PROBLEMS IN TOTAL PARENTERAL NUTRITION IN PAEDIATRIC PATIENTS

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SYNOPSIS

Total parenteral nutrition (TPN) has been established as an important nutritional therapy for children who cannot tolerate enteral feeding in a variety of clinical situations. However, there are many problems inherent in this form of treatment. In the establishment of TPN therapy for children in the University Department of Paediatrics and Department of Paediatric Surgery, we had encountered a number of problems in the last four years. The purpose of this paper is to review some of these problems and to discuss the measures that we have adopted to prevent and to minimise these problems. The topics of discussion include problems on selection of patients for TPN therapy in children, the choice of feeding route, the complications of TPN therapy, the cost of TPN therapy, blood tests in children and the Nutrition Support Team.

INTRODUCTION

Total parenteral nutrition (TPN) is a major medical advancement in nutritional therapy in recent years. The first successful use of TPN in children was reported exactly forty years ago by Helfrick and Abelson (1) who infused hypertonic dextrose, a caesin hydrolysate, and a homogenized emulsion of olive oil and lecithin in an alternating manner to a marasmic infant for five days. They were able to demonstrate significant improvement of nutritional status in this infant. In the ensuing quarter of a century TPN in children was unsuccessful largely due to the inability of the

veins to tolerate the hyperosmolar infusates and the many toxic, allergic and metabolic side effects of protein hydrolysate and the early preparation of fat emulsions. In 1968, Duldrick and co-workers (2) at the University of Pennsylvania published the epochal work on TPN demonstrating convincingly for the first time the feasibility of supplying adequate energy and nutrients for normal growth and development by continuous infusion of hypertonic dextrose and amino acids through deep venous catheters. 1975 marked the new era of TPN as Intralipid, distributed by Cutter Laboratories, was approved for use in the United States. Subsequently other fat emulsions like Liposyn and Lipofundin were also added to the market.

In Singapore some form of parenteral alimentation, using the combination of 10% glucose, Sohamin solution containing the various 1-form aminoacids, postprandial plasma, electrolytes and vitamins, was administered to babies with intractable infantile diarrhoea in 1973 in the University Department of Paediatrics, Singapore General hospital (3). Subsequently, with the availability of safe intravenous emulsions, a more "complete" form of TPN was administered to our patients but only a selected few could benefit from this form of nutritional therapy because of its coast. TPN therapy at that time was rather haphazard and it was only after 1980, together with the Department of Paediatric Surgery, that more concerted effort by two of the departmental staff members who had then returned from The Hospital for Sick Children, Great Ormond street, London, was put into TPN therapy. Practical guidelines were set up for other staff members who helped to carry out the TPN therapy (4) and computer programs were written to simplify calculation of the TPN regimen (5). The organisation of the TPN team in the Department was possible largely due to the availability of amino acid infusate (Aminoplasmal-ped) and fat emulsion (Lipofundin-S 10 %) by the generosity of B. Braun in the initial phase of the TPN program. September 1983 marked the beginning of a new phase of TPN therapy in children when the Pharmacy of Singapore General Hospital helped to prepare the nutrient solutions under laminar flow condition for our two patients who underwent bone marrow transplantation under the supervision of Prof. Shimon Slavin from Hadassah University in Israel. Now whenever possible, the nutrient solutions are prepared by our Pharmacy.

The purpose of this review is to highlight some of the problems in TPN therapy in children as we encountered them in the last few years and to discuss our initial experience in solving some of these problems as new comers to the game of this sophisticated form of nutritional therapy. Problems related to special topics like TPN therapy in extremely premature babies, home TPN therapy in children and TPN therapy in special categories of children with acute renal failure, malignancy and extensive burn, however, will not be discussed because of lack of personal experience and also because of the controversial nature of some of these topics.

PROBLEMS OF PATIENT SELECTION

Although TPN is a potentially life saving therapy and is now an accepted practice, increasing experience has demonstrated numerous metabolic, mechanical and infectious complications which may be fatal in some instances. Therefore candidates for TPN therapy should be selected carefully and indications considered diligently. The decision to put a particular patient on TPN therapy is often difficult and is based essentially on clinical assessment according to the individual's state. Generally this form of treatment should only be considered when nutrition cannot be supported by enteral feeding, and when there is strong evidence to except that such a state will be prolonged and constitute a serious threat to the life or health of the patient. Its use for improved nutrition to maintain life or reduce morbidity has to be cautiously balanced against the many serious complications which frequently occur in TPN therapy.

