

Parenteral Nutrition in Neonates, Infants & Children

Cape Town Metropole Paediatric Interest Group

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1. Glossary

Term	Definition
AGA	Appropriate for gestational age
AMA	Arm muscle area [requires MUAC & TSF to calculate]
CPM	Calcium, phosphorus, magnesium
CVP	Central venous catheter
DRV's	Dietary Reference Values
ELBW	Extremely low birth weight [<1000g]
EFA	Essential fatty acids
% EWA	Percentage estimated weight for age
% EHA	Percentage estimated height for age
% EHW	Percentage estimated height for weight
EN	Enteral Nutrition
ESLD	End stage liver disease
HA	Height age
HE	Hepatic encephalopathy
IMCI	Integrated management of childhood illness
IMCI: Not Growing Well	<p><i>Severe Malnutrition:</i></p> <ul style="list-style-type: none"> ▪ Very low weight < 60% EWA. ▪ Visible signs of severe wasting ▪ Oedema on the feet <p><i>Not Growing Well:</i></p> <ul style="list-style-type: none"> ▪ Low weight < 3rd centile ▪ Poor weight gain - gaining weight but curve flattening or ▪ Mother reports weight loss. <p><i>Growing Well:</i></p> <ul style="list-style-type: none"> ▪ Not low weight and ▪ Good weight gain.
IUGR	<ul style="list-style-type: none"> ▪ Intra uterine growth retardation
LBW	<ul style="list-style-type: none"> ▪ Low birth weight < 2.5kg
LCPUFA	Long chain polyunsaturated fatty acids
LGA	Large for gestational age
MUAC	<p>Mid upper arm circumference [6months – 5 years of age]</p> <ul style="list-style-type: none"> • > 15cm normal • >11.5cm - <14.5cm moderately malnourished • <11.5 cm [<-3SD] severely malnourished
MAC	Mid arm area circumference
MEN	Minimal enteral nutrition
Schofield Equation	Predicting estimated energy requirements [Appendix 1]
NSP	Nutrition supplementation programme (NSP)
NSP Definition: Growth faltering	<ul style="list-style-type: none"> ▪ Birth – 5 years: when an infant or child's growth curve flattens or drops over two consecutive visits on his/her RTHC. ▪ >5 - < 18 yrs: when a child's growth curve flattens or drops over two consecutive months on his/her weight-for-age growth chart.
PICC	Peripherally inserted central catheter
PN	Parenteral Nutrition
SD	<p>Standard Deviations used to determine moderate to severe malnutrition:</p> <ul style="list-style-type: none"> • 0 - <-1 SD Normally Nourished • >-2 – -3 SD Moderately Malnourished • >-3SD Malnourished
SGA	<ul style="list-style-type: none"> ▪ Small for gestational age
TSF	<ul style="list-style-type: none"> • Tricep Skinfold Thickness [cannot be completed in infants younger than 3 months of age]
VLBW	<ul style="list-style-type: none"> ▪ Very low birth weight [1kg – 1.5kg]
WA	Weight age
WH	Weight for height
Waterlow Criteria (WHO)	<p>Used to determine malnutrition:</p> <p><i>Acute malnutrition: Weight/ Height</i></p> <ul style="list-style-type: none"> • Normal WH >90%, • Mild 81% - 90%, • Moderate 70% - 80%, • Severe <70%. <p><i>Chronic malnutrition: height for age</i></p> <ul style="list-style-type: none"> • Normal >95%, • Mild 90 –95%, • Moderate 85% to 89% • Severe < 85%.

2. Paediatric Working Group Guidelines: Developers Summary

2.1 Scope and Purpose

The Guidelines for Parenteral Nutrition have been developed by the Western Cape Paediatric Nutrition Working Group. The aim of this Guideline is to provide an evidence based nutrition management resource tool, which may be used by health professionals involved in the prescription and supply of nutrition support to infants or children requiring Total Parenteral Nutrition

This Guideline uses an “A, B, C, D” approach e.g. Anthropometry, Biochemistry, Clinical and Dietary, to provide a step by step reference as to how to approach nutrition support.

These guidelines outline nutrition support in children requiring Parenteral Nutrition from the ages of 0 – 18 years of age. They are not meant to be prescriptive and there may be individual case variations.

