Guidelines for the Administration of Enteral and Parenteral Nutrition in Paediatrics

SickKids
Toronto, Ontario, Canada

A joint effort by the Nutrition Team

Andrea Aquilina
Ray Bisson
Joan Brennan
Megan Carricato
Bairbre Connolly
Gloria Green*
Debra Harrison
Elizabeth Harvey
Joann Herridge
Lorrie Hagen
Penni Kean*
Julia Kelly
Marnie MacKenzie
Nadia Nalli
Debbie O'Connor
Paul Pencharz
Aneta Plaga
Donna Secker
Laura Stefanizzi
Debbie Stone
Joyce Touw
Paul Wales

Original editors for first and second editions

Mark Bedford
Joan Brennan
Daina Kalnins
Marni MacKenzie
Donna Secker
Paul Pencharz

Third Edition, June 2007

*Editors for third edition

Table of Contents

Table of Contents

Introduction

These guidelines are intended to guide health care practitioners in providing optimal nutrition support for neonates, children and adolescents. Nutrition Team members are available for consultation, either formal or informal, on any patient requiring nutritional support.

Nutrition Team Members	Pager (416)	Extension
Dr. Paul Pencharz	237-3652	7733
Dr. Stanley Zlotkin	237-8929	6171
Enterostomy Nurse Practitioner	582-1584	7274
Enteral Nutrition Support Nurse	377-1271	7177
Parenteral Nutrition Support Nurses	377-1272	8217
G-tube Clinic (follow-up; 4th floor Gerrard)		7270
Parenteral Pharmacists		6702
Clinical Dietitians (listed by program)		
Adolescent Medicine	370-5297 530-3273 370-5044 442-6817	
Cardiology	442-6952 330-3036 242-0257	
Critical Care	237-3797 370-5224	
Endocrinology	242-0252 530-3279 370-5225	
FTT Clinics/Allergy	242-0249	
General Surg/Ortho/ENT/Urology	232-5744	
General Paediatrics Inpatients	242-0255	
Genetic Metabolics	442-9693 242-0254	
GI Nutrition/Hepatology	530-3291 589-8063 246-4162	
Gynaecology	370-5225	
Haem/Onc &BMT	589-6006 242-0251 442-9150	

Clinical Dietitians (listed by program) cont'd	Pager	Extension
Home TPN	242-0256	
Ketogenic Diet	530-7245	
Neonatology	242-0181 377-9796	
Nephrology	235-8771 242-0174	
Neurosciences/Trauma/Burns/Plastics	582-1907 232-5854	
PKU	237-3693	
Respiratory Medicine	242-0182 242-0249	
Rheumatology	589-8063	
Lactation Consultants	517-3084 442-0659 237-2844 330-3025	5777
Indirect Calorimetry	246-4561	6151
Occupational Therapists (listed by program)		
Cardiology	370-5052 232-4527	
Cleft Lip/Palate, Craniofacial	582-0548	
Critical Care Medicine	370-4804	
General Paediatrics Inpatients	235-3309 232-7358	
General Surg/ENT	582-1065 237-3671	
GI/Nutrition	232-4527	
Haem/Oncology & BMT	237-3671	
Neonatal Follow Up Clinic	237-6547	
Neonatology	582-0264 232-7356	
Neuro/Oncology	582-0697	
Neuroscience: Neurology Neurosurgery	 237-3671 582-5129	
PAMOT (Transplant)	370-4804	
Respiratory Medicine	232-7356	
Rheumatology	232-4336	
Trauma	582-1297	

ENTERAL NUTRITION

Indications for Use

Enteral tube feeding is initiated when a patient is unable to meet nutrient or fluid needs orally. Conditions that often require enteral support include:

- anorexia associated with chronic illness
- chewing, swallowing disorders*
- coma
- acute metabolic stress (e.g., trauma, burns)
- failure to thrive
- inflammatory bowel disease (e.g., Crohn's disease)
- neuromuscular handicaps (e.g., cerebral palsy)
- prematurity
- short gut.

** With precautions and careful monitoring, enteral feeding can be successfully used in patients at high risk for pulmonary aspiration*

For best outcomes:

1. Use enteral feeding in preference to parenteral feeding whenever possible because of its established benefits:
   - maintains gut mucosal integrity
   - prevents pancreatic and biliary flow dysfunction
   - has fewer complications/lower risk of infection
   - incurs lower costs.

2. Start enteral feeding as soon as possible, within 48 to 72 hours of admission for hemodynamically stable:
   - infants
   - patients who were malnourished before illness or injury
   - septic or injured patients in whom a prolonged intensive care course is anticipated.

3. Start enteral feeding at any time during an admission for:
   - patients who have been unable to eat for 3-5 days
   - patients whose documented energy intake is ≤50%-75% of recommended levels for ≥2-3 days for infants and ≥3-5 days for children and adolescents.

Contraindications for Use

Absolute contraindications include:

- necrotizing enterocolitis
- bowel obstruction or ileus
- hemodynamic instability.

Possible contraindications that should be evaluated individually:

- persistent vomiting or diarrhea
- acute abdominal distention
- gastric, small- or large-bowel fistula
- upper gastrointestinal bleeding.

Route

To select the route of delivery see the algorithm in Figure 1, and consider the following:

ORAL GASTRIC/NASOGASTRIC/NASOJEJUNAL

Oral gastric (OG) or nasogastric (NG) tubes are usually easy to place, although resistance may be met with older children. Occasionally, nasal problems (e.g., irritation, increased secretions) cause discomfort. OG-tubes are sometimes placed in infants with a cleft palate or children with facial abnormalities (e.g., trauma to face or nose) that preclude nasal feedings. Nasojejunal (NJ) tubes are more difficult to position and require radiological placement.

Long-term use of NG- or NJ-tubes is associated with esophagitis and/or gastro-esophageal reflux (GER). If tube-feeding is required for more than 8-12 weeks, gastrostomy (G) or gastrojejunostomy (GJ) tube placement should be considered instead.

GASTROSTOMY/GASTROJEJUNOSTOMY/JEJUNOSTOMY

A gastrojejunostomy (GJ) tube may be warranted if a gastronomy (G) tube has been unsuccessful in managing GER and/or aspiration pneumonia, despite treatment with prokinetic and acid inhibitory agents and nonpharmacologic measures (see page 42, Treatment of Gastric Dysmotility and Gastroesophageal Reflux). Alternatively, a surgical fundoplication may be considered.

G- and GJ-tubes are usually placed in the Image Guided Therapy (IGT) suite using the retrograde percutaneous radiological technique. Due to the complexity of patient's medical problems, approximately 95% of the patients at SickKids require general anaesthesia or "anaesthesia-standby"; the occasional patient may need only light sedation and local anaesthesia.

G-tubes and/or jejunostomy (J) tubes are less frequently inserted in the operating room. Surgically placed tubes may be indicated for children in whom a radiologically placed tube cannot be performed (e.g., unfavourable anatomy when the stomach does not come close to the abdominal wall) or at the time a child is undergoing another surgical procedure.

Jejunal tube feeding via a GJ or surgically placed jejunostomy requires continuous feeding administration; bolus feeds are contraindicated because of the small diameter of the jejunum (see Table 7).

For potential complications associated with enteral feeding see Table 10.

TUBE SIZES

Tubes are available in a range of sizes (5-24 French). Tubes placed radiologically are pigtail catheters (8-14 Fr). These tubes are electively changed to a catheter with an inflatable balloon, which parents/caretakers can be taught to change.

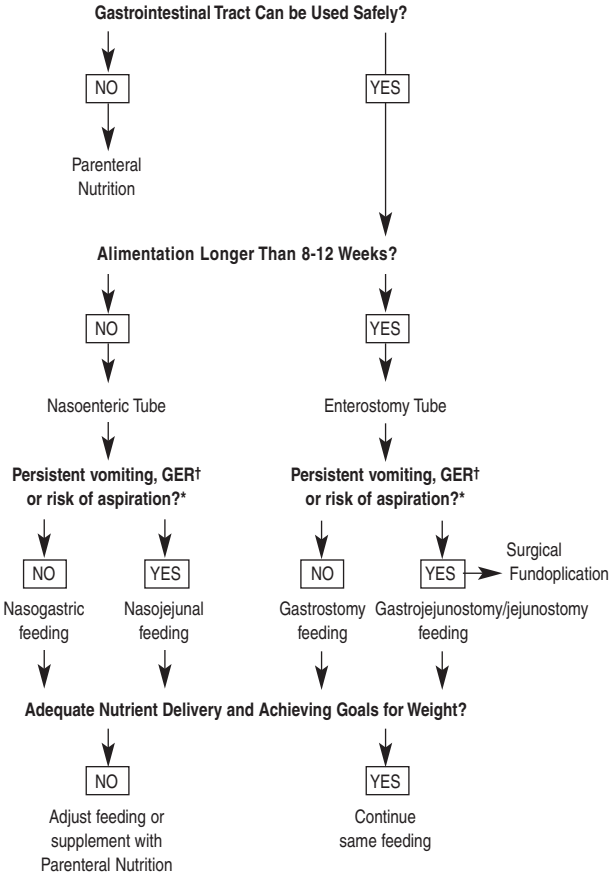
Replacement tubes are either standard or low-profile devices. Standard tubes are usually held in place with an inflatable balloon; their main disadvantage is their bulky external portion. Some tubes have fixed bulbs. Many families prefer to have the tube size increased gradually so that a low-profile tube can be inserted.

Features of available low-profile tubes:

Feature	*MIC-KEY or Tyco Nutriport Button*	*Bard, Abbott or Sandoz Buttons*
Sizes available	12 FR and up	18 FR and up
Held in place by	Inflatable balloon	Molded head
Approximate cost Cost to family	$190 $50 (subsidized 75%)	$250 $250
Length of time tube lasts	4-8 months	3-4 years
Other	Parents can be taught to insert a new tube. No sedation required. Changed in clinic setting.	Not replaceable by parents. Cannot fall out, but can be pulled out. General anesthesia required. Changed in Interventional Radiology.

Contact an Enteral Nutrition Support nurse or see the SickKids parent education booklet, Your Child Has an Enteral Feeding Tube, for additional information.

Figure 1. **Algorithm for Selecting the Route of Nutritional Support**



† *Gastroesophageal reflux*

** Despite treatment with prokinetic and acid inhibitory agents and non-pharmacological mean (see page 42, Treatment of Gastic Dysmotility an Gastroesophageal Reflux)*

IGT Enterostomy Tube Referral and Pre-insertion Process

For inpatients, referrals for enterostomy tube placement are made using KidCare via the diagnostic IGT pathway. For outpatients, request forms are required for Enterostomy Access and Diagnostic Imaging Consultation. Referral forms can be found on most wards and outpatient clinics or ordered (Enterostomy Access forms can be requested from the SickKids Gastroenterology, Hepatology and Nutrition Clinic (ext. 7270); Diagnostic Imaging Consultation forms (form 05983) can be ordered directly from RelizonTM (phone 905-696-8884). Completed referral forms must be faxed to 416-813-8124.

Referrals are triaged and assessed by the Enterostomy Access Team including the Enteral CNS/NP, IGT, and the Paediatrician on IGT service. Considerations for sedation are individualized. Consultation with Anaesthesia may be indicated for certain medical conditions. Guidelines for antibiotic coverage for IGT-placed feeding tubes can be found in the SickKids Drug and Formulary Guidelines (see Antibiotic Prophylaxis for Image Guided Therapy and Endocarditis Prophylaxis).

Nutritional Requirements

ENERGY (CALORIES)

As a child grows, energy requirements per kilogram decrease (see Tables 1 and 2). Requirements will be greater in children who have compromised respiratory status, sepsis, thermal burns, some other disease states). Requirements will be lower in ventilated children and those with limited physical activity (e.g., on paralytic drugs, or with physical handicaps). Consult the dietitian to more accurately predict an individual's requirements according to clinical condition and activity level.

Measurement of energy expenditure using indirect calorimetry may be warranted for children who respond inappropriately to energy intakes based on predictive methods, as predictive equations may be inaccurate in certain disease or clinical states (e.g., critical illness, sedation, altered lean mass). *Indirect calorimetry measurements can be booked by calling ext. 6151.*

PROTEIN

To ensure that protein is used for anabolism, and not as a source of energy, a minimum amount must be supplied along with the correct proportion of non-protein calories (carbohydrate and fat). Goal protein requirements are outlined in Table 3. Excess protein is undesirable for young infants with immature kidneys and older children with acute or chronic renal failure.

CARBOHYDRATE

The percentage of calories from carbohydrate ranges from ~40% in breastmilk and commercial infant formulas to ~50-60% in enteral feedings. In cases of carbohydrate intolerance or respiratory distress a lower carbohydrate content may be desirable. Goal carbohydrate intakes are outlined in Table 3.

FAT

Fat restriction is contraindicated in children, except for those with medical conditions warranting it (e.g., chylothorax). Formula feedings for infants should contain ~50% of calories from fat, similar to breastmilk. From the age of 2 years until the end of linear growth, there should be a transition from the high fat content of breastmilk or infant formulas to an enteral feeding containing ~30% of calories from fat. Goal fat intakes are outlined in Table 3. In conditions of fat maldigestion and/or malabsorption, a formula containing part of the fat source as medium-chain triglycerides may be indicated (see Appendices A and B).

VITAMINS AND MINERALS

For recommended nutrient intakes of selected vitamins and minerals for healthy children, refer to Tables 4 and 5. For nutrients not listed, or for altered requirements due to medical status, please contact the dietitian.

FLUID

Fluid requirements for paediatric patients are influenced by medical and environmental factors. Certain conditions (e.g., fever, high urinary output, excessive losses through vomiting, diarrhea or drains) raise maintenance fluid requirements; others (e.g., renal, cardiac, respiratory) lower them.

The following guide can be used for estimating maintenance fluid needs:

Patient weight	*Daily maintenance fluid requirements*
<10 kg	100 mL/kg
10-20 kg	1000 mL+ 50 mL for each kg >10 kg
20 kg	1500 mL+ 20 mL for each kg >20 kg

In situations where fluid restriction is necessary, calorie-dense formulas are often needed to meet nutritional requirements (see Table 6). In situations where fluid intake is marginal* or when constipation due to inadequate fluids is suspected, consideration of the free water content of a formula may be important. See Appendices D, E for the free water content of oral supplements and tube feedings.

** Check urine for specific gravity and electrolytes*

When fluid needs exceed the volume of formula required to meet nutritional requirements, provide additional fluid as water, not formula, to avoid undesired weight gain. Additional fluid can be given either by diluting the formula with water or giving water between intermittent feedings or after every 8 hours of continuous feedings.

Table 1. **Summary of Recommended Nutrient Intakes for Preterm Infants**

Age	*Sex*	*Energy (kcal/kg/d)*	*Protein (g/kg/d)*	*Vit A (µg/d)*	*Vit D (µg/d)*	*Vit E (IU/kg)*	*Vit C (mg/kg)*	*Folate (µg/d)*	*Vit B12 (µg/d)*	*Ca (mmol/kg/d)*	*PO_4 (mmol/kg/d)*	*Mg (mmol/kg/d)*	*Iron (mg/k/d)*	*Zinc (mmol/kg/d)*
Premature infants														
birth-7d		70-80	1.0-3.0	450	1.0-6.5	6-12	30 to 40	50	0.15	3-5	2-3.5	0.18-0.13	0	7.6-12.2
7d-2 mo		105-135	3.0-4.0	450	10	6-12	30 to 40	50	0.15	3-5	2-3.5	0.18-0.13	0	15.3-30.6

Sources

Nutrition Committee. Canadian Pediatric Society. Nutrient needs and feeding preterm infants. *Can Med Assos J* 1995; 152:1765-1785.

Tsang R, Uauy R, Koletzko B, Zlotkin S (eds). Nutrition of the Preterm Infant – Scientific Basis and Practical Guidelines. 2nd ed. Cincinatti: Digital Educational Publishing, Inc., 2005.

Table 2. **Summary of Estimated Energy Requirement (EER) for Infants and Children**

		Estimated Energy Requirement (EER) (kcal/kg/d)*			
Age	*Sex*	*Physical Activity Level (PAL)+*			
Infants (mo)					
0-2	M	107			
	F	104-102			
3-6	M	95-82			
	F	95-82			
7-9	M	79-80			
	F	80			
10-20	M	79-82			
	F	82			
21-35	M	82-83			
	F	83	*Sedentary*	*Low Active*	*Active*	*Very Active*
Children (y)						
3-4	M		81-75	93-86	104-97	117-109
	F		78-72	89-83	100-94	118-111
5-6	M		69-64	80-74	90-84	103-97
	F		66-62	77-72	87-82	104-97
7-8	M		60-57	70-66	80-75	92-87
	F		57-53	67-62	75-71	90-85
9-10	M		54-50	63-59	71-67	83-78
	F		49-45	57-53	65-60	78-72
11-12	M		47-44	55-52	64-60	74-70
	F		41-39	49-46	56-53	67-64
13-14	M		42-41	50-48	57-56	67-64
	F		37-35	44-41	50-47	60-57
15-16	M		40-38	47-45	54-52	62-60
	F		33-32	40-38	45-44	55-54
17-18	M		37-36	43-42	50-49	58-57
	F		31-30	37-36	43-42	52-51

+PAL for infants not determined

**EER (kcal/kg) calculated based on equations on p. 19 divided by reference weights.*

Reference weights for Infants 0-35 mo and reference weights and heights for children 3-18 years used for calculations. Reference weight from Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, Mei Z, Curtin LR, Roche AF, Johnson CL. 2000. CDC growth charts: United States. *Adv Data* 314:1-28.

EER (kcal/day)

Infants

0-3 mo	EER = (89 x weight [kg] - 100) + 175
4-6 mo	EER = (89 x weight [kg] - 100) + 56
7-12 mo	EER = (89 x weight [kg] - 100) + 22
13-36 mo	EER = (89 x weight [kg] - 100) + 20

Children

Boys	
3-8 y	EER = 88.5 - 61.9 x age[y] + PA x (26.7 x weight [kg] + 903 x height [m]) + 20
9-18 y	EER = 88.5 - 61.9 x age[y] + PA x (26.7 x weight [kg] + 903 x height [m]) + 25
Girls	
3-8 y	EER = 135.3 - 30.8 x age[y] + PA x (10.0 x weight [kg] + 934 x height [m]) + 20
9-18 y	EER = 135.3 - 30.8 x age[y] + PA x (10.0 x weight [kg] + 934 x height [m]) + 25

Physical Activity (PA) Coefficients used in EER equations

	Sedentary	*Low Active*	*Active*	*Very Active*
Boys				
3-18 y	1.00	1.13	1.26	1.42
Girls				
3-18 y	1.00	1.16	1.31	1.56

Source

Food and Nutrition Board, Institute of Medicine-National Academy of Sciences. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients). (2005). Available at www.nap.edu

Note for Tables 3-5

RDAs and AIs may both be used as goals for individual intake. RDA: the average daily nutrient intake sufficient to meet the needs of nearly all (97-98 percent) healthy individuals in a particular age and life stage group. AI: For healthy infants fed human milk, the AI is the mean intake. For other ages and gender groups, the AI is the recommended average daily nutrient intake based on observed or experimentally determined estimations of nutrient intake by a group (or groups) of apparently healthy people. *These are reference values for normal, apparently healthy children. An individual child may have physiological, health, or lifestyle characteristics that may require tailoring of specific nutrients.*

Table 3. **Summary of Dietary Reference Intakes (DRIs): Macronutrients for Infants and Children**

Age	*Sex*	*Protein (g/kg/d)*	*Carbohydrate (Digestible) (g/d)*	*Total Fat (g/d)*	*Linoleic Acid (g/d)*	*_-linolenic Acid (g/d)*	*Total Fiber (g/d)*	*Total Water (g/d)*
Infants								
0-6 mo	Both	1.52*	60*	31*	4.4*	0.5*	ND	0.7*
7-12 mo	Both	**1.2**	90*	30*	4.6*	0.5*	ND	0.8*
Children								
1-3 y	Both	**1.05**	**130**	ND	7*	0.7*	19*	1.3*
4-8 y	Both	**0.95**	**130**	ND	10*	0.9*	25*	1.7*
9-13 y	M	**0.95**	**130**	ND	12*	1.2*	31*	2.4*
	F	**0.95**	**130**	ND	10*	1.0*	26*	2.1*
14-18 y	M	**0.85**	**130**	ND	16*	1.6*	38*	3.3*
	F	**0.85**	**130**	ND	11*	1.1*	26*	2.3*

Recommended Daily Allowances (RDAs) in bold type and Adequate Intakes (AIs) in ordinary type followed by an asterisk (*). ND not determinable.

