

# National Parenteral Nutrition Practice Guidelines for Paediatrics

September 2016



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# National Parenteral Nutrition Practice Guidelines for Paediatrics

National Department of Health  
Directorate: Nutrition  
September 2016

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**MP Matsoso**  
**Director-General: Health**  
**Date:**

## Acronyms

<b>ASPEN</b>	American Society for Parenteral and Enteral Nutrition
<b>BMR</b>	Basal metabolic rate
<b>BMD</b>	Bone mineral density
<b>CLABSI</b>	Central line-associated blood stream infection
<b>CO<sub>2</sub></b>	Carbon dioxide
<b>CVC</b>	Central venous catheter
<b>CVP</b>	Central venous port
<b>ESPGHAN</b>	European Society for Paediatric Gastroenterology, Hepatology and Nutrition
<b>EFA</b>	Essential fatty acid
<b>ELBW</b>	Extremely low birth weight
<b>EN</b>	Enteral nutrition
<b>GIT</b>	Gastrointestinal tract
<b>LBW</b>	Low birth weight
<b>MBD</b>	Metabolic bone disease
<b>MCT</b>	Medium chain triglyceride
<b>MDT</b>	Multidisciplinary team
<b>MEF</b>	Minimal enteral feeding
<b>MUAC</b>	Mid upper arm circumference
<b>NEC</b>	Necrotising enterocolitis
<b>NGT</b>	Nasogastric tube
<b>NJT</b>	Nasojunal tube
<b>NPE</b>	Non-protein energy
<b>NST</b>	Nutrition support team
<b>NTT</b>	Nutrition therapy team
<b>PICC</b>	Peripherally inserted central catheter
<b>PNALD</b>	Parenteral nutrition-associated liver disease
<b>PVT</b>	Peripheral vein thrombosis
<b>PN</b>	Parenteral nutrition
<b>PNAC</b>	Parenteral nutrition associated cholestasis
<b>REE</b>	Resting energy expenditure
<b>SBS</b>	Short bowel syndrome
<b>SGA</b>	Small for gestational age
<b>SOP</b>	Standard operating procedure
<b>TPN</b>	Total parenteral nutrition
<b>VLBW</b>	Very low birth weight
<b>WFH</b>	Weight-for-height
<b>WHO</b>	World Health Organization



## 1. Definitions

<b>Total parenteral nutrition:</b>	Total parenteral nutrition (TPN) is the intravenous infusion of amino-acid (protein) solutions, hypertonic glucose, lipid emulsions, electrolytes, vitamins and trace elements into a central vein. TPN may, however, under specified conditions, be administered peripherally. It serves as the sole source of nutrition for the individual <sup>1</sup>
<b>Parenteral nutrition:</b>	Parenteral nutrition (PN) is used as adjunct to enteral nutrition in paediatric patients <sup>1</sup> .
<b>All-in-one parenteral nutrition bag:</b>	All macronutrients and micronutrients to meet the recommended dietary allowance are contained in one bag.
<b>Three chamber parenteral nutrition bags:</b>	This bag contains macronutrients in separate pouches. Macronutrients are combined prior to use by rolling the bag to break the seals, allowing macronutrients to mix. These bags do not contain micronutrients in sufficient amounts.
<b>Enteral nutrition:</b>	Nutrition support administered via a feeding tube.
<b>Preterm/premature:</b>	Infant born before 37 weeks completed gestation
<b>Neonate:</b>	A newborn infant under 28 days of age
<b>Infant:</b>	One month to one year of age
<b>Child:</b>	One to 12 years of age
<b>Adolescent:</b>	13-18 years of age
<b>Low birth weight:</b>	Birth weight of less than 2 500g.
<b>Very low birth weight:</b>	Birth weight of less than 1 500g.
<b>Extremely low birth weight:</b>	Birth weight of less than 1 000g
<b>Small-for-gestational-age:</b>	Infants (weight-for-age) born below the 10th percentile or -2 z-score.

## 2. Introduction

### 2.1 Purpose of the nutrition guideline

The aim of this guideline is to provide recommendations based on current evidence for best practice in the management of paediatric parenteral nutrition (PN) by health professionals and care workers for all patients at health facilities.

It is outside the scope of this guideline to provide extensive clinical recommendations for nutrition requirements of clinical states commonly seen, however a general overview of nutrition requirements has been provided.

### 2.2 Goals and objectives

Enteral nutrition (EN) should always be the first option when feeding a patient who is not able to consume adequate food orally. Parenteral nutrition should be used when the gastrointestinal tract (GIT) is not functioning or not able to absorb nutrients supplied on a short or long term basis. Parenteral nutrition can be used either alone or in combination with enteral or oral foods to meet patients' estimated nutrition requirements. The goals of parenteral nutrition are to ensure:

- optimal and standardised use of parenteral nutrition
- effective use of parenteral nutrition
- that employees are aware of the coordinated policy regarding parenteral nutrition

## 3. Roles and responsibilities of the nutrition therapy team

It is recommended that nutrition therapy teams (NTT) be established in each facility to ensure that all the goals are met. Parenteral nutrition is an invasive and relatively expensive form of nutrition therapy, which has associated septic morbidity. It is therefore important that patients requiring parenteral nutrition are appropriately identified by the NTT as stipulated in **Table 1**.

**Table 1: The hospital nutrition therapy team** <sup>1, 2, 3)</sup>

Health professional	Role
Dietitian	Dietary prescription and coordinator
Pharmacist	Procurement
Surgeon	Prescribing privileges
Paediatrician	Prescribing privileges
Professional nurse in ward	Administration and care of parenteral nutrition

Note: Other healthcare providers may be co-opted onto the NTT as the need arises

#### 4. Indications and contra-indications of parenteral nutrition<sup>1</sup>

Parenteral nutrition should be initiated when the patients' nutrition needs are not being met via the oral/enteral route or there is a contraindication for using the GIT. Other factors to consider are the age of the infant e.g. premature infant with limited existing body stores, clinical condition and length of time that parenteral nutrition is required.

##### 4.1 Early nutrition in premature infants<sup>4,5</sup>

Early nutrition is required in premature infants as they can develop essential fatty acid (EFA) deficiency within two days of life. Extremely low birth weight infants require early nutrition as they only have existing body stores [one per cent body fat] to survive for four days without nutrition. Therefore recommendations are to initiate early nutrition as soon as possible in these infants to ensure optimal protein for positive nitrogen balance and minimal lipid administration.

##### 4.2 Common indications for parenteral nutrition

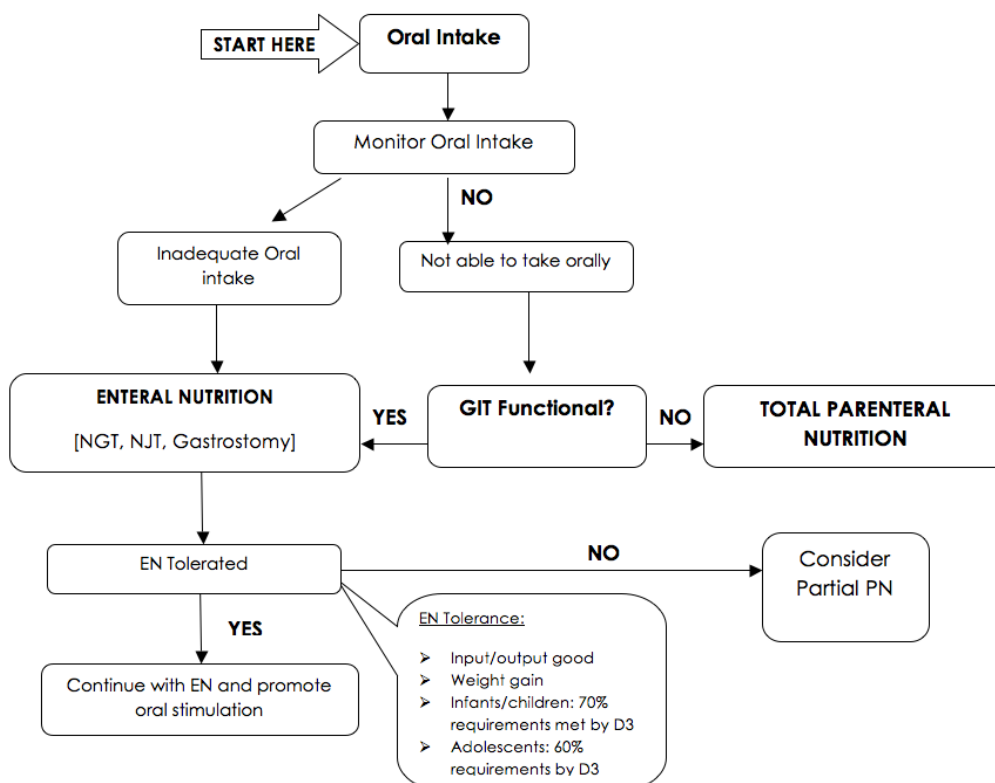
- inflammatory bowel disease
- functional immaturity
- severe pancreatitis
- intensive chemotherapy causing mucositis
- bone marrow transplant
- intractable vomiting/diarrhoea
- enterocutaneous fistula
- intestinal failure (e.g. short bowel syndrome)
- lymphatic disorders (chylous ascites, chylothorax)
- necrotising enterocolitis (NEC)
- radiation enteritis
- motility disorders (e.g. scleroderma)
- chronic idiopathic intestinal pseudo-obstruction
- surgical gastrointestinal abnormalities (e.g. gastroschisis, intestinal atresia etc.)
- malabsorption syndrome

##### 4.3 Contra-indications for parenteral nutrition

- functional GIT
- prognosis that does not warrant aggressive nutrition support intervention
- parenteral nutrition risk exceeds potential benefits e.g. severe sepsis
- inability to obtain venous access

Figure 1 provides a decision tree for parenteral nutrition.

Figure 1: Decision tree for parenteral nutrition



## 5. Nutritional assessment

### 5.1 Anthropometric

The patient's nutritional parameters should be measured and classified accordingly to determine their nutritional status.

**Table 2** indicates the anthropometry required.

**Table 2: Anthropometry: Growth parameters monitored during paediatric parenteral nutrition**

Parameter	Frequency
Weight	Daily
Length or height <sup>3</sup>	Monthly in term infants and older children Weekly in preterm infants
Head circumference <sup>3</sup>	Monthly in term infants and older children Weekly in preterm infants
Mid upper arm circumference (MUAC)	Monthly

All anthropometry should be plotted on the growth charts and classified accordingly. Refer to **Table 3** for classification of children under the age of five years. Refer to **Annexure 1** for the following growth charts:

- premature growth charts (Fenton)
- standard growth charts (boys and girls)

**Table 3: World Health Organization (WHO) classification of malnutrition**

	Bilateral pitting oedema	MUAC	Weight-for-height (WFH) z-score
Severe acute malnutrition	Present	< 11.5 cm	< -3
Moderate acute malnutrition	Not present	≥ 11.5 cm and < 12.5 cm	≥ -3 and < -2

### 5.2 Biochemical

A number of routine blood tests as indicated in **Table 4** should be done at various intervals for the duration of parenteral nutrition. This is to ensure that patients' biochemical parameters are used to assess organ function.

**Table 4: Routine blood tests required for TPN<sup>1</sup>**

Biochemistry	
Name of test	Frequency
Blood glucose monitoring	6-hourly
Urea and electrolytes	Baseline, twice weekly, then weekly
Liver function test	Baseline, weekly
Total bilirubin and conjugated bilirubin	Baseline, weekly
Calcium, magnesium, phosphorus	Baseline, weekly
Full blood count	Baseline, weekly
Serum triglycerides	Baseline, thereafter weekly

<sup>1</sup>Baseline = prior to patient being commenced on TPN

These frequencies of tests are guidelines unless there is a change in the clinical condition of the individual.

### 5.3 Clinical

Complete a thorough clinical examination considering any medical history and physical examination looking for signs of deficiency or excess. Other factors to review include:

- clinical appearance
- daily temperature
- weight trends

### 5.4 Diet history

A complete diet history is required, including recent changes in dietary intake, review of enteral feeds, GIT symptoms (e.g. diarrhoea or vomiting) and any medical and surgical problems.