TPN therapy is indicated for most patients who are unable to tolerate enteral feedings for a significant period of time (6). The important question is how long is this period of time. Some considered that four or five days without adequate oral nutrition is sufficient indication for TPN (7). We cannot subscribe to this view and would generally not consider TPN therapy unless it is reasonable to expect that enteral feeding is likely to be unsuccessful for a period longer than one week or when enteral feeding is proven to be not tolerated and the patient has significant degree of malnutrition.

Hence, patients with simple gastrointestinal operations for conditions like pyloric stenosis, intussusception without significant bowel resection, diaphragmatic hernia, etc. should not be put on TPN therapy routinely. Similarly infants who are being investigated for chronic diarrhoea should usually have a trial of enteral feeding with Isomil or Pregestimil, instead of rushing into TPN therapy hastily. Therefore, in a recent review in the University Department of Paediatrics and the Department of Paediatric Surgery, Singapore General Hospital, from May 1982 to May 1984, only 42 children were put on TPN therapy (Table 1). About half of these were neonates, slightly more than a third were younger and about 10% were older than one year of age. The average duration of therapy was 14 days with a range of 5 to 52 days. The main indications (Table 2) were bowel resection with ileus

TABLE 1
AGE OF CHILDREN RECEIVING TPN THERAPY

AGE	NUMBER	%
Less than 1 month	22	52.4
1 month to 1 year	16	38.1
Older than 1 year	4	9.5
TOTAL	42	100.0

TABLE 2
INDICATIONS FOR TPN THERAPY IN SINGAPORE CHILDREN

INDICATIONS	NUMBER
Bowel resection with ileus	29
Intractable infantile diarrhoea	5
Prematurity with ileus or enterocolitis	3
Massive omphalocoele	3
Bone marrow transplantation	2
TOTAL	42

(29 cases) followed by intractable infantile diarrhoea (5 cases), prematurity with ileus and enterocolitis (3 cases) and massive omphalocoele (3 cases). There were two patients who were put on TPN after bone marrow transplantation. We did not have any patients with chronic, inflammatory bowel disease which is extremely rate in Chinese children.

ROUTE OF DELIVERY — CENTRAL OR PERIPHERAL VEIN

There are two ways of delivering TPN to children, either by peripheral or central vein. Our current preference is to delivery TPN by peripheral vein. Central vein is used only when peripheral veins are exhausted or when prolonged TPN therapy is expected and high caloric input is required. Others have also suggested that satisfactory TPN can be achieved by peripheral veins (8, 9). The two biggest deterrants to central venous nutrition especially in small children are the problem of venous accessability and the complications associated with central venous catheterization.

Ziegler and co-workers (10) compared the complication rates among children receiving TPN via central and peripheral veins. Their findings are summarized in Table 3. Serious infective complication occurred in about 10% of the patients in the central vein group but none in the peripheral vein group. Metabolic complications were also more frequent in the central vein group. However, morbidity related to solution administration was more prevalent in the peripheral vein group. The peripheral vein group suffered primarily soft tissue sloughs, whereas such complications like pleural effusion and thrombosis occurred in the central vein group. The overall complication rates were greater and more serious in the central vein group, but the complication rate per patient day was equal in the two groups.

The relative merits of the two venous routes are listed in Table 4. In summary, TPN therapy by peri-

TABLE 3
COMPLICATIONS OF TPN THERAPY:
CENTRAL VERSUS PERIPHERAL VENOUS ROUTE

DETERMINANT	CENTRAL VEIN	PERIPHERAL VEIN
Number of patients	200	385
Mean duration (days)	33.7	11.4
Therapy days	6629	4389
Percent who maintained or gained weight	82.5%	63%
Complications		
Infections	21	0
Administration	7	32
Metabolic	12	3
Complication rate		
Total number	40 (20%)	35 (9.1%)
Per patient day	0.60%	0.79%

Source: Ziegler et al: Route of paediatric parenteral nutrition : Proposed criteria revision. J Pediatr Surg 1980; 15: 472.

TABLE 4
RELATIVE MERITS OF TPN THERAPY BY CENTRAL AND PERIPHERAL VENOUS ROUTES

RELATIVE MERITS	CENTRAL VEIN	PERIPHERAL VEIN
Ease of insertion	No	Yes
Serious infections	+ + +	+
Mechanical complications	+ + +	–
Local complications	+	+ + +
Metabolic complications	+ +	+
Caloric density	higher	lower
Fat requirement	lower	higher

pheral vein appears to be safer with less serious complications. However, the caloric density of the infusate is lower than that could be supplied by the central venous route. Furthermore with frequent peripheral vein infiltrations, the amount of calories actually infused is often less than ordered (11). Thus, if minimal stress is present and only a brief course of maintenance therapy, without full growth and development, is the therapeutic goal, the peripheral route is appropriate. In the stressed, growing child, for whom prolonged therapy is projected, TPN by central venous route is the treatment of choice (10, 12).