Source: Food and Nutrition Board, Institute of Medicine-National Academy of Sciences. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients). (2005). Available at www.nap.edu

Table 4. **Summary of Dietary Reference Intakes (DRIs) for Infants and Children: Vitamins**

Age	*Sex*	*Vit A (µg/d)*	*Vit C (mg/d)*	*Vit D (µg/d)*	*Vit E (mg/d)*	*Vit K (µg/d)*	*Thiamin (µg/d)*	*Riboflavin (µg/d)*	*Niacin (mg/d)*	*Vit B_6 (mg/d)*	*Folate (µg/d)*	*Vit B_{12} (µg/d)*	*Pantothenic (mg/d)*	*Biotin (µg/d)*	*Choline (mg/d)*
Infants															
0-6 mo	Both	400*	40*	5*	4*	2.0*	0.2*	0.3*	2*	0.1*	65*	0.4*	1.7*	5*	125*
7-12 mo	Both	500*	50*	5*	5*	2.5*	0.3*	0.4*	4*	0.3*	80*	0.5*	1.8*	6*	150*
Children															
1-3 y	Both	**300**	**15**	5*	**6**	30*	**0.5**	**0.5**	**6**	**0.5**	**150**	**0.9**	2*	8*	200*
4-8 y	Both	**400**	**25**	5*	**7**	55*	**0.6**	**0.6**	**8**	**0.6**	**200**	**1.2**	3*	12*	250*
9-13 y	M	**600**	**45**	5*	**11**	60*	**0.9**	**0.9**	**12**	**1.0**	**300**	**1.8**	4*	20*	375*
	F	**600**	**45**	5*	**11**	60*	**0.9**	**0.9**	**12**	**1.0**	**300**	**1.8**	4*	20*	375*
14-18 y	M	**900**	**75**	5*	**15**	75*	**1.2**	**1.3**	**16**	**1.3**	**400**	**2.4**	5*	25*	550*
	F	**700**	**65**	5*	**15**	75*	**1.0**	**1.0**	**14**	**1.2**	**400**	**2.4**	5*	25*	400*

Table 5. **Summary of Dietary Reference Intakes (DRIs) for Infants and Children: Minerals**

Age	*Sex*	*Calcium (mg/d)*	*Chromium (µg/d)*	*Cu (µg/d)*	*Flouride (mg/d)*	*Iodine (µg/d)*	*Iron (mg/d)*	*Magnesium (mg/d)*	*Manganese (mg/d)*	*Molybdenum (µg/d)*	*Phosporus (mg/d)*	*Selenium (µg/d)*	*Zinc (mg/d)*	*Potassium (g/d)*	*Sodium (g/d)*	*Chloride (g/d)*
Infants																
0-6 mo	Both	210*	0.2*	200*	0.01*	110*	0.27*	30*	0.003*	2*	100*	15*	2*	0.4*	0.12*	0.18*
7-12 mo	Both	270*	5.5*	220*	0.5*	130*	11	75*	0.6*	3*	275*	20*	3	0.7*	0.37*	0.57*
Children																
1-3 y	Both	500*	11*	340	0.7*	90	7	80	1.2*	17	460	20	3	3.0*	1.0*	1.5*
4-8 y	Both	800*	15*	440	1.0*	90	10	130	1.5*	22	500	30	5	3.8*	1.2*	1.9*
9-13 y	M	1300*	25*	700	2*	120	8	240	1.9*	34	1250	40	8	4.5*	1.5*	2.3*
	F	1300*	21*	700	3*	120	8	240	1.6*	34	1250	40	8	4.7*	1.5*	2.3*
14-18 y	M	1300*	35*	890	2*	150	11	410	2.2*	43	1250	55	11	4.5*	1.5*	2.3*
	F	1300*	24*	890	3*	150	15	360	1.6*	43	1250	55	9	4.7*	1.5*	2.3*

Recommended Daily Allowances (RDAs) in bold type and Adequate Intakes (AIs) in ordinary type followed by an asterisk (*). ND not determinable.

Sources

Food and Nutrition Board, Institute of Medicine-National Academy of Sciences. Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate (2004). Available at www.nap.edu

Food and Nutrition Board, Institute of Medicine-National Academy of Sciences. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc (2000). Available at www.nap.edu

Food and Nutrition Board, Institute of Medicine-National Academy of Sciences.Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids (2000). Available at www.nap.edu

Food and Nutrition Board, Institute of Medicine-National Academy of Sciences.Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline (1998). Available at www.nap.edu

Food and Nutrition Board, Institute of Medicine-National Academy of Sciences. Detary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride (1997). Available at www.nap.edu

Table 6. **Energy Density of Infant Formulas and Enteral Feedings**

Kilojoules/litre (kJ/L)	*Kilocalories/mL (kcal/mL)*	*Kilocalories/ounce (kcal/oz)*
2800	0.67	20
3300	0.8	24
3800	0.9	27
4200	1.0	30
4600	1.1	33
5000	1.2	36
5500	1.3	39
5900	1.4	42
6300	1.5	45
6700	1.6	48
7100	1.7	51
7600	1.8	54
8000	1.9	57
8400	2.0	60

Considerations in Enteral Feeding Administration

METHOD OF INFUSION

The most common methods of delivering a feeding are bolus and continuous. See Table 7.

Bolus feedings are given over a relatively short period of time at specific intervals throughout the day using a syringe or gravity flow. Variations are dependent on the child's age, size and tolerance. These feedings imitate a more normal feeding pattern for infants and children.

Continuous feedings are usually delivered using a pump at a constant infusion rate over an established number of hours during the day and/or at night. Continuous infusions over 24 hours are often better tolerated by critically ill patients. Cycled continuous feedings over a decreased number of hours throughout the day (e.g., 20 hours of infusion with 4 hours "off") allow freedom for developmental activities and stimulation of hunger and thirst in infants. Continuous overnight feedings may facilitate the development of hunger and thirst during the day for children able to feed orally. Overnight continuous feedings into the stomach are not routinely recommended for children under one year of age or any child at risk for reflux and aspiration. Continuous infusions must be used for infusions into the jejunum. For home patients, financial support for a pump is available only if the infusion time is equal to or greater than 6 hours per 24 hour period.

INITIATION AND PROGRESSION

Rates for initiating and advancing enteral feedings are based on patient age and body weight. Guidelines for starting and progressing enteral feedings are provided in Tables 8 (NICU) and 9 (infants and children). Tolerance of each rate should be established for 8-24 hours before the next change is made.

POST ENTEROSTOMY TUBE INSERTION

Following insertion of an enterostomy tube, patients are kept NPO and on IV fluids for a **minimum** of 12 hours for radiologically placed tubes or 24-48 hours for surgically placed ± fundoplication tubes. If clinically stable with minimal NGT drainage and no signs of postoperative ileus, tube feeding is initiated using an oral electrolyte solution (OES) to establish tube patency and identify signs of leakage. Regardless of whether or not the patient has previously been NG- or NJ-fed, start OES at the initiation rate recommended in Table 8 or 9 for either bolus or continuous feedings. Give the OES continuously for 4-6 hours or intermittently for 2 feedings. ***Note:*** OES is contraindicated as the initial enteral fluid for a children with hyperkalemia, dextrose water (D5W) can be used instead.

The NG drainage tube can be removed after initiation of feedings. The NG-tube may be left in for longer periods if there are concerns about gastric distention, feeding intolerance, or peritonitis.

If there is no sign of leakage at the enterostomy site and the feeding rate is tolerated, change from OES (or D5W) to the selected feeding and continue at the same rate for a **minimum** of 8-12 hours. Unless the feeding is hypertonic, full-strength formula may be used. Initial signs of feeding intolerance may include abdominal distention, vomiting or diarrhea (see Table 10). The patient should also be observed for signs of mechanical complications, such as fever, redness, pain, swelling or wound separation around the enterostomy site (see Table 10) and peritonitis.

When tolerance has been established, gradually increase the rate and volume of feeding, following the guidelines in Table 8 or 9. Once the patient is tolerating the goal rate and volume, increase the strength or caloric density of the feeding as pre-determined (see Strength of Feedings).

PREVENTING PERITONITIS

With radiologically-placed tubes, disruption of the newly formed tract that connects the skin to the stomach (caused by excessive movement of the tube) and increased gastric pressure (caused by gastric distention, large volume of feedings, vomiting, or post-operative ileus) can result in peritoneal leakage of gastric contents, and peritonitis. In newly placed tubes, these usually occur within the 48 hours of initiating feedings. Children with peritonitis often manifest with fever, vomiting, or abdominal tenderness, and may have absent bowel sounds and abdominal distention. To avoid post-operative peritonitis, the following are recommended:

1. Give nothing through the tube for a **minimum** of 12 hours post-tube insertion.

2. a) To prevent stomach distention, give nothing by mouth until tube feeding has been tolerated for 24 hours (i.e., at least 36 hours post-enterostomy tube insertion).Re-introduction of oral feeds should be gradual, starting with full fluids and advanced cautiously as tolerated. Smaller, more frequent meals may be better tolerated initially.

   b) Infants and children at high risk of post-operative peritonitis should be given nothing by mouth for at least 48 hours after tube-feedings have been initiated. If peritonitis is suspected, hold all feedings, insert NG-tube to drain and decompress the stomach, start intravenous fluids, perform abdominal x-rays, and request surgical consult.

   Patients at high risk for developing post-operative peritonitis include:

   - those with a history of gastrointestinal dysmotility and/or vomiting
   - those with severe neurological impairment
   - those with in-situ peritoneal dialysis (PD) catheters. ***Note:*** Whenever possible, an enterostomy tube should be inserted prior to PD catheter insertion. Post-operative management of patients with in-situ PD catheters should start with 24-48 hours of peritoneal rest, if tolerated by the patient's fluid and biochemical status, followed by PD using low dialysate volumes.

3. Advance tube feedings gradually over a **minimum** of 48 hours before final goals are reached. Consider longer periods for certain populations (e.g., Oncology, Cystic Fibrosis, those who have not been recently enterally fed) to avoid overdistention or vomiting.

4. Within the first 48 hours of starting feedings, maximum volume should not exceed the previously tolerated maximum rate (bolus or continuous).

ENTERAL FEEDING HANG TIME

Hang time of enteral feeds needs to be closely monitored. Feeding bags and tubing should be emptied and replaced with a fresh supply of EBM /formula every 4 hours. To avoid wastage, the maximum feeding volume to be hung is that required for the 4 hour hang time. (1). Feeding bags for continuous feeds should be flushed with sterile water every 8 hours and bolus feeding systems should be thoroughly cleaned with hot water and rinsed with sterile water at the end of each feeding. All enteral feeding set-ups should be changed every 24 hours.

While the aforementioned hang times should be adhered to regardless of the feeding type, it is important to note that feedings prepared from powders (e.g., powdered formulas, human milk fortifiers) are of particular concern. Unlike most liquid nutritional products, powders are not sterile. Recent outbreaks of Enterobacter sakazakii infection have been linked to powdered infant formula (2). Enterobacter sakazakii is a rare but life-threatening cause of neonatal meningitis, sepsis, and necrotizing enterocolitis.

Source:

1. Pediatric Nutrition Practice Group of the American Dietetic Association. Delivery and bedside management of infant feedings. In: Infant Feedings: Guidelines for Preparation of Formula and Breastmilk in Health Care Facilities. Robbins ST, Beker LT eds, Diana Faulhaber, 2004, pp 88-95. Adapted version available at www.eatright.org.
2. FAO (2006) Enterobacter sakazakii and Salmonella in powdered infant formula: Meeting Report. Rome, Italy. Available at ftp://ftp.fao.org/ag/agn/jemra/e_sakakazii_salmonella.pdf

PREVENTING FUTURE FEEDING PROBLEMS

Some children may develop an oral aversion as a result of negative oral stimuli (such as frequent vomiting, ventilation, nasal/oral intubation, suctioning), and/or extended periods of not eating and missing the opportunity to learn how to eat by mouth.

To reduce the risk of oral hypersensitivy or food refusal, provide infants with opportunities to acquire oral-feeding skills through non nutritive sucking by offering 'empty' breastfeeding (mother pumps to empty her breastmilk before breastfeeding so the baby can latch and practice breastfeeding), a clean finger/glove, a pacifier, or later on, a teething ring, as soon as tube feedings are started. Although there is limited scientific evidence on the efficacy of these methods, they are commonly recommended.

For the older infant or toddler, tube feeding should be associated with the normal custom of eating at the table. The opportunity to see, smell, taste and play with food, especially while being tube-fed, provides a positive association with food and the social enjoyment of a family activity.

Table 7. **Methods of Tube Feeding Infusion**

Method	*Indications*	*Advantages*	*Disadvantages*
Continuous (pump or gravity)	• initiating tube feeding • critically Ill patient • jejunal feedings (NJ/GJ/J) • intolerance of bolus feeding • Short Bowel Syndrome	• decreases risk of gastric residuals and pulmonary aspiration • decreases risk of metabolic abnormalities (e.g., post-feed hyperglycemia) • "cycled" feedings in infants or continuous overnight feedings in older children may stimulate hunger and thirst during time "off" • imparied bowel adaptation	• restricted ambulation • increased cost for equipment and supplies • used primarily in hospital • **may not tolerate faster infusion rate necessary for cycled or overnight feedings especially jejunal feeding** • not suitable for overnight feedings into the stomach (NG, Gtube) for infants to children at risk for GER and aspiration
Bolus (gravity, pump or syringe)	• stable patient • home tube feeding	• short time to feed • allows free time and mobility between feedings • easy to administer • inexpensive if no pump	• potential GI intolerance (aspiration, nausea, vomiting, abdominal pain, distention diarrhea) due to faster infusion rate • may need hypercaloric formula

Adapted with permission from Tube Feeding Administration Methods. In: Nutrition Support Dietetics Core Curriculum. *American Society for Parenteral and Enteral Nutrition. 1993, p. 90.*

Table 8. **Guidelines for Initiating and Advancing Enteral Feeding in Stable NICU Infants**

These guidelines may not be appropriate in cases where feeding management must be determined on a more individual basis (e.g., poor growth, asphyxia, polycythemia, hypotension, sepsis).

Weight	*Feeding Options*	*Method*	*Induction Feedings*	*Full Feeds (mL/kg/d)*
<750 g	EBM or SSC 2800	NG	• begin at 1 mL q8h on Day 2-3 x 96 h • change to 1 mL q6h x 48 h • ↑ to 2 mL q6h x 48 h • change to 2 mL q4h x 48 h • ↑ to 3 mL q4h x 48 h • change to 2 mL q2h x 48h • ↑ by 1 mL q48h as tolerated	150
750-1000 g	EBM or SSC 2800	NG	• begin at 1 mL q6h on Day 2-3 x 48 h • ↑ to 2 mL q6h x 48 h • change to 2 mL q4h x 48 h until tolerated • ↑ to 3 mL q4h x 48 h • change to 2 mL q2h x 48 h • ↑ by 1 mL q 24h as tolerated	150

Table 8. **Guidelines for Initiating and Advancing Enteral Feeding in Stable NICU Infants (continued)**

Weight	*Feeding Options*	*Method*	*Starting Volume*	*Frequency*	*Increased by*	*Full Feeds (mL/kg/d)*
1000-1250 g	EBM or SSC 2800	NG & introduce Kangaroo care	1-2 mL	q2h	1mL q12h	140-160
1250-1500 g	EBM or SSC 2800	NG & introduce Kangaroo/Breast	1-2 mL	q2h	1 mL q12h once tolerated 1/3-1/2 full feeds can increase by 1-2 mL q12h	140-160
1500-2000 g	EBM or SSC 2800	NG & introduce Kangaroo/Breast/ Bottle	2-3 mL	q3h	2 mL q6h	160-180
2000-2500 g	EBM or Enfalac 2800	Kangaroo/Breast/ Bottle (NG as indicated)	4-5 mL	q3h	3 mL q6h (alternate feeds)	160-180
>2500 g	EBM or Enfalac 2800	Kangaroo/Breast/ Bottle (NG as indicated)	5-10 mL	q4h q2-4h if demand	4-8 mL q8h (alternate feeds)	160-180
Term Surgical Infants	D_5W, EBM, Enfalac 2800	Kangaroo/Breast/ Bottle (NG as indicated)	5-10 mL	q4h q2-4h if demand	4-8 mL q8h (alternate feeds)	160-180

Tolerance is indicated by pre-feed gastric aspirates and abdominal distention.
Gastric aspirates of >1-2 mL may be regarded as excessive.

Higher aspirates may be acceptable in some term surgical infants e.g., pyloric stenosis, bowel obstruction.

NPO GUIDELINES FOR NICU INFANTS
Undergoing Anaesthesia

1. Clear liquids until 2 hours pre-anaesthetic
2. Breastmilk until 4 hours pre-anaesthetic
3. Formula until 6 hours pre-anaesthetic

Undergoing Sedation for Diagnostic Imaging

1. No breastmilk or formula for six hours prior to study
2. Clear fluids two hours prior to study

GUIDELINES FOR RESTARTING FEEDS FOR NICU PATIENTS FOLLOWING NPO
Requires a medical order

1. NPO for a procedure – restart at previously tolerated amount and type of feeding.
2. NPO due to bowel surgery or NEC – recommend restarting feeds at the beginning of the weight-appropriate category.
3. NPO due to intolerance – assess each infant individually, discuss plan with medical team.

Table 9. **Guidelines for Initiating and Advancing Tube Feedings in Infants and Children**

Age	*Initial Hourly Infusion*	*Daily Increases*	*Goal*
Continuous Feedings			
0-1 year	10-20 mL/h ***or*** 1-2 mL/kg/h	5-10 mL/8h ***or*** 1 mL/kg/h	21-54 mL/h ***or*** 6 mL/kg/h
1-6 years	20-30 mL/h ***or*** 2-3 mL/kg/h	10-15 mL/8h ***or*** 1 mL/kg/h	71-92 mL/h ***or*** 4-5 mL/kg/h
6-14 years	30-40 mL/h ***or*** 1 mL/kg/h	15-20 mL/8h ***or*** 0.5 mL/kg/h	108-130 mL/h ***or*** 3-4 mL/kg/h
>14 years	50 mL/h ***or*** 0.5-1 mL/kg/h	25 mL/8h ***or*** 0.4-0.5 mL/kg/h	125 mL/h
Bolus Feedings			
0-1 year	60-80 mL q4h ***or*** 10-15 mL/kg/feed	20-40 mL q4h	80-240 mL q4h ***or*** 20-30 mL/kg/feed
1-6 years	80-120 mL q4h ***or*** 5-10 mL/kg/feed	40-60 mL q4h	280-375 mL q4h ***or*** 15-20 mL/kg/feed
6-14 years	120-160 mL q4h ***or*** 3-5 mL/kg/feed	60-80 mL q4h	430-520 mL q4h ***or*** 10-20 mL/kg/feed
>14 years	200 mL q4h ***or*** 3 mL/kg/feed	100 mL q4h	500 mL q4h ***or*** 10 mL/kg/feed

Note: *Rates expressed per kg body weight are useful for small-for-age patients.*

Source

Wilson SE. Pediatric Enteral Feeding. In: Pediatric Nutrition, Theory and Practice. Grand RJ, Sutphen JL, et al. eds. Toronto, Ont: Butterworth; 1987.

NPO GUIDELINES FOR INFANTS AND CHILDREN
Undergoing Anaesthesia
See SickKids Policy & Procedure: Preoperative Fasting Guidelines

Undergoing Sedation
See SickKids Policy & Procedure: Care of the Child Receiving Procedural Sedation

GUIDELINES FOR RESTARTING FEEDS FOR INFANTS AND CHILDREN FOLLOWING NPO
Requires a medical order

1. NPO for a procedure – restart at previously tolerated amount & type of feeding.
2. NPO due to bowel surgery or NEC – recommend restarting feeds at the beginning of the age-appropriate category. For small-for-age infants use rates expressed per kg body weight.
3. NPO due to intolerance – assess each infant or child individually, discuss plan with medical team.