## 5.5 Medication

Review all prescribed medication that could exacerbate GIT symptoms e.g.

- antibiotics
- oral magnesium or phosphate supplementation
- sugar containing medication

## 6 Nutritional recommendations and disease-specific requirements

The dietitian is responsible for the planning of the individual nutritional requirements. The patient's clinical condition with regards to sepsis, nutritional state and other factors should be considered in these requirements. The requirements should then be translated into a nutritional prescription by the dietitian. Each nutritional prescription should include at least the following information:

- patient name
- hospital number
- ward
- date
- parenteral nutrition code prescribed
- total volume/administration rate

It is recommended that the responsible NTT member facilitates the placement of the parenteral nutrition prescription via the pharmacy using a parenteral nutrition prescription schedule, which is signed by the medical doctor. The aim of this process is to ensure that parenteral nutrition is administered to patients in an appropriate and coordinated manner.

### 6.1 Macronutrients

#### 6.1.1 Energy

Energy supply should aim to provide the nutritional needs of the patient, i.e.:

- basal metabolic rate (BMR)
- physical activity
- stress factor
- correction of pre-existing malnutrition
- support of anabolic function

**Note:** The ideal balance between underfeeding and overfeeding needs to be established as both factors may have detrimental outcomes. Overfeeding may result in:

- hyperglycaemia
- hypertriglyceridemia
- increased fat deposition
- fatty liver and other complications

Underfeeding may result in:

- malnutrition
- impaired immunological responses
- impaired growth

Premature infants have increased energy needs due to limited stores and for optimal protein accretion. Newborn infants receiving parenteral nutrition need fewer calories than a newborn fed enterally as energy is not lost in the stools and the thermogenesis is less<sup>1</sup>. Parenteral nutrition energy needs are less compared to enteral nutrition energy needs due to lack of dietary induced thermogenesis. Dietary induced thermogenesis accounts for 10 per cent of the daily energy requirement<sup>3</sup>. Stable patients will have their energy requirements met as per the recommendations in **Table 5**.

**Table 5: Parenteral nutrition energy requirements for stable patients (kcal/kg/day)**

Preterm	110-120
0–1 year	90-100
1–7 years	75-90
7–12 years	60-75
12–18 years	30-60

Adopted from ESPGHAN 2005

Haemodynamically unstable patients should have an individual assessment to determine requirements. Critically ill children will require energy equivalent to resting energy expenditure (REE) in the acute phase of illness but other patients, particularly those who are malnourished, may require 130-150% of the REE<sup>1</sup>.

There are predictive equations to calculate REE. Refer to **Annexure 3**.

#### 6.1.1.1 Risk of re-feeding

Re-feeding syndrome is a condition that results when an individual who is malnourished or presents in a starvation state develops electrolyte shifts as a response to rapid feeding of carbohydrates and other nutrients. Malnourished individuals are at risk of re-feeding syndrome when parenteral nutrition is administered and to reduce this risk cautious feeding is indicated. Regular monitoring of potassium, phosphorous and glucose is necessary and these should be corrected if low. (**Refer to section on complications**).

#### 6.1.2 Protein

There are several amino acids that are considered to be semi-essential during the neonatal period. These include cysteine, tyrosine and taurine. These amino acids need to be considered with all paediatric parenteral nutrition solutions.

##### a. Cysteine

Cysteine is a major substrate for glutathione, which has important antioxidant properties, in addition to maintaining redox potential and calcium homeostasis. It is recommended that a child receive between 200-350 µmol/kg/day<sup>1</sup>

##### b. Tyrosine

The lower limit of tyrosine in preterm infants is approximately 18 mg/kg/d. However, there is no available data on the upper limits. Excessive amounts of tyrosine should be avoided due to the preterm infant's immature tyrosine catabolic enzyme pathway that could lead to neurological impairments<sup>1</sup>

##### c. Taurine

Taurine is synthesised from methionine and cysteine and is considered one of the most important amino acids in early infancy. Deficiency in taurine has been shown to lead to glycol-conjugates of bile acids and results in cholestasis. It may also result in retina dysfunction. Studies have shown that those receiving prolonged parenteral nutrition free of cysteine and taurine had low plasma levels of taurine<sup>1</sup>.

#### 6.1.2.1 Protein requirements

Protein requirements vary depending on the age of the child. It is thought that the preterm infant excretes between 0.6-1.1 g/kg protein per day and an intake of 0.9g/kg per day is required to prevent significant loss<sup>1</sup>.

Sufficient energy should be given alongside adequate nitrogen to ensure optimal protein utilisation. The right non-protein energy (NPE): nitrogen ratio is needed to ensure this, which is 30-40kcal per gram of protein or 250kcal/gram nitrogen.<sup>3</sup>If NPE is inadequate the child will become hypoproteinemic as nitrogen will be used for energy and resulting in poor growth.

It is proposed that protein should be commenced on the first day of life in the preterm infant and should provide at least 1.5g/kg/day and maximum 4 g/kg/day as indicated in **Table 6**.

**Table 6: Parenteral nutrition amino acid requirements<sup>1</sup> [g/kg]**

Preterm	1.5-4.0
Term	1.5-3.0
second month - 3 years	1.0-2.5
3 years – 18 years	1.0-2.0

Adopted from ESPGHAN Guidelines

These maximum levels are recommended as excessive protein intake may lead to metabolic acidosis, hyperammonemia and prerenal azotemia.<sup>6</sup>

### 6.1.3 Carbohydrate

In parenteral nutrition glucose is provided as a D-Glucose (dextrose), which is in the monohydrate form. This is the major contributor to the osmolality of a parenteral nutrition solution. It is important to calculate glucose supply correctly and to consider the consequences of providing too much glucose. It should make up 60 to 70 per cent of the NPE.

When glucose is administered in excess of the amount that can be oxidised, it is directed to lipogenesis, therefore promoting fat deposition. Excessive carbohydrate can result in hyperglycemia and hypertriglyceridemia. It may impair liver function, especially by inducing steatosis. In critically ill children, excessive glucose can lead to increased carbon dioxide (CO<sub>2</sub>) production and therefore increased minute ventilation.

The ESPGHAN 2005 guidelines recommend that the glucose oxidation rate should not exceed 12 g/kg/day (8.3 mg/kg/min) in the preterm infant.<sup>1</sup> Other research has found that preterm infants can tolerate levels of 15 g/kg/day (10 mg/kg/min) without any difficulties.<sup>3,8</sup> Glucose should be administered gradually over three to four days to maximum infusion rate<sup>3</sup>. The recommended parenteral glucose supply [g/kg BW/ day] is indicated in **Tables 7 and 8**.

**Table 7: Glucose supply [day-by-day]<sup>1,3,4,8</sup>**

Recommended parenteral glucose supply [g/kg BW/ day]				
	Day 1	Day 2	Day 3	Day 4
Up to 3kg	10	14	16	18
3 - 10kg	8	12	14	16-18
10 -15kg	6	8	10	12-14
15 - 20kg	4	6	8	10-12
20 - 30kg	4	6	8	<12
>30kg	3	5	8	<10

**Table 8: Carbohydrate recommendations<sup>1, 4, 8</sup>**

	Recommendation	Glucose supply (max amounts)
Preterm infant	Commence glucose at 4-8 mg/kg/min Maximum glucose oxidation 8.3-13mg/kg/min	12-15 <sup>3,8</sup> g/kg/day
Full term neonate - 2 years	8-9mg/kg/min Maximum glucose oxidation rate = 13 mg/kg/min	18 g/kg/day <sup>1</sup>
Older children	7 mg/kg/min – 8.3 mg/kg/min	10-12 g/kg / day
Adolescents	4mg/kg/min/day	5.7g/kg/day
Critically ill	May require to be limited to 5 mg/kg/min (1)	7.2 g/kg/day

- Glucose oxidation rate: Gram CHO/kg x 1 000 divided by 1 440 minutes
- Maximum delivery rates: 1.2g/kg/hour should not be exceeded

### 6.1.4 Fat

Lipids are an integral part of paediatric parenteral nutrition and should ideally contribute between 25 to 40 per cent of NPE. This source of energy is low in volume, low in osmolality, decreases CO<sub>2</sub> production (in contrast to glucose) and provides essential fatty acids (EFAs). **Table 9** indicates the recommended parenteral nutrition lipid requirements.

**Table 9: Recommended parenteral nutrition lipid requirements<sup>1</sup>**

EFAs	0.25g/kg/day linoleic to preterm infants 0.1g/kg/day linoleic acid to term infants and older children
Preterm and infants	3-4 g/kg/day infused over 24 hours, incremental increase of 0.5-1 g/kg/day
Children	1-3 g/kg/day, incremental increase of 0.5-1 g/kg/day

Lipids should be included in the parenteral nutrition and rather adapted, not stopped, when there is intolerance such as hypertriglyceridemia. Lipids are a good source of energy and omitting them would result in increasing glucose supply and inappropriate glucose/lipid balance on nitrogen retention.

- Lipids can be infused from day one in preterm infants, but in the extremely low birth weight (ELBW) infants (<800g), this should be increased incrementally with careful monitoring of ventilation, triglycerides and liver function.
- Do not exceed 3.5 g/kg/day in these patients. Lipids should be delayed no later than three days of life in preterm infants.
- Lipid emulsions should not be withheld from septic critically ill children.
- Commence at 0.5g/kg - 1g/kg/day with more frequent monitoring of plasma triglyceride concentration and bilirubin levels.

## 6.6 Micronutrients<sup>1,9,10</sup>

It is recommended that all children on parenteral nutrition should receive vitamins, minerals and trace elements and current recommendations are based on a daily infusion, except for vitamin K, which can be given weekly. The recommended micronutrient intakes for parenteral nutrition are indicated in **Table 10 to 12** or as specifically indicated by disease condition.

As current recommendations are mainly based on expert opinion, it may be necessary to measure vitamin, mineral and trace element levels in patients on long term parenteral nutrition, those with excessive losses and those with a poor nutritional status prior to commencing parenteral nutrition.

Iron is not routinely provided in parenteral nutrition as there are no well-defined recommendations on the content of iron in parenteral nutrition and a major concern is iron overload. In addition, there are concerns about iron's impact on the immune system and bacterial overgrowth, a commonly documented complication related to iron supplementation. There is also compatibility issues related to iron in parenteral nutrition solutions.

**Table 10: Fat soluble and water soluble vitamins requirements<sup>1</sup>**

Recommended intakes for parenteral supply					
Fat soluble vitamins - dose per kg/day			Water soluble vitamins - dose per kg/day		
	Infants	Children		Infants	Children
Vitamin A [µg]*	150-300	150	Vitamin C [mg]	15-25	80
Vitamin D [µg]	0.8 [32 IU]	10 [400 IU]	Thiamine	0.35-0.50	1.2
Vitamin E [mg]	2.8-3.5	7	Riboflavin [mg]	0.15-0.2	1.4
Vitamin K [µg]	10	200	Pyridoxine [mg]	0.15-0.2	1.0
* [µg] RE = 3.33 IU of vit A			Niacin [mg]	4-6.8	17
			B12 [µg]	0.3	1
			Pantothenic acid [mg]	1.0-2.0	5
			Biotin [µg]	5.0-8.0	20
			Folic acid [µg]	56	140

**Table 11: Calcium, phosphorous and magnesium requirements<sup>1</sup>**

Recommended parenteral calcium, phosphorous and magnesium intakes			
Age	Suggested parenteral intake of Ca mg [mmol/kg]	Suggested parenteral intake of P mg [mmol/kg]	Suggested parenteral intake of Mg mg [mmol/kg]
0-6 months	32 [0.8]	14 [0.5]	5 [0.2]
7-12months	20 [0.5]	15 [0.5]	4.2 [0.2]
1-13 years	11 [0.2]	6 [0.2]	2.4 [0.1]
14-18 years	7 [0.2]	6 [0.2]	2.4 [0.1]

**Table 12: Trace element requirements<sup>1</sup>**

Trace element requirements for paediatrics				
Trace element	Preterm neonates (mcg/kg)	Term neonates (mcg/kg)	3 month and older (mcg/kg)	Older children and adolescents
Zinc***	450-500	250	100	50mcg
Copper	20	20	20	200-500mcg
Manganese	1	1	2-10	50mcg
Chromium	0.2	0.2	0.14-0.2	5-15mcg
Selenium	2-3	2-3	2-3*	30-40mcg
Iodine	1**	1**	1**	-

\*Limit - 40 mcg/kg  
 \*\* Percutaneous absorption of protein bound iodine may be inadequate  
 \*\*\*Max 5.0mg/day

### 6.3 Osmolality

The osmolality of blood is 280 – 295 mOsm/L. When intravenous infusates, which are significantly different from the osmolality of blood, are administered into a peripheral vein, pain and phlebitis may occur. **Table 13** gives risk levels of phlebitis via peripheral vein.