PROBLEMS OF COMPLICATIONS IN TPN THERAPY

The list of complications during TPN therapy is rather lengthy and can be broadly divided into two main categories, namely catheter related and infusate related complications as shown in Table 5. The mechanical complications are secondary to central venous catheterization. These occur not only at the time of catheter insertion, but are also associated with ongoing catheter use. Infusate related complications are due to metabolic abnormalities like carbohydrate and protein dysmetabolism, electrolyte disturbances, organ dysfunction, especially impairment of liver function and azotaemia, deficiency of essential nutrient like essential fatty acid and trace element.

If all the major and minor complications during TPN therapy by central vein are included, the overall reported incidence may be as high as 70% and death attributable to TPN has occurred in about 9% of 118 patients In a particular series reported by Heird et al (13) (Table 6). It is important to note that septicaemia occurred in 37% of the cases. Although this series of cases was published 10 years ago, it serves to remind us of the seriousness of the complications.

The major complications that were observed in the 42 patients in our series are listed in Table 7. Septicaemia occurred in about a quarter of them and episodes of hypoglycaemia and hyperglycaemia were very frequent. Metabolic acidosis and liver function abnormalities were detected in more than one fourth of the cases. Electrolyte disturbances were also quite common and raised blood urea occurred in 7% of these cases.

MEASURES TO MINIMISE COMPLICATONS

Although we fortunately did not have any death as a result of TPN in this particular review, but the complications in our patients as well as those reported in the literature were rather frequent and potentially very serious. How then could we minimise these complications? The measures to reduce the complications of TPN therapy in children are listed in Table 8.

Stringent criteria should be applied in the selection of patients for TPN therapy, so that unnecessary complications would not occur in patients whose nutritional needs could be otherwise adequately met by the enteral route. Peripheral vein should be used instead of central vein as far as possible unless other advantages of TPN by central vein outweigh its other serious disadvantages. Thirdly, personnel skilled in central venous catheterization should be called to do the job rather than an occasional operator. Even for peripheral venous cannulation, experienced paediatric trainees rather than inexperienced house officers should be called to the job. Recently a two month old infant with intractable diarrhoea was initially put on TPN by the peripheral vein. He was subsequently put on central venous TPN and three days later he suddenly collapsed and chest roentgenogram showed dense opacification of the right hemithorax with shift of the

TABLE 5
RECOGNIZED COMPLICATIONS OF TPN THERAPY

CATHETER RELATED	INFUSATE RELATED
1. Septicaemia	1. Phlebitis
2. Mechanical complications	2. Hyperglycaemia/hypoglycaemia
a. Pneumothorax	3. Electrolyte disturbance
b. Catheter dislodgement & extravasation	4. Metabolic acidosis
c. Injury to heart	5. Hypophosphataemia
d. Catheter embolisation	6. Hyperammonaemia
	7. Azotaemia
	8. Heart failure
	9. Hepatic dysfunction
	10. EFA deficiency
	11. Trace element deficiency
	12. Others
	a. Fat overload
	b. Nephromegaly
	c. Nephrolithiasis

TABLE 6
FREQUENCY OF COMPLICATIONS DURING TPN THERAPY IN PAEDIATRIC PATIENTS

		NO.	%
Patients reported		118	100
Deaths attributable to TPN therapy		10	9
Total complications reported		81	70
a. Complications related to catheter	61		
1. Septicaemia	44		
2. Thrombosis of major vessels	3		
3. Plugging or dislodgement of catheter	6		
4. Improper catheter placement	1		
5. Extravasation of fluid	4		
6. Local skin infection	3		
b. Complications related to infusate	20		
1. Persistent significant glycosuria	5		
2. Dehydration	3		
3. Acidosis	1		
4. Postinfusion hypoglycaemia	2		
5. Skin rash	2		
6. Hypocalcaemia	1		
7. Hypokalaemia	1		
8. Radiologic bone changes	4		
9. Hepatic changes	1		

Source: Heird WC, Driscoll JM Jr, Schullinger JN, et al: Intravenous alimentation in paediatric patients. J Pediatr 1972; 80: 351.

