ARTICLE

Total Parenteral Nutrition Practices in Canadian Neonatal and Pediatric Care Units: Results of a Survey

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ABSTRACT

Objectives: To describe formulations and practices for total parenteral nutrition in the neonatal and pediatric units of Canadian hospitals.

Methods: Hospitals with a neonatal or pediatric care unit (or both) were identified through the *Guide to Canadian Health Care Facilities*. Those where the working language was not English and those with fewer than 10 pediatric beds were excluded. A 72-item questionnaire was mailed to a designated health care professional at each hospital, and a reminder letter was sent 2 months later.

Results: Thirty (71%) of the 42 eligible hospitals returned a total of 41 questionnaires, 25 for neonatal nutrition and 16 for pediatric nutrition. Approximately half of the hospitals had a printed handbook of guidelines for total parenteral nutrition. A variety of products were used in the hospitals. The choice at a given hospital usually depended on cost (for lipid solutions) and on recommendations in the scientific literature and previous experience (for amino acid solutions). Physicians, dietitians, and pharmacists were the primary professionals involved in total parenteral nutrition. A team approach was favoured by 31 (76%) of the 41 respondents, yet only 16 (39%) of the 41 units had such teams. All 16 respondents from pediatric units and 24 (96%) of the 25 respondents from neonatal units thought that standardization of practices and formulations across Canada was important.

Conclusions: The finding that formulations and practices for total parenteral nutrition varied widely across Canadian hospitals and the opinions of respondents support the establishment of minimum national standards for total parenteral nutrition in neonates and children.

Key words: neonatal, pediatric, total parenteral nutrition, practices

RÉSUMÉ

Objectifs : Décrire les formules et les modalités de nutrition parentérale totale dans les unités de soins néonatals et pédiatriques des hôpitaux du Canada.

Méthodes : Les hôpitaux dotés d'unités de soins néonatals ou pédiatriques (ou des deux) ont été identifiés à partir du *Guide des établissements de santé du Canada*. Les hôpitaux dont la langue de travail n'était pas l'anglais et ceux de moins de 10 lits pédiatriques ont été exclus. Un questionnaire de 72 questions a été posté aux professionnels de la santé désignés pour chaque hôpital et une lettre de rappel leur a été envoyée deux mois plus tard.

Résultats : Des 42 hôpitaux admissibles à participer à l'étude, 30 (71 %) ont retourné un total de 41 questionnaires ; 25 sur la nutrition néonatale et 16 sur la nutrition pédiatrique. Environ la moitié des hôpitaux possédaient des lignes directrices imprimées sur la nutrition parentérale totale et les hôpitaux utilisaient une variété de produits. Le choix de ceux-ci dépend habituellement du coût (pour les solutions de lipides) ainsi que des recommandations trouvées dans la documentation scientifique et l'expérience (pour les solutions d'aminoacides). Les médecins, les diététiciens et les pharmaciens étaient les principaux professionnels de la santé qui intervenaient en matière de nutrition parentérale totale. Une approche multidisciplinaire était favorisée par 31 (76 %) des 41 répondants, alors que seulement 16 (39 %) des 41 unités avaient une équipe multidisciplinaire à cette fin. Tous les 16 répondants des unités de soins pédiatriques et 24 (96 %) des 25 répondants des unités de soins néonatals estimaient qu'il était important de standardiser les formules et les modalités de nutrition parentérale totale au Canada.

Conclusions : Les constatations à l'effet que les formules et les modalités de nutrition parentérale totale varient grandement dans les hôpitaux du Canada et les opinions des répondants confirment le besoin de mettre sur pied des normes nationales minimales en matière de nutrition parentérale totale chez les nouveau-nés et chez les enfants.

