Commentary

iMedPub Journals
http://www.imedpub.com/

Medical & Clinical Reviews
ISSN 2471-299X

2016
Vol.2 No.1:4

DOI: 10.21767/2471-299X.1000013

Parenteral Nutrition in Hospitalized Children

Mantegazza C[1*], Landy N[1], Hill SM[1], Zuccotti GV[2] and Koglmeier J[1]

[1]Great Ormond Street Hospital for Children NHS Foundation Trust London, UK

[2]Department of Paediatrics, University of Milan, Ospedale dei Bambini Vittore Buzzi, Milan, Italy

[*]**Corresponding author:** Mantegazza C, Great Ormond Street Hospital for Children NHS Foundation Trust London, UK, Tel: 0039257995329; Fax: 0039257995329; E-mail: cecimante@hotmail.com

Received date: Nov 29, 2015; **Accepted date:** Jan 19, 2016; **Published date:** Jan 22, 2016

Abstract

Objective: Parenteral Nutrition (PN) is prescribed to children with a non functioning gut or to those who fail to meet their nutritional requirements enterally. Complications should be balanced against the benefit for the patient. The aim of this study was to establish if the indications for PN prescribing in a tertiary referral children's hospital were appropriate.

Study Design: Children and newborns (infants <4 weeks of age) receiving inpatient PN between October 2013 and March 2014 were enrolled and data was collected prospectively. The appropriate indications for the use of PN were based on the 2005 guidelines by the European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN).

Results: 303 children (67 newborns) were enrolled. Patients were referred from different departments across the hospital. The median duration of PN was 18 days (1-160). PN was mainly prescribed to critically ill children on intensive care (66/303), those ungergoing surgery (63/303) and bone marrow transplantation (28/303). The ESPGHAN recommendations were followed in 91.7% (278/303) of cases (newborns 64/67, 95.5%; children 214/236, 90.8%). The use of PN was considered inappropriate in 12/303 patients and in 13/303 it was not possible to reach a conclusion.

Conclusion: Although the indications for inpatient PN in children is mostly justified, there is still a proportion of patients receiving intravenous nutrition unnecessarily highlighting the need for more PN training and better access to nutritional support teams.

Keywords: Pediatric parenteral nutrition; ESPGHAN guidelines; Indications; Appropriateness

Abbreviations

PN: Parenteral Nutrition; EN: Enteral Nutrition; ESPGHAN: European Society of Paediatric Gastroenterology, Hepatology and Nutrition; GI: Gastrointestinal; NEC: Necrotising Enterocolitis; IC: Intensive Care; NST: Nutritional Support Team; IF: Intestinal Failure

Introduction

Parenteral Nutrition (PN) is an invasive therapy used when the oral or enteral application of nutrition is not possible [1]. The European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the European Society for Clinical Nutrition and Metabolism, supported by the European Society of Paediatric Research have published guidelines in 2005 to aid medical teams caring for such patients in prescribing PN appropriately [2].

Malnutrition is a common problem amongst hospitalised children and has a negative impact on recovery and length of hospital stay [3,4]. Newborns in particular are affected by suboptimal nutrient intake making them more prone to infections and prolonged ventilatory support [5].

Specialised nutritional support therapy is aimed at those who cannot meet their nutritional requirements orally and consists of both enteral and parenteral nutrition [6]. The enteral route is generally preferred due to its major role in the maintenance of mucosal structure and function of the intestine [7] as well as for the known cost and complications associated with PN [8]. However, in well selected patients, PN is undoubtedly a potential lifesaver and has become a well established practice in children and newborns with intestinal failure.

In most European countries PN is prescribed in line with the 2005 ESPGHAN guidelines [2]. The purpose of these guidelines was to identify the most common and reasonable indications for the use of PN in newborns, infants and children in order to reduce the inappropriate use of PN.

Sepsis, electrolyte disturbances, metabolic bone disease, micronutrient deficiencies, liver disease, pulmonary embolism and loss of central venous access are well known complications of PN [9,10].

Moreover inappropriate prescribing does not only increase the burden of disease to the patient but also has a substantial economic impact on the health care system [11].

The aim of this observational study was to get a better understanding as to why hospitalised children are started on PN and if the indications, based on the 2005 ESPGHAN guidelines, were appropriate. We wanted to use this knowledge to develop strategies to avoid inappropriate PN prescribing in the future.

Methods

All patients admitted to a large national referral centre for children who were started on PN between October 2013 and March 2014 were identified from the pharmacy database and entered into the study prospectively. Children who were already established on home PN were excluded.