2.2 Stakeholder Involvement

Members of the Paediatric Working Group are outlined in table 1:

Table 1: Paediatric Working Group Members and Reviewers

	Principal Author	Affiliations
Full Time Members		
Luise Marino	<ul style="list-style-type: none"> ◆ Refeeding Syndrome ◆ Total Parenteral Nutrition ◆ Liver Disease ◆ GORD 	Department of Dietetics, Red Cross War Memorial Children's Hospital
Sonja Stevens	<ul style="list-style-type: none"> ◆ Cardiac Disease 	Dietitian, Netcare Christian Barnard Hospital
Lourentia van Wyk	<ul style="list-style-type: none"> ◆ Diabetes [May 2007] 	Department of Dietetics, Tygerberg Hospital
Nazneen Osmany	<ul style="list-style-type: none"> ◆ Anthropometry 	Department of Dietetics, Tygerberg Hospital
Elisna van Wyk	<ul style="list-style-type: none"> ◆ Pre Term Infants 	Department of Dietetics, Tygerberg Hospital
Gina Stear		Dietitian, Private Practice
Nadia Bowley		Dietitian, Netcare Regional Office N1 City
Ad Hoc Members		
Vivienne Norman	<ul style="list-style-type: none"> ◆ GORD 	Department of Speech and Language Therapy, Red Cross War Memorial Children's Hospital
Shihaam Cader	<ul style="list-style-type: none"> ◆ Short Bowel Syndrome 	Department of Dietetics, Red Cross War Memorial Children's Hospital
Bernadette Saayman	<ul style="list-style-type: none"> ◆ Oncology 	Department of Dietetics, Red Cross War Memorial Children's Hospital
Claudia Schubl		Department of Dietetics, Tygerberg Hospital
Clinical Reviewers		
Prof J Ireland	<ul style="list-style-type: none"> ◆ Liver Disease ◆ GORD ◆ PN 	Dept of Gastroenterology, Red Cross War Memorial Children's Hospital
Dr. E Goddard	<ul style="list-style-type: none"> ◆ Liver Disease ◆ GORD ◆ SBS ◆ PN 	Dept of Gastroenterology, Red Cross War Memorial Children's Hospital
Prof M McCullough	<ul style="list-style-type: none"> ◆ Liver Disease 	Department of Renal Medicine, Red Cross War Memorial Children's Hospital
Dr. L Cooke	<ul style="list-style-type: none"> ◆ Liver Disease ◆ GORD 	Ambulatory Medicine, Tygerberg Hospital
Dr. E Nel	<ul style="list-style-type: none"> ◆ Liver Disease ◆ GORD ◆ PN 	Department of Gastroenterology, Tygerberg Hospital
Mrs. Gordon Graham	<ul style="list-style-type: none"> ◆ Refeeding Syndrome 	Pharmacy, Red Cross War Memorial Children's Hospital
Mrs. G Green	<ul style="list-style-type: none"> ◆ Refeeding Syndrome 	Pharmacy, Red Cross War Memorial Children's Hospital
Dr. J Lawrenson	<ul style="list-style-type: none"> ◆ Cardiac Disease 	Department of Cardiology, Red Cross War Memorial Children's Hospital
Dr. S Vosloo	<ul style="list-style-type: none"> ◆ Cardiac Disease 	Private Cardio Thoracic Surgeon, Netcare: Christian Barnard Hospital

Prof. Hartley	◆ Oncology	Department of Oncology, Red Cross War Memorial Children's Hospital
Prof H Rode	◆ Short Bowel Syndrome	Department of General Surgery, Red Cross War Memorial Children's Hospital
Dr. Kaposky	◆ Short Bowel Syndrome	Department of General Surgery, Red Cross War Memorial Children's Hospital

2.3 Rigour of Development

A Pubmed search was completed using key words such as “parenteral nutrition and children”. Table 2 was used to define the type of articles desired. Sixteen were identified using the key words. The search was narrowed to include papers graded as being level 4 due to the lack of good quality clinical trials in children requiring parenteral nutrition. The recommendations are primarily drawn from expert consensus documents produced by the ESPHAGAN Guidelines for Parenteral Nutrition in Children and Neonates 2005.

Table 2: Grading of levels of evidence (LOE) according to the Scottish Intercollegiate Guideline Network (SIGN) 2000

Grading	Level of evidence
1+++	High quality meta analyses, systematic reviews of RCT's or RCT's with very low risk of bias
1+	Well conducted meta analyses, systematic review of RCT's or RCT's with low risk of bias
1-	Meta analyses, systematic reviews of RCT's or RCT's with a high risk of bias
2++	High quality systematic reviews of case controlled or cohort studies
2+	Well conducted case control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal
2-	Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal
3	Non-analytical studies e.g. case reports, case series. Evidence from non analytical studies e.g. case reports, case series
4	Evidence from expert opinion

The principle author was responsible for compiling the Parenteral Nutrition guideline, which was circulated amongst members of the working group in addition some of the ad hoc members.

All guidelines went through a process of first to third drafts. The recommendations within the guidelines were drafted following a review of the literature and discussions within the group.

All benefits and potential harm of the nutrition recommendations within the guidelines have been discussed and reviewed by the panel at length. The recommendations provided within the text and summary tables are referenced and evidence based.

The Gastroenterology Team at Red Cross Children's and Tygerberg Hospital, who are considered to be experts in their field have reviewed this guideline. Comments received have been incorporated into the clinical guidelines.