TABLE 7
COMPLICATIONS OF TPN THERAPY IN SINGAPORE CHILDREN

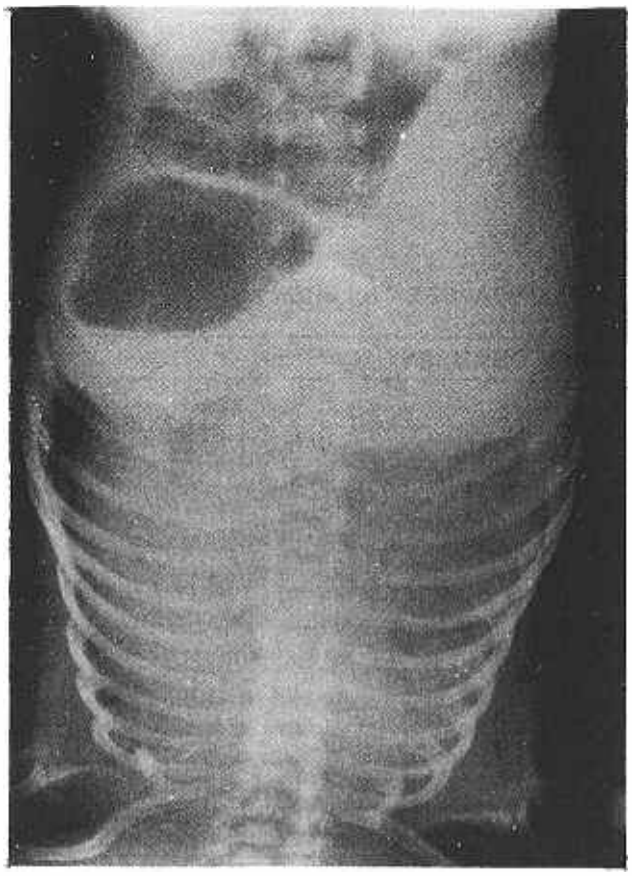
COMPLICATIONS	NO. OF CHILDREN	%
Septicaemia	10	23.8
Metabolic complications		
Hyperglycaemia	24	57.1
Hypoglycaemia	17	40.5
Metabolic acidosis	12	28.6
Azotaemia	3	7.1
Electrolyte disturbances		
Hyponatraemia	22	52.4
Hypokalaemia	15	35.7
Hyperkalaemia	7	16.7
Hypochloraemia	8	19.0
Hyperchloraemia	6	14.3
Hepatic dysfunction	10	23.8

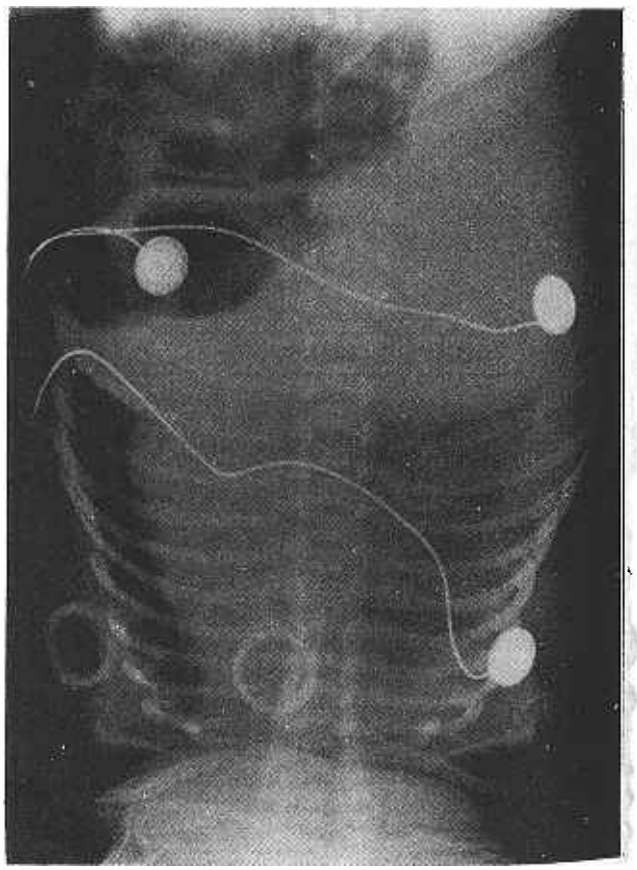
TABLE 8
MEASURES TO REDUCE THE COMPLICATIONS OF TPN THERAPY