**Table 13: Risk level of phlebitis via peripheral vein**<sup>1,11,12</sup>

Risk level of phlebitis via peripheral vein	Level of osmolality (mOsm/L)
Normal	280-295
Low risk	< 450
Moderate risk	450 – 600
High risk	> 600

Central access is recommended in children when solutions have an osmolality of more than 1 000 mOsmo/L. All administration sites for parenteral nutrition should be inspected and monitored daily for signs of pain and inflammation.  
<sup>1,11,12</sup>

Medications have varying osmolarities based on chemical compounding and delivery vehicles. A dedicated parenteral nutrition line should be used to decrease the risk of “cracking” the parenteral nutrition and chemical related phlebitis.

### 6.4 Fluid and electrolytes<sup>1</sup>

#### 6.4.1 Fluid

The fluid requirements vary greatly between the premature infant and the older child or adolescent. It is thought that the blood volume of a neonate is between 85-100 ml/kg body weight and that of an adolescent, 60-70 ml/kg. Immediately after birth the adaptation processes of water and electrolyte metabolism commences, as a result of the discontinuation of placental exchange and the onset of considerable insensible water loss and thermoregulation.

Fluid requirements in children as per **Table 14**, should account for basal blood volume requirements, losses through urine, stool and insensible losses that may vary depending on the clinical condition of the patient (i.e. temperature, ventilation).

**Table 14: Fluid requirements**<sup>1, 3</sup>

Fluid requirements	
Age	ml/kg/day
Premature/LBW	140-150-160-180
Term from second month	120-150 [*180]
1- 2 years	80-120 [*150]
3 -5 years	80-100
6-12 years	60 -80
13 -18 years	50 - 70

*\*Maximum allowed per age group*

Volumes should be increased gradually.

#### 6.4.2 Electrolytes<sup>1</sup>

The electrolyte balance in **Table 15** should be monitored daily in the early phases of parenteral nutrition, especially during the early immediate postnatal phase of the neonate, unstable ventilated critically ill children and those with excessive losses (i.e. ileostomy, protracted diarrhoea).

**Table 15: Electrolytes beyond neonatal period<sup>1</sup>**

	Infants	>1 year
Sodium [mmol/kg/day]	2.0 – 3.0	1.0 – 3.0
Potassium [mmol/kg/day]	1.0 – 2.0	1.0 – 3.0



## 6.4 Disease-specific requirements

**Table 16: Disease-specific requirements<sup>1</sup> use as guide only**

Newborn infant	90-100kcal/kg
Sick infant	110kcal/kg
Underweight-for-age	1.3 – 1.5 x REE
Burns	2 x REE
Head injury	0.6 – 1.37x REE
Cardiac and pulmonology	Increased requirements
Post uncomplicated surgery	90-110kcal/kg
General requirements	1-1.2x REE or REE x appropriate activity factor Use WHO/Schofield < 10 years Use WHO/Schofield/Harris Benedict >10 years

## 7 Nutritional intervention

### 7.1 Medical nutrition therapy

#### 7.1.1 Lipid emulsions<sup>13,14,15</sup>

All lipid solutions contain phospholipids and glycerol with different concentrations such as 10 per cent and 20 per cent. A higher concentration of lipid emulsions, such as 20 per cent solution [200g triglyceride/1000ml] are recommended compared to a 10 per cent solution due to the higher phospholipid: triglyceride ratio in a lower concentration solution.<sup>1,3</sup> The advantage of better phospholipid: triglyceride ratio is to achieve normal plasma phospholipids and cholesterol levels.

There has been significant research over the last 10 years on the ideal lipid emulsion for parenteral nutrition. This follows the marked side effects of soy-based lipid emulsion on liver function in long term parenteral nutrition.

The precise mechanisms by which fat emulsions contribute to parenteral nutrition related liver disease are not well understood. Different lipid emulsions have their own benefits and may contribute to or improve the development of parenteral nutrition related liver disease. These are:

1. Soya based lipid emulsion
  - a. Majority of parenteral nutrition solutions are composed of plant-based lipids, primarily soya.
  - b. This contains predominantly n6 fatty acids and also has phytosterols, which are thought to be a major contributing factor for development of parenteral nutrition related liver disease.<sup>16</sup>
  - c. The presence of phytosterols increases the lithogenicity of bile resulting in bile sludging and cholestasis.<sup>16</sup>
2. Medium chain triglyceride (MCT) lipid emulsion
  - a. Readily available form of energy which minimises triglyceride load.
  - b. It has more rapid clearance rate from the plasma due the advantage of MCTs not dependent on carnitine uptake by the mitochondria.
3. Olive oil lipid emulsion
  - a. Predominantly n9 fatty acids that reduce lipid peroxidation.
  - b. Improves antioxidant intake and vitamin E status.
  - c.  $\alpha$ -tocopherol needed to help prevent tissue damage by free radicals produced from peroxidation of lipid solutions.
4. Fish oil lipid emulsion
  - a. Contain predominantly n3 fatty acids that play a role in the modulation of inflammation by promoting a more anti-inflammatory process.
  - b. Helps to improve bile flow and decreases steatosis
  - c. Shown to be beneficial in improving liver function tests and dropping conjugated bilirubin but only as a temporary monotherapy due to risk of EFAs if given long term. Its considered a 'rescue therapy' in parenteral nutrition-associated liver disease (PNALD).<sup>3</sup>

## 7.2 Administration of parenteral nutrition

Parenteral nutrition may be administered via the central or the peripheral route as indicated in **Table 17**.

**Table 17: Comparison of administration methods**

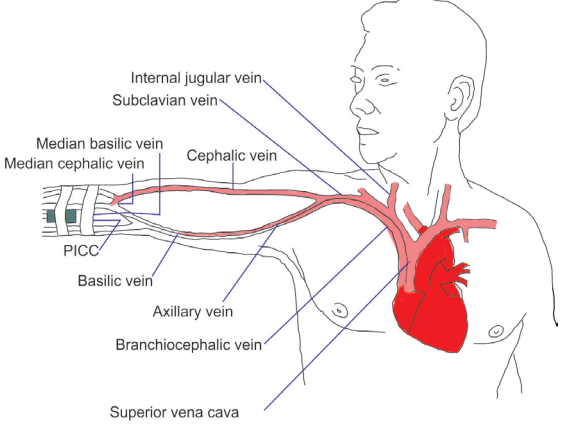
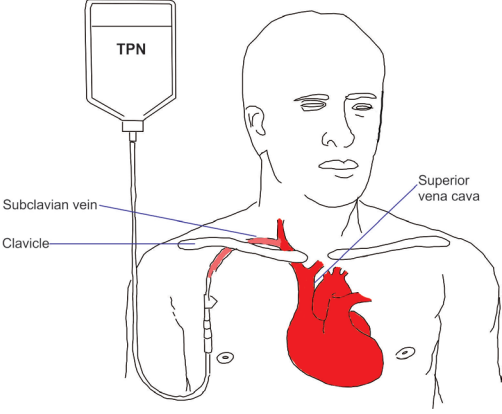
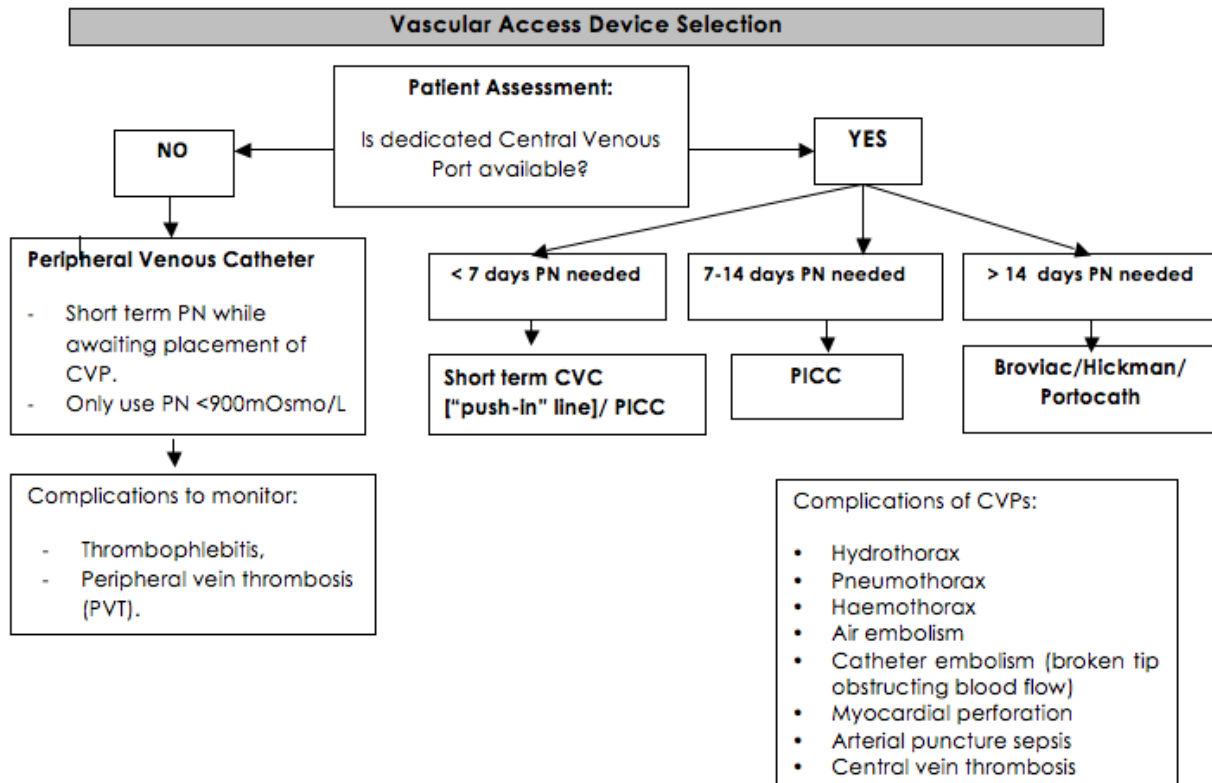
 <p><b>Peripheral parenteral nutrition</b></p>	 <p><b>Central parenteral nutrition</b></p>
<b>Description</b>	
<ul style="list-style-type: none"> <li>Parenteral nutrition is administered in the central venous system through a peripheral vein. It is recommended that the largest accessible vein is accessed using a small cannula or catheter, which should be covered with a sterile and occlusive transparent dressing.</li> </ul>	<ul style="list-style-type: none"> <li>A central venous port (CVP) is surgically inserted using strict aseptic techniques at the juncture of either the superior vena cava or the right atrium.</li> <li>A single or multiple lumen catheter may be used, but one lumen dedicate to TPN</li> </ul>
<b>Indications and features</b>	
<ul style="list-style-type: none"> <li>Peripheral parenteral nutrition is not recommended for paediatrics due to the high osmolality of the solutions and the risk of extravasations of parenteral nutrition solution into interstitial tissues. Therefore a central or PICC line is recommended for all paediatric patients receiving parenteral nutrition.</li> <li>Peripheral lines may be used for short term parenteral nutrition. There are problems associated with peripheral feeding such as thrombophlebitis, which may be decreased through the use of low osmotic load parenteral nutrition solutions (&lt; 900 - 1000mOsmo/L) and or prohibiting the catheter for non-feed use such as drug administration.</li> <li>Maximum glucose concentration is 12%<sup>3</sup></li> <li>Parenteral nutrition via peripheral lines is usually provided to patients in whom parenteral nutrition is required for a short duration (less than 14 days), where the nutritional needs are &lt; 1800 kcal per day and fluid restriction is not a concern.</li> </ul>	<ul style="list-style-type: none"> <li>Patients requiring parenteral nutrition for a longer duration (more than seven to 14 days)</li> <li>Parenteral nutrition solutions with higher osmolarities should only be administered via CVP</li> <li>Exchanged every seven to 14 days</li> <li>Maximum glucose concentration in a CVC = 25%<sup>3</sup></li> </ul>
<b>Special considerations/precautions</b>	
<ul style="list-style-type: none"> <li>Problems associated with peripheral feeding such as thrombophlebitis, which may be decreased through the use of low osmotic load parenteral nutrition solutions (&lt; 900 - 1000mOsmo/L) and or prohibiting the catheter for non-feed use such as drug administration.<sup>1,11,12</sup></li> <li>Catheters should be inspected by the medical team at least once a day and should be managed with an appropriate aseptic technique. A catheter should be re-sited if there is any redness or pain around the site.<sup>11</sup></li> <li>Catheter related complications may include peripheral vein thrombosis (PVT).</li> <li>To avoid PVT: <ul style="list-style-type: none"> <li>Use polyurethane/ silicone catheters</li> <li>Use a dedicated line for feeding</li> <li>Use "all in one" solutions with fat to reduce osmolality</li> <li>Use aseptic technique when handling</li> <li>Place glycerine trinitrate patch distal to exit site</li> <li>Inspect daily for redness or discomfort – resite catheters</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Placement should be confirmed via a chest x-ray, including absence of any complications such as hydrothorax, pneumothorax, haemothorax etc before commencement of feeding.<sup>1,11,12</sup></li> <li>Other catheter related complications are: <ul style="list-style-type: none"> <li>air embolism</li> <li>catheter embolism (broken tip obstructing blood flow)</li> <li>myocardial perforation</li> <li>arterial puncture sepsis</li> <li>central vein thrombosis</li> </ul> </li> <li><b>Types of CVPs</b> <ul style="list-style-type: none"> <li>PICC</li> <li>A fine bore polyurethane or silicone catheter in the form of a peripherally PICC line may be used in preference. This is placed in the antecubital fossa and can be left for longer periods.</li> <li>The procedure may be done at the bedside by a trained operator following strict aseptic technique and appropriate protocols but is preferably done as a theatre procedure.</li> <li>Broviac and Hickman These are used for long term parenteral nutrition</li> <li>Portocath</li> </ul> </li> </ul>