Information was obtained from the PN prescription, medical, nursing and dietetic records. Patient demographics, underlying diagnosis, referring department, feeding regimen prior to and on PN documented, and the current pathology, indication for PN and its duration recorded.

Clinical scenarios justifying the use of PN were divided into medical and surgical, due to primary intestinal failure (IF), defined as directly related to underlying anatomical or structural gut pathology, or secondary IF as a consequence of other conditions leading to enteral feed intolerance.

PN indications were classified as appropriate, inappropriate or indeterminate based on the ESPGHAN 2005 guidelines [2].

In infants and children PN was classified as appropriate if the energy and nutrient demands of the patient were not met through the enteral route; in particular following the ESPGHAN guidelines on pediatric enteral nutrition (EN), enteral support was considered to have failed if 60-80% of calorie requirements were not met for more than 5 days in children older than one year of age and more than 3 days in infants [11].

Moreover PN was considered appropriate if the child/infant was expected not to meet 60-80% of the expected calorie requirements for more than 7 days in all those situations where EN was contraindicated such as paralytic or mechanical ileus, anatomical disruption of the gastroinestinal (GI) tract, intestinal obstruction, necrotising enterocolitis (NEC), GI ischemia, diffuse peritonitis, perforation or a state of severe shock [11-13].

In the neonatal group PN was considered appropriate in all premature infants <32 week of gestation and <1500 g and all seriously ill infants with more than 32 weeks of gestation, in particular surgical neonates, with acquired or congenital disease causing GI failure [2,14].

PN was considered inappropriate in infants and children in the absence of evidence of a non-functioning gut when EN could have been easily established or supplementation with intravenous calories was nutritionally not indicated. In patients older than 1 year of age a duration of PN therapy for <5 days was also considered inappropriate, unless the child was undernourished [13,15,16]. Under-nutrition was defined according to the WHO criteria [17].

In newborns the start of PN was considered inappropriate in all neonates >32 week of gestation and a birth weight of more >1500 g without primary gut pathology, who were clinically well and could hence be expected to establish full enteral.

The use of PN was considered indeterminate if a judgement could not be made due to scanty information, if EN was achievable but not used because of concerns over potential complications associated with feeding or a delay in passsing a suitable enteral feeding tube, eg if the child rejected or if jejunal feeding was required but jejunal access was unsuccesful.

The study was approved by the Ethical Committee of Great Ormond Street Hospital and informed consent was obtained from parents or legal guardians of the patients.

All data collected were analysed using Microsoft Access and Excel.

Results

In the study period PN was prescribed to 318 patients; 15 children were home PN dependent. The total number of patients enrolled was hence 303 (165 (54.5%) females) of which 67 (22.1%) were newborns, 98 (32.3%) were infants and 138 (45.5%) were children and adolescents. Median age was 38 months, ranging from 0 to 223 months. Median duration of PN was 18 days (1-160 days). At the end of the study period 15 patients were still on PN, 233 (76.9%) children had received PN <28 days.

All but 17 of the enrolled patients had a an underlying diagnosis at the start of PN. Congenital heart disease, malignancies and GI disorders were the most common (Table 1).

Table 1: Pre-existing diagnosis.

Pre-existing diagnosis	No	Percentage
Cardiopathy	90	29.7
Tumour	68	22.4
GI pathology	41	13.5
congenital pathologies of the immune system	20	6.6

no pre existing pathology	17	5.6
congenital metabolic diseases	16	5.3
Prematurity	16	5.3
pathology of the neurological system	15	5.0
Syndrome	7	2.3
congenital pathologies of the endocrine system	3	1.0
congenital bone diseases	3	1.0
lung diseases	3	1.0
rheumatological disease	3	1.0
Other	1	0.3

Among the children with a malignancy 37 (54.4%) had leukemia, and 31 (45.6%) a solid tumour. In the group of patients with pathologies of the GI tract 26 (66.6%) were born with a congenital malformation, 5 (12.8%) had short bowel syndrome, 3 were diagnosed with inflammatory bowel disease, 6 suffered from a GI motility disorder and 1 a congenital enteropathy.

Patients were referred from medical specialities (34%-majority oncology 64/103), surgery (35%-majority cardiothoracic 81/106) and intensive care (IC) units (31%, majority pediatric IC 57/94) (Table 2).

Table 2: Referring departments.