Table 10. **Potential Complications Associated with Enteral Feeding**

Complication	*Possible Cause*	*Treatment*
Gastrointestinal		
nausea, vomiting	• large gastric residuals • rapid infusion rate • hyperosmolar formula • dysmotility • improper tube location • medication (i.e., antibiotics)	• consider prokinetic and acid inhibitory medication • ↓rate • if possible, switch to lower osmolality of current formula • check/adjust tube position • position child at 45° or child upright • vent NG-/G-tube
large gastric residuals	• hyperosmolar formula • high fat content of formula • gastroparesis	• ↓osmolality • ↓fat content • ↓rate of feeding • continuous feedings into jejunum • vent NG-/G-tube • consider prokinetic and acid inhibitory medication
diarrhea	• medication (sorbitol containing elixirs, antibiotics) • lactose intolerance • nutrient malabsorption • bacterial overgrowth (due to antibiotic therapy) • inadequate fibre • rapid infusion rate • hyperosmolar formula • hypoalbuminemia may or may not be associated	• consult pharmacy for alternate medications • lactose-free formula • semi-elemental formula • check stool for rotavirus, torovirus, c. difficile (for c. difficile, treat with appropriate antibiotics) • fibre-containing formula • ↓rate; change to continuous feedings • ↓osmolality • increase protein
constipation	• dehydration • fecal impaction • obstruction • inadequate fibre • ↓activity • electrolyte abnormalities • medications (i.e., narcotics, codeine, morphine) • intestinal dysmotility – common in child with neuromuscular handicap	• increase fluids if possible • stool softener, laxatives, abdominal x-ray of fecal load • disimpaction • ? surgical intervention • fibre-containing formula • ambulate if possible • connect electrolyte abnormalities • consult pharmacy for alternate • increase fluids/soluble fibre; offer lactulose
peritonitis	• see p. 25 under Preventing Peritonitis	

Table 10. **Potential Complications Associated with Enteral Feeding (continued)**

Complication	*Possible Cause*	*Treatment*
Metabolic		
dehydration	• fluid losses (i.e. drains, fistula, ostomy output, stool)	• replace fluids as indicated, check electrolytes (serum, sternal, urine, stool) and replace as indicated
	• fever, infection, inadequate fluid, excessive weight loss	• increase fluid • check serum eletrolytes, replace if needed
	• drug therapy	• consult pharmacy
increased serum electrolytes	• high electrolyte content of formula	• formula with lower electrolytes
	• inadequate fluid intake • excess fluid losses	• increase fluid
	• diabetes insipidus	• desmopressin, increase fluid
	• renal failure	• low electrolyte formula
	• drug therapy	• consult pharmacy
decreased serum electrolytes	• excessive fluid intake; water retention; SIADH	• decrease fluid • higher electrolyte formula
	• inadequate electrolytes in formula	• prescribe supplements
	• drug therapy	• consult pharmacy
hypokalemia *hypophosphatemia*	• refeeding syndrome • medications (diuretics, phosphate-binding antacids) • excessive losses (diarrhea, large wounds)	• decrease rate of refeeding • supplement with K, PO_4 • consult pharmacy
hyperglycemia	• metabolic stress	
	• diabetes	• insulin
	• excess glucose intake	• decrease IV glucose, if running
	• refeeding syndrome	• avoid overfeeding • increase fat content of formula and decrease glucose content
	• drug therapy	• consult pharmacy
hypoglycemia	• abrupt cessation of feeding while on insulin or oral hypoglycemic agent	• monitor serum glucose • gradually taper
	• prolonged fasting or feeding interval, especially infants	• increase feeding frequency, avoid prolonged fasting, start IV dextrose

Table 10. **Potential Complications Associated with Enteral Feeding (continued)**

Complication	*Possible Cause*	*Treatment*
Mechanical		
clogged tube	• excess residue in formula • inappropriate mixing of medication administered in tube	• use 1-3cc syringe, remove red adapter, flush with warm water or carbonated beverage. If unsuccessful, contact Enteral Feeding Nurse • flush with water q4h with continuous feedings and after each intermittent feeding. Replace tube if unsuccessful. • dilute medication according to pharmacy
NG- and NJ-tube displacement	• migration of NG-tube into esophagus, duodenal junction; NJ-tube →stomach • stomach distention	• verify position of tube prior to initiating feeding (NG – ph testing of tube aspirate and auscultation; NJ – xray check • tape tubes securely after position verified
GJ-, J- and G-tube migration/ dislodgement	• G-tube into duodenum • GJ-tube into stomach • G-tube out/deflated balloon • stretched ostomy • J-tube dislodgement from site	• tape all tubes securely • replace in radiology/surgery • G-tube replaced on ward by MD or Enteral Nutrition Support Nurse or IGT/Surgery • consult Surgery
GJ-tube intussuception	• distal pigtail may act as lead point due to larger size of pigtail relative to bowel lumen diameter	• contact IGT immediately. Action to reduce intussuception, risk ischemic bowel • replace with GJ-tube with shortened pigtail • air contrast medium flushing post GJ-tube exchange, ultrasound to ensure reduction of intussuception • follow closely to ensure clinically improved and no symptoms of recurrence

Table 10. **Potential Complications Associated with Enteral Feeding (continued)**

Complication	*Possible Cause*	*Treatment*
Mechanical cont'd		
Granulation Tissue	• usually mechanical irritation (i.e. excessive movement of the tube, feeding tube is accidentally pulled, or tube positioned in one direction continuously) • aggravated by area which is wet	• secure tube to abdomen • rotate tube position once daily • cleanse site daily with soap and water only • keep dry • do not apply creams/ointments to site on a regular basis unless infection or skin is irritated • if granulation tissue is present, apply warm saline soaks to site TID, and dry tissue by air; if saline soaks not effective, use silver nitrate to treat every 2-3 days until resolves (topical antibiotics are NOT effective treatment for granulation tissue) • Allevyn dressing to site to absorb discharge until tissue is gone • if site presents with small pinpoint rash, may be a yeast infection, treat with mixture of hydrocortisone/ nystatin ointment topically to site.
leakage around tube	• deflated balloon • stretched ostomy • constipation/stomach distention	• check/replace tube • correct stomach distention
Skin		
skin excoriation	• from acid leakage around tube • from keeping skin too moist	• correct leakage; add acid inhibitory medication • use barrier cream
infection	• overuse of antibiotics • too occlusive dressing	• keep skin clean and dry • light dressing
granulation tissue	• usually mechanical irritation • aggravated by area which is wet	• keep dry • stabilize tube • prescribe silver nitrate

Table 10. **Potential Complications Associated with Enteral Feeding (continued)**

Complication	*Possible Cause*	*Treatment*
Skin cont'd		
leakage around tube	• stretched ostomy (i.e. feeding tube not secured to abdomen resulting in excessive movement, site is always moist causing stoma to stretch, and or feeding tube is pulled too tightly causing the tract to stretch) • abdominal distention (i.e. due to poor gastrointestinal motility, constipation) • infant/child unwell, coughing and/or vomiting • if balloon device, may be deflated or tube or may have migrated further into stomach resulting in leakage around the internal securing device • gastric outlet obstruction	• tape tube securely to abdomen • use creams/ointments only as indicated if skin is irritated or infected • if poor motility, may benefit from motility agent and/or lower rate of infusion of feeding volume • if constipated may benefit from stool softener, fiber containing formula, increase in fluid intake as appropriate • keep skin dry and clean until coughing/vomiting subsides • check ballon regularly (every 2 weeks) for recommended amount of water, and fill as required • if balloon broken, change feeding tube as instructed • check tube; pull back on tube gently until resistance felt to ensure internal securing device is flush to stomach wall. Do not pull tube too tight • if skin breakdown from leakage: protect with barrier cream (proshield); Allevyn dressing to absorb any drainage; Consider acid blocking agent(zantac/losec) • For suspected gastric outlet obstruction consult surgery
nasal irritation or erosion (sinusitis, nose bleeds)	• improper taping of tube; prolonged use of NG-tube (i.e., >4 weeks)	• tape tube securely to avoid pressure on nose • use softer, smaller tube • consider G-tube if enteral feeding >8-12 weeks

Sources

Connolly BL, Chait PG, Siva-Nandan R, Duncan D, Peer M. Recognition of intussusception around gastrojejunostomy tubes in children. *AJR* 1998; 170:467-470.

Friedman JN, Ahmed S, Connolly B, Chait P, Mahant S. Complications associated with image-guided gastrostomy and gastrojejunostomy tubes in children. *Pediatr* 2004.114:458-461.

Hughes UM, Connolly BL, Chait B, Muraca S. Further reports of small-bowel intussusceptions related to gastrojejunostomy tubes. *Pediatr Radiol* 2000; 30:614-617.

Russell MR, Crommer M, Grant J. Complications of enteral nutrition therapy. In: ASPEN, The Science and Practice of Nutrition Support: A Case-Based Core Curriculum. Gottschlich MM, Fuhrman MP, Hammond KA, Holcombe BJ, Seidner DL, eds, Kendall/Hunt Publishing Co., 2001, pp 189-210.

Feeding Selection

TYPES OF FEEDINGS

In choosing a feeding, consider:

- age
- nutritional requirements (energy, protein, fat, fluid, vitamins, minerals)
- GI function
- clinical status
- disease entity
- cost.

Breastmilk

Breastmilk is the optimal feeding for infants. The World Health Organization, Health Canada, and Canadian Pediatric Society recommend exclusive breastfeeding until six months of age, with the addition of solids at 6 months and continued breastmilk feeding until 2 years of age and beyond. Breastmilk has nutritional and non-nutritional benefits. Early introduction and sustained feeding of breastmilk results in significant improvement in feeding tolerance, optimal growth and immune status, and reduced risk of infectious disease and necrotizing enterocolitis, particularly in preterm infants. There is also evidence of longer term benefits of human milk such as improved neurocognitive development, reduced risk of atopic dermatitis and early wheeze, and reduced risk of obesity in later life. For the nutritional components of human milk see Appendix C). Unlike infant formula, human milk has over two hundred beneficial non-nutritive components (see Appendix C continued on p. 96-97).

For infants NPO from birth or >3 hrs, it is important for mothers to pump frequently (q3h) using a hospital grade pump to establish and maintain their milk supply. Please see p. 46 on establishing milk supply. Hospital grade pumps are available on all wards and can be rented or purchased from the SickKids Specialty Food Shop on the main floor for continued use at home.

For hospital guidelines on labeling and storing expressed breastmilk (EBM) see SickKids Policy & Procedure: Handling, Storage, Thawing & Administration of Expressed Breastmilk.

Infant Formula and Enteral Feedings

Where breastmilk is unavailable, or in rare conditions where it is contraindicated, a variety of infant formulas are available for specific medical conditions (see Appendix A).

EBM and infant formulas contain 68 kcal/100 mL (2800 kJ/L); they can be modified to increase their nutrient density by adding formula powder or concentrate, and/or by adding glucose polymers and/or fat.

A variety of complete enteral products designed for specific clinical conditions are available for children and adolescents (see Appendix B).

The complete nutrient content per litre of infant feedings or enteral supplements and tube feedings can be found in Appendices C-E.

Note: *The cost of formula per year is higher than the cost of a breast pump used to express breastmilk. The cost of therapeutic/specialized feedings is higher than standard ones. Financial support may be available for breast pumps and some therapeutic/specialized formulas. Indications for use must be carefully and continually assessed, keeping in mind the goal of weaning the child to breastmilk or a standard formula if and when medically appropriate.*

STRENGTH OF FEEDINGS

In the majority of cases, isotonic feedings should be initiated at full strength. Initiate hypertonic feedings at half or three-quarter strength when feeding small infants, malnourished patients, those whose gut has not been used for several days, or those being fed into the small bowel. Feeding strength or energy density should be increased every 8-24 hours until desired strength or caloric density is tolerated.

Note: *Changes to feeding strength/energy density and infusion rate should not be made simultaneously, as the cause of an intolerance would be unclear.*

Ordering Enteral Nutrition

All orders, including changes to previous orders, are processed through KidCare. Feeding orders are received by the Diet Office and prepared in the SickKids Formula Room from 0800-1630 hr. New orders, including restarting feeds following an NPO order, must be received by 1600 hr. Orders received after the 1600 hr deadline may not be available until the next day. In this case, if appropriate, a standard feeding may be used (e.g., EBM for infants, or an age appropriate ready to feed formula for infants/children).

If a specialized formula is required, consult the dietitian regarding the appropriate feeding to use until the specialized formula is available the next day. Direct questions about feeding orders and delivery to the Diet Office at ext. 6743.

Monitoring Enteral Nutrition

FEEDING TOLERANCE

For all methods of feeding, clinical signs of feeding intolerance include coughing, abdominal distention or pain, obvious signs of discomfort, restlessness, vomiting and diarrhea. Stop feedings if these signs are observed and assess the patient's status, tube placement, rate and method of delivery, strength and choice of feeding. Refer to Table 10 for potential complications and suggested treatments.

RESIDUALS

If the patient is awake and alert, irritability, nausea or vomiting, or abdominal distention may indicate poor gastric emptying or tube misplacement.

For patients who are at risk for GER and/or aspiration (e.g., comatose or intubated patient), check gastric residuals before intermittent feedings or every 4 hours for continuous feedings.

Note: *For patients fed via intestinal (GJ/J) tubes, checking residuals is not necessary unless an ileus, severe small intestinal dysmotility, or obstruction is suspected.*

Bolus feedings

If the residual is greater than 50% of previous feeding, then return feeding via tube and check again in 4 hours (100-150 mL acceptable in children under 12 years of age on full feedings). If the same volume is aspirated, the physician or dietitian should be notified. If residual volume is less than 50% of previous feeding (or less than 100-150 mL for children under 12 years), continue with the next feeding at the previous rate and check residuals again in 4 hours.

Continuous feedings

If residual volume is greater than twice the hourly rate, stop feeding and refeed formula. One hour later, if the same volume of feeding is aspirated again, the physician or dietitian should be notified. If the residual volume is less than twice the hourly rate, resume feeding at previous rate and check for residuals again within 1-2 hours.

Note: *Addition of blue food dye to enteral feedings to detect signs of feeding intolerance or aspiration is NOT recommended. Health Canada has issued a safety warning to hospitals on the Use of Blue Food Dye.*

There have been several reports of systemic toxicity (blue discolouration of body fluids and skin) with serious complications of refractory hypotension, metabolic acidosis, and death, associated with the use of Brilliant Blue FCF dye (FD & C Blue No. 1) in enteral feeding solutions. Critically ill individuals, particularly those at risk for increased intestinal permeability (including sepsis, burns, trauma, shock, surgical interventions, renal failure, celiac sprue, inflammatory bowel disease) appear to be at increased risk of absorbing the dye. In addition to the potential for toxicity, dyed feedings may also interfere with diagnostic stool tests. The safety of dye added to enteral feedings has not been proven. Other blue dyes, such as methylene blue, may have similar if not greater toxicity potential.

Source: Adapted with permission from: *Health Canada, Health Products and Food Branch, Canadian Adverse Drug Reaction Monitoring Program (CADRMP), Marketed Health Directorate. Notice to hospitals: Safety warning concerning the use of blue food dye in enteral feedings, December 2003. Available at www.hc-sc.gc.ca/dhp-mps/medeff/advisories-avis/prof/2003/food_dye-colorant_nth-ah_e.html*

TREATMENT OF GASTRIC DYSMOTILITY AND GASTROESOPHAGEAL REFLUX

GER is especially common in infants, peaking at approximately 4 months of age, with uncomplicated cases usually resolving by the end of the first year of life. Insertion of an enteral feeding tube (G or GJ) may initially affect gastric motility; however, over a period of weeks to several months, this problem will usually resolve.

Management of GER can involve both non-pharmacological and pharmacological means. Some cases of vomiting or GER can be effectively treated by thickening formula feeds (1 tbsp of infant cereal per 30 to 120 mL formula; Note: expressed breastmilk does not thicken properly with the addition of infant cereal) and elevating the head during and after feeding. Prone and left lateral positioning of preterm and term infants are associated with significantly less GER than right lateral and supine positioning. In view of the association of prone positioning with SIDS, left lateral positioning is recommended. Also, decreasing feed volume/rate and/or adjusting feeding frequency (e.g., more frequent smaller oral/NG/GT boluses and/or slower rate continuous feeds) may help manage vomiting. The type of formula may also contribute to GER. High osmolality feedings may worsen reflux. Also, casein-predominant feedings have slower gastric emptying than whey-predominant feedings; whey-hydrolysate is the most rapid. Furthermore, a subset of infants may have cow's milk protein allergy-induced vomiting. A 1-2 week trial of hypoallergenic formula can help clarify whether cow's milk allergy is playing a role. For breastmilk fed infants, the mother may try eliminating cow's milk protein from her diet for a similar period.

Gastroesophageal reflux may also be associated with gastric dysmotility, which may trigger vomiting. Therefore, combined use of motility agents with drugs that suppress gastric acid secretion is recommended. Currently available medications that can improve gastric emptying include Domperidone (Motilium®) and Metoclopramide (Maxeran®). The motility agent of choice is Domperidone. Domperidone can be crushed and added to the feeding to treat dysmotility occurring with continuous feeding. Cisapride (Prepulsid®) may be an option for patients with severe dysmotility who have failed trials of other motility agents. A cardiology work-up and GI consult must be completed before Cisapride can be prescribed.

Ranitidine, a histamine$_2$ (H_2) receptor antagonist, is used as the first-line acid inhibitory agent. In selected patients (usually those with pH probe-proven GER), proton pump inhibitors (PPI) Lansoprazole (Prevacid®, Prevacid FasTab®) or Omeprazole (Losec®), may be more effective when the maximum dose of ranitidine is ineffective. Lansoprazole is the only proton pump inhibitor indicated for the treatment of GER specifically in children aged 1 to 17 and hence it is the preferred PPI for use at Sick Kids. However, due to solubility issues, Lansoprazole is currently not recommended for administration through smaller feeding tubes (<10 Fr) as tube blockage may occur. The Prevacid FasTab® may also block smaller tubes. Omeprazole can be given via smaller feeding tubes (see SickKids Policy and Procedure – Omeprazole Nursing Instructions). Note: Omeprazole is enteric coated because it is acid-labile and requires protection from stomach acid. Therefore, if the enteric coating is broken and administered orally or via NG- or G-tubes, acid neutralization is usually required for at least the first week of omeprazole treatment. If administered by jejunal tubes (NJ/GJ/J), acid neutralization is not required.

For recommended dosages of the above medications, please see the SickKids Drug Handbook and Formulary (available online on SickKids website or as hardcopy on hospital units).

For infants/children who do not respond to above therapeutic approaches, jejunal feeding (NG/GJ/J) and/or surgical fundoplication should be considered (see Figure 1).

STOOLS

A change in stool characteristics does not necessarily indicate formula intolerance (e.g., green, mucus-like stools may naturally occur with protein hydrolysate formulas).

LABORATORY VALUES

Daily to biweekly monitoring is initially required in malnourished or critically ill patients or in those with renal or metabolic complications. With other disease states, monitor as required. The following chemistry values may assist with assessment of feeding tolerance: serum glucose, urea, creatinine, electrolytes, and osmolality, and urine-specific gravity.

ANTHROPOMETRICS

Record weight and height before initiating tube feeding for all patients. Record weight daily for infants and children. An infant's head circumference and length (to 2 years of age) and a child's height should be measured on admission and then monitored monthly during hospital admission.

Reference goals for rates of weight gain are available for preterm infants, see Appendix F. Reference goals for rates of gain for weight, length and head circumference are available for term infants; also reference gains in weight and height are available for children and adolescents, see Appendix G.

Together with appropriate laboratory measurements, weight gain or weight change (in relation to fluid balance) is sufficient to assess the adequacy of short term enteral nutrition support. For patients requiring tube feeding for longer than 3 weeks, growth and adequacy of nutrients provided should be assessed by additional anthropometric measurements, such as length and head circumference (to 2 years of age), height, skinfold measurements, mid-arm circumference, and mid-arm muscle circumference.