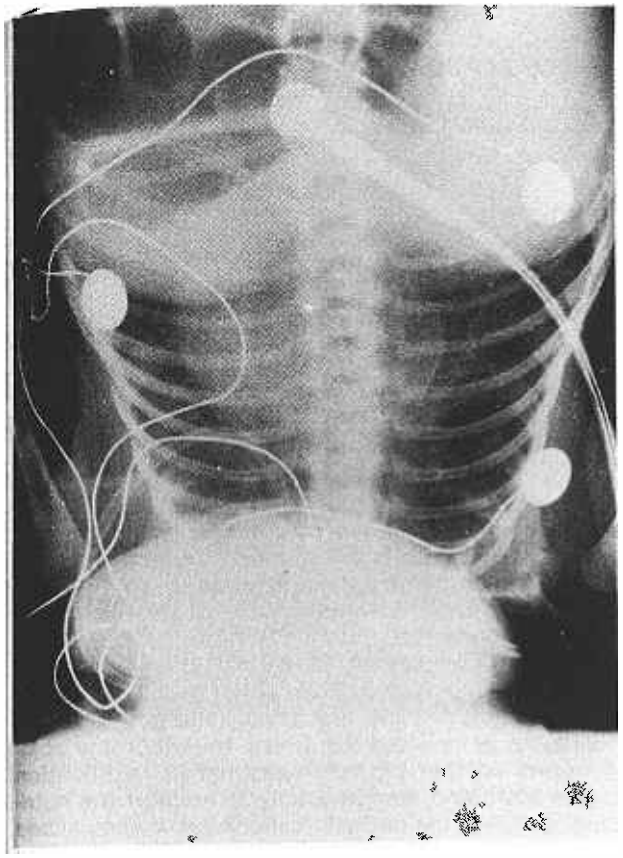
1. Careful selection of patients — more stringent criteria.
2. Use peripheral vein instead of central vein, unless otherwise indicated.
3. Experienced personnel to catheterize central vein and to insert infusion line to the peripheral vein.
4. Careful calculation and writing of orders for parenteral nutrition solutions with the aid of microcomputer.
5. Strict aseptic technique in the insertion and care of the venous infusion line and preparation of the infusate.
6. Careful monitoring for complications by following a strict protocol.
7. Prompt rectification of complication and thorough investigation and aggressive treatment of septicaemia.
8. Early weaning to partial and eventually complete enteral feeding.

Electrolytes — Na, K, Cl, Ca, Mg,

mediastinum (Figure 1). He was in great respiratory distress and blood gases showed severe hypoxaemia, hypercarbia and mixed acidosis. He was intubated and sixty ml of fluid was aspirated from the right pleural space (Figure 2). Fortunately, the right lung re-expanded (Figure 3) and he was lucky to survive this major catastrophe. However, this reminded us once again the very serious potential complication of central venous TPN.







Writing parenteral nutrition orders is not an easy task as there are many factors need to be considered (Table 9), eg. patient's weight and caloric requirement and the recommended daily allowance of the individual components of the parenteral nutrition solutions. Mistakes in the calculation and omission of important components of the TPN will spell disaster for the patient. Basically, parenteral nutrition solutions can be ordered using either of two basic formats, tailored or standardized (Table 10). Tailored solutions are formulated specifically to meet the daily requirements of the individual patient, whereas standardized solutions are designed to provide a formulation that meets the majority of the nutritional needs of those patients with stable biochemical and metabolic parameters. When we first started, specific orders of TPN solutions were written specifically for the individual patients. As more and more patients were put on TPN therapy, these mental exercises became more and more taxing and mistakes tended to occur more frequently. Hence we later opted for standardized solutions using various concentrations of dextrose, saline, Aminoplasmal-ped, Lipofundin-S 10% and various electrolyte solutions and vitamins. With the aid of the microcomputer (5), the calculations are greatly simplified and minor modifications from the computer print-out can be manually adjusted to suit the individual needs.

Spticaemia is a very serious complication in a child who is on TPN therapy as it often carries a high mortality. Hence prevention of septicaemia is of utmost importance (Table 11). Strict aseptic technique in the insertion and maintenance of the venous line cannot be over stressed. It is absolutely important to observe

TABLE 9
FACTORS TO BE CONSIDERED IN WRITING PARENTERAL NUTRITION ORDER

PATIENT FACTORS	TPN FACTORS
1. Weight	1. Carbohydrate — dextrose
2. Caloric requirement	2. Protein — amino acids
3. Recommended allowance & special requirement	3. Fat emulsion
	4. Electrolytes — Na, K, Cl, Ca, Mg, P
	5. Vitamins
	6. Trace elements