Figure 2 indicates the most appropriate vascular access device selection.



### 7.2.1. Micronutrients

All children should receive parenteral nutrition vitamins, minerals and trace elements. All paediatric parenteral solutions do contain micronutrients; however certain children may require additional micronutrients.

These should ideally be added to the lipid emulsion and should not be infused as a single “shot” infusion. The following micronutrients as indicated in **Table 18** are available:

**Table 18: Properties, administration and dosage of parenteral nutrition vitamins, minerals and trace elements**

	Water soluble vitamins	Fat soluble vitamins	Trace elements
Properties	1 vial = 10ml	1 vial = 10ml	
<b>Administration</b>	<ul style="list-style-type: none"> <li>• Lyophilised powder must be reconstituted with 10ml of sterile water for injection and added to at least 200ml of an electrolyte-free Dextrose 5% infusion before being administered peripherally.</li> <li>• Alternatively a water soluble vitamin preparation may be reconstituted with 10ml of a fat soluble vitamin preparation and added to 100ml of 20% lipid emulsion, which may then be infused peripherally.</li> <li>• Should not be infused over less than 2-3 hours in patients with normal renal function so as to minimise renal losses.</li> </ul>	<ul style="list-style-type: none"> <li>• The low osmolarity of fat soluble vitamin preparation allows for easy administration.</li> <li>• To be administered ideally with lipid emulsion [10% or 20%].</li> <li>• Care should be taken as it does contain Vitamin K.</li> <li>• Add aseptically within 1 hour.</li> <li>• Use within 24 hours.</li> </ul>	<ul style="list-style-type: none"> <li>• Up to 6ml of a commercial trace element preparation can be added to 100 ml of a glucose solution (50 - 500 mg/ml).</li> <li>• Given during a minimum infusion period of 8 hours.</li> <li>• Only add mixtures with 50 – 500mg/ml glucose to be used.</li> <li>• Addition of other medicines should be avoided due to risk of precipitation.</li> <li>• Add aseptically within 1 hour.</li> <li>• Use within 24 hours.</li> </ul>
<b>Dosage</b>	<ul style="list-style-type: none"> <li>• &lt; 10kg: 1/10 of vial per kg body weight.</li> <li>• Above 10kg : Use whole vial.</li> </ul>	<ul style="list-style-type: none"> <li>• Under 11 years of age is 1ml/kg/day.</li> </ul>	<ul style="list-style-type: none"> <li>• The requirements for infants (&lt; 15 kg) are met by 1 ml/kg/day of commercial trace element solution to a maximum dose of 15 ml/ day.</li> <li>• The efficacy of a daily dose of 15 ml commercial trace element in children weighing more than 15 kg has not been established and regular monitoring of trace element plasma levels is recommended.</li> </ul>

## 7.2.2 Safety

### 7.2.2.1 Administration standards

- All parenteral nutrition must be administered through a dedicated feeding line using a volumetric pump with occlusive and air-in-line alarms to minimise infusion-related complications. The prescription should be checked and the volume and rate of infusion must be clearly recorded. The use of 1.2µm air eliminating filters for lipid containing solutions [changed every 24 hours] as they protect patients against the consequences of air emboli, particulate, microprecipitates, phlebitis and microbial contamination.
- Filters have sometimes been criticised as they may clog, causing infusion pumps to alarm requiring nursing attention. It should however, be recognised that a clogged filter is a potential sign of a precipitate. It is never appropriate to remove a clogged filter and allow the admixture to infuse without a filter. The entire administration set, filter and admixture solution should be discarded in preference of an entirely fresh administration set, filter and parenteral nutrition.
- Filters should not be viewed, as a “cure” to potential sources of infection and contamination and strict aseptic techniques should still be employed in order to minimise the risk of harm to the patient.
- A dedicated catheter or lumen (if using multi-lumen catheter) should be used for the parenteral nutrition solution. Protocols for the catheter care site should be followed strictly.
- All parenteral nutrition should only hang for 24 hours and should be discarded thereafter. Details of hang time need to be included into the parenteral nutrition monitoring protocol in **Annexure 4**.
- Parenteral nutrition should be administered at the rate prescribed on the patient fluid balance chart.

### 7.2.2.2 Individualised parenteral nutrition versus standard parenteral nutrition

- Standard parenteral nutrition solutions should be used as far as possible to prevent errors in prescription and compounding and to achieve better nutrient delivery.
- Individualised bags should only be used for specific patients and checks should be in place to ensure that prescriptions are correct.
- No medication should be added to the parenteral nutrition at ward level. If co-infusion (same line, but different port) has to take place due to limited line access, it must be discussed with the pharmacist/physician in charge.

### 7.2.2.3 Line management

*[Refer to the section on complications and annexure for further details regarding parenteral nutrition and line management]*  
Meticulous care with regards to the catheter should be employed with the principles of aseptic technique adhered to using sterile gloves, towels and antiseptic solutions. All members of the NTT involved with the administration or prescription of parenteral nutrition should receive training with regards to aseptic techniques.

## 8. Complications of parenteral nutrition (including risk of re-feeding)

The main complications of parenteral nutrition may be categorised into metabolic, physiological, mechanical or infectious complications.

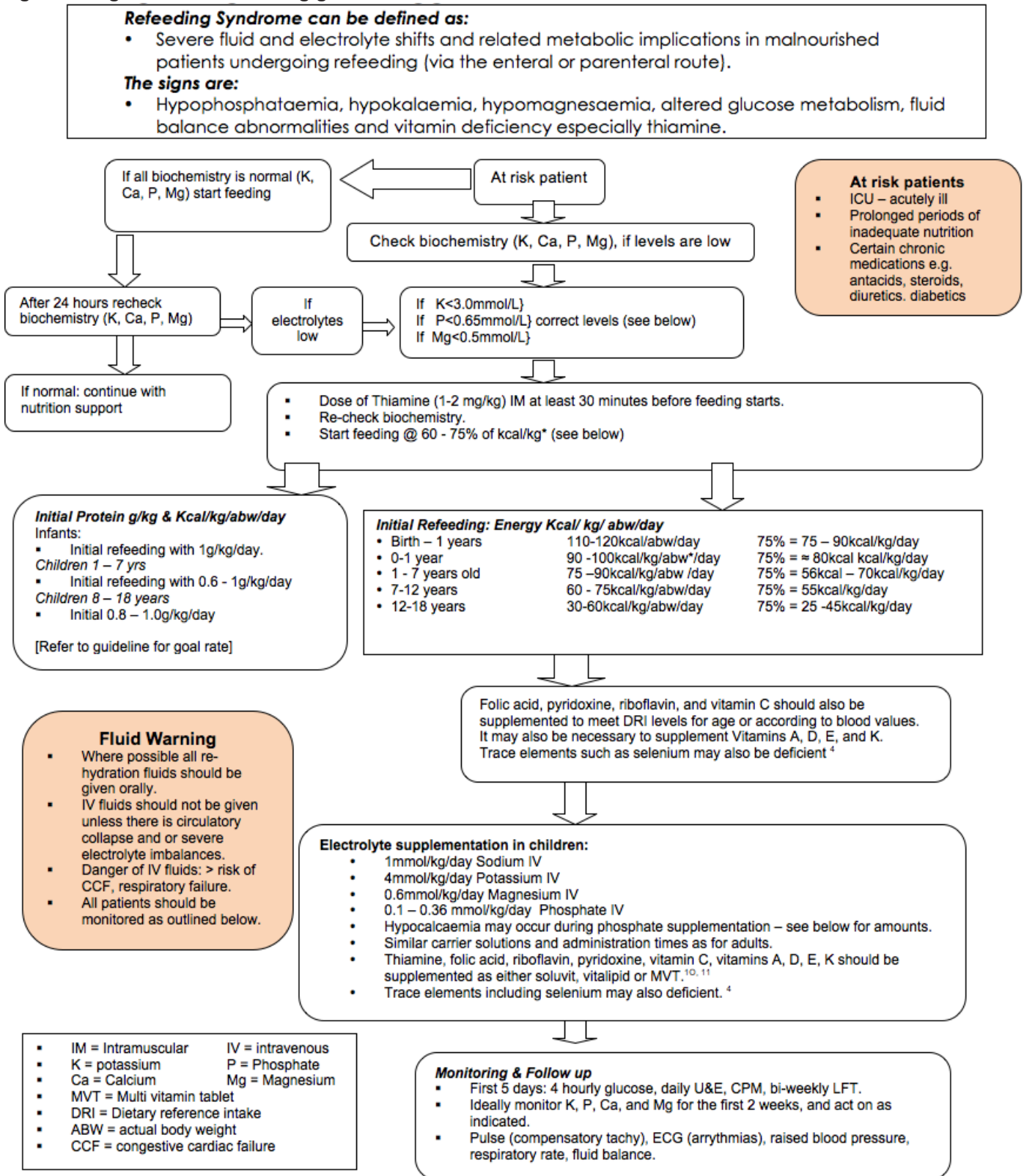
### 8.1 Metabolic complications

#### 8.1.1 Re-feeding:

An algorithm of re-feeding guidelines is depicted in **Figure 3**.

Reference: <sup>15</sup>

Adapted from Shaw V, Lawson M. *Clinical Paediatric Dietetics*. 3 ed. Blackwell Publishing; 2007.