Complications

Gastrointestinal, mechanical and metabolic complications are usually preventable. The most common ones are gastrointestinal and tend to occur during the first week, as the gut adapts to the formula and its delivery. Mechanical complications, including obstruction, displacement, or dislodgement of the tube, may occur because of the small tubes used in paediatrics. Metabolic problems are similar to those that develop during parenteral therapy; however, they are usually less severe owing to the buffering capacity of the gut. Infection-related complications occur infrequently as a result of improvements in formulas and in their handling, storage and administration.

For a listing of potential complications, their possible causes, and methods of prevention or treatment, see Table 10.

Transition of Feedings

PARENTERAL TO ENTERAL

After more than 50%-75% of caloric needs are tolerated enterally, gradually wean patient off parenteral nutrition by reducing volume by half. Continue weaning while enteral feedings are increased, being careful not to overload with fluids. Discontinue parenteral nutrition after more than 75% of caloric needs are tolerated enterally.

WHEN IS IT APPROPRIATE TO CONSIDER ORAL FEEDING?

Infants are safe and ready to feed orally if they are able to gag and reflexively protect their airway, and demonstrate rhythmic, non-nutritive sucking with even respirations and swallowing of secretions. For preterm infants, 32 weeks of gestational age is generally the earliest that some limited ability to suck and swallow would be demonstrated.

The original medical problems that warranted tube feeding (e.g., anatomic or functional impediments to swallowing) must be resolved or stabilized. Swallowing ability should appear appropriate. Common signs of abnormal swallowing include choking, coughing, regurgitation, audible 'gulping' sounds, and difficulty swallowing secretions. Assess child for signs of aspiration, including peri-oral duskiness, a 'wet' voice, or increased upper airway sounds after feeding, and for frequent colds, upper respiratory tract infections, pneumonia or bronchiolitis. Conduct videofluoroscopic studies to document adequate swallowing mechanisms or do radiographic testing for the presence of reflux only if clinically indicated.

Nutritional status should be good, with a weight for height that indicates the presence of some nutrition reserves, so that the child can tolerate a short period of inadequate weight gain at the start of weaning.

ENTERAL TO ORAL

Consider continuous overnight feedings to encourage oral intake during the day, offering 50%-75% of caloric needs via enteral feeding. Record and assess oral intake. Once 50%-75% of energy needs are met orally, stop enteral feeding.

Consider the short-term use of oral supplements to support oral intake.

MANAGING ORAL FEEDING PROBLEMS

A multidisciplinary approach to feeding therapy (including the physician, occupational therapist, lactation consultant, dietitian, nurse and caregiver) is recommended to manage feeding problems.

The breastmilk fed infant having difficulty transitioning to breastfeeding should be referred to a lactation consultant (ext. 5757 (2)). Please see Transition to Breastfeeding for the Hospitalized Infant for further recommendations on the next page.

Infants and children with oral feeding difficulties (e.g., oral aversion, oral-motor and/or swallowing difficulties) should be referred to an occupational therapist (OT) for a feeding assessment.

TRANSITION TO BREASTFEEDING FOR THE HOSPITALIZED INFANT

Phase 1: *Establishing a Milk Supply*

Begins immediately after birth – continues through the duration of hospitalization. From birth through Day 7 it is important that a hospital grade electric pump be used as much as possible to establish a 750 mL volume/day.

1. Obtain a hospital grade breast pump for home use (rental or purchase). Please see Specialty Food Shop product list.
2. Refer to 'Expressing Breast Milk Pamphlet' for tips on establishing a milk supply.
3. Goal of 8-12 pumping sessions within 24 hours. Milk volumes should be between 750-1000 mL/24 hours, after 2 weeks of pumping (if <500 mL at Day 7, call Lactation Consultants for assistance.
4. Record 24 hr pumping volumes using a pumping log to detect early decreases in milk volumes.
5. Use relaxation techniques to assist with stimulating milk letdown. Pump at baby's bedside as much as possible.
6. Check with insurance company for financial assistance with pump rental or purchase, obtain insurance letter from staff.
7. 'Power pumping' is a strategy to increase milk volumes by having mom pump more often when she is visiting/holding the baby (q1-2h).

Phase 2: *Familiarization of a Non-Established Breastfeeding Infant*

Non-established infants will include any infant separated from their mother within 48 hours of birth due to illness, or any infant who is unable to latch or who incorrectly latches to the breast resulting in poor milk transfer.

1. Maintain established milk supply as per Phase 1.
2. Provide non-nutritive sucking stimulus for comfort, pain relief using CSA approved soother, parent's washed finger, or nurse's gloved finger.
3. Maximize maternal attachment, skin-to-skin and sensory re-familiarization as soon as possible.
4. With Medical or Surgical team approval, offer EBM for mouth care for taste/smell stimulation.
5. Use pain meds for early holding if required.
6. Med/Surg team approval for non-nutritive 'empty' breast feeding (pump empty immediately prior to latch)
7. Once swallowing noted begin pre/post 'test weights' to monitor intake volume-decrease N/G volume accordingly.
8. If mother has decreased milk volume, or infant requires increased energy feedings – use Lactation Aid at the breast once latch established.
9. As per Med/Surg order, move to demand feeding, responding to infant's hunger cues once fluid volume tolerance is established.
10. If mother who wishes to breastfeed is unable to visit routinely to establish breastfeeding, the decision to maintain an N/G tube or start bottlefeeding should be discussed with the parents reviewing the risk/benefits.

Phase 3: *Re-Familiarization of the Established Breastfeeding Infant post Hospital Interventions*

Interruption of established breastfeeding for any infant who is otherwise thriving prior to a hospital admission for diagnostics, illness, or surgery.

1. Maintain established milk supply as per Phase 1
2. Limit soother use as soon as possible, have parents provide clean finger or knuckle to suck on.
3. Provide Kangaroo 'skin-to-skin' care to re-establish maternal/infant attachment as soon as possible.
4. Provide EBM mouthcare while NPO to continue pleasant taste sensation.
5. Provide pain medication for movement from bed to holding as ordered.
6. With Medical/Surgical team approval, offer 'empty' breastfeeding (pump off milk immediately prior to holding) for non-nutritive sucking until oral volume is approved.
7. Once swallowing noted, begin pre/post 'test weights' to monitor intake volume-decrease N/G volume accordingly.
8. If mother's milk supply is low, call a Lactation Consultant to introduce a Lactation Aid to provide volume or additional energy density at the breast.
9. If bottle feeding has been introduced with parent approval, a nipple shield, supervised by the Lactation Consultant team may be required for transition back to the breast.
10. Once the baby is taking adequate volume by breast, test weighs should be stopped and wet diapers/stools and hunger cues re-taught to parents as required.

Caregiver Education and Discharge Planning

Before their child's feeding tube insertion, all caregivers are requested to attend a 2 hour introductory class offered by the Enteral Nutrition Support nurses and dietitian at which time background information on the insertion, care and changing of tubes; preparation, initiation and advancement of feedings; pumps and other tube-feeding equipment; and costs is provided. For further information and guidance on financial support available for home enteral feeding equipment, supplies, and formulas see SickKids website under Patient Care (Transitional Care: Prescriptions Going Home; Arranging Special Equipment at Home).

Before discharge, Unit nurses provide instruction in enterostomy skin care for the prevention of skin complications and how to set up and work feeding equipment. The Program dietitian provides education on the nutritional plan including feeding preparation, storage, and administration, and outpatient nutritional follow-up. Discharged patients return to the SickKids Enteral Feeding Clinic 8 weeks after tube insertion, and then as necessary for monitoring or insertion of a larger or different feeding tube.

Drug Compatibility

ADMINISTERING MEDICATIONS

Medication(s) given via a feeding tube should be in liquid form whenever possible, particularly for jejunal tubes as replacement due to occlusion can be difficult. Where necessary, some tablets may be crushed and mixed with 5-20 mL of water. Similarly, some capsules may be emptied into 5-20 mL of water. In both cases, mixing should occur just before administration. Please note that special precautions need to be taken for any medication that is listed as cytotoxic (see SickKids Policy & Procedure: Safe Handling of Hazardous Drugs).

Before administration by NG-tube, introduce 5 mL of air (less for preterm infants or neonates) through the tube to ensure proper placement. *Note:* air introduction is not necessary for G-tubes or GJ/J-tubes. If any resistance is encountered, assess tube positioning before administering medication. Push the medication into the tube as a bolus dose. Flush the tube with a minimum of 5-10 mL water. Air may be used for fluid-restricted patients; however, some water will need to be flushed afterwards to remove residue from sides of tube. This will ensure that the entire drug volume is delivered. If air is required, the child may require venting with an NG- or G-tube.

Note: *A consistent flushing method should be used after each dose.*

SPECIAL CONSIDERATIONS

- Neonatal tubes (#5 & #8 French): flush with volumes of 0.5-1.0 mL water to propel the medication the full length of the tube.
- Cyclosporin (Neoral®): generally recommended to be given orally because it adsorbs to tubing, making it difficult to achieve appropriate therapeutic blood cyclosporine levels. However, if the patient requires NG-, G- or GJ-tube administration, cyclosporine doses are flushed with breastmilk/formula only, as water will not effectively propel this microemulsion through the tube. Note: it is important that the route chosen for cyclosporine administration be consistent, as there is wide variation in blood levels achieved between oral and feeding tube routes.
- Phenytoin (Dilantin®): shake suspension well, flush with 10-20 mL water. For preterm infants or neonates use air or 2-3 mL of water. Blood concentrations will be inconsistent if not all of the dose is flushed fully through the tube. The dose requires close monitoring, especially when changing routes (e.g., NG to PO). The suspension may be diluted 1:1 with water if serum levels remain below the therapeutic target.

TIMING

Medications should be given at times recommended by the physician or pharmacist. Check with the pharmacist about compatibility and timing of medication doses.

MEDICATIONS INCOMPATIBLE WITH TUBE FEEDING

Whenever possible, medication(s) should **not** be mixed with formula. Also, some medications may block feeding tubes, even when mixed well.

Decreased medication absorption or tube blockage

The following medications should **NEVER** be mixed directly with enteral feedings because of incompatability causing either decreased medication absorption or tube blockage:

calcitriol
ciprofloxacin
liquid ferrous sulphate
magnesium oxide (crushed tablets)
methyldopa
phenytoin (Dilantin®) suspension
pseudoephedrine syrup
sodium polystyrene sulfonate (Kayexalate®)
theophylline
thioridazine solution

Medications causing tube blockage

The following medications easily block feeding tubes, even when mixed well. These medications should **NEVER** be given by feeding tubes:

Clarithromycin (Biaxin®)
Levocarnitine (may reconsider use >8 weeks post tube insertion)
Magnesium oxide (crushed tablets) *(Note: magnesium hydroxide chewable tablets/suspension are both fine)*
Sodium polystyrene (Kayexalate®)

The following is a list of medications that may block smaller size tubes. Ensure that the medications are dissolved well. Give extra flushes to propel the medications through the feeding tube.

Cholestyramine resin
Ciprofloxacin
Co-enzyme Q-10 (powder form)
Cornstarch
Lactulose
Lansoprazole (Prevacid®) Fas-tabs (for <10 French tube sizes)
Nelfinavir
Omeprazole (Losec®) (see SickKids Policy and Procedure-Omeprazole Nursing Instructions)
Pyridoxine (vitamin B_6)

UNBLOCKING A FEEDING TUBE

Consult the Enteral Nutrition Support Nurse when feeding tube is blocked. Several methods can be used to unblock the tubes; however, if attempts fail, a NG-tube will need to be replaced on the ward, a G- or GJ-tube must be changed by IGT, and surgically placed G-, GJ-, or J-tubes require surgical consultation.

Bibliography

A.S.P.E.N. Board of Directors. Guidelines for the use of parenteral and enteral nutrition in adult and pediatric patients. JPEN 2002; 26(1Suppl):9-16A.

American Academy of Pediatrics Section on Breastfeeding. Breastfeeding and the use of human milk. Pediatr 2005; 115(2):496-506.

American Gastroenterological Association. American Gastroenterological Association technical review on tube feeding for enteral nutrition. Gastroenterology 1995; 108(4):1282-1301.

Anand K, Brown M, Causon R, Christofides N, Bloom S, Aynsley-Green A. Can the human neonate mount an endocrine and metabolic response to surgery? J Pediatr Surg 1985; 20(1):41-48.

Avitzur Y, Singer P, Dagan O, et al. Resting energy expenditure in children with cyanotic and noncyanotic congenital heart disease before and after open heart surgery. JPEN J Parenter Enteral Nutr 2003; 27(1):47-51.

Axelrod D, Kazmerski K, Iyer K. Pediatric enteral nutrition. JPEN 2006; 30(1):S21-S26.

Baskin WN. Acute complications associated with bedside placement of feeding tubes. Nutr Clin Pract 2006; 21:40-55.

Beckwith CM, Feddema SS, Barton RG, Graves C. A guide to drug therapy in patients with enteral feeing tubes: dosage form selection and administration methods. Hosp Pharm 2004; 39(3):225-237.

Canadian Paediatric Society. Undernutrition in children with neurodevelopmental disability. Can Med Assoc J 1994; 151:753-759.

Canadian Paediatric Society. Exclusive breastfeeding should continue to six months. Pediatr Child Health. 2005; 10(3):148. Available at www.cps.ca/english/statements/N/breastfeedingMar05.htm

Connolly BL, Cahit PG, Siva-Nandan R, Duncan D, Peer M. Recognition of intussusception around gastrojejunostomy tubes in children. AJR 1998; 170:467-470.

Faubion WA, Zein NN. Gastroesophageal reflux in infants and children. Mayo Clinic Proc 1198; 73:166-173.

Friedman JN, Ahmed S, Connolly B, Chait P, Mahant S. Complications associated with image-guided gastrostomy and gastrojejunostomy tubes in children. Pediatr 2004; 114:458-461.

Grunow JE, Chait P, Savoie S, Mullan C, Pencharz P. Gastrostomy feeding. In: Recent Advances in Pediatrics 12. David TJ ed., Churchill Livingstone, 1994, pp. 23-39.

Hardy CH, Dwyer J, Snelling LK, Dallal GE, Adelson JW. Pitfalls in predicting resting energy requirements in critically ill children: A comparison of predictive methods to indirect calorimetry. Nutr Clin Pract 2002; 17:182-189.

Health Canada. Exclusive Breastfeeding Duration: 2004 Health Canada Recommendation. Ottawa, 2004. www.hc-sc.gc.ca/hpfb-dgpsa/onpp-bppn/exclusive_breastfeeding_duration_e.html

Holtz L, Milton J, Sturek JK. Compatibility of medications with enteral feedings. JPEN 1987; 11(2): 183-186.

Hughes UM, Connolly BL, Chait B, Muraca S. Further reports of small-bowel intussusceptions related to gastrojejunostomy tubes. Pediatr Radiol 2000; 30:614-617.

Jones M, Pierro A, Hammond P, Lloyd D. The metabolic response to operative stress in infants. J Pediatr Surg 1993; 28(10):1258-1262.

Lawrence R. Breastfeeding: A guide for the medical profession, 5th edition. Mosby Inc., 1999.

Ledermann SE, Spitz L, Maloney J, Rees L, Trompeter R. Gastrostomy feeding in infants and children on peritoneal dialysis. Pediatr Nephrol 2002; 17:246-250.

Lucas A and Cole TJ. Breast milk and neonatal necrotising enterocolitis. Lancet 1990; 336:1519-1523.

Magnuson BL, Clifford TM, Hoskins LA, Bernard AC. Enteral nutrition and drug administration, interactions, and complications. Nutr Clin Pract 2005; 20:618-624.

Moore MC and Green HL. Tube feeding of infants and children. Pediatric Clinics of North America 1985; 32(2):401-417.

Mullan H, Roubenoff R, Roubenoff R. Risk of pulmonary aspiration among patients receiving enteral nutrition support. J Parenteral Enter Nutr 1992; 16:160-164.

Mihatsch WA, von Schoenaich P, Fahnenstich H, Dehne N, Ebbecke H, Plath C, von Stockhausen H, Muche R, Franz A, Pohlandt F. The significance of gastric residuals in the early enteral feeding advancement of extremely low birth weight infants. Pediatr 2002; 109:457-459.

Nelson S, Chen E, Syniar G, Christoffel K. Prevalence of symptoms of gastroesophageal reflux during infancy: A pediatric practice-based survey. Arch Pediatric Adolescent Med 1997; 6:569-572.

O'Connor DL, et al. Growth and development of premature infants fed predominantly human milk, predominantly premature infant formula or a combination of human milk and premature formula at least until term corrected age. JPGN 2003; 37(4):437-446.

Orenstein SR. Consultation with the specialist: Gastroesophageal reflux. Pediatr Rev 1999; 20:24-28.

Owen CG, et al. Effect of infant feeding on the risk of obesity across the life course: A quantitative review of the published evidence. Pediatrics 2005; 115:1367-1377.

Pearce CB, Duncan HD. Enteral feeding. Nasogastric, nasjejunal, percutaneous endoscopic gastrostomy, or jejunostomy: Its indications and limitations. Postgrad Med J 2002; 78:198-204.

Pediatric Nutrition Practice Group of the American Dietetic Association. Delivery and bedside management of infant feedings. In: Infant Feedings: Guidelines for Preparation of Formula and Breastmilk in Health Care Facilities. Robbins ST, Beker LT eds., Diana Faulhaber, 2004, pp 88-95. Adapted version available at www.eatright.org

Pinelli J, Symington A. Non-nutritive sucking for promoting physiologic stability and nutrition in preterm infants. The Cochrane Database of Systematic Reviews. 2005; 4 Art. No: CD001071. DOI: 10.1002/14651858. CD001071.

Powis M, Smith K, Rennie M, Halliday D, Pierro A. Effect of major abdominal operations on energy and protein metabolism in infants and children. J Pediatr Surg 1998; 33(1):49-53.

Ramage IJ, Harvey E, Geary DF, Hébert D, Balfe JA, Balfe JW. Complications of gastrostomy feeding in children receiving peritoneal dialysis. Pediatr Nephrol 1999; 13:249-252.

Rombeau J and Caldwell MD (eds). Enteral and Tube Feeding. Philadelphia: W.B. Saunders, 1992.

Rudolph CD, Mazur LJ, Liptak GS, Baker RD, Boyle JT, Colletti RB, Gerson WT, Werlin SL. Guidelines for evaluation and treatment of gastroesophageal reflux in infants and children: Recommendations of the North American Society for Pediatric Gastroenterology and Nutrition. J Pediatr Gastroenterol Nutr 2001; 32:S2:S1-S31.

Russell MR, Crommer M, Grant J. Complications of enteral nutrition therapy. In: A.S.P.E.N., The Science and Practice of Nutrition Support: A Case-Based Core Curriculum. Gottschlich MM, Fuhrman MP, Hammond KA, Holcombe BJ, Seidner DL eds., Kendall/Hunt Publishing Co., 2001, pp 189-210.

Schack-Nielsen L and Michaelsen KF. Breastfeeding and future health. Curr Opin Clin Nutr Metab Care 2006; 9:289-296.

Secker D. Gastroesophageal reflux disease. Heinz Infant Nutrition Institute, In Touch 2001; 18(2):1-4. Available at www.hini.org

Shanbhogue R, Jackson M, Lloyd D. Operation does not increase resting energy expenditure in the neonate. J Pediatr Surg 1991; 26(5):578-580.

Vandenplas Y, Belli D, Cadranel S, et al. Dietary treatment for regurgitation-recommendations from a working party. Acta Paediatr 1998; 87:462-468.

Wales PW, Diamond IR, Dutta S, Muraca S, Chait P, Connolly B, Langer JC. Fundoplication and gastrostomy versus image-guided gastrojejunal tube for enteral feeding in neurologically impaired children with gastroesophageal reflux. J Pediatr Surg 2002; 37:407-412.

Weckwerth JA. Monitoring enteral nutrition Support tolerance in infants and children, Nutr Clin Pract 2004; 19:496-503.

Wessel J, Balint J, Crill C, Klotz, A.S.P.E.N. Board of Directors and Task Force. Standards for Specialized Nutrition Support Hospitalized Pediatric Patients. Nutr Clin Pract 2005; 20:103-116.