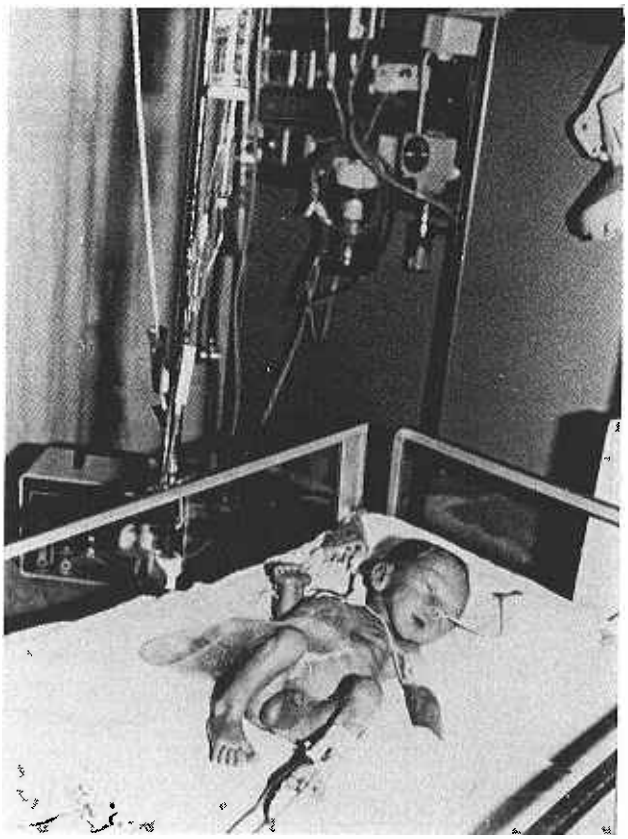
TABLE 10
METHODS IN WRITING PARENTERAL NUTRITION ORDERS

TAILORED SOLUTIONS	STANDARDIZED SOLUTIONS
1. For individual patients	1. For general patients
2. Cater for specific needs	2. Cater for general needs
3. More flexibility	3. Less flexibility
4. Tedious calculations	4. Simpler calculations

TABLE 11
MEASURES TO REDUCE THE RISK OF SEPTICAEMIA

1. Avoid central venous line if possible.
2. Strict aseptic technique in the insertion and maintenance of the venous line.
3. Use separate venous line for administration of drugs and blood samplings.
4. Avoid multiple 7 connections.
5. Strict aseptic technique in the mixing of the nutritional solutions under laminar flow condition.

that the venous line is only for delivery of the parenteral nutrition solutions and it is not meant for administration of antibiotics or other medications or for blood samplings. Avoid multiple Y connections as far as possible as these are good entry points for micro-organisms (Figure 4). Ideally, the various nutritional solutions should be pre-mixed under laminar flow condition (Figure 5) to avoid contamination. With the aid of the hospital, pharmacy, we are now spared the headache of mixing the various solutions ourselves and hopefully with less risk of septicaemia.



Complications during the TPN therapy are bound to occur despite the most careful precautionary measures. Hence careful monitoring with a strict protocol is absolutely essential. We personally feel that if this cannot be done, then the patient should not be put on TPN therapy in the first place. The goal of close monitoring is two-fold, i.e. firstly to detect any complications so that prompt measures of rectification can be instituted, and secondly to monitor the nutritional status of the patient. A check list of clinical and laboratory parameters for close monitoring during TPN therapy currently used in the University Department of Paediatrics is shown in Table 12.

Once any complications is detected, this should be promptly treated and depending on the nature of the complication, TPN therapy may have to be modified or temporarily interrupted until the complication is removed. Of all the complications, we would like to highlight septicaemia and discuss a little further the problem of fever occurring in a child on TPN therapy with a central venous line. This is because the incidence of infection in children has remained as high as 15% even in recent years (14) although a dramatic decline in incidence of infection from 14-37% (15) to as low as 2% (16) has been observed in adult patients.

Fever in a patient receiving TPN via central vein presents a dilemma. It is undesirable to remove the central line on the one hand, but it is hazardous to permit an infected line to remain in place on the other. The crux of the matter is, when is septicaemia a likely complication because fever can be due to many other causes. Clinical features suggestive of septicaemia include persistent temperature spikes above 38.4°C every 12 to 24 hours, chills, sudden glucose intolerance (gylcosuria, elevated serum glucose), leukocytosis, failure to gain weight, deteriorating clinical or mental status, hypotension and oliguria. A suggested protocol (15, 17) to deal with this problem is as follows.