The contents of this guideline should be reviewed in two years from the date of publishing, with a view to incorporating the latest developments and research findings and field experiences.

2.4 Clarity and Presentation

The format of this clinical guideline aims to direct the health professional through a logical Nutrition Care Plan approach using A, B, C, D e.g. Anthropometry, Biochemistry, Clinical and Dietary using a series of summary tables, which can be used as a quick reference abridged version for the key recommendations. In addition to these tables the full text may be consulted as required.

A variety of management options have been present targeting clients within the Public and Private Health Care sector. The guideline provides a stratified management approach and identifies current nutrition support systems through which they could be implemented.

2.5 Applicability

The working group did not perceive any potential barriers as all nutrition support strategies are currently available within Public and Private Health Care centres and are available on national tenders. All cost implications have been considered and the most cost effective nutrition management strategies have been recommended.

Within the Nutrition Care Plan Summary Tables appropriate review processes have been identified. In addition all tools are presented with an audit process.

2.6 Editorial Independence

The principal author, working group and or reviewers did not receive any funding to complete these guidelines and the team records no conflicts of interest.

3. Precis

The aim of this guideline is to provide recommendations based on current evidence for best practice in the management of parenteral nutrition in neonates, infants and children.

It is outside the scope of this guideline to provide extensive clinical recommendations for nutrition requirements of clinical states commonly seen, however a general overview of nutrition requirements has been provided. More appropriate texts or evidence-based research in the areas of enquiry should be consulted for more definitive recommendations.

4. Summary of Recommendations for Parenteral Nutrition ^{1 - 16}

Overview	
<ul style="list-style-type: none"> Parenteral nutrition (PN) is used in children with severe intestinal failure. Need to provide adequate calories to meet requirements and maintain growth. A 1kg pre-term infant contains only 1% fat and 8% protein with a non-protein energy reserve of 110kcal/kg body weight. A 10.5kg child has increased amount of reserves and 220kcal/kg body weight. A small pre term infant (1kg) has sufficient stores for four days of starvation and a larger preterm baby sufficient for twelve days. 	
Indications for PN	
<p>Some clinical conditions in which PN may be required are as follows:</p> <ul style="list-style-type: none"> Patients who have undergone extensive excisional surgery in whom the use of the intestine is not expected in the early post-operative period e.g. jejunal atresia Mucositis following chemotherapy, which prevents enteral, access being established, Low Birth Weight Infant <1,500g in conjunction with minimal enteral feeding. Short bowel syndrome. All infants < 32 weeks of age and or 1.5kg should be commenced on PN 24 hours post delivery until full enteral feeds may be established. In older children/ adolescence up to 7 days of inadequate nutrition may be tolerated depending on age, nutritional status, disease, medical or surgical intervention. 	
Recommendations	Comments
Organizational Aspects of PN	
<ul style="list-style-type: none"> PN does not improve outcome. 	
<ul style="list-style-type: none"> <i>Goals for PN:</i> <i>Essential Pre requisites:</i> <i>Management structure:</i> <i>Delivery of PN</i> <i>Type of PN</i> <i>Initial Prescription</i> 	<ul style="list-style-type: none"> Prevention of weight loss, maintenance of normal growth, promotion of catch up growth. Secure venous access, availability of skilled nursing, dietetic, medical and pharmacy staff in the management of PN and complications. Nutrition support team, anthropometrical, biochemical and clinical management parameters. PN may be given via a peripherally inserted central catheter (PICC) or central venous port (CVP). The choice of route is dependant on the osmolality of the solution to be given. It is recommended that all organizations use a gamma irradiated standardize PN but critical attention to individual requirements is required. An initial prescription should be calculated detailing protein, lipid, kcal, ml/kg and mg glucose/ min/kg.
Line Management	
<ul style="list-style-type: none"> All health facilities administering PN should develop organizational specific policies and guidelines, which should be readily available to all members of the medical team. 	<p>Suggestions for policies to be implemented are:</p> <ul style="list-style-type: none"> A policy for the setting up of parenteral nutrition using a volumetric pump, A protocol for the care of the exit site, A procedure for managing air in the line, catheter occlusion, catheter damage and other complications Aseptic technique should be used with regards to the care of catheter e.g. use of sterile gloves, towels and antiseptic solutions.
Route of Administration	
<ul style="list-style-type: none"> Peripheral Parenteral Nutrition is not advocated in children due to the high osmolality of the solutions and the risk of extravasations of PN solution into interstitial tissues. 	<ul style="list-style-type: none"> All PN in children should be provided via a central or PICC line.
Administration Standards: Volumetric Pumps and Filters	
<ul style="list-style-type: none"> All PN must be administered through a dedicated feeding line using a volumetric pump with occlusive and air-in-line alarms to minimize infusion related complications. The prescription should be checked and the volume and rate of infusion must be clearly recorded. The use of a 1.2µm air eliminating filters for lipid containing solutions [changed every 24hours] is recommended for use as they protect patients against the consequences of air emboli, particulate, microprecipitates, phlebitis and microbial contamination e.g. pyrogens, infection. 	<ul style="list-style-type: none"> Filters have sometimes been criticized as they may clog, causing infusion pumps to alarm requiring nursing attention. It should however, be recognized that a clogged filter is a potential sign of a precipitate. It is never appropriate to remove a clogged filter and allow the admixture to infuse without a filter. The entire administration set, filter and admixture solution should be discarded in preference of an entirely fresh administration set, filter and PN. Filters should not be viewed, as a "cure" to potential sources of infection and contamination and strict aseptic techniques should still be employed in order to minimize the risk of harm to the patient.