W.H.O. Collaborative Study Team on the Role of Breastfeeding on the Prevention of Infant Mortality. Effect of breastfeeding on infant and child mortality due to infectious diseases in less developed countries: A pooled analysis. Lancet 2001; 355:451-455.

Wilson DC, Pencharz PB.Nutritional care of the chronically ill. In: Nutrition During Infancy: Birth to 2 Years. Tsang RC, Zlotkin SH, Nichols BL, Hansen JW, eds, Cincinnati: Digital Educational Publishing Inc., 1997, pp 37-56.

Wilson SE, Dietz WH, Grand RJ. An algorithm for pediatric enteral alimentation. Pediatric Annals 1987; 16(3):233-240.

World Health Organization. Global Strategy for Infant and Young Child Feeding, The Optimal Duration of Exclusive Breastfeeding. Geneva, 2001. www.who.int/gb/ebwha/pdf_files/WHA54/ea54id4.pdf

PARENTERAL NUTRITION

Indications for Use

Children unable to ingest or absorb oral or enterally delivered nutrients for a significant period are candidates for parenteral nutrition (PN). They include infants who have gone 2-3 days without adequate intake and older children who have gone 4-5 days. Although the GI tract should be used whenever possible, parenteral nutrition may be used as a primary source of nutrition, providing full nutrition support, or as a partial source, providing nutrition repletion or augmentation in patients unable to tolerate full enteral nutrition.

Choose peripheral parenteral nutrition when:

- the patient is not fluid-restricted
- nutrient needs can be met, and
- central PN is not feasible.

Choose central parenteral nutrition when:

- the patient is fluid-restricted
- peripheral access is limited, and
- nutritional needs cannot be met by peripheral PN.

Nutritional Requirements

ENERGY (CALORIES)

Although energy requirements vary, they are estimated to be approximately 7-15% less (child-infant) and ~25% less (neonate) than with enteral feedings because gastrointestinal energy losses and the cost of digestion are minimal. To account for this decreased energy requirement, basal metabolic rate (BMR) is used (Table 11) instead of the DRI for calories for all patients except for preterm infants.

Energy requirements will be greater in children who have compromised respiratory status, sepsis, thermal burns, cardiac failure, chronic growth failure, and some other disease states or who are recovering from surgery. It is useful to directly measure energy needs in some of these patients using indirect calorimetry (Call ext. 6151 to request).

Together with appropriate laboratory measurements, weight gain or weight change is sufficient to assess the adequacy of short-term parenteral nutrient provision. For patients on PN longer than 3 weeks, growth and adequacy of nutrients provided should be assessed by other anthropometric measurements, such as length, head circumference (in infants), skinfold measurements (including triceps), mid-arm circumference, and mid-arm muscle circumference as well as by lab measurements.

Table 11. **Calculating Parenteral Energy Requirements: Equations for Predicting Basal Metabolic Rate from Body Weight (W)**

	Kcal/day	
Age Range (yrs)	*Males*	*Females*
0-3	60.9W – 54	61.0W – 51
3-10	22.7W + 495	22.5W + 499
10-18	17.5W + 651	12.2 W + 746

Note: *Does not account for physical activity, growth or any specific nutritional stressors*

Source: World Health Organization. Energy and Protein Requirements. Technical Report Series 724. Geneva, Switzerland; World Health Organization; 1985.

Situation	*Activity Factor*
Paralyzed, comatose	0.8-1.0
Confined to bed	1.2
Sedentary	1.5
Normal Activity	1.7

Approximate energy requirements for preterm infants 110-80 kcal/kg/d

AMINO ACIDS

Ideally, protein is not used for energy but for maintaining or promoting lean body mass. To ensure that amino acids are being used for anabolism, and not as a source of energy, a minimum amount must be supplied with the right proportion of non-protein calories (carbohydrate and fat). Alone, carbohydrate or lipids do not provide adequate protein-sparing. There are no good markers of amino acid tolerance. The relationship between blood urea nitrogen and protein intake is not clear. Both dehydration and renal impairment will increase serum urea in the absence of excess amino acid.

Primene®, Travasol C® and Prosol® are the amino acid solutions available in this hospital. Only Primene should be used for patients weighing less than 5 kg. Prosol is used in the preparation of more concentrated solutions.

Table 12. **Guidelines for Administration of Parenteral Amino Acids**

	Preterm	*Term*	*1-12 yrs*	*>12 yrs*
Initial Dose (g/kg/d)	1.5	1.5-2.0	1.5-2.0	1.5
Advance Daily* (g/kg/d)	1.0	1.0	-	0.5
Maximum (g/kg/d)	3.0-3.5	2.5-3.5	1.5-2.0	1.5-2.0

** rate of advancement is determined by protein tolerance*

CARBOHYDRATE

Dextrose in the monohydrate form supplies the majority of non-protein calories and osmolality in parenteral nutrition solutions. Unlike enteral glucose, this form provides 3.4 kcal/g of carbohydrate. Solutions greater than 12.5% dextrose should not be infused in a peripheral line due to the increased incidence of phlebitis and decreased life span of the peripheral vein. Carbohydrate should be initiated in a stepwise fashion to stimulate endogenous insulin secretion and to prevent hyperglycemia. Calculation of the glucose infusion rate (GIR; mg/kg/min) and comparison to reference values is used to estimate the body's ability to metabolize the infused glucose. This is especially important for fluid restricted patients where a higher dextrose concentration may be used to deliver the appropriate amount of carbohydrate per unit time. The guidelines for GIR are only recommendations for intake. Ongoing evaluation of serum glucose levels will determine glucose tolerance and the need to reduce or increase the amount of infused dextrose.

To calculate the Glucose Infusion Rate in mg/kg/min use the following equation:†

$$\text{GIR} = \frac{\text{volume per 24 h of amino acid/dextrose solution (Litres)} \times \text{g dextrose/Litre solution} \times 1000 \text{ mg/g}}{\text{\# hours of infusion} \times 60 \text{ minutes/hour} \times \text{patient's weight (kg)}}$$

When cycling PN, the total amount of nutrients delivered over a 24 hour period should be compared to daily requirements. This is particularly important for carbohydrate because patients with little or no glycogen stores (e.g., preterm infants) will be unable to mobilize sufficient carbohydrate to maintain normal serum glucose concentrations during the time they are off PN. To reduce the risk of delivering an inadequate amount of dextrose and development of hypoglycemia, the total amount of glucose given over a 24 hour period (g/kg/day) is calculated using the equation below and compared to reference values.

$$\text{Daily glucose intake}^{\dagger} = \frac{\text{volume per 24 h of amino acid/dextrose solution (Litres) x g dextrose/Litre solution}}{\text{patient's weight (kg)}}$$

Alternatively, the daily glucose intake (g/kg/day) can be calculated by multiplying the GIR (mg/kg/min) by 1.44.

*† **Note:** include all glucose infusions (e.g., D_5W) when calculating the GIR or daily glucose intake*

Table 13. **Guidelines for Administration of Parenteral Dextrose**

	Preterm	*Full Term/Children*	*Adolescents*
Initial Dose (mg/kg/min)	5-8	5-8	3-5
Advance Daily* (mg/kg/min)	1-2	1-3	1-3
Maximum† (mg/kg/min)	10-16	11-12	5-8

** rate of advancement is determined by glucose tolerance*
† maximum intake will be determined by both tolerance and route of administration

FAT

Parenteral lipids (20%, 30%) are isotonic and provide a concentrated source of calories. They can prevent or reverse essential fatty acid deficiency and prolong the viability of the intravenous site in patients with limited venous access. Intralipid® is used at SickKids and contains purified soybean oil (mostly linoleic and oleic acid). Lipid emulsions of 30% are well tolerated and are especially suitable for severely fluid-restricted patients. Ideally, lipids should be infused over 24 hours for better tolerance. Tolerance is measured by an Intralipid level, a measure of unmetabolized intravenous fat or artificial chylomicrons. A level <1.0 g/L indicates acceptable clearance. **Do not give intravenous lipids to patients with an allergy to egg or soy due to the presence of egg and soy protein in the intravenous preparation.**

Table 14. **Guidelines for Administration of Parenteral Lipids**

	Preterm	*Term*	*Children/Adolescents*
Initial Dose (g/kg/d)	1.0	1.0	1.0
Advance Daily* (g/kg/d)	1.0	1.0	1.0
Maximum (g/kg/d)	3.0-4.0	3.0-4.0	2.0-4.0

** rate of advancement is determined by lipid tolerance*

FLUID

Fluid requirements for paediatric patients are influenced by medical and environmental factors. Fluid management should be individualized whenever possible, especially in preterm, renal, cardiac, and hepatic patients and those with any disorder that requires fluid adjustments. In general, the amount of fluid needed to meet energy needs exceeds maintenance requirements, especially when given by the peripheral route.

FLUID LOSSES (E.G., OSTOMY OUTPUT) SHOULD BE REPLACED THROUGH A SEPARATE "REPLACEMENT" IV SOURCE AND NOT USING THE PN ROUTE. SEE TABLE 15, COMPOSITION OF IV FLUIDS FOR APPROPRIATE REPLACEMENT FLUIDS

Replacement fluids are not calculated as part of the daily total fluid intake nor are the nutrients, e.g., glucose, sodium, potassium, used as part of the daily requirements.

Certain incompatible medications make it necessary to cycle the total PN volume over a shorter period. Careful consideration should be given to the total fluid and nutrients given to avoid delivering too much or too little.

The initial volume of parenteral nutrition for patients without disorders dictating fluid restriction may be based on maintenance fluid requirements, calculated as follows:

Patient weight	*Daily maintenance fluid requirements**
<10 kg	100 mL/kg
10-20 kg	1000 mL+ 50 mL for each kg >10 kg
20 kg	1500 mL+ 20 mL for each kg >20 kg

** not relevant for newborns*

Other IV fluids may be necessary to make up maintenance requirements or to replace ongoing losses.

Initial Fluid Therapy In Neonates	*Fluid intake (mL/kg/d)*		
Birthweight (g)	*<24 hrs*	*24-48 hrs*	*>48* hrs
<1000	100-150	120-150	140-190
1000-1500	100-120	90-130	130-160
1500-5000	80-100	80-120	120-160

Table 15. **Composition of IV Fluid Solutions**

Solutions	*Calories kcal/L*	*Dextrose g/L*	*Na mmol/L*	*Cl mmol/L*	*Osmolarity mOsmol/L*
Dextrose 5% in water – D5W	170	50	0	0	252
Dextrose 10% in water – D10W	338	100	0	0	505
Normal saline 0.9%	0	0	154	154	308
Sodium chloride 0.45%	0	0	77	77	154
Sodium chloride 3%	0	0	513	513	1027
Dextrose 5% + NaCl 0.45	169	50	77	77	406
Dextrose 5% + NaCl 0.9%	169	50	154	154	560
Dextrose 10% + NaCl 0.9%	338	100	154	154	813
Ringer's lactate	0	0	130	109/K4 HCO3 28	272

Other IV additives used in NICU 10% calcium gluconate, 0.23 mmol/mL Ca and KCl injection, 2.0 mmol/ml K. CCU KCl infusions 25 mmol/50ml = 0.5 mmol/ml

Table 16. **Summary of Daily Parenteral Nutrition Requirements***

	Preterm	*Term*	*1-12 yrs*	*>12 yrs*
Energy (kcal/kg)	110-80	100-80	90-60	60-30
Protein (g/kg)	3.0-3.5	3.0-3.5	1.5-2.0	1.5-2.0
Dextrose (mg/kg/min)	10-16	11-12	11-12	5-8
Fat (g/kg)	3.0-4.0	3.0-4.0	2.0-4.0	2.0-4.0
Fluid (mL/kg)	100-200	100-160	100-140	80-120

• maximum requirements may be exceeded but are not recommended routinely

Considerations in Parenteral Nutrition Administration

ACETATE

If acidosis is present, acetate can be substituted for chloride to provide a source of bicarbonate. (Acetate is metabolized by the liver to produce bicarbonate on a 1:1 molar ratio.) Bicarbonate itself cannot be added directly to PN, as it may lead to the liberation of carbon dioxide, changes in the pH of the solution, and instability of other electrolytes. These changes may in turn precipitate insoluble calcium, magnesium, and phosphate salts. Sodium acetate or potassium acetate may be substituted for chloride salts.

The type of amino acid solution (Primene, Travasol C or Prosol) used to prepare the PN will also influence the amount of acetate present. Travasol- and Prosol-based solutions will have a higher acetate concentration than Primene-based solutions.

CALCIUM

Calcium circulates bound to serum albumin and does not indicate the amount of free calcium (ionized) in patients with hypoalbuminemia. The corrected serum calcium should be calculated and the amount in the PN solution adjusted accordingly.

$$\text{Corrected Calcium Value (mmol/L)} = \text{serum calcium (mmol/L)} - \left(\frac{\text{serum albumin (g/L)}}{40}\right) + 1$$

CALCIUM AND PHOSPHATE

The interaction of calcium and phosphate in PN solutions is complex and influenced by many factors. Calcium and phosphorous requirements may exceed the solubility of these two minerals and lead to precipitation and embolization or to catheter occlusion. Optimal delivery is restricted by the pH of the solution, which in turn is determined primarily by its amino acid concentration. If a special solution is being used, the parenteral pharmacist will use solubility curves and clinical experience to determine the maximum concentration with the minimum risk. It is imperative that a separate calcium or phosphate infusion is not linked together or "Y"d into a PN solution, as this will also increase the risk of precipitation.

CHOLESTASIS

Cholestasis is marked by elevated conjugated bilirubin and other liver function tests. Patients most at risk to develop cholestasis:

- are being overfed parenteral nutrients (may be carbohydrate, protein, and/or fat)
- lack enteral nutrition
- have been or are now on long-term parenteral nutrition
- have had gastrointestinal surgery
- were preterm, and/or
- have a history of recurrent sepsis
- peak conjugated bilirubin may occur up to one month after cessation of PN.

In most cases, starting enteral nutrition while weaning, cycling, or discontinuing parenteral nutrition reverses this phenomenon. It may also be prudent to remove Mn for patients on long term parenteral nutrition. Manganese is excreted by the biliary system and can be hepatotoxic (refer to Manganese section) In other cases, cholestasis may lead to irreparable liver cell damage with elevated liver function tests.

CHYLOTHORAX

When chylothorax cannot be managed using one of the formulas containing medium-chain triglycerides parenteral nutrition may be the logical alternative. The use of both parenteral lipid, amino acids and dextrose is necessary to maintain nutritional status and avoid depletion of protein and electrolytes from chyle drainage. Lipid emulsions of 20% and 30% may be used safely and effectively because they do not enter the lymphatic system.

CYCLING PN

Intermittent administration of PN may decrease the risk of cholestasis, help to wean the patient off PN either partly or completely, enable incompatible medications to be delivered through one IV site, and allow the patient greater freedom during the day for other activities.

A sudden cessation of a PN solution with a high glucose concentration (>15%) may result in rebound hypoglycemia. Ideally, tapering should take place over 1-2 hours, with half the full PN rate given over the first 1/2 to 1 hour and one quarter of the full rate over the second 1/2 to 1 hour. Calculations for infused nutrients should be made over the total amount of time the infusion is running, not over 24 hours (e.g., calculate over 20 hours if patient is off PN for 4 hours due to incompatible medications).

DISCONTINUING PN

Optimal nutrition and euglycemia should be maintained while moving from parenteral to enteral nutrition. Neonates on separate lipid and glucose/amino acid solutions must maintain their total fluid intake while being weaned off PN.

Decrease the rate of glucose/amino acid solution by 1 mL for every 1 mL increase in enteral intake until the rate of the solution is 25% of the original order. At this point, PN can be discontinued and an appropriate solution (either D5W or D10W) used to make up the remaining fluid. Lipids may then be discontinued without tapering the rate.

Total nutrient admixture (TNA) solutions should be tapered off as enteral intake increases. When the decision has been made to discontinue PN, give half the rate for 30 minutes, then half that rate again for the next 30 minutes, then stop.

ELEVATED SERUM UREA

An elevated serum urea may be due to excess protein intake, inadequate provision of energy and subsequent endogenous protein breakdown, or to adequate energy provision accompanied by dehydration or renal impairment. Assess the total amount of amino acid and fluid being delivered by the PN solution and adjust based on desired intake.

GLYCOSURIA

Some neonates have a low renal threshold for glucose. Glycosuria may occur despite normal serum glucose levels. An osmotic diuresis and subsequent dehydration may occur unless the glucose concentration in the PN solution is reduced. Electrolyte losses occur rapidly with diuresis and should be monitored, especially Na, K, PO_4, and Mg. Urine glucose monitoring should not be substituted for blood glucose monitoring.

HYPERBILIRUBINEMIA

Preterm infants often develop physiologic jaundice with hyperbilirubinemia because of their inability to conjugate bilirubin. Fatty acids hydrolyzed from triglycerides compete for binding sites on albumin and displace unconjugated bilirubin, leading to an increased risk of kernicterus. Displacement occurs only when excessive parenteral lipid is given; therefore hyperbilirubinemia is not an absolute contraindication for lipid. If the bilirubin approaches exchange level, an intake of intravenous fat sufficient to prevent essential fatty acid deficiency is recommended (0.5-1.0 g/kg/d).

HYPERGLYCEMIA

Hyperglycemia occurs frequently in:

- infants weighing <1000 g, especially those with a glucose infusion rate >4-6 mg/kg/min, often from the administration of more than one glucose-containing solution,
- infants in whom counter-regulatory hormones are present because of surgery or trauma,
- infants with sepsis or undergoing steroid therapy. Occasionally, false elevated serum glucose levels result from blood sampling from the central line.

  Hyperglycemia may cause osmotic diuresis, and urinary electrolytes should be monitored.

Treatment options include:

a) decreasing the amount of dextrose in the PN solution and substituting fat calories if possible, or

b) delivering a previously tolerated rate of dextrose infusion from a decreased volume of PN and "Y"ing in lower dextrose or non-dextrose containing solution.

Simultaneous lipid infusions will help restore glucose homeostasis. Insulin treatment may be necessary to control hyperglycemia in cases where:

a) sufficient nutrition cannot be delivered to the patient, or

b) the hyperglycemia cannot be controlled due to concomitant delivery of glucocorticosteroids or other drugs that elevate blood glucose.

HYPERLIPIDEMIA

Decreased lipid clearance has been associated with preterm infants and with malnourished, septic, and/or acutely ill infants. Excess fat may interfere with host defences. Careful monitoring of Intralipid levels allows for continued use of intravenous fat (IVF). If the Intralipid level is between 1.0 and 1.5 g/L, the dose should be cut in half and the level repeated. If the repeated level is acceptable, increase as outlined above in Guidelines for Administration of Parenteral Lipid. If the level is over 1.5 g/L, the lipid should be held for 24 hours, restarted at a lower dosage, and the Intralipid level measured again. For Haematology/Oncology patients, when the rate of lipid infusion exceeds the rate of removal (lipid overload), the unmetabolized lipid may affect platelet function. Due to this risk, if the intralipid level is over 1.0 g/L, the lipids should be held and the level repeated. Lipids should be restarted at a lower level only after the repeat intralipid level is less than 1.0 g/L.

20% lipids are recommended for most patients and 30% lipids for those who are fluid-restricted.

HYPOGLYCEMIA

Hypoglycemia occurs if an infusion of glucose is abruptly decreased or stopped, as in sudden loss of peripheral or central access. Infants who are small for gestational age have lower glucose stores and are more likely to become hypoglycemic. Infants who are severely fluid-restricted are also at risk, especially in cases where delivery of adequate glucose supply is limited by peripheral access. A steady increase in carbohydrate infusion from 6 to 11-12 mg/kg/min after about 4-5 days is usually tolerated.

IRON

Use of IV iron is controversial because of concerns about the risk of gram-negative sepsis and other illnesses related to iron's oxygen-scavenger properties and the need for antioxidants. Dilute iron dextran in the current dosage in our standard solutions is safe and effective. Because IV iron is absorbed directly, only 5-20% of the oral dosage is needed to meet requirements.

