a week) or in the form of trace elements for infants (Dr. Franz Köhler Chemie, Germany). Zinc, copper, manganese, chromium and silicon are inexchangeable enzyme activators, cofactors and stabilizers, that, when deficient in nutrition, lead to characteristic deficiency symptoms (3, 4, 37, 57).

Clinical and laboratory tests are necessary to monitor the infusion program during parenteral nutrition (table 5).

Table 5. Control plan during parenteral nutrition.

Clinical		
(daily)	(weekly)	(monthly)
Weight, edemas, tolerance, circulation control, take temperature several times, respiration, fluid balance (intake and output)	Head circumference (of infants), size of liver and spleen 3 times	Psychomotor development, length 2 times, wrist/X-ray every 3 months
Clinico-chemical		
Acid-base balance and blood sugar (after the 1st week 3 times weekly) test urine several times for glucose, acetone, specific gravity, pH	Na, K, Cl, osmolarity, urea 3–4 times, total protein and electrophoresis, transaminases, Ca, P, Hb, Hct 2 times, total blood count 1–2 times	Alkaline phosphatase 3 times, ammonia, iron, magnesium 2 times, zinc and copper 1 times

The most essential controls for parenteral nutrition are included in this plan. This program can be expanded according to the individual case requirements. In any case, the amino acid pattern, the fatty acid distribution in the serum and the total urinary nitrogen have to be tested in long-term parenteral nutrition. If fever develops, bacteriological tests such as blood and urine culture are necessary. After removal of the catheter, the tip must also be tested bacteriologically. Fat infusions necessitate controls of the coagulation status, fat clearance and leucocyte smear on fat granules.

Side-effects and their prophylaxis

The most frequent complications (table 6) which might interfere with parenteral nutrition are of technical, septical and metabolic nature (12, 13, 24, 29, 45, 53, 54, 58). Therefore, it is important to observe some basic rules and to take preventive measures in time to minimize any complications. Strict asepsis is mandatory for the insertion and care of the catheter as well as the infusion systems. The same applies to the production of the infusion mixtures.

The most frequent complication is a sepsis caused by bacteria or mycosis. Aseptic conditions (as discussed above), the use of a local antibiotic-

Table 6. Complications during parenteral nutrition.

I. Due to the catheter	II. Metabolic complications
Septic infection, thrombosis, phlebitis, occlusion of peripheral or central veins, local inflammations, faulty catheter placement, extravascular infusion	Imbalance, persistent glucosuria, dehydration, metabolic acidosis, hypoglycemia or hyperglycemia, hypoproteinemia, dermatoses, hypocalcemia, rickets, hypophosphatemia, hyperammoniemia

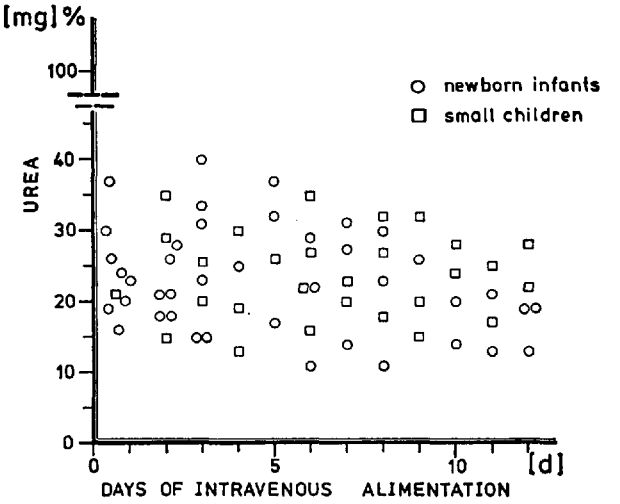


Fig. 3. For explanations see text.

antimycotic substance and regular blood cultures are part of the preventive measures. With the occurrence of fever, leucocytosis, thrombocyte decrease and positive microbial detection, the catheter must be removed immediately and chemotherapy initiated. We consider an antibiotic or antimycotic prophylaxis for the decrease of catheter infections to be unsuitable. The interposition of a Millipore filter to avoid infections is controversial. X-ray control of the catheter position when being placed is necessary to avoid faulty positioning and extravascular infusions. The insertion of a central venous catheter must only be performed by an experienced physician in the intensive care unit or in the operating room. Siliconized polyethylene catheters should be used. The rate of thrombosis and inflammation is thus significantly reduced (8).