Anthropometry			
Measure <i>At least 4 times per annum</i>		<i>At least 4 times per annum</i>	
<ul style="list-style-type: none"> • Head Circumference [< 3 years of age] • TSF • MUAC • MAC • AMA • Plot growth velocity biannually if on long term PN. 		<ul style="list-style-type: none"> • HA • WA • WH • % EWA • % EWH • % EHA • Plot on appropriate neonatal [including correcting for gestational age], infant, child growth chart. • Define neonates appropriate according to: AGA, SGA, LGA, IUGR & LBW, VLBW, ELBW. 	
Waterlow (WHO) Criteria		<i>Acute malnutrition: Weight-for-height/ length</i> <ul style="list-style-type: none"> • Normal WH >90%, • Mild 81% - 90%, • Moderate 70% - 80%, • Severe <70%. <i>Chronic malnutrition: Height-for-age</i> <ul style="list-style-type: none"> • Normal >95%, • Mild 90 –95%, • Moderate 85% - 89% • Severe < 85% 	
Classification of Birth Weight			
Low birth weight (LBW)		• < 2500 g	
Very Low birth weight (VLBW)		• < 1500 g	
Extremely Low birth weight (ELBW)		• < 1000 g	
Classification for Weight-for-Gestation-Age at Birth			
Small for gestation age (SGA)		10 th percentile or z-score < -2	
Appropriate for gestation age (AGA)		Between the 10 th and 90 th percentile	
Large for gestation age (LGA)		90 th percentile or z-score > +2	
Classification of Growth Restriction			
Symmetrical Growth Restriction		Wt, Lt and HC fall below the 10th percentile.	
Asymmetrical Growth		Restriction Only: one or two of the parameters falls below the 10th percentile.	
Biochemistry			
<i>Monitor the following</i>		<ul style="list-style-type: none"> • If Mg, PO₄ or K: low provide IV supplementation as per Refeeding syndrome guideline. • If INR > 2 & TPN required: consider delaying commencement until INR < 1.0 – 1.5 • If triglycerides >2 mmol/l consider decreasing amount of lipid being provided to <2g/kg. • If repeat TG levels remain high decrease further – aim to provide sufficient lipid daily to prevent EFA def. 	
<ul style="list-style-type: none"> • U & E: Urea, creatinine, sodium, potassium • Ammonia • Glucose • Calcium, phosphate, Magnesium • Liver function: Albumin, ALT, AST, GGT, Bilirubin [conjugate, unconjugated] • INR • FBC: platelets, differential WCC • Cholesterol & Triglycerides 			
<i>Others</i>			
<ul style="list-style-type: none"> • Pre albumin • C – reactive protein 			
Frequency of Biochemistry			
Daily	Twice Weekly	Weekly	Long Term
<ul style="list-style-type: none"> • Urea • Creatinine • Na • K 	<ul style="list-style-type: none"> • PO₄ • Bicarbonate • Calcium • Liver function test • Albumin² 	<ul style="list-style-type: none"> • Zinc • Magnesium • C-reactive protein 	<ul style="list-style-type: none"> • Selenium • Other trace elements
¹ Continued weight loss may indicate inadequate energy from PN or from optimal PN in the presence of major illness e.g. sepsis. ² As a marker of disease state rather than nutritional status. ³ All electrolyte imbalances should be corrected prior to the commencement of PN. If refeeding syndrome is suspected refer to the Clinical Guideline for the management of Refeeding Syndrome.			