(1) TPN solution, intravenous tubing and filter are replaced, but the catheter is left in place and TPN is continued.
(2) Three blood cultures are obtained at the peak of the febrile spikes during the next 24 hours.
(3) Other sources of infection are sought: drip site, nose, throat, ears, sinuses, lungs, abdomen, urinary tract and brain (when indicated).
(4) If a source of infection is found, treat appropriately.
(5) If fever continues and the cause is still obscure

TABLE 12
A CHECK LIST FOR CLOSE MONITORING

FREQUENCY	CLINICAL AND LABORATORY PARAMETERS
Daily	Body weight
	Intake-output
	*Blood sugar
	*Urine sugar & acetone
	Urine specific gravity or osmolality
	Serum turbidity
Twice weekly	Full blood count
	Blood urea, creatitine, electrolytes, bicarb
	Blood gases
Weekly	Length, triceps skinfold, arm circumference
	Head circumference
	Liver function test
	Triglyceride, cholesterol
	PT, APTT
	Blood ammonia
	Urine urea, creatinine
Monthly	Peripheral blood film
	Serum iron, total iron binding capacity
	Serum folate, B12
	Serum immunoglobulins
When indicated	Group and cross matching of blood
	Blood culture & full septic work up
	Culture of the tip of the central venous catheter whenever it is removed or when septicaemia is suspected

* Every 6 hourly initially then daily

TABLE 13
NUTRITION SUPPORT TEAM

Clinician	: a.	Provide consultation & patient assessment
	b.	Conduct rounds & supervision of administration
	c.	Update guidelines of TPN therapy
	d.	Education of health care professionals
	e.	Organise research projects & conferences
Pharmacist	: a.	Assist in initiating, maintaining & monitoring patients
	b.	Preparation of nutrient solutions
	c.	Assist clinician in his functions
Dietitian	: a.	Complete nutritional assessment
	b.	Recommend patient-specific enteral feeding regimen
	c.	Provide nutritional care plan on discharge
	d.	Assist clinician in his functions
Nurse	: a.	Implement & assist in the practical procedure
	b.	Provide specialised nursing care
	c.	Record & review clinical, laboratory & microbiological data
	d.	Assist clinician in his function

after another 24 to 36 hours, the TPN catheter is assumed to be infected. Blood culture (for both aerobic and anerobic organisms) is then taken through the catheter. The catheter is removed and the tip is cultured for bacteria and fungi. Broad spectrum antibiotics like combination of ampicillin and gentamicin are initiated before culture results. Frequently TPN can be restarted soon in the opposite subclavian vein or by peripheral vein.

In view of the many complications associated with TPN therapy, it is important to switch to enteral feeding as soon as the gastrointestinal tract is ready. Great care, however, must be taken during the transition from parenteral to enteral feedings (Table 13). One must avoid giving either excessive or insufficient fluids during the transition period by carefully calculating the portions to be administered via the enteral and parenteral routes combined. The change should be gradual and oral feeds of small volume (e.g. 30 ml/kg/day) and low concentration (e.g. 1/4 strength) should be tried first. This is given in addition to the full TPN therapy. If this is tolerated the concentration of the oral feed is gradually increased to full strength. The volume is then gradually increased with corresponding reduction of the parenteral infusion. The goal during this transition period is to achieve a total intake of 3 g/kg/day of amino acid plus protein, a caloric intake of 120 cal/kg/day and a total fluid intake of 150 ml/kg/day. When 70 to 80% of the total above requirement can be achieved by the anteral route, the dextrose-amino acid and fat emulsion can be stopped. 10% dextrose is administered followed by 5% dextrose before total cessation of TPN therapy. During this transitional period, close monitoring, especially of blood glucose level, is very important because of the danger of hypoglycaemia.

The special infant formulae that we have been using for enteral feeding after TPN therapy in our Department are Pregestimil, Nutramigen, Isomil, and Prosorbee (Table 14). Recently Ensure is also available in our Pharmacy. All are lactose-free. We tend to use Pregestimil as the first enteral formula after TPN therapy as many of those infants with intractable diarrhoea are also intolerant to soy protein. There is little to choose between Pregestimil and Nutramigen except that the latter contains sucrose and the osmolality is higher. Ensure is a predigested diet. The caloric density is quite high, almost 1 cal/ml. However, the osmolality is also high.

For infants older than 4 to 5 months of age, after starting them on special infant formula, we also enlist the help of the dietitian to prepare a simple diet consisting of protein in the form of comminuted chicken or fish, MCT oil and porridge with supplement of vitamins. It is important that the clinical dietitian is actively involved in the nutritional therapy after TPN therapy in the hospital as well as at home after discharge from the hospital.

OTHER PROBLEMS IN TPN THERAPY IN CHILDREN

There are still many other problems in TPN therapy in children. Three among these, namely the problems of blood tests, cost and the Nutrition Support Team deserve further attention.

The problem of blood tests is very pertinent to paediatric patients on TPN therapy. Using the current method of assay, for full monitoring in the beginning of the TPN therapy, approximately 35 to 40 mls of blood is required and this works out to be about 1/6 of the blood volume of a 3 kg infant. Hence frequently we have to give blood or to economise on blood sampling. The only solution is to use micro method if we want to have strict monitoring of the tiny infants on TPN therapy.