In NICU, iron is either removed or not added to a PN solution if an infant has had a blood transfusion within a 2 week period. Iron dextran,18 µmol/L, is routinely added to the I-10, I-20 and C-30 solutions. Iron is not routinely added to parenteral solutions for the preterm infant. If an infant has been on P-7.5, P-10, or PI-10 for longer than 4-6 weeks, 18 µmol iron per litre may be added in Parenteral Pharmacy. However, for long-term patients, a serum ferritin level is necessary to assess body stores, as IV iron is retained in the body and daily losses are usually minimal.

Parenteral Nutrition Solutions

Table 17. **Composition of Standard Solutions**

Variable	*Measure*	*P-5/7.5*	*P-10**	*PI-10**	*I-10* /I-20*†*	*C-30†*
Calories	kcal/mL	0.23/0.31	0.42	0.42	0.46/0.80	1.22
Amino acids	g/L	15	20	20	30	50
Dextrose	g/L	50/75	100	100	100/200	300
Sodium	mmol/L	20	20	30	30	30
Potassium	mmol/L	20	20	30	30	30
Chloride	mmol/L	22	18	35	40	30
Calcium	mmol/L	9	12	12	9	9
Phosphorus	mmol/L	9	12	12	9	9
Magnesium	mmol/L	3	4	4	4	4
Zinc	µmol/L	46	46	46	46	46
Copper	µmol/L	6.3	6.3	6.3	6.3	6.3
Manganese	µmol/L	1.8	1.8	1.8	5	5
Iodine	µmol/L	0.47	0.47	0.47	0.47	0.47
Chromium	µmol/L	0.076	0.076	0.076	0.076	0.076
Selenium	µmol/L	0.25	0.25	0.25	0.25	0.25
Iron	µmol/L	nil	nil	nil	18	18
Acetate	mmol/L	8.85	9.8	13.8	46.1	52.25
Osmolarity	mOsm/L	485/611	769	824	874/1378	2101
pH (approx.)		5.97/5.91	5.85	5.91	5.62/5.5	5.85

** Available as Total Nutrient Admixture, containing 20% fat emulsion. A 1.2 micron in-line filter must be used during administration.*

† Must be administered via central venous line only.

LIPID EMULSIONS

Table 18. **Composition of Lipid Emulsions**

	20%	*30%†*	*Serum*
Calories, kcal/mL	2.0	3.0	
Fat, g/mL	0.2	0.3	
Osmolality, m0sm/kg H_2O	350	310	285
pH	8.0	7.5	7.32-7.42
Purified egg phospholipid, g/L	12	12	
Glycerol anhydrous, g/L	22.0	16.7	

† For fluid-restricted patients.

TOTAL NUTRIENT ADMIXTURE (TNA)

TNA's, or 3-in-1 solutions, are PN solutions in which the lipid 20% emulsion has been mixed with the other ingredients to form one solution. The "3" refers to amino acid, dextrose, and lipid. A TNA provides the PN solution in a single bag as opposed to the traditional system, in which a bag or syringe of lipid is administered via a separate line that is "Y"d with the amino acid/dextrose solution near the patient.

Since everything is in one bag, only a single pump and tubing set is required to administer the solution. The exact amount of lipid prescribed is added to the bag, thus eliminating overfill wastage. The benefits are lipid cost savings and a simpler system.

However, the destabilizing effects of the PN constituents on the lipid emulsion mean that only certain solutions can be formulated as TNA's. These are P-10, PI-10, I-10 and I-20. Studies have been done on these solutions to determine the maximum allowable electrolyte and mineral concentrations. If concentrations higher than these are required, then the traditional 2-in-1 system must be used. Lower than standard electrolyte and mineral concentrations can be formulated as a TNA.

Certain home PN formulations that fall outside this range may be prepared as TNA's, but only if the stability of the solution has been investigated by the supplying home care pharmacy. As an added safety measure, even though the stability of these solutions has been studied, **TNA's must be administered through a 1.2 micron in-line filter.** This prevents any large lipid droplets or chemical precipitate (which cannot be seen owing to the opacity of the TNA) from reaching the patient.

TNA's are only available during the hours of operation of the Parenteral Pharmacy. At other times the 2-in-1 system must be used and the patient switched to a TNA the next day.

VITAMINS

- Vitamins are added to the amino acid/dextrose solution or the TNA on the day of dispensing to the unit.
- Vitamins may be omitted by the Parenteral Pharmacy if a new order is received after the PN dispensary has closed. Vitamins will be added the following day.
- PN without vitamins may be ordered if the patient is receiving complete oral vitamin supplementation.
- Multi-12/K_1 Pediatric is used for all NICU patients, home PN patients, and any patients weighing <2 kg and patients on long term PN (>6 weeks). MVI-HSC is the standard multivitamin for other patients. If the patient is on anticoagulation therapy (warfarin), MVI-12 or Multi-12, which contains no vitamin K, may be considered for short-term use. The ingredients of these three multivitamins are shown in the following table.

Multivitamin injections

Table 19. **Composition of Multivitamin Injections**

Ingredient	*Unit*	*Multi-12/K_1 Pediatric 5 mL*	*MVI-HSC 6 mL*	*MVI-12 or Multi-12 10 mL*
Vitamin A	RE	690	1201	990
Vitamin D	µg	10	10	5
Vitamin E	mg	4.7	2.7	6.7
Vitamin K	mg	0.2	0.2	none
Thiamin (B1)	mg	1.2	18	3
Riboflavin (B2)	mg	1.4	4	3.6
Niacin (B3)	mg	17	40	40
Pantothenic acid (B5)	mg	5	10.4	15
Pyridoxine (B6)	mg	1	4.8	4
Vitamin B12	µg	1	2	5
Folic acid	µg	140	160	400
Biotin	µg	20	24	60
Ascorbic acid	mg	80	400	100

TRACE ELEMENTS

A pre-mixed solution of 4 trace elements (copper, selenium, iodine, chromium) is added daily to each bag of parenteral nutrition solution. For exact content, refer to Table 17, Composition of Standard Solutions. Trace elements manganese* and zinc need to be ordered individually. Suggested requirements for trace elements are listed in Table 20.

Table 20. **Trace Element Daily Requirements**

Trace Element	*Preterm <3 kg (µg/kg/d)*	*Term 3-10 kg (µg/kg/d)*	*Children 10-40 kg (µg/kg/d)*	*Adolescents >40 kg (per day)*
Zinc	400	50-250	50-125	2-5 mg
Copper	20	20	5-20	200-500 µg
Manganese	1	1	1	40-100 µg
Chromium	0.05-0.2	0.2	0.14-0.2	5-15 µg
Selenium	1.5-2	2	1-2	40-60 µg

Adapted from: Mirtallo J, Canada T, Johnson D, Kumpf V, Petersen C, Sacks G, Seres D, Guenter P. Safe practices for parenteral nutrition. JPEN 2004; 28(8):S39-S40.

***Manganese**

Manganese (Mn) should be removed from parenteral nutrition (PN) solutions for patients at risk of developing PN-associated liver disease and/or have existing liver disease unrelated to PN. Mn is excreted primarily in the bile into feces. Therefore providing Mn in the presence of a low bile flow state may lead to excess Mn accumulation and produce toxicity to the liver and brain. A maximum dose of parenteral manganese should be 1µg/kg/d for all age groups, including preterm infants. Isolated removal of Mn should be considered once conjugated bilirubin is greater than 25 µmol/L. In patients requiring a MRI, such as an asphyxiated newborn, a delay in adding Mn to the PN solution prior to the MRI will avoid false positive signals in the basal ganglia of the brain.

References

Groff JL, Gropper SS. Advanced Nutrition and Human Metabolism 3rd ed. Toronto: Nelson/Thomson Learning, 2000; 457-459.

Greene H, Hambidge K, Schanler R. Guidelines for the use of vitamins, trace elements, calcium, magnesium, and phosphorus in infants and children receiving total parenteral nutrition: Report of the Subcommittee on Pediatric Parenteral Nutrient Requirements from the Committee on Clinical Practice Issues of the American Society for Clinical Nutrition. Am J Clin Nutr 1988; 48:1324-1342.

For information on parenteral iron, see section on "Iron" under Considerations in Parenteral Nutrition Administration.

SPECIAL PN SOLUTIONS

Any variation in the content of standard SickKids amino acid/dextrose solutions is considered a special solution. The following may be altered, alone or in combination:

- amino acid content
- dextrose concentration
- electrolytes and/or minerals/trace elements
- vitamins.

Solutions with alterations in either the amino acid or dextrose content are labeled "special solutions." Solutions with alterations to other constituents (e.g., electrolytes) are labeled as the base solution, with the altered constituents highlighted on the label.

A doctor or nurse may not make any additions to a PN or lipid bag. Short term sodium chloride (3%) additions to the amino acid-dextrose solution may be made on certain nursing units (e.g., NICU) through the volume control set. Additions of potassium chloride are not permitted.

Minerals may not be added to the amino acid-dextrose solution either through the volume control set or in a separate IV solution through a Y-connection to the PN line, while the PN is still running. Any increase in the mineral concentration may result in precipitation in the amino acid-dextrose solution. Contact the pharmacy for further compatibility information.

If a patient requires additions on an ongoing basis, a special solution should be ordered and prepared in the PN pharmacy.

ELECTROLYTES AND MINERALS

Table 21. **Daily Electrolyte and Mineral Requirements for Paediatric Patients**

	Preterm Neonates	*Infants/Children*	*Adolescents & Children >50 kg*
Sodium	2-5 mmol/kg	2-5 mmol/kg	1-2 mmol/kg
Potassium	2-4 mmol/kg	2-4 mmol/kg	1-2 mmol/kg
Chloride	As needed to maintain acid-base balance	As needed to maintain acid-base balance	As needed to maintain acid-base balance
Calcium	1-2 mmol/kg	0.25-2 mmol/kg	5-10 mmol/d
Phosphorus	1-2 mmol/kg	0.5-2 mmol/kg	10-40 mmol/d
Magnesium	0.15-0.25 mmol/kg	0.15-0.25 mmol/kg	5-15 mmol/d
Acetate	As needed to maintain acid-base balance	As needed to maintain acid-base balance	As needed to maintain acid-base balance

Reference: The ASPEN Nutrition Support Manual, 2nd Edition, American Society for Parenteral and Enteral Nutrition, 2005.

Table 22. **Maximum Concentration of Individual Electrolytes and Minerals in Standard Parenteral Nutrition Solutions (not TNA)**

Ingredient (mmol/L)	*P-10*	*PI-10*	*I-10*	*I-20*	*C-30*
Sodium	154	154	154	154	154
Potassium	240 (60*)	240 (60*)	240 (60*)	240 (60*)	240 (60*)
Calcium†	15	15	30	30	30
Phosphorus†	15	15	24	24	30
Magnesium	8	8	24	24	24

** Via a peripheral line.*

†Refers to maximum individual levels. Contact the parenteral pharmacist if higher concentrations of both minerals is required.

Table 23. **Maximum Concentration of Individual Electrolytes and Minerals in TNA**

Ingredient	*Concentration (mmol/L)*
Sodium	100
Potassium	80
Chloride	100
Calcium	12
Phosphate	12
Magnesium	12*
Iron	54 µmol/L

**4 mmol/L in P-10 and PI-10*

Monitoring Schedule for Patients on Parenteral Nutrition

NICU

Routine parenteral nutrition bloodwork is done on Monday and Thursday mornings except in the following situations, where it is not necessary:

- PN was started in the previous 24 hours.
- The tests below have been done in the previous 24 hours.
- Enteral feedings are being increased and exceed 50% of the total fluid intake.

These recommendations may not be appropriate for infants with renal and/or liver impairment. In these cases, more frequent monitoring may be necessary, and Medicine should be contacted for clarification.

Table 24. **Monitoring Schedule for Stable NICU Patients on Parenteral Nutrition**

Parameter	*Initial Period (first 3 weeks on PN)*	*Later Period (after 3 weeks on PN)*
Glucose	Twice weekly	1-2 times a week
Electrolytes	Twice weekly	1-2 times a week
Intralipid level	Twice weekly	Once a week
Urea	Once a week	Once a week
Calcium, phosphate	N/A	Every 2 weeks
Conjugated bilirubin, alkaline phosphatase, AST	N/A	Every 2 weeks
Albumin	N/A	Every 3 weeks

AST = aspartate aminotransferase; N/A = not applicable.

NON-NICU

Table 25. **Monitoring Schedule for Stable Patients on Parenteral Nutrition***

Parameter	*At start of therapy*	*Monday*	*Thursday*
Glucose	Yes	Yes	Yes
Electrolytes	Yes	Yes	Yes
Intralipid level	No	Yes	Yes
Complete blood count	No	Yes	No
Urea, phosphate, calcium, conjugated bilirubin, albumin, Mg	Yes	Yes	No
AST, alkaline phosphatase, creatinine, acid base	Yes	If indicated	If indicated

**Excluding patients in NICU*
AST = aspartate aminotransferase

Ordering PN

All orders, including changes to previous orders, are processed through KIDCOM or written on form No. 33643, Doctor orders – Total Parenteral Nutrition. Questions about the ordering of PN may be directed to a parenteral pharmacist at ext. 6702.

Standard PN solutions and lipids (20% and 30%) are available 24 hours a day. Standard solutions dispensed outside regular hours will not have vitamins added to the bag. Standard solutions with electrolyte/mineral additions, special solutions and TNAs are available only during regular PN pharmacy hours; to ensure sufficient preparation time, orders for these should arrive in the pharmacy at least 1 hour before closing time.

Orders received after the appropriate deadline may not be available until the next day. A standard solution will have to be used unless prior arrangement has been made with the PN pharmacist.

Drug Compatibilities

The tables below list the drugs that are compatible with parenteral nutrition and those that are not. For the most recent information, see the current SickKids Formulary of Drugs.

Table 26. **Drugs Compatible With Parenteral Nutrition***

Ampicillin	Fluconazole	Metoclopramide
Cefazolin	Furosemide	Morphine
Cefotaxime	Gentamicin	Norepinephrine
Ceftazidime	Heparin	Penicillin G
Cefuroxime	Insulin	Piperacillin
Clindamycin	Iron Dextran	Ranitidine
Cloxacillin	Isoproterenol	Tazocin®
Dobutamine	Lidocaine	Tobramycin
Dopamine	Meperidine	Vancomycin
Erythromycin	Methylprednisolone	

*For compatibility information on any drugs not listed, contact the pharmacy department.

Table 27. **Drugs Incompatible With Parenteral Nutrition**

The following drugs are incompatible with PN and must not be given concurrently with a PN solution under any circumstances. These drugs may be administered through a Y-connection, provided that the PN solution is stopped and the line clamped immediately above the Y, then adequately flushed.

Acetazolamide	Cisplatinum	Mannitol
Acyclovir	Cyclosporine	Metronidazole
Amphotericin	Deferoxamine	Pantoprazole
Antithymocyte	Doxorubin	Phenytoin
Globulin (ATGAM)	Etoposide	Sodium Bicarbonate
	Ganciclovir	Teniposide

- Drug compatibilities with PN solutions can never be guaranteed.
- If there is a separate IV site or catheter lumen available, use it for drug administration.
- If the PN is turned off for scheduled drug administration, cycle the total PN prescription over the number of remaining hours.

For drugs not listed above, the following steps are taken:

1. The pharmacist can discuss with the nurse, physician or dietitian the possibility of finding a separate IV site or turning off the PN to allow drug administration. If a patient's condition allows, new rates can be suggested that would give the required PN volume over the number of hours available.
2. If this is not possible, the pharmacist can discuss the situation with the prescribing healthcare professional. The pharmacist relays the information available on the drug and the individual patient is assessed.
3. The physician makes the decision to run (or not to run) a drug simultaneously with PN.
4. The physician documents the decision as a physician's order, e.g., Drug X may be run concurrently with PN.

In all cases where drugs are infused concurrently with PN solutions, the IV lines should be carefully monitored for signs of incompatibility

Management of Peripheral Intravenous PN

1. Many patients requiring PN can be managed using peripheral veins. Solutions containing 12.5% glucose or less and with an osmolarity of <1050 mOsmol/L can be given through a peripheral vein. Both 20% and 30% fat emulsions are isotonic.

2. Use two administration sets, one for the amino acid/dextrose solution and one for the fat emulsion. The hospital also uses TNA solutions, in which the ordered amounts of amino acid/dextrose and lipid solutions are premixed in one bag. In this case only one administration set is needed. Infusions must be regulated by infusion pumps.

3. Butterflies and angiocatheters may be used with peripheral PN. Particular attention must be paid to skin preparation as explained below (See Policies and Procedures: IV and vascular access/peripheral lines).
   - Perform basic hand wash.
   - Prepare skin with chlorhexidine and allow to dry for 60 seconds.
   - Prepare finger that will be palpating vessel.
   - Timing: as per physician orders or medical 3.
   - Consider a peripherally inserted central catheter (PICC) or a central venous line if a patient requires PN for more than 2 weeks.

4. Nursing staff should monitor the infusion site hourly for early signs of extravasation of IV fluids and/or thrombophlebitis. Early detection and action can minimize or eliminate the serious complication of skin and tissue necrosis. Thrombophlebitis is usually avoided by changing the infusion site every 72 hours and by cleaning the skin before insertion of the needle or cannula.

5. PN can be administered through a midline. The IV team, and specially certified nurses in NICU, insert midlines. A physician's order is required. Only solutions containing 12.5% glucose or less may be administered through the midline.

6. A 1.2 micron filter must be added to the IV tubing for all PN/TNA solutions.

Management of Central Intravenous PN

1. All central lines should be placed under full aseptic conditions, preferably in the operating room or in the Diagnostic Imaging Department by a surgeon or an interventional radiologist. In the NICU, specially certified nurses are also able to insert peripherally inserted central catheters in select patients. Sterile IV tubing should be connected to a newly inserted central venous line (CVL).

2. The following are acceptable catheters used at SickKids:
   - Peripherally inserted central catheter (PICC)
   - Cook – single, double, or triple lumen (tunneled or percutaneous)
   - Subcutaneous ports – adult, or low-profile
   - Quinton – dialysis
   - L. Cath – Long line, umbilical arterial catheter, umbilical venous catheter – NICU

3. The skin exit site for the catheter should be located in an area that can be easily and meticulously cleaned, and away from any natural or acquired orifices, such as gastric and intestinal stomas, tracheotomies, suprapubic catheters, burns, or lesions.

4. Care of the PN system and the catheter should be performed by nurses and doctors competent in CVL skills. All CVLs must be accessed and dressed in a sterile fashion according to the appropriate nursing procedure. (See Policies and Procedures IV and vascular access: Central lines).

5. In the event of suspected sepsis, blood must be drawn from each lumen as well as a peripheral site, and specimens labeled clearly. If the catheter is removed for sepsis, the tip must be sent for semi-quantitative culture. (See Policies and Procedures IV and vascular access: Central lines).

6. In most circumstances, do not use a PN central line to measure central venous pressure. If the CVL becomes sluggish and/or there is no blood return, the cause should be investigated. Administration of blood products and/or medications can lead to the formation of a fibrin sheath in the catheter lumen and increase the risk of sepsis and occlusion. Flushing the line is imperative. Stopcocks should not be used on central venous lines on units other than the intensive care units. Only trained health-care professionals should draw blood from central venous lines.

7. Following the placement of a percutaneous central line, a chest x-ray (upright if possible) must be taken to check catheter position, possible pneumothorax, and extravasation of fluid.

Nursing Responsibilities and Administration of Parenteral Nutrition

1. Ensure pre-PN bloodwork is done before the infusion is started. Routine PN bloodwork is done every Monday and Thursday morning so that changes can be made to the PN order before the deadline in PN Pharmacy.

2. Check the patient's name, SickKids number, unit, solution type and expiry date against the order for the PN solution.

3. Remove the PN from the refrigerator a minimum of 1 hour before hook-up and a maximum of 24 hours to infusion completion.

4. Administer PN with an infusion pump.

5. For traditional two-line systems, use non-vented solutions set. NICU/CCU use syringe sets. A 1.2 micron filter is needed. The two lines are joined with a Y connector.

6. Medications should be added as close as possible to the entry site.

7. Change tubing every 72 hours (48 hours in NICU) if PN is continuous. If PN is cycled or stopped for more than 4 hours change of tubing is required.