Figure 3: Algorithm on re-feeding guidelines<sup>2</sup>

To reduce the risk of refeeding complications, the following must be considered during the initial phase of refeeding [1]:

- prevention of water and sodium overload can be achieved by reducing water and sodium intake (by up to 60 per cent of theoretical requirements in some cases), depending on hydration status
- close monitoring of weight changes to detect fluid retention and excessive losses
- correction of potassium and phosphorus depletion should be achieved progressively. Phosphorus should be administered at 0.5mmol/kg per day and increased to 1.0mmol/kg per day proportionally according to protein-energy intake
- both nitrogen and calories should be provided simultaneously, in the correct protein: NPE ratio and should be increased very slowly. An intake of 0.5-1g/kg of parenteral amino acids is adequate to maintain the plasma amino acid pool

**Monitoring should include:**

- infusion rate
- body temperature
- cardiac and respiratory function
- urinary volume
- weight
- digestive output
- plasma and urinary ion, plus calcium, phosphorus, magnesium, glucose and haematocrits should be obtained twice during the first week and then weekly thereafter

**8.1.2 Glucose control**

Parenteral administration of glucose requires care because of risk of hyperglycaemia. According to the age of the patient, the continuous glucose infusion rate may be at least equal to the glucose production rate. Possible complications of IV glucose supply are listed in **Table 19**.

**Table 19: Possible complications of IV glucose supply**

	Possible causes:	Management approach:
<b>Hyperglycaemia</b>	<ul style="list-style-type: none"> <li>• re-feeding syndrome</li> <li>• excess glucose infusion via parenteral nutrition</li> <li>• Systemic Inflammatory Response</li> <li>• systemic steroid therapy</li> </ul>	<ul style="list-style-type: none"> <li>• monitor parenteral nutrition for total energy, particularly glucose</li> <li>• calculate glucose oxidation rate and ensure that this is not exceeded</li> </ul>
<b>Hypoglycaemia</b>	<ul style="list-style-type: none"> <li>• too little glucose supply in parenteral nutrition</li> <li>• sudden discontinuation of parenteral nutrition – rebound hypoglycaemia (rare)</li> </ul>	<ul style="list-style-type: none"> <li>• calculate glucose and lipid supply</li> </ul>
<b>Steatosis</b>	<ul style="list-style-type: none"> <li>• excessive glucose leads to lipogenesis and liver steatosis</li> </ul>	<ul style="list-style-type: none"> <li>• monitor both glucose and lipid infusions</li> <li>• check glucose infusions, in particular glucose oxidation rate</li> </ul>

**8.1.3 Metabolic bone disease<sup>18</sup>**

Parenteral nutrition-related metabolic bone disease (MBD) and decreased BMD, osteoporosis, pain and fractures have been reported in children weaned from long-term parenteral nutrition. Neonates are particularly at risk of MBD due to inadequate supply of vitamin D, calcium and phosphate.

The following needs to be monitored in those receiving long term parenteral nutrition as indicated in **Table 20**.

**Table 20: Indicators to monitor in patients receiving long term parenteral nutrition**

<ul style="list-style-type: none"> <li>• Monitor provision of fat soluble vitamins, calcium and phosphate.</li> <li>• Commence vitamin D supplementation.</li> <li>• Monitor serum calcium, phosphate, alkaline phosphatase.</li> <li>• Monitor medication (i.e. steroids) that may impact on BMD.</li> </ul>
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

**8.1.4 Hyperlipidemia**

Plasma lipids need to be monitored regularly to ensure adequate clearance and utilisation. Lipid clearance is dependent on the activity of lipoprotein lipase. Lipid infusion exceeding fat oxidation may lead to hyperlipidaemia.

The following can be done should there be raised triglyceride:

- gradual increase of rate of parenteral nutrition by 1g/kg/day over three to four days to maintain steady rate of infusion does help to prevent hypertriglyceridemia<sup>3</sup>
- to reduce lipid infusion by 0.5-1 g/kg to ensure still adequate EFAs and monitor lipid levels
- lipid infusion should not be stopped due to risk of EFAs and insufficient energy
- levels should only be checked after four hours of being infused

## 8.2. Physiological complications

### 8.2.1 Increased serum bilirubin levels:

This may occur as a result of a reduction in bilirubin binding capacity due to an increase in circulating free fatty acids from the lipid emulsion competing with bilirubin for the binding sites on plasma albumin. Bilirubin levels usually normalise following the cessation of parenteral nutrition.

If there are significant hepatic changes, which are of clinical concern the following is suggested:

- consider non-nutritional causes such as sepsis
- avoid overfeeding
- reduce the total energy intake by decreasing the lipid or glucose infusion but maintain the protein [nitrogen] intake and monitor
- if possible, provide a small amount of oral or enteral nutrition as this may help to reduce cholestasis
- consider changing the lipid emulsion to a multilipid solution containing fish oils
- consider the use of Ursodeoxycholic Acid, a synthetic bile acid and treatment of bacterial overgrowth caused by intestinal stasis<sup>3</sup>.
- where practical, and if the child is stable, consider cyclical feeding e.g. 18-20 hours out of 24 hours

#### 8.2.1.1 Cyclical parenteral nutrition <sup>1, 19,20</sup>

Cyclical parenteral nutrition is usually well tolerated from three to six months of age. In order to maintain blood sugar levels, it is suggested that the cyclical regime is started and ended with a "build-up" (50 per cent, 75 per cent and then 100 per cent of aim rate) or "build-down" regime. The maximal glucose infusion should not exceed 1.2g/kg per hour [20mg/kg/min].

Cyclical TPN should be used with caution in the following patient populations:

- patients with presumed low glycogen stores (e.g. severe malnutrition and neonates)
- patients with sensitive fluid status (e.g. congestive heart failure)
- patients receiving long acting insulin therapy

Cyclical TPN should be avoided in patients that are hemodynamically unstable and patients receiving mechanical ventilation.

#### 8.2.1.2 Parenteral nutrition associated cholestasis (PNAC) <sup>13,14,15, 21,31,22</sup>

Long term parenteral nutrition is associated particularly with PNAC, also referred to as 'intestinal failure-associated liver disease' because it occurs mostly in infants and children with intestinal failure. It has been reported that up to 65 per cent of infants on parenteral nutrition develop abnormal liver function tests within two to three weeks of starting parenteral nutrition.<sup>3</sup> PNAC has a mortality rate of 40 per cent in infants and has become a major indication for paediatric liver transplantation.

The causes of PNAC are multifactorial:

- hepatic immaturity in VLBW/SGA infants
- ELBW infants with gastroschisis or jejunal atresia
- presence of sepsis
- impaired bile flow due to surgical resection of distal ileum
- absence of enteral feeds
- overfeeding
- type of lipid emulsion [see section on lipid emulsions]

### 8.3 Mechanical and line complications

Table 21 provides information on mechanical and line complications related to parenteral nutrition.

**Table 21: Mechanical and line complications**

Line related		
Complication	Possible cause	Possible solution
Infectious complication - bacterial translocation	Mucosal atrophy, increased translocation of micro organisms and their toxins	<ul style="list-style-type: none"> <li>ensure best CVC line care and attempt trophic enteral feeding</li> </ul>
Line infection	Bacterial contamination, bacterial translocation	<ul style="list-style-type: none"> <li>prevention is better with optimal aseptic technique</li> <li>CVC cultures should be taken and antibiotic treatment should be tailored accordingly</li> <li>infusion sets should be changed every 24 hours</li> <li>parenteral nutrition line should be removed with the tip being sent for microscopy culture and sensitivity</li> <li>in the case of confirmed line sepsis, the patient should be kept line free for 48 hours before a new central line is reinserted</li> <li>trophic feeding may help with line infections</li> </ul>
Line occlusion	Related to blood clotting, fibrin sheath, parenteral nutrition fluid precipitate or related to positioning of the CVC	<ul style="list-style-type: none"> <li>when CVC not used, it should be flushed</li> <li>in line filters should be used</li> <li>using CVC lines for taking blood should be avoided</li> <li>syringes &lt; 10 ml should not be routinely used on CVC and unblocking with guide-wire is not recommended</li> </ul>
Thrombosis/ embolism	Complications of long term parenteral nutrition. Associated with CVC infections, repeated CVC changes, proximal location of the CVC tip in the superior vena cava, frequent blood sampling, concentrated glucose solutions, chemotherapeutic agents or it may be idiopathic	May be treated with thrombolytic agents but anticoagulation remains the most common therapeutic approach. Catheter may need to be removed. Vitamin K antagonists and low molecular weight heparins may reduce the risk in long term parenteral nutrition patients or those with previous risk of thrombo-embolism

These may be secondary to the catheter or other non-catheter concurrent infections.

## 9. Weaning from parenteral nutrition

The following should be considered prior to weaning from parenteral nutrition:

- whether it is necessary for a patient to achieve full nutrition intake from an alternate route e.g. oral/enteral before parenteral nutrition is discontinued
- whether or not the clinical symptoms which required the use of parenteral nutrition have sufficiently abated
- introduction of oral/enteral feeds should be accompanied by a reduction in the amount of parenteral nutrition administered to minimise the risk of overfeeding and fluid overload. It is recommended that the parenteral nutrition volume is only reduced once enteral feeds make up 25 per cent of the calculated dietary requirements, granted that the patient is not fluid restricted.<sup>1,3</sup> The weaning process should be controlled with a gradual increase in oral intake, while simultaneously decreasing the parenteral nutrition intake. The osmolalities of the enteral and parenteral solutions are not similar. When more than 75 per cent of the patients' requirements are being met via an enteral/oral route, parenteral nutrition may be discontinued.<sup>1,3</sup> In short term parenteral nutrition users, the weaning process may take a few days, whereas in long term support weaning may be very gradual over months.

### 9.1 Trophic feeding<sup>3,23,24,25</sup>

Minimal enteral feeds (MEF) or trophic feeding of 12 to 24 ml/kg/day<sup>3</sup> depending on age, birth weight and is associated with improved intestinal motility, improved mucosal mass, increased intestinal hormone and enzyme secretion and earlier establishment of full enteral feeds. It has been shown that MEF does not increase the risk of adverse effects or NEC.

The following factors should be considered when introducing small trophic feeds or commencing enteral nutrition:

- make one change in treatment at a time in order to assess tolerance e.g. if the volume of enteral nutrition is increasing the concentration of the feed should remain the same
- enteral nutrition may be given over a four to 24-hour period via an enteral feeding pump
- if gastric feeds are poorly tolerated, continuous jejunal feeds may be considered
- children who rapidly recover intestinal function may be weaned directly on to food. Some children may be weaned directly from TPN onto bolus feeds and by mouth where ever possible
- expressed breast milk is always the milk of choice in infants, particularly in SBS. In severe intestinal failure, feeds should be increased slowly as tolerance permits



## 9.2 Oral hypersensitivity

Food aversion or oral hypersensitivity can occur in individuals not receiving any form of oral stimulation for long periods of time. Not only lack of stimulation, but unpleasant oral experiences such as intubations, suction, vomiting and unpalatable nutritional products may lead to long term feeding problems.<sup>3</sup>

The early involvement of a speech therapist to advise on oral stimulation is recommended.

## 10. Monitoring and evaluation

*Monitoring* is the periodic and timely collection of data to determine if activities are being implemented as per national guidelines. The *evaluation* process assists in determining the achievement of goals and objectives on a national and provincial level. Evaluation will give an opportunity to comprehensively assess and document the effectiveness of the inpatient management of parenteral nutrition. In the context of the current parenteral nutrition guidelines, monitoring will take place at inpatient level by the hospital-based MDT and by the provincial nutrition team using the parenteral nutrition monitoring tool (**Annexure 9: Parenteral nutrition monitoring tool**).

### 10.1 Nutritional assessment, monitoring and follow-up

Although parenteral nutrition is beneficial and life-saving in a variety of clinical conditions, it can result in numerous, potentially serious, side-effects. The risk of such complications can be minimised by carefully monitoring patients and the use of NTT.

The NTT should review all patients receiving parenteral nutrition on a daily basis as they require careful monitoring of clinical, laboratory and nutritional indices. This ensures that the nutrition prescription is appropriate and adequate and that the risks of complications are minimised through the thorough interpretation of the monitoring results and clinical examination.

It is recommended that all patients are monitored using the examinations in **Table 22**.