Clinical	
<ul style="list-style-type: none"> Complete a thorough clinical exam considering. It is recommended that all patients be monitored using the following examinations: A medical team [including a dietitian] should review <i>all patients</i> daily whilst on PN as they require careful monitoring of clinical, laboratory and nutritional indices. 	<ul style="list-style-type: none"> Medical, dental history and physical examination looking for signs of deficiency or excess. Clinical appearance, Daily temperature, Daily fluid balance, Weights, daily [neonates] weekly in children [where possible], Hourly temperature
Complications	
<ul style="list-style-type: none"> <i>Infection</i> <i>Compatibility</i> <i>Dedicated Line</i> <i>Refeeding Syndrome</i> 	<ul style="list-style-type: none"> Administration sets should be changed daily. CVP blood cultures should be taken for unexplained fever or signs of sepsis. For suspected catheter related sepsis broad-spectrum antibiotics should be commenced and changed to a narrower spectrum once sensitivity is determined. CVP complications should be regularly audited. Nothing should ever be added to a sterile ready to use 3 in 1 solution or 2 in 1 solution. Mixing of medication with PN administration lines should be avoided unless validated by the manufacturer or laboratory. Medications known to affect plasma protein binding of bilirubin should be avoided in parenterally fed newborn patients with severe hyperbilirubinaemia. Refer to refeeding syndrome guidelines.
Hepatobiliary Complications	
<ul style="list-style-type: none"> <i>Prevention & Treatment of Cholestasis:</i> Some of the following measures may limit or reverse liver disease such as: <i>Persistent Cholestasis</i> 	<ul style="list-style-type: none"> Stimulation of the entero-biliary axis by promoting oral feeds with breast milk or long chain triglyceride containing formula. Reduction of intraluminal bacterial overgrowth caused by intestinal stasis by giving metronidazole. Use of ursodeoxycholic acid 10 – 30mg/kg per day. Commence cyclical PN as soon as possible. Early referral to paediatric liver transplant centre for further assessment in infants or children on PN for > 3 months and serum bilirubin > 50 umol/l, platelet count < 100, PT > 15 sec, PTT > 40 sec or hepatic fibrosis, INR > 2. If cholestasis continues in spite of above preventative management clinician should rule out drug toxicity, biliary obstruction and or infection. A decrease in platelet count below 150, 000/ mm³ and an increase in plasma transaminases may suggest lipid toxicity. Bone marrow aspiration, liver biopsy and or temporary suspension of lipids for not more than 3 days should be considered.
Dietary	
<ul style="list-style-type: none"> Complete a thorough dietary history considering recent changes in dietary intake, review of enteral feeds, gastrointestinal (GIT) symptoms e.g. diarrhea and vomiting, medical and surgical problems. Each patient should have a nutrition prescription calculated by an appropriately qualified nutrition expert e.g. dietitian. <ul style="list-style-type: none"> Each nutrition prescription should include the following information: 	
<ul style="list-style-type: none"> Patient Name Hospital Number Ward Date All in One bag prescribed Note: All PN not used should be discarded after 24 hours.¹³ 	<ul style="list-style-type: none"> Energy requirements [kcal] Protein requirements [g] Total protein Protein/kg Total Lipids Lipids/kg
<ul style="list-style-type: none"> Total Volume MI/hr MI/kg Total energy [kcal] Energy/kg Glucose mg/min/kg 	<ul style="list-style-type: none"> It is important not to provide excessive calories to patients receiving PN as this increases the incidence of co-morbid complications such as increased fat deposition and a fatty liver.
<p>Energy requirements should also take into account according to medical parameters:</p> <ol style="list-style-type: none"> Weight gain required per day i.e. target growth and or catch up growth Nutrition prescription Tolerance of PN solution e.g. hyperglycaemia, hypertriglyceridaemia, liver enzyme abnormalities, cholestasis etc. 	