Mots clés : néonatal, pédiatrique, nutrition parentérale totale, modalités

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INTRODUCTION

Total parenteral nutrition (TPN) is a form of IV feeding used to supply nutrition to patients unable to tolerate oral or enteral feeding. TPN solutions should be tailored to the patient's clinical status, energy expenditure, and growth patterns, to ensure that appropriate nutrients are supplied.[1] A nutritionally adequate solution consisting of fluids, carbohydrates, protein, lipids, electrolytes, vitamins, and trace elements can be easily administered to most patients. Additional considerations include the total volume to be administered daily, the duration of therapy, and the compatibilities of nutritional solutions with concomitantly infused medications.[2]

Neonates and children have specific nutritional requirements that relate to their cognitive and physical development. Deficiency, excess, or imbalance of these essential nutrients upsets the body's metabolic status and can exert a wide range of effects, depending on the nutrients involved.[3] One consequence is growth failure: poor weight gain, failure to achieve normal height, or a delay in development of secondary sexual characteristics.[4] Other consequences can be life-threatening. For example, malnutrition causes impaired immunity, which increases the risk of infections and poor wound healing.[4]

Many hospitals have protocols for the care of neonates and children receiving TPN. However, standard TPN formulations, practices, and procedures may vary across hospitals in Canada. Product availability and affordability, the existence of and funding for TPN teams within an institution, and the local experiences of dietitians, pharmacists, and physicians are some of the factors that may influence procedures. Additional factors that can complicate the standardization of TPN procedures include lack of scientific information about TPN in the neonatal and pediatric populations and controversies regarding specific aspects of TPN.[5] Current controversial issues include albumin, iron, carnitine, and cysteine supplementation.[6-15]

The purpose of this study was to describe TPN formulations and practices pertaining to neonatal and pediatric patients in English-language Canadian hospitals.

METHODS

Sample

All 148 hospitals listed in the *Guide to Canadian Health Care Facilities*[16] as having a neonatal or pediatric care unit (or both), with the exception of hospitals in which the working language was French and those with fewer than 10 pediatric beds, were initially considered for participation. A researcher (K.W.) contacted each hospital by telephone and asked to speak with an individual involved in pediatric or neonatal care. From these conversations, it was determined that only 42 of the 148 potentially eligible hospitals provided neonatal or pediatric TPN services. The person contacted at each hospital was asked to identify the most appropriate health care professional to answer questions regarding TPN. The researcher explained the purpose of the study to this designated "expert" and asked if he or she would be willing to complete a questionnaire. All 42 agreed to

participate, and a questionnaire (along with a stamped return envelope and a cover letter explaining the survey) was sent to each of these potential participants. Those working at hospitals with both neonatal and pediatric care units were asked to complete one questionnaire for each unit. Two months after the questionnaires were mailed, a reminder letter was sent to participants who had not yet replied.

Questionnaire

On the basis of a literature review, a questionnaire (requiring approximately 30 minutes to complete) was developed. The questions covered the following areas: hospital characteristics (8 items), TPN practices (42 items), and TPN formulations (22 items). A copy of the questionnaire may be obtained on request to the corresponding author. Most of the items examining TPN practices and formulations were posed as closed-ended questions with fixed responses such as "yes" or "no" or a list of options. Respondents were also able to write in their own responses. For items that were designed to elicit an opinion, a 3- or 5-point Likert scale was used (e.g., strongly agree, agree, neutral, disagree, strongly disagree). For many of these items, respondents were asked to explain or comment on their response. The questionnaire was reviewed for content validity by 2 hospital pharmacists working in pediatric and neonatal TPN care.

Data Analysis

The data were entered into a Microsoft Excel spreadsheet (Microsoft Corporation, Seattle, Washington). Summary statistics were calculated for each question as either the mean (± standard deviation) or frequency, depending on the response format for the question. Inferential statistics (i.e., independent *t*-test on means or χ^2 test on frequencies) were used to test for differences in TPN practices or formulations between groups defined by location (eastern versus western Canada), hospital size (small versus large), city size (greater or less than 500 000), team versus nonteam approach, and type of respondent (pharmacist versus other). A p value of less than 0.05 was considered evidence of a significant difference.