**Table 22: Nutritional assessment, monitoring and follow-up checklist**

	Parameter	Frequency
<b>Anthropometry</b>	Weight	Infants: Daily Children: Every second day - once a week
	Height/length	Infants: Every two weeks to two months Children: Every three months Older children: Every year
	Head circumference	Infants: Monthly
	MUAC	Monthly
<b>Biochemistry:</b>  (frequency of measurements may change based on clinical condition)	Serum electrolytes, blood urea nitrogen, creatinine	Baseline, then once per week
	Calcium, magnesium, phosphorous	Baseline, then once per week
	Serum glucose	Four to six hourly
	FBC	Baseline, then once per week
	Liver function tests	Baseline, then once per week
<b>Clinical:</b>	Abdominal distension and discomfort	Daily
	Fluid intake and output	Daily
	Gastric residuals	Every four hours where appropriate
	Signs and symptoms of oedema or dehydration	Daily
	Stool output and consistency	Daily
	Temperature	Daily
<b>Diet</b>	Nutritional intake adequacy	Daily
	Readiness to introduce enteral or oral nutrition and wean parenteral nutrition support	Guided by clinical condition

Patients receiving parenteral nutrition require more intense biochemical monitoring, especially where there are ongoing losses and changes in patient condition. The most profound and possibly most dangerous changes in biochemical parameters can occur during the re-feeding phase of establishing nutrition support as indicated in **Table 23**.

**Table 23: Protocol for laboratory monitoring of patients on nutrition support**

Parameter	Frequency	Rationale	Interpretation
Sodium, potassium, urea, creatinine	<ul style="list-style-type: none"> <li>baseline</li> <li>daily until stable</li> <li>then one to two times weekly</li> </ul>	Assessment of renal function, fluid status and Na and K status	Interpret with knowledge of fluid balance and medication
Magnesium, Phosphate	<ul style="list-style-type: none"> <li>baseline</li> <li>daily if re-feeding risk</li> <li>three times weekly until stable</li> <li>weekly once stable</li> </ul>	Depletion is common and under recognised	Low levels indicate poor status
Calcium, albumin	<ul style="list-style-type: none"> <li>baseline</li> <li>then weekly</li> </ul>	Hypo or hypercalcaemia may occur	<ul style="list-style-type: none"> <li>hypocalcaemia can be secondary to Mg deficiency</li> <li>low albumin reflects disease, not protein status</li> </ul>
Liver functions tests, including INR, total bilirubin and conjugated bilirubin	<ul style="list-style-type: none"> <li>baseline</li> <li>twice weekly until stable</li> <li>then weekly</li> </ul>	Abnormalities common in parenteral nutrition	Complex. May be due to sepsis, other disease or inappropriate nutritional intake
Full blood count	<ul style="list-style-type: none"> <li>baseline</li> <li>one or two times per week until stable</li> <li>weekly once stable</li> </ul>	Anaemia due to iron or folate deficiency is common	Effects of sepsis may be important
Cholesterol and triglycerides	<ul style="list-style-type: none"> <li>baseline</li> <li>twice a week for duration of parenteral nutrition</li> </ul>	Fatty liver can occur as a result of inappropriate parenteral nutrition prescription	Indication of nutritional status at baseline. Thereafter, indication of liver metabolism of fat
Iron, ferritin	<ul style="list-style-type: none"> <li>baseline</li> <li>then every three to six months</li> </ul>	Iron deficiency is common in long term parenteral nutrition	In acute phase response, ferritin↑, iron ↓
Folate, Vitamin B <sub>12</sub>	<ul style="list-style-type: none"> <li>baseline</li> <li>then every two to four weeks</li> </ul>	Folate deficiency is common	Interpret with FBC
Glucose	<ul style="list-style-type: none"> <li>baseline</li> <li>six-hourly while on parenteral nutrition</li> </ul>	Glucose intolerance is common	Good glycaemic control is important
C-reactive protein	<ul style="list-style-type: none"> <li>baseline</li> <li>two to three times weekly until stable</li> </ul>	Assists interpretation of protein, trace element and vitamin results	<ul style="list-style-type: none"> <li>to assess the presence of an acute phase response</li> <li>the trend is important</li> </ul>
Zinc, Copper	<ul style="list-style-type: none"> <li>baseline</li> <li>Every three to four weeks, depending on result</li> </ul>	Deficiency is common, especially with increased losses	Especially important when acute phase anabolism causes ↓zinc ↑copper
Selenium	<ul style="list-style-type: none"> <li>baseline if at risk for depletion</li> <li>monitoring depend on result</li> </ul>	Likely in severe illness, sepsis and long term nutrition support	Acute phase reaction causes ↓selenium
Manganese	<ul style="list-style-type: none"> <li>Every three to six months on HPN</li> </ul>	Avoid excess provision	Red blood cells or whole blood, better indicator than plasma

Observe any possible clinical signs of parenteral nutrition-related deficiencies and refer to **Table 24**.

**Table 24: Clinical signs of parenteral nutrition-related deficiencies**

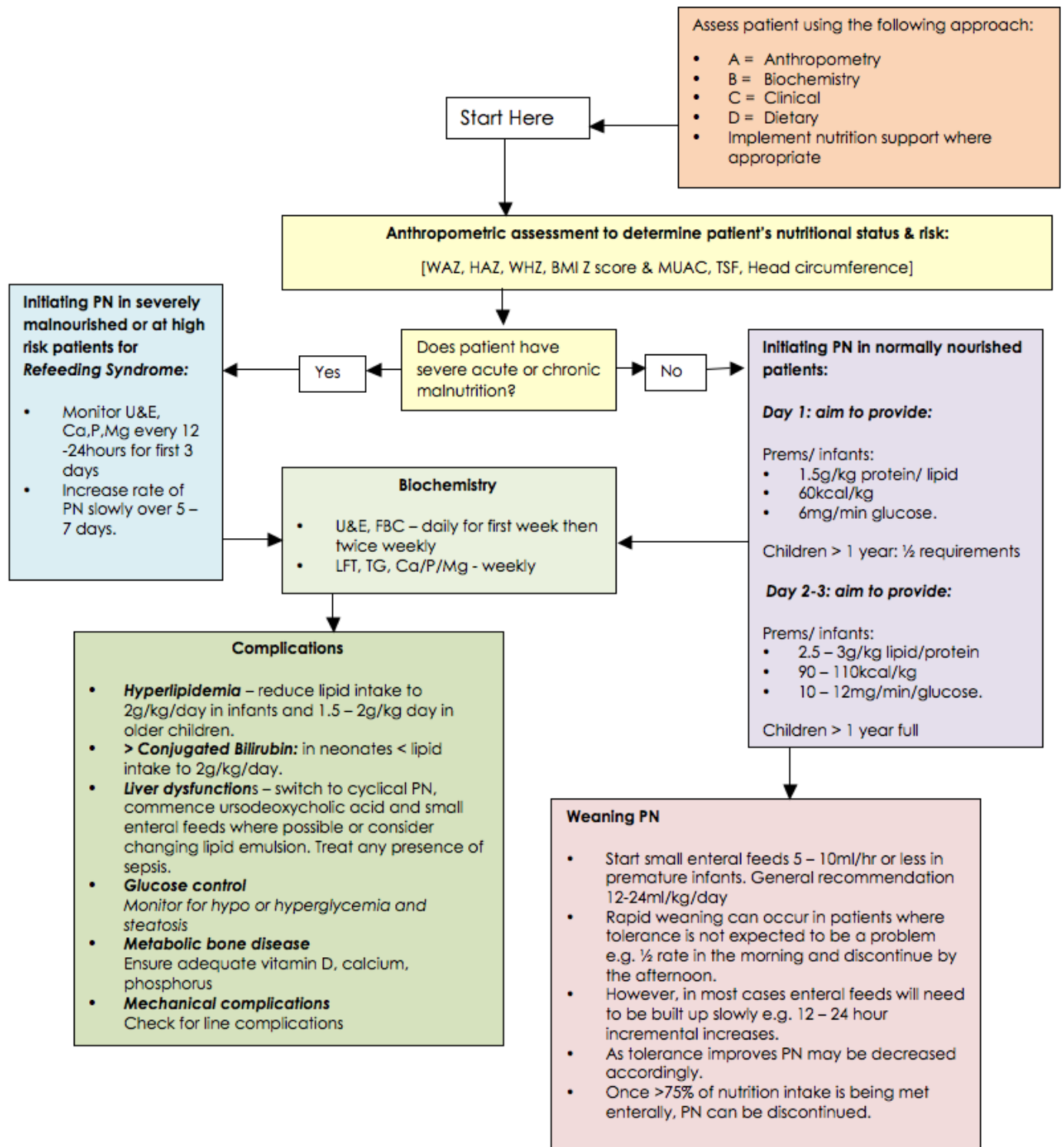
Clinical sign	Possible cause	Possible solution
Wasting/stunting	Low energy and protein supply in parenteral nutrition (patient more catabolic) Inappropriate energy: Protein ratio for catch-up growth	Review prescription and delivery of parenteral nutrition and adjust
Hair loss	Can occur in long term parenteral nutrition (more than three months) and can be related to selenium, zinc or iron deficiency	Monitor these levels and provide supplementation if required
Scaly dermatitis	EFA deficiency	Ensure that the infant receives sufficient lipids and EFAs. See section on lipids on supply of EFAs
Generalised pallor	Check iron levels, especially in long term parenteral nutrition patients iron deficiency is common	Provide iron as an oral supplement
Confusion/Nystagmus/Ataxia	Thiamine deficiency (Wernicke Korsakoff Syndrome), which is very rare and only seen in chronically malnourished patients	Ensure that the child has received thiamine via parenteral nutrition and consider additional supplementation
Signs of vitamin deficiencies: Follicular Hyperkeratosis Xerosis Beri-beri (very rare) Glossitis Stomatitis Cheilosis Seborrheicdermatosis Bleeding gums Signs of rickets	Some clinical signs may manifest as a result of medical treatment (i.e. chemotherapy)  Can be as a result of poor nutritional status and following inadequate supply of vitamins	Establish the cause. Measure appropriate vitamin levels. Discuss supplementation and its impact with the pharmacist and dietitian

## 11. Summary

The information contained in this parenteral nutrition protocol should assist in ensuring an evidence-based and standardised approach to parenteral nutrition prescriptions. The goal of the protocol is to ensure that each patient who requires parenteral nutrition attains/maintains an optimal nutritional status. **Figure 4** provides a summary of the parenteral nutrition protocol.