Estimating Energy Requirements		
Age in Years	DRI – for enteral intake	DRI – 10% for Diet induced thermogenesis: Use in calculations for PN
Pre Term	110 – 130	99 – 117
0 – 1 years	90 – 110	89 – 90
1 – 7 years	75 – 90	62.5 – 91
7 – 12 years	60 – 75	54 – 68
12 -18 years	30 - 60	27 - 54
Estimating Protein Requirements		
Categories	Recommendations for Protein Intake	
Pre Term	<ul style="list-style-type: none"> Amino acid supply should commence on the first day of life. Minimum of 1.5g/kg of protein is required to prevent negative nitrogen balance. A maximum of 4g/kg of protein is recommended. 	
Term Neonates	<ul style="list-style-type: none"> Minimum of 1.5g/kg of protein is required to prevent negative nitrogen balance. A maximum of 3g/kg of protein is recommended. 	
1 st month to 3 rd year of life	<ul style="list-style-type: none"> Minimum of 1.0g/kg of protein is required to prevent negative nitrogen balance. A maximum of 2.5g/kg of protein is recommended. 	
3 rd – 5 th year of life	<ul style="list-style-type: none"> Minimum of 1.0 - 2g/kg is required to prevent negative nitrogen balance. A maximum of 3g/kg of protein is recommended in critically ill children. 	
6 th – 12 th year of life	<ul style="list-style-type: none"> Minimum of 1 - 2g/kg is required to prevent negative nitrogen balance. A maximum of 4g/kg protein is recommended in critically ill children. 	
Adolescents	<ul style="list-style-type: none"> Minimum of 1g/kg of protein is required to prevent negative nitrogen balance. A maximum of 2g/kg of protein is recommended. 	
Glutamine & Taurine	<ul style="list-style-type: none"> There is no conclusive evidence for the need to provide glutamine supplementation in the preterm infant. There is no conclusive evidence to support the supplementation of taurine in the preterm infant. However, it is advised that taurine be supplemented in the same amount as is present in human breast milk approx. 22ug/gram amino acids or 2.8 mg/g amino acids. 	
Lipid Requirements		
Essential fatty acid deficiency	<ul style="list-style-type: none"> Omission of lipid emulsions from PN may lead to biochemical evidence of EFA deficiency. Pre Term: In order to prevent EFA deficiency 0.25g/kg linoleic acid should be given per day. Term: In order to prevent EFA deficiency 0.1g/kg linoleic acid should be given per day. 	
Fat Intake	<ul style="list-style-type: none"> Fat administration should not exceed fat oxidation rates. Pre Term > 1000g: a lipid supply of 3g/kg was tolerated. Pre Term < 1000g: lipid tolerance may be less than 3g/kg. Term infants: tolerate up to 4g/kg of lipid given when maximal glucose intake does not exceed oxidation rates about 18g/kg or 12.5mg gluc /min/kg. Parenteral lipid infusion should usually be limited to a maximum of 3 – 4g/kg per day (0.13 – 0.17g/kg/hour) in infants and 2 – 3 g/kg/day (0.08 – 0.13g/kg/hour) in older children. 	
Application	<ul style="list-style-type: none"> Lipid administration should not exceed the capacity for lipid clearance and should be adapted if hyperlipidaemia occurs. In infants, neonates and premature infants lipid is best tolerated as a 24-hour infusion. If cyclical PN is administered, then lipid should be given over the same duration as the other PN components. There is no evidence to support gradual incremental increases of lipid improves tolerance. If lipids are increased from 0.5 – 1g/kg day it is possible to monitor for hypertriglyceridaemia. Heparin does not improve the utilization of lipids and should not be added to a PN solution. 	
Monitoring	<ul style="list-style-type: none"> Monitor plasma triglycerides (TG) in all patients receiving PN, particularly in patients with marked hyperlipidaemia. Reduction of per/kg lipids should be considered if plasma or serum TG is >250mg/dl in infants and > 400mg/dl in children. 	
Critical Illness and infection	<ul style="list-style-type: none"> More frequent lipid monitoring is recommended. 	
Respiratory Failure	<ul style="list-style-type: none"> There is no conclusive evidence of the effects of lipid emulsions in children with severe acute respiratory failure with or without pulmonary hypertension. It may be wise to avoid high lipid intakes. However, minimal amounts of lipids should be continued to prevent EFA deficiency. 	
Premature & Neonates	<ul style="list-style-type: none"> In neonates who are not able to receive sufficient nutrients orally lipids should be started no later than the 3rd day of life, but may be started on the first day of life. Early administration of lipid does not increase the risk of chronic lung disease or death in premature infants. However, there are concerns about some adverse effects in ELBW < 800g. Lipid emulsions have not been demonstrated to have an adverse effect on hyperbilirubinaemia in premature infants. However, bilirubin, triglycerides and the level of hyperbilirubinaemia should be monitored and lipid levels reduced accordingly. There are some recommendations to suggest that if conjugated bilirubin levels are above 200mg/l then lipid levels should be reduced to 2g/kg day or less ensuring sufficient lipid is provided to prevent EFA deficiency. 	
Thrombocytopenia	<ul style="list-style-type: none"> In patients with severe unexplained thrombocytopenia serum triglyceride levels should be monitored and a reduction of lipid infusion to less than 2g/kg/day should be considered. Lipids supplying a minimum of EFA should be provided to maintain normal platelet function. 	