Cost is perhaps one of the most important problems for those contemplating TPN therapy. The current estimated cost for a 3 kg baby on full TPN therapy is S$30.0 per day and for an average adult, it works out to be S$70.0 per day by Miss Maureen Low, Pharmacist, Singapore Hospital. This cost, however, does not include salary of the staff members and the cost of all the laboratory and microbiological tests. As TPN

therapy is very expensive, ultimately only the hospital could pay for the bill. However, unless the hospital is convinced of its importance, we would have to find other solutions. When we first started TPN therapy, those patients who could afford it paid for the cost of TPN solutions. B. Braun has been very generous in the support of our TPN program and has sponsored many cases. Now as the hospital is convinced of its importance, the cost is absorbed by the hospital. However, for speical projects, we could apply for research grant from the University or the Ministry of Health. This is only possible if we have a good organisation in the form of a Nutrition Support Team.

Finally we must stress that it is impossible to administer TPN therapy properly if we do not have a Nutrition Support Team. This should consist of the clinician, pharmacist, dietitian and the special nurse. The clinican's specialty interest is of little importance. He may be a paediatrician, surgeon, anaesthetist or gastroenterologist. The major requirements are an interest in the general problems of parenteral nutrition and an intimate knowledge of metabolism, nutrition and the specific disease entity for which TPN therapy is administered. In the beginning when we first started TPN therapy in children, the paediatricians had to do all the jobs listed in Table 15 including training of the nurses. Now, the hospital pharmacists are helping us in the preparation of the nutrient solutions and some of our staff nurses are better trained. The job has been a litle easier for us. However, further progress can only come about if we have proper supervision of TPN therapy for all the patients with close monitoring, proper documentation of the progress and analysis of the results and complications of the TPN therapy. To achieve this purpose, the Nutrition Support Team must be firmly established and individual members must carry out their specific roles (Table 13). We are sure that the administrative problems can be solved.

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REFERENCES

1. Helfrick FW, Abelson NM: Intravenous feeding of a complete diet in a child. J Pediatr 1944; 25:400.
2. Dudrick SJ, Wilmore DW, Vars HM, et al: Long term total parenteral nutrition with growth, development and positive nitrogen balance. Surgery 1968; 64:134.
3. Wong HB, Phua KB: Parenteral alimentation in malignant diarrhoea. J Singapore Paediatr Soc 1973; 15:1.
4. Yip WCL, Tay JSH, Ho TF, Wong HB: Total parenteal nutrition in paediatric practice. J Singapore Paediatr Soc 1984; 26:59.
5. Yip WCL, Tay JSH, Ho TF, Wong HB, Ngiam TE: Computers in Paediatrics — II. Microcomputer programs in paediatric practice. J Singapore Paediatr Soc 1984; 26:51.
6. Levy JS, Winters RW, Heird WC: Total parenteral nutrition in paediatric patients. Pediatrics in Review 1980; 2:99.
7. Kerner JA: Indications for parenteral nutrition in paediatrics. In: Kerner JA, ed. Manual of paediatric parenteral nutrition. New York: John Wiley & Sons. 1983, p. 3.
8. Grotte G, Jacobsen S, Wretlind A: In: Fischer JE. ed. Total parenteral nutrition. Boston: Little Brown & Co. 1980, p. 335.
9. Jeejeebhoy KN, Close M: Total parenteral nutrition by peripheral venous infusion. Acta Chir Scand (Supply) 1980; 507:419.
10. Ziegler M, Jakobowski D, Hoelzer D, et al: Route of paediatric parenteral nutrition: Proposed criteria revision. J Paediatr Surg 1980; 15:472.
11. Faubion WC, Wesley JR, Coran AG: Calories ordered versus calories received in 20 neonates on peripheral parenteral nutrition. JPEN 1980; 4:592.
12. Heird WC: Panel report on nutritional support of paediatric patients. Am J Clin Nutr 1981; 34:1223.
13. Heird WC, Driscoll JM Jr, Schullinger JN, et al: Intravenous alimentation in paediatric patients. J Pediatr 1972; 80:351.
14. Ward J, TPN infection: Prevention in sick children. ASPEN 6th Clinical Congress, San Francisco, 1982.
15. Andolina AS, Septic complications. In: Kerner JA. ed. Manual of paediatric parenteral nutrition. New York: John Wiley & Sons. 1983, p. 217.
16. Maki DG: Nosocomial bacteraemia: An epidemiologic review. Am J Med 1981; 70:727.
17. Hodges RE: Total parenteral nutrition. An important therapeutic advance. Post Med 1979; 65:171.