Figure 4: Summary of the parenteral nutrition protocol

Goal: To ensure that each patient requiring Parenteral Nutrition maintains or achieves an optimal nutritional status

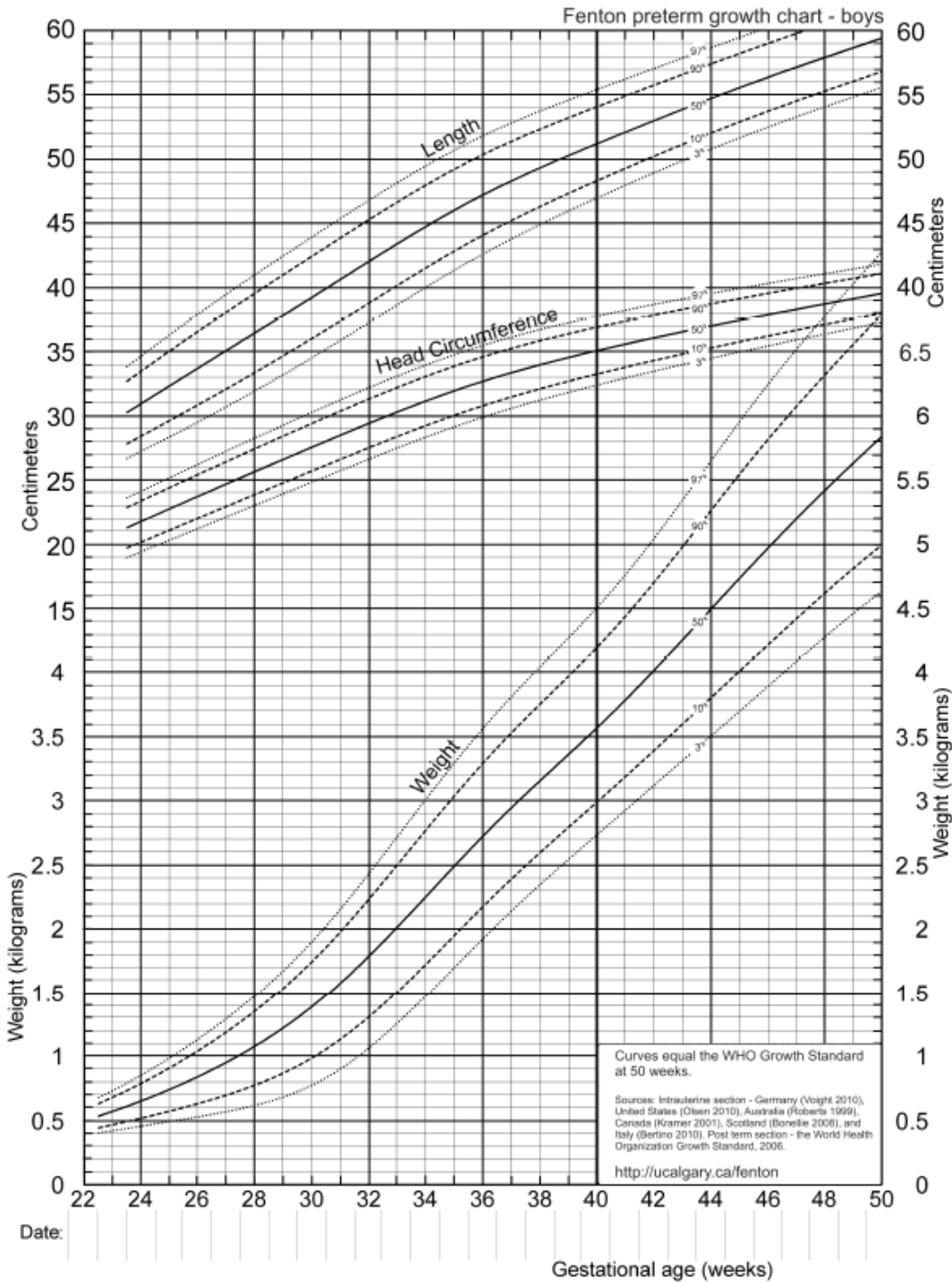


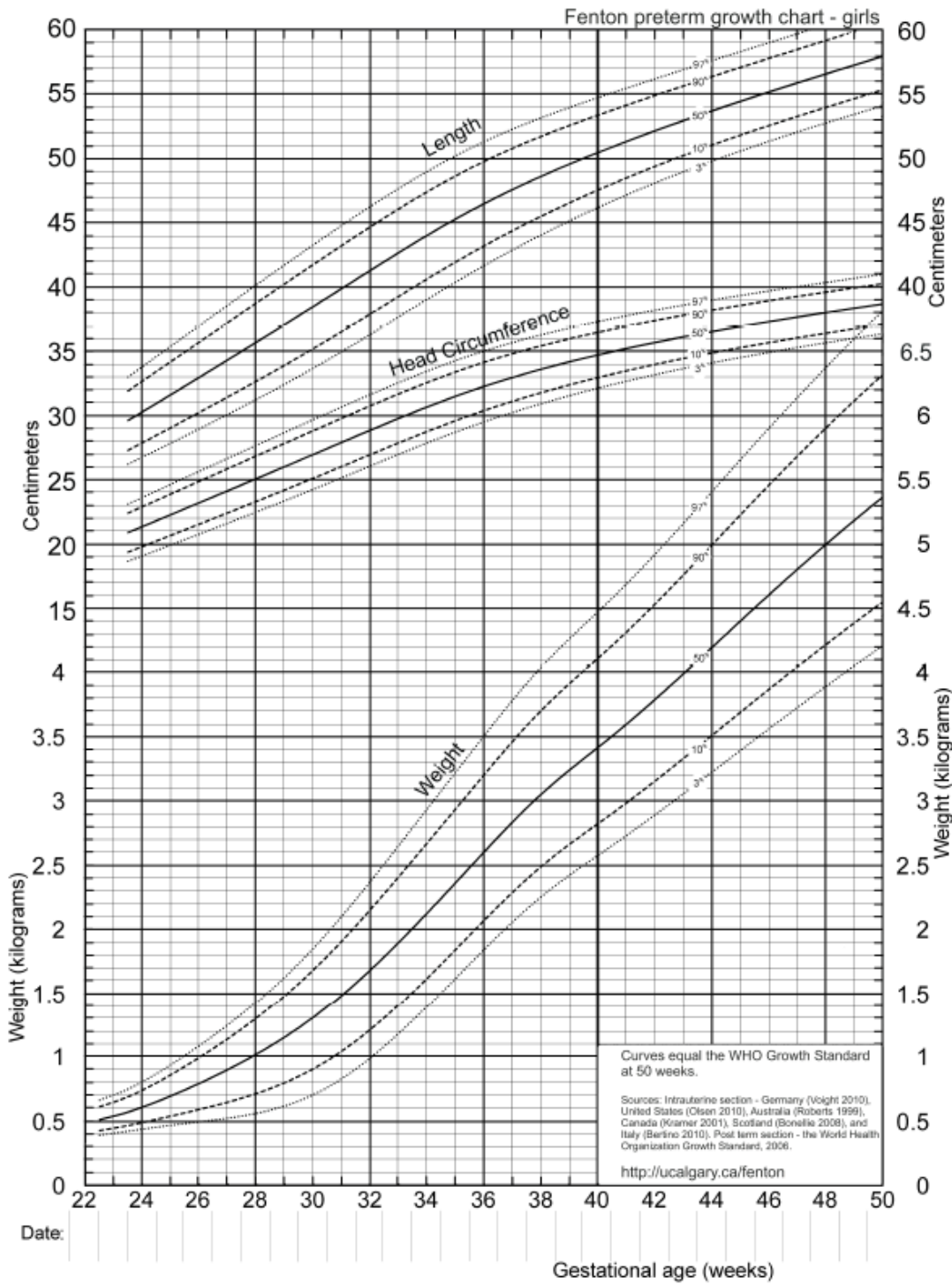
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13. Annexures

Annexure 1: FENTON preterm growth charts - boys and girls

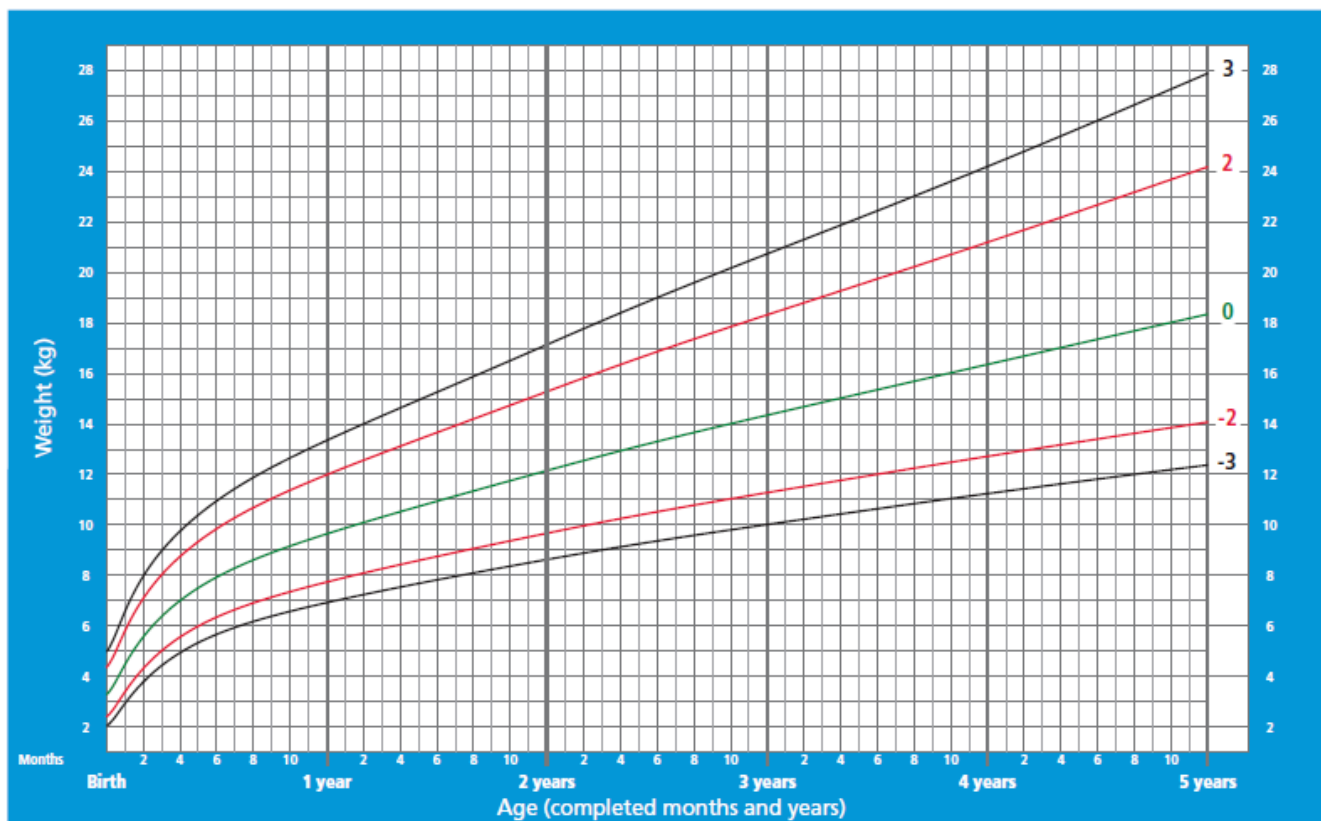




Annexure 2: WHO growth charts for boys and girls

# Weight-for-age BOYS

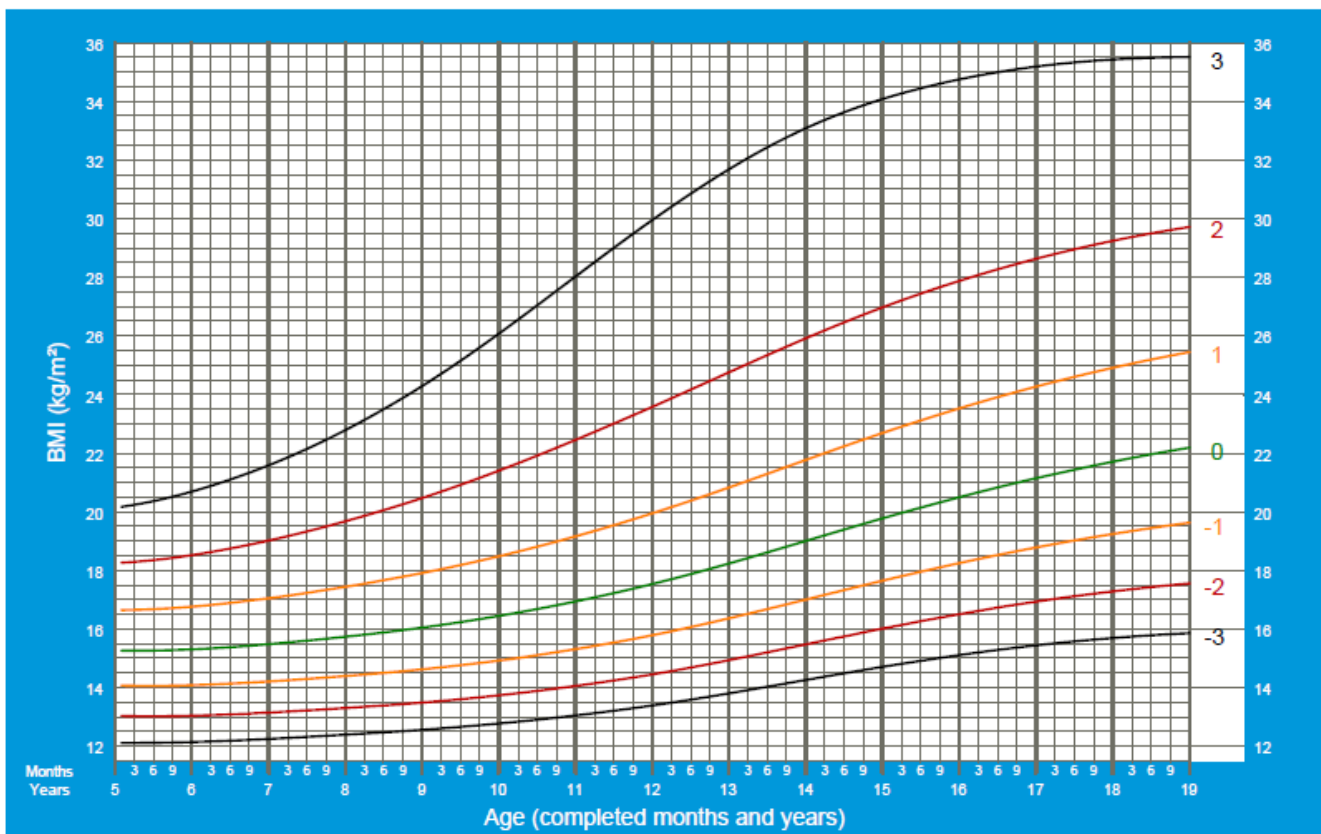
Birth to 5 years (z-scores)