Cholestasis	<ul style="list-style-type: none"> In patients with severe progressive PN associated cholestasis, which is unrelated to infection should be investigated. In some cases a decrease or even transient interruption in the amount of lipid should be considered. 			
Effects on Immune system	<ul style="list-style-type: none"> The significant nutrition benefits of lipid emulsions outweigh any potential risks or adverse effects on the immune system. 			
Carnitine	<ul style="list-style-type: none"> In prolonged PN decreased levels of carnitine occur. Carnitine supplementation should be considered on an individual basis in patients receiving PN for more than 4 weeks. 			
Carbohydrate Requirements [G/kg/ glucose & mg/min/kg/glucose]				
Weight	Day 1	Day 2	Day 3	Day 4
Up to 3kg	• 10	• 14	• 16	• 18 • 12.5
3 – 10kg	• 8	• 12	• 14	• 16 – 18 • 11 – 12.5
10 – 15kg	• 6	• 8	• 10	• 12 – 14 • 8 – 9.7
15 – 20kg	• 4	• 6	• 8	• 10 – 12 • 6.9 – 8.3
25 – 30kg	• 4	• 6	• 8	• < 12 • 8
> 30kg	• 3	• 5	• 8	• < 10 • 6.9
> 60kg	<ul style="list-style-type: none"> Hyperglycaemia causing marked glycosuria should be avoided. Hypoglycaemia (< 2.5mmol/l) should be avoided. Insulin should be administered in pre term infants with extreme care. 			• 3 – 5 • 2 – 4
Fluid Requirements				
Age (years)			ml/kg actual body weight	
Premature			180-200	
0-1			150	
1-3			100	
3-6			90	
7-10			70	
10-15			60	
Daily electrolyte recommendations to paediatric PN				
Electrolyte	Neonates	Infants/Children	Adolescents	
Sodium	2 – 5 mEq/kg	2 – 6 mEq/kg	Individualized	
Chloride	1 – 5 mEq/kg	2 – 5 mEq/kg	Individualized	
Potassium	1 – 4 mEq/kg	2 – 3 mEq/kg	Individualized	
Calcium	3 – 4 mEq/kg	1 – 2.5 mEq/kg	10 – 20mEq	
Phosphorus	1- 2 mmol/kg	0.5 – 1 mmol/kg	10 – 40mmol	
Magnesium	0.3 – 0.5 mEq/kg	0.3 – 0.5 mEq/kg	10-30mEq	
Recommended Daily Vitamin & Trace Element Supplementation to Paediatric PN Formulations ^{a,b}				
Multivitamin	Dose (ml)	Paediatric Multivitamin Recommended to contain (5ml)		
Weight (kg)		A (IU) 2300, D (IU) 400, E (IU) 7, K (mcg) 200, C (mg) 80, B1 (mg) 1.2, B2 (mg) 1.4, B3 (mg) 17, B5 (mg) 1, B12 (mcg) 1, biotin (mcg) 20, folic acid (mcg) 140		
1	2			
1-3	3.5			
>3	5			
Trace Element Requirements for Paediatrics				
Trace Element	Pre Term Neonates (mcg/kg)	Term Neonates (mcg/kg)	< 5 years old (mcg/kg)	Older children & Adolescents
Zinc	400	300	100	2-5mg
Copper	20	20	20	200-500mcg
Manganese	1	1	2 – 10	50-150mcg
Chromium	0.2	0.2	0.14 – 0.2	5-15mcg
Selenium	2 – 3	2 – 3	2 – 3*	30-40mcg
Iodine	1**	1**	1**	-
*Limit – 40mcg/kg				
**Percutaneous absorption of protein bound iodine may be inadequate.				
^a Assumes normal organ function.				
^b Vitamin K supplementation 2-4mg/week in PN patients not receiving oral anticoagulation therapy.				