Referring department	No	Percentage
Medical	103	34.0
Dermatology	2	0.6
Endocrine	5	1.6
Gastroenterology	15	4.9
haematology/oncology	64	21.1
Immunology	6	2.0
Metabolic	11	3.6
Surgical	106	35.0
Cardiothoracic surgery	81	26.8
GI surgery	19	6.3
Other surgery	4	1.3
Orthopedic	1	0.3
Urology	1	0.3
IC	94	31.0
Pediatric IC unit	57	18.8
Neonatal IC unit	37	12.2

The majority of children (57.4%) who were prescribed PN had secondary intestinal failure as a consequence of an acute or chronic medical condition. Multi-organ, respiratory, renal or heart failure, shock, sepsis and macrophage activation syndrome were the most common causes (21.8%) followed by bone marrow transplantation (9.8%) or feed intolerance due to chemotherapy (8.2%) or radiation induced mucositis (6.3)

The remaining patients (42.6%) were admitted for surgery of which most was not related to the GI tract (61.7%). Only 38.3% of children had primary intestinal failure as a consequence of GI surgery.

On the surgical wards PN was mostly used as nutritional support in the pre and perioperative period (20.8%) and mainly given to children who underwent surgery for congenital

heart defects (61/63), followed by NEC (7.3%) and intestinal resection for congenital malformations of the GI tract (6.9%) (Table 3).

Table 3: Pathologies with an indication for PN.

Pathologies with an indication for PN	No	Percentage
Pre-peri surgery nutritional support	63	20.8
Post operative nutritional support	3	1.0
Post surgical ileus	4	1.3
Intestinal resection in congenital malformation of the GI	21	6.9
Other intestinal resections	10	3.3
NEC	22	7.3
Organ transplant	6	2.0
Autoimmune disorder associated with intestinal failure	4	1.3
Feed intolerance	25	8.2
GI dysmotility	4	1.3
Meconium aspiration	2	0.7
Malnourishment	3	1.0
Condition associated with malabsorption	9	3.0
BMT	28	9.2
Mucositis due to chemo	19	6.3
Critical illness	66	21.8
Decompensation in patients with metabolic condition	7	2.3
Acute pancreatitis	2	0.7
Heart cachexia	1	0.3
Miscellaneus	4	1.3

The use of PN was considered appropriate in 278/303 (91.7%), inappropriate in 12 (4.0%) and indeterminate in 13 (4.3%) patients.

In the group of children older than 12 months 16 (11.6%) had less then 5 days of PN. Five of them did not meet the ESPGHAN criteria as their nutritional status was good. In seven patients the use of PN was felt to be appropriate irrespective of the short duration as two children were malnourished (2/7) and in five the assumption that PN would be required longer was justifiable. Four cases were considered indeterminate as it was not possible to establish if the use of PN was truly indicated or not.

Four infants were given PN despite a functional GI tract and one was kept nil by mouth and given PN for one day for query NEC. Two term newborns were precribed PN unnecessarily as they were able to tolerate >80% of their requirements enterally when PN was started and PN was only given for one day. Table 4 summarizes patients who received PN inappropriately.

Table 4: Inappropriate use of PN: Patients.

Number	Inappropriate PN use
5	PN <5 days in child >12 months of age with a proper nutritional status according to WHO criteria
4	Infant with functional GI tract. Enteral route not attempted as first line therapy
2	Term infant with >80% feed tolerance enterally
1	Infant >32 weeks GA PN for 1 day only (suspected NEC, not confirmed)

According to age PN was defined as appropriate in 95.5% of newborns and in 90.8% of infants and children (Table 5).

Table 5: Appropriateness of PN divided by age.

Current Audit		
	Newborns No, Percentage	Infants/children No, Percentage

Appropriate	64, 95.5	214, 90.7
Indeterminate	1, 1.5	12, 5.1
Inappropriate	2, 3.0	10, 4.2

Discussion

The administration of PN is well a established practice in Paediatrics providing nutritional support to infants and children with a non functioning gut or to those who cannot meet their nutritional requirements enterally. However, PN is by far no panacea and complications can be serious with significant consequences to the patient and financial burden to the health care system [8-10]. The joint ESPGHAN/ESPEN guidelines published in 2005 make recommendations when PN should be prescribed to children [2].