RESULTS

Demographic Characteristics

Forty-one questionnaires (25 for neonatal units and 16 for pediatric units) were returned from 30 of the 42 hospitals surveyed (71% response rate). The response rate from hospitals in the Atlantic provinces was particularly low, with only 1 of 6 hospitals returning a completed questionnaire. Nineteen hospitals completed a questionnaire for either a neonatal or a pediatric unit, and 11 completed questionnaires for both types of units. Twenty questionnaires were returned from British Columbia and the Prairie provinces, 19 from Ontario and Quebec, and 2 from New Brunswick.

Eleven of the 41 questionnaires were completed by more than one health care professional. A pharmacist was involved in completing 32 questionnaires, a dietitian in completing 14, a nurse in completing 5, and a physician in completing 4.

Table 1. Characteristics of 30 Hospitals Responding to a Survey on TPN

Characteristic	No. of Hospitals or Mean (and SD)	
Location		
British Columbia	5	
Prairie provinces (Alberta, Saskatchewan, Manitoba)	9	
Ontario	13	
Quebec	2	
New Brunswick	1	
City size		
>500 000	14	
250 000 – 500 000	4	
<250 000	12	
Mean no. of beds*		
Neonatal units		
Total beds (*n* = 24)	37	(24)
Critical care beds (*n* = 25)	20	(12)
Pediatric units		
Total beds (*n* = 15)	79	(82)
Critical care beds (*n* = 10)	14	(18)
TPN patients per month*		
Neonatal units (n = 23)		
0–9 patients	11	
10–19 patients	5	
≥20 patients	7	
Pediatric units (n = 14)		
0–9 patients	10	
10–19 patients	3	
≥20 patients	1	

TPN = total parenteral nutrition, SD = standard deviation.
*Parenthetical *n* values represent the number of units for which responses were received.

The number of patients receiving TPN each month varied widely. In one institution over 400 patients received TPN each month, whereas another institution reported as few as 1 or 2 patients receiving TPN per year.

The characteristics of responding hospitals are presented in Table 1.

Practices and Opinions Concerning Total Parenteral Nutrition

Although only 12 (48%) neonatal and 4 (25%) pediatric units had TPN teams, a majority of respondents in each group (17 [68%] and 14 [88%], respectively) strongly agreed with the statement that "The best approach to TPN is a team approach." Support for other statements about teamwork in TPN ("Presence of a TPN support team may be used as evidence of a hospital's commitment to providing good nutritional care" and "A TPN support team helps to reduce costs and waste of supplies and solutions") was somewhat weaker: 11 (44%) and 12 (48%) of neonatal unit respondents and 9 (56%) and 6 (38%) of pediatric unit respondents agreed strongly with these 2 statements, respectively.

Table 2. Frequency of Practices Related to TPN

Characteristic	No. of Neonatal Units (*n* = 25)	No. of Pediatric Units (*n* = 16)
Involvement of health professionals*		
Initiating TPN		
Physician	22	14
Pharmacist	5	0
Dietitian	7	7
Nurse	2	0
Team	0	0
Ordering TPN		
Physician	21	14
Pharmacist	10	5
Dietitian	9	7
Nurse	0	0
Team	0	0
Monitoring TPN		
Physician	20	15
Pharmacist	12	9
Dietitian	11	9
Nurse	11	8
Team	3	1
Terminating TPN		
Physician	20	16
Pharmacist	5	1
Dietitian	7	4
Nurse	6	1
Team	3	0
Existence of hospital guidelines		
Hospital handbook for TPN	13	7
Guidelines for nutritional assessment	12	7
Guidelines for biochemical tests in nutritional assessment†	16/22	10
Guidelines for monitoring TPN	22	15
Guidelines for biochemical tests in monitoring TPN	20	16
Guidelines for trace elements†	22/24	14

TPN = total parenteral nutrition.
*Respondent could choose as many options as appropriate.
†Responses were not available for all units; denominator indicated.