Administration of PN	
Initiating PN	
<ul style="list-style-type: none"> In children who have not has a prolonged period of starvation and in whom refeeding syndrome is considered unlikely to occur, PN may be started at ½ the total volume required on day 1 and increased to full volume by day 2, including neonates. In children in who refeeding syndrome is considered to be a significant risk a more cautious approach should be considered taking 5 – 10 days to reach goal nutrition intake. 	<ul style="list-style-type: none"> All electrolyte abnormalities should be correct prior to PN being commenced. Repeat bloods should be completed 2 – 3 times per week during the first week in a stable child not at risk of refeeding syndrome and weekly thereafter. In children at severe risk of refeeding syndrome 12 hourly bloods may be required in order to monitor and correct electrolyte imbalances.
Cyclical PN	
<ul style="list-style-type: none"> Cyclical PN is usually well tolerated from 3 – 6 months of age. 	<ul style="list-style-type: none"> In cyclical PN the maximal rate of glucose infusion may exceed that is glucose oxidation. The maximal infusion should not exceed 1.2g/kg per hour (20mg/kg/min). A stepwise increase and decrease of glucose infusion should be considered at onset and discontinuation of PN to avoid hyper and hypoglycaemia. Recommend taking 2 hours to wean on and off.
Weaning from PN	
<p>Weaning from PN</p> <ul style="list-style-type: none"> Children with acute episodes of severe intestinal failure e.g. post surgery or during a course of chemotherapy may tolerate the rapid reintroduction of food. Children with primary gut pathology may require a more gradual and stepwise approach. Introduction of oral/ enteral feeds should be accompanied by a reduction in the amount of PN administered in order to minimize the risk of overfeeding and fluid overload. When more than 50% of the patients' requirements are being met via an enteral/ oral route then PN may be discontinued.³ 	<p>The following factors should be considered when introducing enteral feeds:</p> <ul style="list-style-type: none"> Minimal enteral feeds (MEM) should be given where possible to prevent gut atrophy, maintain enterohepatic circulation & gut integrity, encourage adaptation, reduce the risk of PN associated liver disease. In short bowel syndrome expressed breast milk is the milk of choice. Make one change in treatment at a time in order to assess tolerance e.g. if the volume of EN is increasing the concentration of the feed should remain the same. In severe intestinal failure feeds should be increased slowly as tolerance permits. An experienced dietitian/ nutrition support team should be involved. CVP access should be maintained until the child tolerates full EN. EN may be given over a 4 to 24 hour period via enteral feeding pump. In order to decrease risk of pathogenic organism infection from powdered feed a ready to use sterile infant/ paediatric feed should be used. Some children may be weaned directly onto bolus feeds and by mouth where ever possible. Infants should not be woken at night to give feeds in order to avoid fatigue. If gastric feeds are poorly tolerated then continuous jejunal feeds may be considered. Children who rapidly recover intestinal function may be weaned directly onto food.
<p>Type of Feed</p>	<ul style="list-style-type: none"> Children with primary gut pathology may require specialized feeds: hydrolyzed, partially hydrolyzed or intact protein sources. If TPN was provided for other reasons e.g. spinal shock, bowel resection a normal intact protein source will usually be tolerated. See Short Bowel Syndrome guidelines for the management of SBS, especially in infants with no IC valve or colon. However, briefly breastmilk is the preferred milk of choice in all SBS infants for up to 2 years of age.
<p>When to wean</p>	<ul style="list-style-type: none"> PN may be weaned as soon as the child is stable e.g. intestinal losses from vomiting and diarrhea are minimal and optimal nutrition status is being met. Underlying pathology should be investigated in a specialist unit by a Paediatric Gastroenterologist. ENT should be given at normal concentration and not diluted. PN should decreased by a similar amount or slightly more than the increase in EN. If weaning strategy fails: try an alternative option e.g. weaning more slowly and providing feeds as a continuous infusion rather than bolusly.
<p>Psychosocial development</p>	<ul style="list-style-type: none"> Where ever possible small amounts of oral feeding should be maintained.

Infusion Equipment and Inline filters

- All PN solutions should be administered via an accurate infusion pump.
- Peripheral infusions should be closely monitored for signs of extravasations.
- The pump should have free flow protection if opened during use and have lockable settings.
- All PN solution should be administered via a terminal filter.
- Lipid emulsions should always be administered via a lipid filter, which should be changed daily.

5. Summary: Establishing Parenteral Nutrition

Goal: To ensure that each patient requiring Parenteral Nutrition attains/ maintains an optimal nutrition status.

To read the chart:
Follow the arrows

Assess patient using the following approach:

- A = Anthropometry
- B = Biochemistry
- C = Clinical
- D = Dietary
- Implement nutrition support where appropriate

Start Here

Anthropometric assessment to determine patient's nutritional status & risk:

- Height MAC TSF %EHA HC MUAC Weight %EWA
- %EWH AMA

Initiating PN in severely malnourished or at high risk patients for Refeeding Syndrome:

- Monitor U&E, CPM every 12 hours for first 3 days
- Increase rate of PN slowly over 5 – 7 days.

Yes

Does patient have severe acute or chronic malnutrition?

No

Initiating PN in normally nourished patients:

Day 1: aim to provide:

- Prems/ infants: 1.5g/kg protein/ lipid, 60kcal/kg & 6mg/min glucose.
- Children > 1 year: ½ requirements.

Day 2: aim to provide:

- Prems/ infants: 2.5 – 3g/kg lipid/protein, 90 – 95kcal/kg, 10 – 12mg/min/glucose.
- Children > 1 year full requirements.

Biochemistry

- U&E, FBC – daily for first week then twice weekly
- LFT, TG, CPM - weekly

Complications

- **Platelets < 100** – reduce lipid intake to 2g/kg/day in infants and 1.5 – 2g/kg/day in older children.
- **> Conjugated Bilirubin**: in neonates < lipid intake to 2g/kg/day.
- **Liver dysfunction** – switch to cyclical PN, commence ursodexocholic acid 10 – 30mg/kg/day, metronidazole and small enteral feeds where possible.
- **INR > 2** – correct with vitamin K prior to commencing PN.

Weaning PN

- Start small enteral feeds 5 – 10ml/hr or less in premature infants.
- Rapid weaning can occur in patients where tolerance is not expected to be a problem e.g. ½ rate in the morning and discontinue by the afternoon.
- However, in most cases enteral feeds will need to be built up slowly e.g. 12 – 24 hour incremental increases.
- As tolerance improves PN may be decreased accordingly.
- Once >75% of nutrition intake is being met enterally, PN can be discontinued.

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