However, suboptimal care in the administration of PN in newborns and children remains a concern [18]. In our cohort we considered the use of PN appropriate in 95.5% of newborns and 90.5% of children (age 1 month-18 years). PN is still prescriped inappropriately in a number of patients despite the 2005 ESPGHAN guidelines: enteral feeds in children with a functional gut were not tried vigourously enough and conditions associated with a predictable short term feed intolerance such as post-operative ileus were too agressively treated with PN. In children older than 12 months with a good nutritional status, post operative PN is only considered beneficial if the child is expected to remain nil by mouth for more then 7 days and when PN is administered for at least 5 days, otherwise the risk associated with the administration outweighs the benefits [16,17,19,20]. Although poor peri operative nutritional status has been linked to an increase of postoperative complications and less favourable outcome too little emphasis is placed on improving the preoperative nutritional status of children undergoing planned or semi elective surgery [21].

Consultation of a Nutrition Support Team (NST) has been shown to reduce the number of children receiving short term PN. Enteral feeds are more frequently started early and catheter and metabolic complications reduced. Utilisation of an NST is therefore cost effective [22,23].

Our hospital NST is staffed with a Consultant paediatric Gastroenterologist, a dietician and a PN pharmacist. All children receiving PN are reviewed by the team once a week and advise on the nutritional management given. However, it is currently not routine practice to consult the NST prior to the start of PN as the inital request is made by the individual speciality caring for the patient.

Studies on adults have shown that mandatory involvement of the NST prior to the start of PN reduced the number of inappropriate PN prescriptions [24,25]. In the future we would like to make a discussion with the NST compulsary prior to a child being started on PN as part of a robust referral pathway.

Table 6: Nutrition screening tools for hospitalized children.

PN has been used in children for over forty years and was initially prescribed to patients with primary GI pathology such as congenital or acquired short bowel syndrome [20]. PN management has evolved since and PN is now commonly used as nutritional support in other conditions [12].

This is strongly supported by our data, as the majority of children receiving PN in our cohort had a non primary GI pathology (61.7% non GI vs 38.3% GI). Sepsis, respiratory, cardiac, renal or multi organ failure (21.8%), pre and perioperative nutritional support - particularly for children undergoing cardiac surgery (20.8%) - were by far the most common conditions leading to feed intolerance and hence the start of PN.

Nutritional support is a significant aspect of the managment of critically ill children admitted to paediatric intensive care [26]. However, how these patients should be fed (enteral versus parenteral route) and what the optimal timing for the start nutritional support is [27]. Although early initiation of nutritional support appears to be indicated due to a high risk of rapid nutritional depletion which could contribute to the impairment of vital organ function (Briassoulis, trocki, pollack), there is currently no evidence to support that early PN in such patients is beneficial and may indeed be harmful [28]. Overfeeding in particular may have a negative impact on the number of infections, mortality and length of hospital stay [29] Optimising nutritional therapy could hence lead to better outcomes of critically ill paediatric patients [30].

Given that more and more children are admitted to paediatric IC units urgent randomized controlled trials are needed to guide physicians in the decision making process.

Early involvement of the NST is even more crucial in these patients to select potential candidates for PN carefully before the initiation of intravenous feeding. The NST can also help to raise awareness amongst health professionals on the proper use of nutrition support through a structured teaching program which should be accessible to all persons involved in the care of such children [31]. Even if nutrition training is now included in the junior doctor and nurse teaching curriculum to improve knowledge in nutrition, however the enrollment of nutritionists with a strong scientific background is still required to allow health professionals to make a balanced assessment of the nutritional needs of their patients.

Screening tools designed to identify children at risk of developing malnutrition could help physicians to recognise such patients before their nutritional status deteriorates [32] (Table 6) Although the benefit of nutrition assessment is widely recognised there is no standardised approach for children admitted to hospital [33]. Data comparing existing screening tools should however become available in the future allowing to develop a standard in the nutritional assessment of hospitalised children.

Nutrition screening tool	Target population	content	Reference
Nutrition Risk Score	children with medical condition	nutritional status weight loss oral intake severity of underlying disease	Reilly et al. Nutritional screening – evaluation and implementation of a simple nutrition risk score. Clin Nutr 1995; 14 (5): 269-273
Pediatric Nutritional Risk Score	children with medical or surgical condition	oral food intake disease severity pain	Sermet-Gaudelus et al. Simple pediatric nutritional risk score to identify children at risk of malnutrition. Am J Clin Nutr 2000; 72: 64-70
Subjective Global Nutrition Assessment	children with surgical condition	weight loss parenteral height oral intake symptoms GI tract functional capacity nutritional status disease severity	Secker et al. Subjective global nutritional assessment for children. Am J Clin Nutr 2007; 85: 1084-1089
STAMP	children with medical or surgical condition	diagnosis oral intake antropometric measurements	McCarthy et al. Screening for nutrition risk in children: the validation of a new tool. J Hum Nutr Diet 2008; 21: 395-396
PYMS	children with medical or surgical condition	BMI history of recent weight loss oral intake clinical condition	Gerasimidis et al. A four-stage evaluation of the Paediatric Yorkhill Malnurition Score in a tertiary paediatric hospital and a district general hospital. Br J Nutr 2010; 104: 751-756
STRONGkids	Children with medical or surgical condition	nutritional status underlying disease considered high risk oral intake history of weight loss	Hulst et al. Dutch national survery to test the STRONGkids nutritional risk screening tool in hospitalized children. Clin Nutr 2010; 29: 106-111