Metabolic disturbances may result from imbalanced electrolyte and water metabolism. Improperly balanced amino acid solutions cause amino acid imbalances which might damage the organism of the infant. A protein supply of more than 3.5 g/kg BW may lead to azotemia (fig. 3). If the allowed carbohydrate amount is exceeded, an overburdened utilization mechanism results in the storage of carbohydrates, increase of serum bilirubin, serum uric acid (except when glucose is used) and lactate formation. High-percentage glucose intake can cause a glycosuria within the first two days of parenteral nutrition which, over a longer period, results in an osmotic diuresis with subsequent dehydration. Hyperglycemia, which usually occurs at the beginning of the infusion, can be avoided by a gradual increase of the glucose supply. If the blood sugar level is persistently over 250 mg/100 ml, then the administration of pure unmodified insulin (for instance insulin Novo Actrapid) 1 U per 3 g glucose is recommended. Hypoglycemia, which might occur after the end of the infusion, can be avoided through a gradual reduction of the glucose supply.

Hyperchloremic metabolic acidosis, which results from the supply of synthetic L-amino acids due to a cation excess (29, 32), was not observed. An improperly balanced electrolyte metabolism (such as too high a chloride concentration in infusion solutions) is, in our opinon, responsible for this occurrence. In any case, this disturbance constitutes no serious problem and can be successfully treated.

Hyperammoniemia may (25, 32, 41) develop from the administration of protein hydrolysates, which contain a high concentration of ammonium, and also from synthetic L-amino acid solutions which contain small amounts of arginine. Long-term parenteral nutrition requires control of the ammonia level in the blood. Hypophosphatemia was not observed in patients treated by us. This is explained by the fact that we supply phosphate, both inorganic (KH_2PO_4) and organic (in the form of phosphatides), together with the fat emulsion.

The administration of fat infusions is contraindicated in: hyperlipemia, liver damage, states of shock, decreased bone marrow function, disturbed blood coagulation, diabetes not treated with insulin, nephrotic syndrome, cerebral trauma, septic symptoms, and hyperbilirubinemia of premature and newborn infants.

After a 10-day fat supply, a 2–3 day interruption and the control of fat elimination are recommended. Heparin supplies of 50–100 IU/g of fat are appropriate for reduced fat clearance. Fat emulsions must not be mixed with electrolyte concentrates, other infusion solutions and drugs, they may, however, be administered simultaneously via by-pass (Y-piece).

The goal of better total parenteral nutrition is approached when dosage, infusion rate, contraindications, and the guidelines discussed here are observed. We will, however, continue to work for a further improvement of intravenous nutrition.

Summary

Parenteral nutrition (p.N.) is indicated whenever oral food intake is partly or completely disturbed. The objective of this type of treatments is to provide the organism with sufficient nutrients and maintain the structure and growth. The supply of an optimum mixture of water, protein, carbahydrates, fats, minerals, vitamins and trace elements is a prerequisite for this.

In the following parts of this study the indications for p.N., the technique and requirements for different nutrients, minerals, trace elements and vitamins are presented. A type of amino acid mixture especially prepared for pediatric use is prevented and new results of t.p.N. are discussed.

In the following parts of this study the indications for p.N., the tecnique and practice of the infusion programme, the clinical and laboratory investigation of t.p.N., the complications and their prophylaxis during the p.N. are discussed.

The goal of better total parenteral nutrition is approached when dosage, infusion rate, contraindications and the guidelines discussed here are observed. We will, however, continue the work for a further improvement of intravenous nutrition.

Zusammenfassung

In Situationen, in denen die orale Nahrungszufuhr erschwert oder nicht möglich ist, bietet sich der Weg der parenteralen Ernährung (p. E.) an. Der Sinn dieser Therapie ist es, den Organismus ausreichend mit Nährsustanzen zu

versorgen und Strukturerhaltung sowie Wachstum zu gewährleisten. Voraussetzung dazu ist die ausreichende kalorische Versorgung in einer optimalen Mischung aus Wasser, Protein, Kohlenhydraten, Fetten, Mineralien, Vitaminen und Spurenelementen.

Die Grundlagen der p. E. werden in einzelnen Abschnitten dargelegt und Bedarfszahlen für Nährstoffe, Mineralien, Spurenelemente und Vitamine angegeben. Ein bedarfsadaptiertes Aminosäurenmuster, konzipiert für die Pädiatrie, wird vorgestellt, und neue Ergebnisse im Rahmen der p. E. werden diskutiert.

Die weiteren Abschnitte befassen sich mit den Indikationen zur p. E., der Technik und Durchführung des Infusioisprogramms, den klinischen und Laborkontrollen zur Überwachung der totalen p. E. sowie mit den Komplikationen und deren Prophylaxe während der p. E.

Bei Beachtung von Dosierung, Infusionsgeschwindigkeit, Kontraindikationen und den hier besprochenen Richtlinien ist man dem Ziel einer besseren Durchführung der t. p. E. näher gekommen. Eine weitere Verbesserung der Infusionsernährung wird uns aber auch in Zukunft noch zu beschäftigen haben.

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