8. Lipid and PN solutions expire 24 hours after hanging.

9. Check the IV, IV site, the line connections, infusion rate of the pump and the volume administered hourly. Chart according to hospital procedure.

Heparinizing Central Venous Lines (Excluding Dialysis Lines)

Table 28. **Heparinizing for maintaining patency of midline, single lumen, PICC and double lumens (each lumen) (Excluding Dialysis Lines)**
Note: *NICU uses .45 NaCl in heparin lines*

Strength of Heparin is 100 U/mL

Weight	*Fill Volume 1.0 mL*	*Heparin (mL)*	*NS (mL)*
1.0 kg	10 units	0.1	0.9
2.0 kg	20 units	0.2	0.8
3.0 kg	30 units	0.3	0.7
4.0 kg	40 units	0.4	0.6
5.0 kg	50 units	0.5	0.5
6.0 kg	60 units	0.6	0.4
7.0 kg	70 units	0.7	0.3
8.0 kg	80 units	0.8	0.2
9.0 kg	90 units	0.9	0.1
≥10.0 kg	100 units	1.0	

See Policies & Procedures and guidelines for Heparin//Saline for maintaining patency of access catheters

Mechanical Complications of Central Venous Lines

Table 29. **Mechanical Complications of Central Venous Lines**

Complication	*Cause*	*Clinical Signs*	*Intervention*
Arterial injury	Inadvertent puncture of subclavian or carotid artery during catheter insertion	Increased pressure of blood flow and/or bright red blood in syringe noted during sampling	Consult Surgery for CVL removal
Air embolism	Accidental uncoupling of Luer-Lok connections. Improper clamping during insertion, tubing change or blood sampling. Severed catheter	Tachypnea, pain, dyspnea, cyanosis and hypotension	The Luer-Lok must be used. Clamp line immediately. Place patient on left side. Administer oxygen
Venous thrombosis	Prolonged catheterization	Increased resistance to flushing and/or no blood return. Edema of neck, shoulders and arm	Administer alteplase (tpa) or heparin as per venous thrombosis protocol. See SickKids Formulary
Catheter occlusion	*Drug precipitates, PN, fibrin sheath formation, coagulopathies, etc,	Increased resistance, or inability to flush. No blood return	Administer HCl (L:24) or alteplase/tpa (L:23) as per protocol. Refer to SickKids formulary: Antithrombitic therapy: blocked central venous lines. Policies and procedures: IV and vascular access: Central lines

Adapted with permission from Table 17-3, Clinical Nutrition, Parenteral Nutrition, *Rombeau and Caldwell, 2nd Edition, 1993.*

**** Note:** IV solutions containing magnesium, calcium, and phosphorus that are run concurrently with PN (using a Y connection) may lead to precipitation (chemical occlusion). If in doubt, please consult the PN pharmacists at ext. 6702.*

Central Venous Line Infection Management

Management of CVL-related infection is extremely important. Signs and symptoms of infection include fever, malaise, inflammation, and discharge at the exit/subcutaneous pocket/tunnel, or vein insertion site.

CONSIDERATIONS FOR WORK-UP OF POSSIBLE CVL SEPSIS

1. Examine patient thoroughly to identify unrelated sources of infection.
2. Carefully examine all catheter insertion sites and tunnels for pain, redness, or discharge. Send swab for culture and sensitivity testing.
3. Obtain central blood cultures from all CVL lumens as well as peripheral blood cultures.
4. Send infusate for culture if overwhelming septic shock without an obvious source develops during PN infusion.
5. Begin antibiotics (see Sepsis Management section below).

DEFINITION OF INFECTION

1. Systemic infection (sepsis) defined by bacteremia (positive blood cultures) plus two or more of the following symptoms: tachycardia, fever, hypothermia, or hypotension.
2. Local infection at skin CVL exit site, subcutaneous port pocket, or tunnel exit site: inflammation (red, hot, swollen, tender) with/without positive culture swab of suspected infectious site.
3. Septic thrombophlebitis, clinical findings of phlebitis: warm, erythematous skin, over an indurated vein – PICC, CVL, PORT-O-CATH.

SEPSIS MANAGEMENT

Antibiotic therapy

Use beta-lactam plus aminoglycoside, e.g., piperacillin and gentamycin. In postoperative cardiovascular patients who are at risk of endocarditis, vancomycin should be used with gentamycin. Ceftazidime is used only if the patient is known or suspected to be colonized with a multi-resistant organism or if there is significant renal impairment.

Appropriate antibiotic therapy is given for at least 10 days and should be rotated through all lumens if multilumen catheter is in use. Repeat peripheral and CVL cultures should be obtained at 48-72 hours. If the repeat cultures are negative and the patient is afebrile, no further cultures are required. Daily blood cultures are not required unless new symptoms appear.

For more information refer to Antimicrobial Guidelines in SickKids Formulary.

Considerations for CVL removal

- clinical sepsis: patient unresponsive to therapy. Continues to experience septic shock, fever/chills
- refractory or progressive exit site infection
- tunnel infection
- unresolved bacteremia or local infection after 72 hours of appropriate antibiotic therapy
- recurrent bacteremia of the same organism 3-4 times within several weeks
- persistent fever without other focus of infection
- septic pulmonary emboli
- evidence of septic thrombosis of cannulated central vein
- evidence of endocarditis.

Note: *Infectious Disease consult may be required.*

Total Quality Management

Patients with CVL sepsis are identified by the Infection Prevention Control Service in collaboration with the Nutrition Support Nurse and Microbiology.

PARENTERAL NUTRITION STATISTICS

PN/CVL sepsis rates are followed monthly and reported through the Vascular Access Committee and Infection Control Committee.

MEDICATION INCIDENTS

All medication incidents involving PN are reported on the computerized online safety reporting system. The reports are forwarded to the manager of the originating ward and production pharmacy as determined by the manager, and sent to the Nutrition Advisory Committee, who will look for trends in the incidents and raise questions through the appropriate channels (Nursing/Pharmacy Committee, Nursing Quality Practice Committee, and/or the Nutrition Team). The hospital's PN error rate is reported annually.

Home PN Patients

ASSESSMENT OF HOME PN PATIENTS

While in hospital, a GI/Nutrition consult specifically requesting a work-up as a potential home PN candidate is done to ensure all other means of nutrition provision have been explored. Part of the consult includes a social and family assessment. A decision not to proceed with home PN could be made based on these assessments.

The home PN teaching program includes intense training of two caregivers for a minimum of 2 weeks.

NURSING RESPONSIBILITIES FOR HOME PN PATIENTS WHEN ADMITTED TO HOSPITAL

1. At least two bags of home PN solution should be brought into hospital by the family for use until the solution can be manufactured in the SickKids parenteral pharmacy.
2. Physician to order the volumes to be infused of home PN on KIDCOM or as a written order.
3. Home PN should be removed from the refrigerator 12 hours prior to hook-up.
4. A 1.2 micron filter is not required for the home PN solution.
5. Vitamins should be added to the home PN bag immediately before hook-up.
6. Inquiries about a patient's home PN can be made through SickKids PN pharmacy at ext. 6702.

Note: *Home PN patients have their PN solutions made and supplied by an outside pharmacy.*

Bibliography

Acra, S, Rollins, C. Principles and guidelines for parenteral nutrition in children. Pediatr Annals 1999; 28:113-20.

American Academy of Pediatrics. Commentary on parenteral nutrition. Pediatrics 1983; 71:547-552.

Baugh N, Recupero MA, Kerner JA. Nutritional requirements for pediatric patients. In: The ASPEN Nutrition Support Manual. 1998; pp. 1-13.

Collier S, Crouch J, et al. Use of cyclic parenteral nutrition in infants less than 6 months of age. Nutr Clin Pract 1994; 9:49-68.

Driscoll DL, Blackburn GL. Total parenteral nutrition 1990 – A review of its current status in hospitalized patients, and the need for patient-specific feeding. Drugs 1990; 40:346-363.

Forsyth JS, Crighton A. Low birthweight infants and total parenteral nutrition immediately after birth. I. Energy expenditure and respiratory quotient of ventilated and non-ventilated infants. Arch Dis Child Fetal Neonatal Ed. 1995; 73:F4-F7.

Forsyth JS, Murdock N, Crighton A. Low birthweight infants and total parenteral nutrition immediately after birth. III. Randomized study of energy substrate utilization, nitrogen balance, and carbon dioxide production. Arch Dis Child Fetal Neonatal Ed. 1995; 73: F13-F16.

Green HL, Hambidge KM, Schanler R, et al. Guidelines for the use of vitamins, trace elements, calcium, magnesium and phosphorus in infants and children receiving total parenteral nutrition: report of the Subcommittee on Pediatric Parenteral Nutrient Requirements from the Committee on Clinical Practice Issues of the American Society for Clinical Nutrition. Am J Clin Nutr 1988; 48:1324-1342.

Gutcher GR, Farrell PM. Intravenous infusion of lipid for the prevention of essential fatty acid deficiency in preterm infants. Am J Clin Nutr 1991; 54:1024-1028.

Hanning RM, Zlotkin SH. Amino acid and protein needs of the neonate: effects of excess and deficiency. Seminars in Perinatology 1989; 13:131-141.

Haumont D, Deckelbaum RJ, Richelle M, et al. Plasma lipid and plasma lipoprotein concentrations in low birth weight infants given parenteral nutrition with twenty or ten percent lipid emulsion. J Pediatr 1989; 115:787-793.

Kerner JA. Parenteral nutrition. In: Pediatric gastrointestinal disease. Walker A, ed. St. Louis: BC Decker, 1996; 1904-1951.

Klein GL. Metabolic bone disease of total parenteral nutrition. Nutrition 1998; 14:149-152.

Lenders CM, Lo C. Pediatric parenteral nutrition. Nutr in Crit Care 1999; 2:219-229.

Marian M. Pediatric nutrition support. Nutr Clin Pract 1993; 8:199-209.

Murdock N, Crighton A, Nelson LM, Forsyth JS. Low birthweight infants and total parenteral nutrition immediately after birth. II. Randomized study of biochemical tolerance of intravenous glucose, amino acids, and lipid. Arch Dis Child Fetal Neonatal Ed 1995; 73:F8-F12.

Nutrition Committee, Canadian Pediatric Society. Nutrient needs and feeding of preterm infants. Can Med Assoc J 1995; 152:1765-1785.

Rombeau JL, Caldwell MD. Parenteral nutrition. 2nd ed. Philadelphia: WB Saunders, 1986.

Sax HC, Bower RH. Hepatic complications of total parenteral nutrition. JPEN 1988; 12:615-618.

Spitzer JJ, Bagby GJ, Meszaros K, et al. Alterations in lipid and carbohydrate metabolism in sepsis. JPEN 1988; 12:53S-58S.

Task force for the revision of safe practices of parenteral nutrition: MirtalloJ, Canada T, Johnson D, Kumpf V, Petersen C, Sacks G, Seres D, Guenter P. Safe practices for parenteral nutrition. J Parenter Enteral Nutr 2004; 28:S39-S56.

Wilson DC. Randomized controlled trial of an aggressive nutritional regimen in sick very low birthweight infants. Arch Dis Child Fetal Neonatal Ed 1997; 77(1):F4-F11.

Zlotkin SH, Stallings VA, Pencharz PB. Total parenteral nutrition in children. Pediatr Clin NA 1985; 32:381-400.

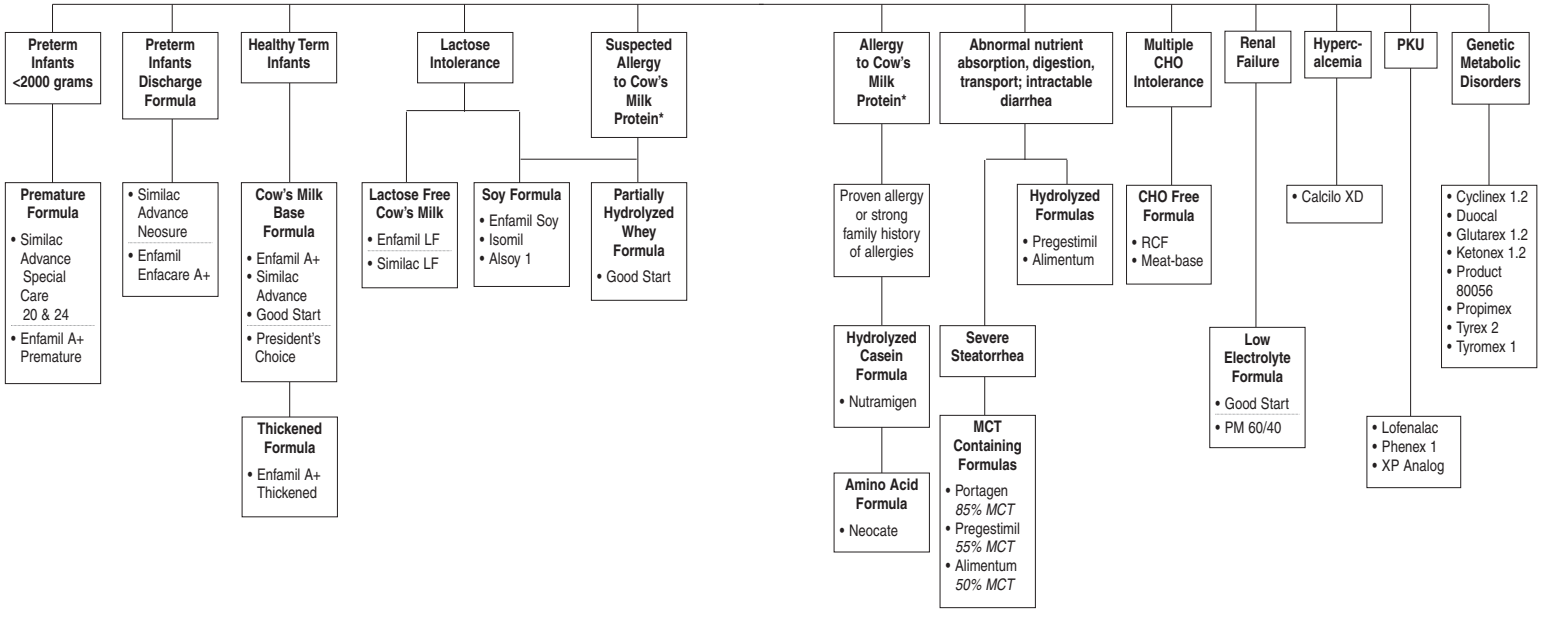
Zlotkin SH, Bryan MH, Anderson GH. Intravenous nitrogen and energy intakes required to duplicate in utero nitrogen accretion in pretermly born human infants. J Pediatr 1981; 99:115-120.

Appendices

Appendix A. **Enteral Feeding Selection for Infants**

Breastfeeding is the preferred feeding for preterm and term infants –
if breastmilk is not available or when weaning choose:

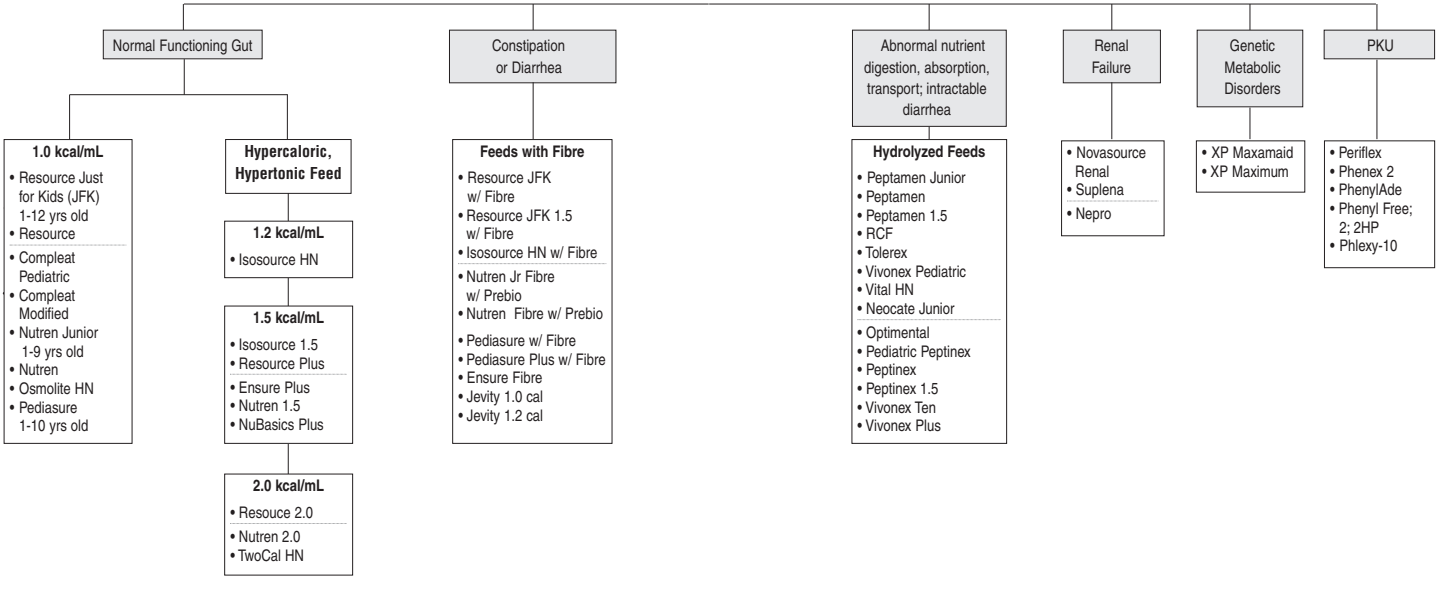
Therapeutic Products



Note: *Products above the line are part of SickKids formulary. Those listed below the dotted line are not inventoried and may be substituted for a formulary product from the same category.*

** Infants with documented cow's milk protein enteropathy or enterocolitis are frequently sensitive to soy protein and should not be given soy formula; they should be given an extensively hydrolyzed formula. Many infants with documented IgE-mediated allergy to cow's milk protein will tolerate a soy formula.*

Appendix B. **Enteral Feeding Selection for Children Older than One Year**



Note: *All products listed are lactose free. Products listed below the dotted line are not inventoried at SickKids and may be substituted for a formulary product from the same category.*

Appendix C. **Nutrient Content per Litre Normal Dilution Infant Feeding**

	Milks		Premature Infant Formulas				Premature Infant Formulas		Cow's Milk Based Formulas			
	Human† mature	*Cow's whole*	*Similac Advance 20*	*Special Care 24*	*Similac HMF△ 3000*	*3300*	*Similac Advance Neosure*	*Enfamil A+**	*Similac Advance*	*Good Start*	*Enfamil Lactose Free**	*Enfamil A+ Thickened**
ENERGY Kcal	680	636	680	810	714	810	750	680	680	670	680	680
PROTEIN g	11.7	32	18	22	21	23	20	14	14	15	14	17
FAT g	39	36	37	44	37	41	41	36	37	34	36	34
CARBOHYDRATE g	72	48	72	86	74	82	77	74	73	75	74	74
VITAMIN A RE	675	320	2060	2440	2663	2952	1039	601	610	601	601	610
VITAMIN D mcg	0.5	9	25	30.4	28.1	29.8	13.2	10.2	10.2	10	10	10.2
VITAMIN E mg	1.5	0.6	14.1	25	17.5	33.5	8.12	9.4	13.4	8.7	9.1	9.4
VITAMIN K mcg	2.5	60	83	100	71	83	83	54	54	60	54	50
VITAMIN C mg	40	0	250	300	314	350	110	81	61	60	81	81
THIAMINE mg	0.21	0.4	1.7	2	2.2	2.5	1.7	0.5	0.68	0.54	0.5	0.5
RIBOFLAVIN mg	0.35	1.68	4.2	5	4.1	4.5	1.1	0.9	1	0.9	0.9	1
NIACIN NE	1.5	8.8	34	40	34	36	15	6.8	7.1	7	6.8	7
VITAMIN B6 mg	0.21	0.4	0.7	0.8	2	2.2	0.75	0.4	0.4	0.5	0.4	0.4
VITAMIN B12 mcg	1	3.5	3.7	4.5	6.1	6.7	3	2	1.7	2	2	2
FOLATE mcg	24	52	290	350	140	256	190	108	100	100	108	100
PANTOTHENIC ACID mg	1.8	3.08	13	15	15	16	6	3.4	3	3	3.4	3
BIOTIN mg	0.004		0.25	0.3	0.21	0.26	0.07	0.02	0.03	0.02	0.02	0.02
CHOLINE mg	92		82	99	100	108	120	162	110	81	162	81
SODIUM mmol	7.8	21.9	15	18	15	17	10.9	7.8	7.0	7.8	8.7	11.7
POTASSIUM mmol	13.5	40.1	21.2	25	27	30	27.4	18.4	18.0	18.5	18.9	18.7
CHLORIDE mmol	11.8	27	18	22	24	25.7	16	11.8	12.0	12.6	12.5	14.6
CALCIUM mmol	7	30.8	25.2	30.5	31.2	34.5	19.8	13.2	13.2	10.8	13.8	13.2
PHOSPHORUS mmol	4.5	30	19.3	23.2	17.9	25.2	15.2	11.6	9.0	7.7	10	11.6
MAGNESIUM mg	35	132	75	90	86	98	70	54	41	47	54	54
IRON mg	0.4	0.40	2.5	3	4.3	4.6	14	12	12	10	12	12
ZINC mg	1.2	3.7	7.2	9	12.1	13.4	9	6.8	5.1	5.4	6.8	7
COPPER mg	0.25		0.9	1.1	2.06	2.28	0.9	0.5	0.61	0.54	0.5	0.5
IODINE mg	0.061		0.15	0.18			0.11	0.07	0.041	0.08	0.01	0.07
MANGANESE mg	tr		0.05	0.06	0.07	0.08	0.075	0.1	0.034	0.05	0.1	0.1
TAURINE mg			45	49		32	45	41	37	54	41	41
CARNITINE mg			12	14		23	41			11	13	14
SELENIUM mg	0.021		0.016	0.018		0.24	0.016	0.019	0.016		0.019	0.02
CHROMIUM mg												
MOLYBDENUM mg												
INOSITOL mg	149		220	260	164.2	248	37	41	32	40	41	41
OSMOLALITY mOsm/kg H_2O	290	315	240	270	350	385	250	300	300	265	165	230