STAMP: Screening Tool for the Assessment of Malnutrition in Paediatrics, PYMS: Paediatric Yorkhill Malnutrition Score, STRONG kids: Screening Tool for Risk of Impaired Nutritional Status and Growth.

There is evidence in the literature showing a link between over aggressive treatment and availability of resources [34]. Patients in countries with a high socioeconomic status and well funded health care systems have treatment escalated to the maximum earlier and more frequently compared to the developing world. The threshold for starting intravenous nutrition is much lower in hospitals where PN is easily accessible as it is the case in a tertiary children's hospital like ours. Care plans should hence be in place which focus on the use of the oral/enteral feeding route whenever possible prior to the consideration of intravenous feeding in order to avoid over prescribing of potentiall risky therapies such as PN.

Conclusion

Based on the ESGPHAN/ESPEN guidelines, the majority of paediatric patients in our unit are prescribed PN appropriately. However, there is still is a percentage of children receiving this expensive and potentially hazardous therapy unnecessarily. Medical staff should be better trained in the recognition of conditions associated with temporary feed intolerance unlikely to impact significantly on nutritional status or clinical outcome and regular nutrition training should be included in the junior doctor and nursing education. A NST should be available in all units using PN and consulted when artificial feeding is considered.

Conflict of Interest Statement and Funding Sources

No source of support. Authors declare no conflict of interest. Cecilia Mantegazza wrote the first draft of the manuscript, no honorarium, grant or other form of payment was given.

References

1. D'Antiga L, Goulet O (2013) Intestinal failure in children: the European view. J Pediatr Gastroenterol Nutr 56: 118-126.
2. Koletzko B, Goulet O, Hunt J, Krohn K, Shamir R (2005) Guidelines on Paediatric Parenteral Nutrition of the European Society of Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the European Society for Clinical Nutrition and Metabolism (ESPEN), Supported by the European Society of Paediatric Research (ESPR). J Pediatr Gastroenterol Nutr 41 Suppl 2: S1-S4.
3. Hendricks KM, Duggan C, Gallagher L, Carlin AC, Richardson DS, et al. (1995) Malnutrition in hospitalized pediatric patients. Current prevalence. Arch Pediatr Adolesc Med 149: 1118-1122.
4. Rocha GA, Rocha EJ, Martins CV (2006) The effects of hospitalization on the nutritional status of children. J Pediatr (Rio J) 82: 70-74.
5. te Braake FW, van den Akker CH, Riedijk MA, van Goudoever JB (2007) Parenteral amino acid and energy administration to premature infants in early life. Semin Fetal Neonatal Med 12: 11-18.

6. Braunschweig CL, Levy P, Sheean PM, Wang X (2001) Enteral compared with parenteral nutrition: a meta-analysis. Am J Clin Nutr 74: 534-542.

7. Hernandez G, Velasco N, Wainstein C, Castillo L, Bugedo G, et al. (1999) Gut mucosal atrophy after a short enteral fasting period in critically ill patients. J Crit Care 14: 73-77.

8. O'Brien DD, Hodges RE, Day AT, Waxman KS, Rebello T (1986) Recommendations of nutrition support team promote cost containment. JPEN J Parenter Enteral Nutr 10: 300-302.

9. Jeejeebhoy KN (2001) Total parenteral nutrition: potion or poison? Am J Clin Nutr 74: 160-163.

10. Maurer J, Weinbaum F, Turner J, Brady T, Pistone B, et al. (1996) Reducing the inappropriate use of parenteral nutrition in an acute care teaching hospital. JPEN J Parenter Enteral Nutr 20: 272-274.