Table 2 lists the various health care professionals involved in initiating, ordering, monitoring, and terminating TPN. Physicians were most commonly involved in all of these processes; however, more than one health care professional was involved in initiating TPN in 12 (48%) of the neonatal units and 7 (44%) of the pediatric units, in ordering TPN in 11 (44%) of the neonatal units and 7 (44%) of the pediatric units, in monitoring TPN in 21 (84%) of the neonatal units and 14 (88%) of the pediatric units, and in terminating TPN in 8 (32%) of the neonatal units and 5 (31%) of the pediatric units.

Several questions on the survey dealt with guidelines for TPN (Table 2). Almost half of the hospitals reported having a specific printed handbook of guidelines; however, a greater proportion of hospitals reported having established guidelines for monitoring

Table 3. Anthropometric Measurements Used in Initial Assessment

Measurement	Type of Unit; No. (and %) of Units			
	Neonatal (*n* = 17)		Pediatric (*n* = 14)	
Weight	17	(100)	14	(100)
Height	13	(76)	13	(93)
Head circumference	14	(82)	9	(64)
Skin fold thickness	0	(0)	3	(21)
Other*	1	(6)	2	(14)

*Chest circumference, bioelectric impedance, indirect calorimetry.

Table 4. Biochemical and Other Tests Used in Initial Nutritional Assessment

Test	Type of Unit; No. (and %) of Units			
	Neonatal (*n* = 22)		Pediatric (*n* = 15)	
Albumin	19	(86)	13	(87)
Hemoglobin	15	(68)	12	(80)
Hematocrit	14	(64)	11	(73)
Total protein	14	(64)	8	(53)
Mean corpuscular volume	7	(32)	8	(53)

the nutritional regimen over the course of TPN, for using biochemical tests in nutritional assessment and monitoring, and for use of trace elements. For instance, 22 (88%) of the neonatal units and 15 (94%) of the pediatric units had established guidelines for monitoring the nutritional regimen.

Questions were also asked about the extent to which guidelines were followed. All 22 neonatal units with monitoring guidelines but only 13 (87%) of the 15 pediatric units with such guidelines always followed them. Monitoring for complications of TPN therapy was always performed in 20 (80%) of the neonatal units and 11 (69%) of the pediatric units.

Biochemical tests used for monitoring TPN therapy by more than 80% of the 16 pediatric units included determining levels of sodium (all 16 units [100%]), chloride (15 [94%]), potassium (16 [100%]), calcium (16 [100%]), phosphorus (16 [100%]), magnesium (15 [94%]), glucose (16 [100%]), triglycerides (13 [81%]), albumin (16 [100%]), urea (16 [100%]), serum creatinine (16 [100%]), and bilirubin (15 [94%]) and obtaining white blood cell count (WBC) (14 [88%]) and WBC differential count (13 [81%]). Of the choices available on the questionnaire, only monitoring of alanine aminotransferase was used less frequently (by only 8 [50%] of the units). There was greater variability among the 25 neonatal units in tests used for monitoring TPN. At least 80% of the units measured sodium (all 25 units [100%]), potassium (24 [96%]), calcium (22 [88%]), phosphorus (20 [80%]), glucose (24 [96%]), urea (24 [96%]), serum creatinine (20 [80%]), and bilirubin (20 [80%]). Other biochemical tests (chloride, magnesium, triglyceride, albumin, WBC count, WBC differential count, alanine aminotransferase) were used by 7 (28%) to 19 (76%) of the responding units. Two (8%) neonatal units and 13 (81%) pediatric units reported that they wanted to make changes to their guidelines for the biochemical tests used in TPN monitoring.

Anthropometric measurements and biochemical tests used for initial nutritional assessment are shown in Tables 3 and 4, respectively. Anthropometric measurements were more commonly used in pediatric units (14/16 or 88%) than in neonatal units (17/25 or 68%). Particularly noteworthy was the finding that only 3 (21%) of the 14 pediatric units measured skin fold thickness as part of the nutritional assessment.