△HMF (Human Milk Fortifier): 50 mL EBM + 1 pkg HMF = 3000 kJ/L (22 kcals/oz);
25 mL EBM + 1 pkg HMF = 3300 kJ/L (24 kcals/oz)

** This product reduces costs for SickKids*

†For other nutritional and non-nutritional components of human milk, see end of Appendix C, page 96, 97

Appendix C. (continued) **Nutrient Content per Litre Normal Dilution Infant Feeding**

	Soy Based Formulas		Hypoallergenic		Protein & Fat Malabsorption		Fat Malabsorption	Carbohydrate Intolerance	Hypercalcemia	Dehydration
	*Enfamil Soy**	*Isomil*	*Nutramigen**	*Neocate*	*Alimentum*	*Pregestimil**	*Portagen*	*RCF*	*Calcilo XD*	*Enfalyte*
ENERGY Kcal	680	680	670	670	680	670	667	405	680	125
PROTEIN g	17	17	19	21	19	19	24	20	15	0
FAT g	36	37	34	30	38	38	32	36	37	0
CARBOHYDRATE g	72	70	75	78	69	69	77	0	69	32
VITAMIN A RE	610	601	610	823	610	765	668	610	609	
VITAMIN D mcg	10	10	7.5	8.2	7.5	11	5	10.25	0	
VITAMIN E mg	9.1	11.4	9.4	5.1	13.4	11	7.4	7.45	11	
VITAMIN K mcg	54	100	50	59	100	110	53	75	54	
VITAMIN C mg	81	55	81	62	61	75	26	55	61	
THIAMINE mg	0.5	0.4	0.5	0.6	0.4	0.7	0.5	0.4	0.7	
RIBOFLAVIN mg	0.6	0.6	0.63	0.9	0.6	0.6	0.6	0.06	1	
NIACIN NE	6.8	9	6.8	10.3	9.1	8.5	7	9	7	
VITAMIN B6 mg	0.4	0.4	0.4	0.8	0.4	2	0.7	0.4	0.4	
VITAMIN B12 mcg	2	3	2.1	1.1	3	3.7	2	3	1.7	
FOLACIN mcg	108	100	100	68	100	110	67	100	101	
PANTOTHENIC ACID mg	3.4	5	3.4	4	5	3.2	3.6	5.1	3	
BIOTIN mg	0.02	0.03	0.02	0.03	0.03	0.05	0.03	0.03	0.003	
CHOLINE mg	162	82	81	88	85	90	90	78.5	81	
SODIUM mmol	10	13	11	11	13	14	15	12.9	6	50
POTASSIUM mmol	21	19	19	27	21	19	21	18.7	14	25
CHLORIDE mmol	15	12	14	15	15	16	16	11.7	11	45
CALCIUM mmol	18	17.5	16	20.8	17.8	15.8	15.8	17.5	1.7	
PHOSPHORUS mmol	15	16	14	20	16.5	13.5	15.2	16.1	5.5	
MAGNESIUM mg	74	50	70	83	51	75	136	50	41	
IRON mg	12	12	12	11	12	12	13	12	12	
ZINC mg	8.1	5	6.8	0.7	5.1	5	6	5	5.1	
COPPER mg	0.5	0.5	0.5	0.1	0.5	0.6	1	0.5	0.6	
IODINE mg	0.2	0.1	0.1	0.18	0.1	0.05	0.05	0.1	0.04	
MANGANESE mg	0.2	0.2	0.2	0.6	0.5	0.4	0.8	0.2	0.03	
TAURINE mg	41	45	50		52	38		58.5		
CARNITINE mg	13.5	11.3	18		15	13	19	20		
SELENIUM mg	0.02	0.02	0.02	0.02	0.02	0.02		0.012		
CHROMIUM mg				0.02		0.02				
MOLYBDENUM mg				0.03		0.04				
INOSITOL mg	41	35	115	156	34	50			162	
OSMOLALITY mOsm/kg H_2O	315	290	320	375	370	330	220	84	360	200

** This product reduces costs for SickKids*

Appendix C. (continued) **Other Nutritional and Non-nutritional Components of Human Milk**

Antimicrobial factors
secretory IgA, IgM, IgG
lactoferrin
lysozyme
complement C3
leucocytes
bifidus factor
lipids and fatty acids
antiviral mucins, GAGs
oligosaccharides

Carbohydrate
lactose
glucose
galactose
neutral and acidic oligosachharides
(80 identified)

Cytokines and anti-inflammatory factors
tumour necrosis factor
interleukins
interferon-g
prostaglandins
a1-antichymotrypsin
a1-antitrypsin
platelet-activating factor: acetyl hydrolase

Hormones
feedback inhibitor of lactation (FIL)
insulin
prolactin
thyroid hormones (T2, T3, Reverse T3)
corticosteroids, ACTH
oxytocin
calcitonin
parathyroid hormone
erythropoietin
progesterone
estrogen

Lipids
triglycerides (167 identified)
phospholipids
sphingolipids
sterols

Non-Protein Nitrogen
nucleotides (variety)
nucleic acid
carnitine
urea
carnitine
creatine
creatinine
uric acid
glucosamine
free amino acids (variety)
amino sugars (variety)
N-acetylneuraminic acid
N-acetylglucosamine
peptides (variety)
epidermal growth factor
somatomedin-C/insulin-like
growth factor
insulin
choline
ammonia

Protein Nitrogen
casein
whey
a-lactalbumin
lactoferrin
B-lactoglobulin
lysozyme
serum albumin
IgA
IgG
IgM

Reference: Handbook of Milk Composition. Robert G Jensen, ed. San Diego: Academy Press,1995

Appendix D. **Nutrient Content per Litre Tube Feedings, Oral Supplements and Modules**

	Tube Feedings					Oral Supplements			Nutrient Content of Modules					
	*Resource JFK**	*Resource JFK with Fibre (g/L)**	*Resource JFK with Fibre1.5 (g/L)**	*Isosource HN**	*Isosource HN with Fibre**	*Resource**	*Resource Plus**	*Resource Fruit Beverage**	*Polycose*	*Corn Oil /100 g*	*MCT Oil /100 mL*	*Microlipid /100 mL*	*ProMod /100 mL*	*Beneprotein /100 g*
ENERGY Kcal	1000	1000	1500	1200	1200	1060	1520	770	380	813	770	450	424	357
PROTEIN g	30	30	42	53	53	37	55	37	0	0	0	0	76	86
FAT g	50	50	75	42	42	37	46	2	0	92	94	50	7.1	0
CARBOHYDRATE g	110	110	165	151	157	150	220	150	94	0	0	0	7.1	0
VITAMIN A RE	721	721	900	990	1000	1270	1586	811						
VITAMIN D mcg	8.3	8.3	11.5	6.75	6.75	8.5	10.5	5.2						
VITAMIN E mg	15.4	15.7	15.4	20.1	20.1	21.5	21.5	16						
VITAMIN K mcg	40	40	40	62	62	84	85	40						
VITAMIN C mg	100	100	100	200	200	150	150	160						
THIAMINE mg	1.2	1.2	1.2	2	2	1.6	2.5	1.6						
RIBOFLAVIN mg	1.5	1.5	1.5	2.3	2.3	1.8	2.9	1.8						
NIACIN NE	17	17	19	27	27	21	34	21						
VITAMIN B6 mg	1.6	1.6	1.6	2.7	2.7	2.1	3.4	2.1						
VITAMIN B12 mcg	2.4	2.4	2.4	8	8	6.3	10	6						
FOLACIN mcg	370	370	370	270	270	420	420	200						
PANTOTHENIC ACID mg	10	10	10	13	13	11	11	5.3						
BIOTIN mg	0.15	0.15	0.15	0.4	0.4	0.32	0.32	0.2						
CHOLINE mg	400	400	400	330	330	420	420	550						
SODIUM mmol	26	26	30	48	49	40	57	13	4.8				7.6	21.4
POTASSIUM mmol	29	29	33.5	46	46	38	50	1.1	0.3				13.6	2.6
CHLORIDE mmol	14	14	21.2	31	31	41	41	27.0	6.3				0	
CALCIUM mmol	28.5	28.5	32.5	25	25	37	32	14.3	1.5				33	2.5
PHOSPHORUS mmol	26	26	32	32.3	32.3	34.0	34.2	22.0	0.4				16	1.6
MAGNESIUM mg	200	200	200	270	270	420	420	210						
IRON mg	14	14	14	12	12	19	19	9.5						
ZINC mg	12	12	12	17	17	16	25	16						
COPPER mg	1	1	1	1.3	1.3	2.1	2.1	1.1						
IODINE mg	0.1	0.1	0.14	0.13	0.16	0.16	0.16	0.09						
MANGANESE mg	2.5	2	2.3	3.3	2	2.1	2.1	2.1						
TAURINE mg	89	89	135											
CARNITINE mg	17	17	26											
SELENIUM mg	0.04	0.04	0.034	0.1	0.07	0.074	0.074							
CHROMIUM mg	0.07	0.07	0.07	0.1	0.12	0.13	0.13							
MOLYBDENUM mg	0.04	0.04	0.06	0.2	0.08	0.079	0.079							
INOSITOL mg	80	80	120											
OSMOLALITY mOsm/kg H_2O	390	390	405	435	435	600	870	700						
FREE WATER mL	853	853	712	813	813	840	766	881						

JFK = Just For Kids

** This product reduces costs for SickKids*

Appendix E. **Nutrient Content per Litre Therapeutic Tube Feedings**

	Malabsorption				Malabsorption		Renal		
	Neocate Junior	*Peptamen Junior*	*Peptamen*	*Tolerex**	*Vital HN*	*Vivonex Pediatric**	*NovaSource Renal**	*Nepro*	*Suplena*
ENERGY kcal	1000	1000	1000	1000	1000	800	2000	2000	2000
PROTEIN g	30	30	40	21	42	24	74	70	30
FAT g	50	38	39	1.5	10.8	24	100	96	96
CARBOHYDRATE g	104	138	130	230	186	130	200	220	250
VITAMIN A RE	730	721	976	835	1000	751	1000	319	319
VITAMIN D mcg	8	10	6.8	5.5	6.8	8	2	2.1	2
VITAMIN E mg	11.4	18.8	20	11.4	20	8	30	35.4	35.4
VITAMIN K mcg	27	30	50	40	53	40	80	85	85
VITAMIN C mg	93	100	340	33	200	80	80	106	110
THIAMINE mg	1	2.4	2	0.83	2	1.5	2.5	2.6	2.6
RIBOFLAVIN mg	1	2	2.4	0.94	2.3	1.8	2.9	2.9	2.9
NIACIN NE	12	20	28	11	26.7	20	34	34	34
VITAMIN B6 mg	1	2.4	4	1.1	2.7	2	8	8.6	8.6
VITAMIN B12 mcg	2	6	8	3.3	8	1.2	10	10	10
FOLACIN mcg	300	400	540	220	530	200	1000	1060	1060
PANTOTHENIC ACID mg	3.9	10	14	5.6	13.3	5	16	17	17
BIOTIN mg	0.02	0.3	0.4	0.17	0.4	0.1	0.5	0.51	0.51
CHOLINE mg	376	300	450	41	400	200	330	630	630
SODIUM mmol	17.8	20	24.4	20	24.7	17	39	36	30
POTASSIUM mmol	35.1	34	38.5	30	36	31	21	26	28
CHLORIDE mmol	18	31	28.6	27	29.5	28	24	28.9	26.6
CALCIUM mmol	28.2	25	20	14	16.7	24	32.5	34.3	34.8
PHOSPHORUS mmol	30.3	26	22.6	18.1	21.5	26	20	22.3	23.9
MAGNESIUM mg	180	200	300	220	267	160	200	210	210
IRON mg	14	14	18	10	12	10	18	19	19
ZINC mg	14	15	24	8.3	15	12	25	24	24
COPPER mg	1.1	1	2	1.1	1.3	1.2	2	2.1	2.1
IODINE mg	0.1	0.12	0.15	0.09	0.1	0.12	0.16	0.16	0.16
MANGANESE mg	2	1.5	2.7	1.1	3.3	2	5	5.3	5.3
TAURINE mg		80	100			80	150		160
CARNITINE mg		40	100			25	270		160
SELENIUM mg	0.03	0.03	0.045	0.04	0.046	0.03	0.01	0.103	0.078
CHROMIUM mg	0.038	0.03	0.04	0.07	0.067	0.045			
MOLYBDENUM mg	0.045	0.03	0.12	0.04	0.1	0.075			
INOSITOL mg		80							
OSMOLALITY mOsm/kg H_2O	607	360	270 - 380	550	460	360	700	665	600
FREE WATER (mL)	840	850	850	864	867	893	709	700	719

** This product reduces costs for SickKids*

Appendix F. **Average Daily Intrauterine Weight Gain for Preterm Infants**

Age interval (weeks)	*Average daily weight gain (g/d)*	*Mean weight (g)*	*Average daily weight gain* (g/kg/d)*
24-25	11.4	904-961	12.2
25-26	15.7	961-1,001	16.0
26-27	18.6	1,001-1,065	18.0
27-28	21.4	1,065-1,236	18.6
28-29	22.6	1,236-1,300	17.8
29-30	23.1	1,300-1,484	16.6
30-31	24.3	1,484-1,590	15.8
31-32	25.7	1,590-1,732	15.5
32-33	27.1	1,732-1,957	14.7
33-34	30.0	1,957-2,278	14.2
34-35	31.4	2,278-2,483	13.3
35-36	34.3	2,483-2,753	13.1
36-37	35.7	2,753-2,866	12.7
37-38	31.4	2,866-3,025	10.7
Mean	25.2		14.9

**Calculated from averaged daily gain + mid-range of mean weight*

Adapted with permission from: Couch JB. Anthropometric Assessment. In: Nutritional Care for High-Risk Newborns. *Groh-Wargo S, Thompson M, Hovasi Cox J. Chicago, Ill: Precept Press; 1994.*

Appendix G. **Reference Gains in Weight, Length and Head Circumference of Term Infants; Gains in Weight and Height of Children†**

	Boys			*Girls*		
Age	*Weight[a,b] (g/day)*	*Length/ Height[a,b] (mm/day)*	*Head Circumference[b,c] (mm/day)*	*Weight[a,b] (g/day)*	*Length/ Height[a,b] (mm/day)*	*Head Circumference[b,c] (mm/day)*
0-1 mo	30	1.10	NA	26	1.03	NA
1-2 mo	35	1.09	0.83	29	1.01	0.78
2-3 mo	26	1.02	0.50	23	0.94	0.47
3-4 mo	20	0.84	0.36	19	0.81	0.34
4-5 mo	17	0.68	0.29	16	0.67	0.28
5-6 mo	15	0.63	0.24	14	0.63	0.23
6-9 mo	13	0.52	0.18	12	0.59	0.18
9-12 mo	10	0.43	0.13	10	0.47	0.13
12-18 mo	7.3	0.36	0.08	7.3	0.37	0.09
18-24 mo	6.2	0.30	0.05	6.7	0.31	0.05
24-30 mo	5.7	0.25	0.04	5.3	0.26	0.04
30-36 mo	5.3	0.22	0.03	5.6	0.23	0.03
3.5 yr	5.4	0.21		5.5	0.21	
4 yr	5.2	0.20		5.4	0.20	
4.5 yr	5.8	0.19		5.2	0.19	
5 yr	5.8	0.19		5.7	0.19	
5.5 yr	6.4	0.19		5.3	0.19	
6 yr	6.5	0.18		6.2	0.18	
6.5 yr	6.4	0.18		6.5	0.17	
7 yr	6.9	0.18		6.5	0.17	
7.5 yr	7.6	0.16		7.3	0.17	
8 yr	8.4	0.17		7.5	0.17	
8.5 yr	7.9	0.16		8.1	0.16	
9 yr	8.6	0.16		8.7	0.16	
9.5 yr	8.5	0.15		8.4	0.15	
10 yr	9.3	0.15		8.6	0.16	
10.5 yr	8.9	0.14		10.8	0.15	
11 yr	9.5	0.14		11.0	0.17	
11.5 yr	10.5	0.14		13.6	0.18	
12 yr	11.0	0.15		15.1	0.18	
12.5 yr	13.5	0.15		15.2	0.18	
13 yr	15.4	0.18		11.8	0.15	
13.5 yr	16.8	0.19		12.7	0.11	
14 yr	18.3	0.22		10.1	0.07	
14.5 yr	20.2	0.20		8.2	0.05	
15 yr	17.8	0.18		5.5	0.04	
15.5 yr	14.2	0.11		5.1	0.03	
16 yr	12.0	0.09		2.0	0.03	
16.5 yr	9.3	0.05		4.1	0.01	
17 yr	6.7	0.05		3.5	0.01	
17.5 yr	6.0	0.02		2.2	0.00	
18 yr	4.2	0.02		2.6	0.00	

† Incremental growth data represent the median (50th percentile). Interpretation of an individual child's growth should be evaluated in relation to age/gestational age (for infants) and stage of physical development (e.g., sensitivity of incremental growth data is highest at ages when growth is less rapid,also children may vary in timing of pubescent growth spurt), genetic potential, body size/composition, weight for length, overall nutritional status and need for catchup growth, and underlying medical condition(s).

Sources

a Values for weight and length <12 months represent the median (50th percentile) incremental rate per day. Source: Adapted with permission from *Guo S, Roche AF, Fomon SJ, Nelson SE, Chumlea WC, Rogers RR, Baumgartner RN, Ziegler EE, Siervogel RM. Reference data on gains in weight and length during the first two years of life. J Pediatr 1991; 119:355-362.*

b Values for head circumference, weight, and length/height >12 months represent the median (50th percentile) incremental rate per day, calculated from 6-month incremental data (by dividing the value by 182 days). Source: Adapted with permission from *Baumgartner, et al. Incremental growth tables: supplementary to previously published charts. Am J Clin Nutr 1986; 43:711-722.*

c Values for head circumference <12 months represent the median (50th percentile) incremental rate per day, calculated from 1-month incremental data (by dividing the value by 30 days). Source: Adapted with permission from *Guo S, Roche AF, Moore W. Reference data for head circumference and 1-month increments from 1-12 months of age. J Pediatr 1988; 113:490-494.*