11. Christian Braegger, Tamas Decsi, Jorge Amil Dias, Corina Hartman, Sanja Kolacek, et al. (2010) Practical Approach to Paediatric Enteral Nutrition:? A Comment by the ESPGHAN Committee on Nutrition. JPGN 51: 110-122.

12. ASPEN Board of Directors (1993) Guidelines for the use of parenteral and enteral nutrition in adult and pediatric patients. American Society for Parenteral and Enteral Nutrition. JPEN J Parenter Enteral Nutr 17: 1SA-52SA.

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

14. Embleton ND, Simmer K (2014) Practice of Parenteral Nutrition in VLBW and ELBW Infants. In: Eds, Koletzko B, Poindexter B, Uauy R. Nutritional care of Preterm infants: Scientific Basis and Practical Guidelines. World Review of Nutrition and Dietetics 110: 177-189.

15. Mehta NM, Compher C; AS.P.E.N. Board of Directors. (2009) A.S.P.E.N. Clinical Guidelines: nutrition support of the critically ill child. JPEN J Parenter Enteral Nutr 33: 260-276.

16. Braga M, Ljungqvist O, Soeters P, Fearon K, Weimann A, et al. (2009) ESPEN Guidelines on Parenteral Nutrition: surgery. Clin Nutr 28: 378-386.

17. World Health organisation (1995) Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. World Health Organ Tech Rep Ser 854: 1-452.

18. Stewart JAD, Mason DG, Smith N, Protopapa K, Mason M (2010) A Mixed Bag: an enquiry into the care of hospital patients receiving parenteral nutrition. A report by the National Confidential Enquiry into Patient Outcome and Death.

19. McClave SA, Martindale RG, Vanek VW, McCarthy M, Roberts P, et al. (2009) Guidelines for the provision and assessment of nutritional support therapy in the adult critically ill patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N). JPEN J Parenter Enteral Nutr 33: 277-316.

20. Dudrick SJ, Wilmore DW, Vars HM, Rhoads JE (1968) Long-term total parenteral nutrition with growth, development, and positive nitrogen balance. Surgery 64: 134-142.

21. Burden S, Todd C, Hill J, Lal S (2012) Pre-operative nutrition support in patients undergoing gastrointestinal surgery. Cochrane Database Syst Rev 14: 11:CD008879.

22. Kennedy JF, Nightingale JM (2005) Cost savings of an adult hospital nutrition support team. Nutrition 21: 1127-1133.

23. Roberts MF, Levine GM (1992) Nutrition support team recommendations can reduce hospital costs. Nutr Clin Pract 7: 227-230.

24. Chuah SW, Ng DH, Liu P, Liu H, Ng JL, et al. (2013) The use of parenteral nutrition in an acute care hospital. Ann Acad Med Singapore 42: 395-400.

25. Chan SL, Luman W (2004) Appropriateness of the use of parenteral nutrition in a local tertiary-care hospital. Ann Acad Med Singapore 33: 494-498.

26. Verger J (2014) Nutrition in the pediatric population in the intensive care unit. Crit Care Nurs Clin North Am 26: 199-215.

27. Joffe A, Anton N, Lequier L, Vandermeer B, Tjosvold L, et al. (2009) Nutritional support for critically ill children. Cochrane Database Syst Rev : CD005144.

28. Fivez T, Kerklaan D, Verbruggen S, Vanhorebeek I, Verstraete S, et al. (2015) Impact of witholding early parenteral nutrition competing enteral nutrition in pediatric critically ill patients (PEPaNIC trial): study protocol for a randomized controlled trial. Trials 16: 202.

29. Leong AY, Field CJ, Larsen BM (2013) Nutrition support of the postoperative cardiac surgery child. Nutr Clin Pract 28: 572-579.

30. Mehta NM, Bechard LJ, Cahill N, Wang M, Day A, et al. (2012) Nutritional practices and their relationship to clinical outcomes in critically ill children--an international multicenter cohort study*. Crit Care Med 40: 2204-2211.

31. Katz SJ, Oye RK (1990) Parenteral nutrition use at a university hospital. Factors associated with inappropriate use. West J Med 152: 683-686.

32. Joosten KF, Hulst JM (2008) Prevalence of malnutrition in pediatric hospital patients. Curr Opin Pediatr 20: 590-596.

33. Hartman C, Shamir R, Hecht C, Koletzko B (2012) Malnutrition screening tools for hospitalized children. Curr Opin Clin Nutr Metab Care 15: 303-309.

34. Frey B (2008) Overtreatment in threshold and developed countries. Arch Dis Child 93: 260-263.