In 17 (68%) neonatal and 13 (81%) pediatric units, medications were allowed to run with TPN as long as the drug was compatible with the TPN solution and the drug was injected into the Y-site or piggybacked into the TPN IV line.

Formulations for Total Parenteral Nutrition

Table 5 presents the most frequently used lipid emulsion and amino acid solutions, as well as the factors used in determining the choice of formulation. Cost was the most important factor in the choice of lipid emulsion, whereas scientific literature and previous experience were as important or more important in the choice of amino acid solution. Few hospitals reported supplementing TPN with albumin, carnitine, iron, or cysteine.

Most respondents indicated a desire to see practices and formulations standardized across Canada. All 16 pediatric unit respondents and 24 (96%) of the 25 neonatal unit respondents felt that this was important or very important.

No statistically significant differences were found in TPN formulations used or TPN practices followed according to factors such as region of Canada, presence of a TPN team, or type of unit (neonatal or pediatric).

DISCUSSION

Most survey respondents believed that a team approach was the best approach to TPN care and helped to reduce costs and waste of supplies and solutions. Respondents from hospitals with teams supported the use of teams, but so did many respondents from "nonteam" hospitals. Furthermore, for

Table 5. Use of Formulations for TPN

Formulation	No. of Neonatal Units (*n* = 25)	No. of Pediatric Units (*n* = 16)
Lipid emulsion*		
Intralipid (Fresinius-Kabi, Stockholm, Sweden; distributed by Baxter Corporation, Toronto, Ontario)	13	10
Travamulsion (distributed by Baxter Corporation, Toronto, Ontario)	8	4
Liposyn II (Abbott Laboratories Ltd, Saint-Laurent, Quebec)	6	2
Others	8	0
*Factors determining choice of lipid emulsion**		
Cost	10	8
Previous experience	7	4
Scientific literature	6	4
Manufacturer	2	2
Amino acids*		
Vamin (Fresinius-Kabi, Stockholm, Sweden; distributed by Baxter Corporation, Toronto, Ontario)	9	3
Primene (Baxter Corporation, Toronto, Ontario)	7	3
Aminosyn (Abbott Laboratories Ltd, Saint-Laurent, Quebec)	1	2
Trophamine (McGaw, Inc, Irvine, California)	4	1
Aminosyn PF (Abbott Laboratories Ltd, Saint-Laurent, Quebec)	2	1
Travasol (Baxter Corporation, Toronto, Ontario)	2	12
*Factors determining choice of amino acid solution**		
Cost	6	7
Previous experience	9	8
Scientific literature	9	7
Manufacturer	0	3
Other	4	0
Use of controversial supplements		
Albumin	3	3
Carnitine	3	2
Iron	7	7
Cysteine for preterm infants	5	NA

TPN = total parenteral nutrition, NA = not applicable.

*Respondent could choose as many options as appropriate.

each aspect of TPN practice (initiating, ordering, monitoring, and terminating therapy), many hospitals reported that more than one health care professional was involved, even when the hospital did not have a formal TPN team. Team management of TPN has been shown to reduce complications, improve nutritional and patient outcomes, and minimize waste and inappropriate use of expensive formulas and supplies.[17] Because the team approach was strongly supported by respondents and because the literature documents the advantages of teams, institutions without a TPN team should consider forming one.

Monitoring TPN patients is necessary to determine the appropriateness of the regimen, to determine if proper nutrients are being infused in adequate quantities, and to detect and prevent complications.[18-20] Therefore, monitoring should be used to evaluate both progress and complications. Although both neonatal and pediatric units monitored their TPN patients and most had guidelines for monitoring, this survey demonstrated variability in monitoring practices across Canadian hospitals. Monitoring for complications was reportedly somewhat less frequent than monitoring of the nutritional regimen, but lack of monitoring of complications may place patients at risk. Also, the type of biochemical tests used for monitoring varied, but determining the reasons for this variability was beyond the scope of this survey. This may be an area for future research.

To provide optimal care to patients receiving TPN, it may be desirable for institutions to have written guidelines regarding appropriate assessment and monitoring. Written guidelines represent an initial step in standardization of TPN practices and formulations. Approximately half of the respondents reported that their institution had a handbook of guidelines. However, there may have been other means of establishing and disseminating guidelines, given that the proportions of respondents reporting established guidelines for the biochemical tests in nutritional assessment and monitoring, for monitoring of the nutritional regimen, and for use of trace elements were greater than the proportions reporting handbooks (Table 2). Nonetheless, the presence of guidelines does not ensure their use. For example, the reported use of skin-fold thickness measurement for nutritional assessment was very low, even though this method has been recommended for determining whether a child is malnourished.[2]

The survey also revealed some deficiencies in guideline availability. Established guidelines for nutritional assessment were present in only about half of the hospitals surveyed. Nutritional assessment helps in determining which patients require TPN, in designing a TPN formulation that will suit the patient's needs, in ensuring that the enteral route cannot be used to meet nutritional needs, and in providing baseline information that will aid in monitoring the patient's nutritional status. Guidelines for nutritional assessment and monitoring should be in place in all institutions providing TPN. Without such guidelines, TPN may be implemented unnecessarily, the solutions used may be suboptimal, and monitoring may be compromised. Furthermore, even when an institution has guidelines, audits of

compliance with guidelines should be carried out to ensure they are having the desired effect.

In this survey, a hospital's choice of TPN formulations was based on many reasons other than scientific evidence, perhaps because there is a lack of such evidence about TPN in neonatal and pediatric populations.[5] Consequently, standardizing lipid and amino acid solutions among Canadian institutions might be difficult.[21]

Another controversial issue is supplementation of TPN with albumin, carnitine, iron, and cysteine. Addition of albumin to TPN solutions, other than for emergency purposes, has been questioned because of its high cost and short duration of effectiveness.[6,7] The benefit of supplementing TPN with carnitine has been questioned because of inconclusive research results.[8-10] Iron supplementation in TPN may be dangerous[11-13] because of incompatibility with TPN solutions and risks of iron overload and anaphylaxis. This survey showed that few Canadian hospitals use these supplements in neonatal and pediatric TPN, which reflects the lack of scientific evidence supporting these practices.

The study had several limitations. Only English-language hospitals were surveyed. TPN practices and formulations may differ in the French-language hospitals. Because only 30 of the 42 hospitals responded, there may be selection bias. For example, hospitals without guidelines for TPN practices or formulations might have been less likely to respond to the survey. Also, the Atlantic provinces were poorly represented among survey respondents. More rigorous follow-up might have yielded a better response rate.

In planning this research project, it was hypothesized that factors such as city size, presence or absence of a TPN team, or location (eastern or western Canada) might affect TPN practices or formulations. However, because of small sample sizes there was insufficient power to detect statistically significant differences. Therefore, no conclusions could be drawn with respect to factors that might affect TPN practices and formulations.

The questionnaire was evaluated for content validity but was not pilot tested with a sample of TPN units. Pilot-testing was omitted because the number of hospitals with neonatal or pediatric TPN services was known to be small, and a pilot test would have reduced the final sample further. However, this might have contributed to failure to obtain the desired information from specific questions.

In Canada, information on neonatal and pediatric TPN formulations and practices has been lacking. This study has documented the degree of variability in patient assessment, TPN formulations, and availability of hospital guidelines for various TPN practices in English-language Canadian hospitals. The American Society for Parenteral and Enteral Nutrition[18,22,23] has suggested that standardization of TPN practices and formulations is desirable to provide consistency in the safe administration of TPN. Therefore, in light of the differences among Canadian hospitals and the strong support of survey respondents for standardization, a recommended next step would be to establish minimum national standards to optimize TPN administration for neonatal and pediatric patients.

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