WHO Child Growth Standards

# BMI-for-age BOYS

5 to 19 years (z-scores)

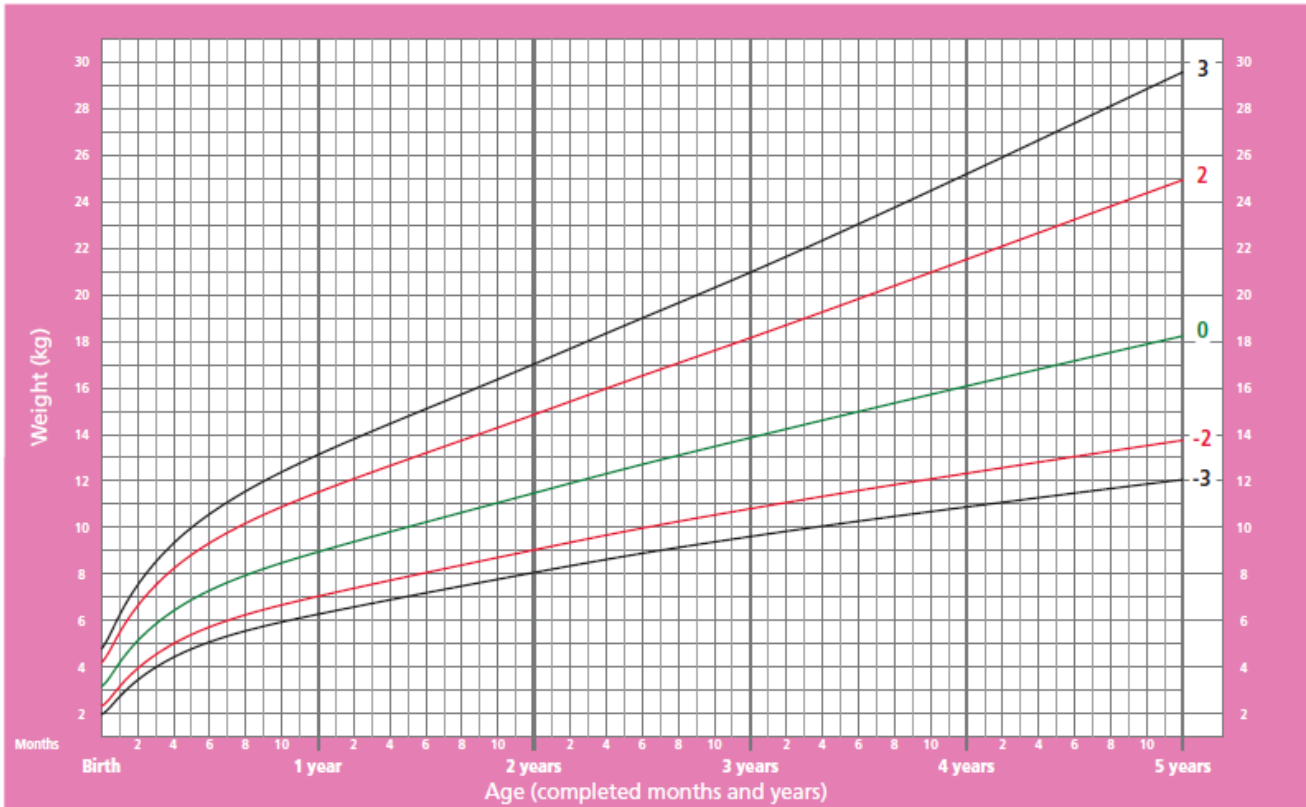


2007 WHO Reference



# Weight-for-age GIRLS

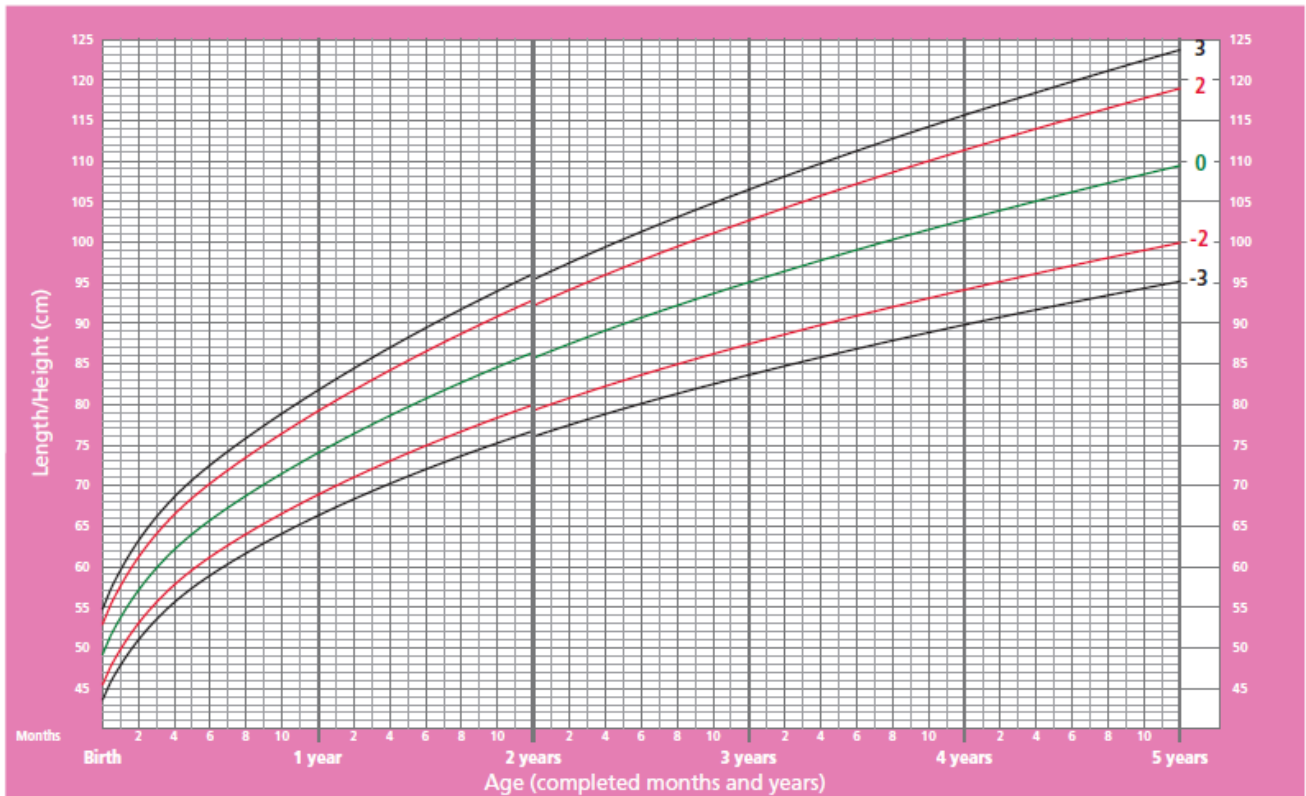
Birth to 5 years (z-scores)



WHO Child Growth Standards

# Length/height-for-age GIRLS

Birth to 5 years (z-scores)

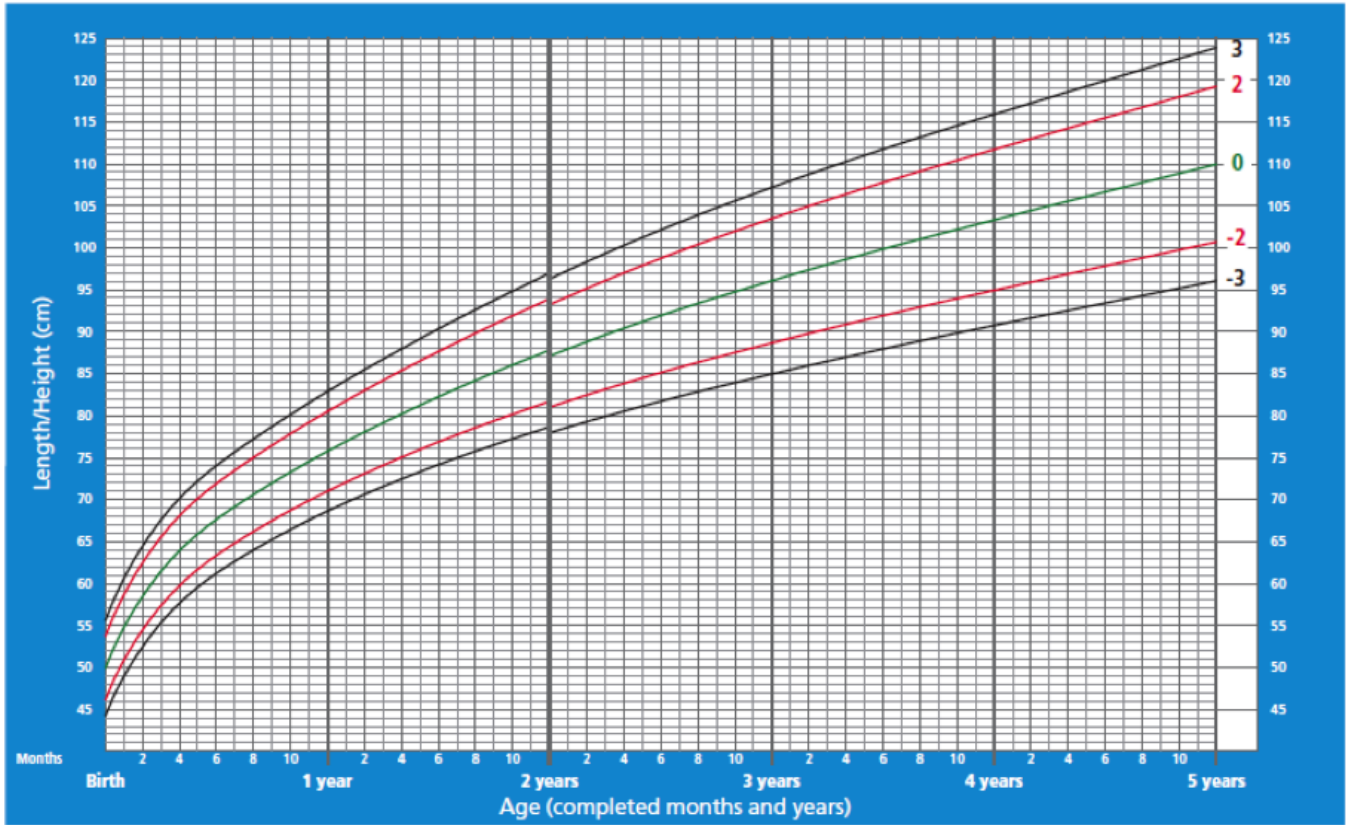


WHO Child Growth Standards

# Length/height-for-age BOYS



Birth to 5 years (z-scores)

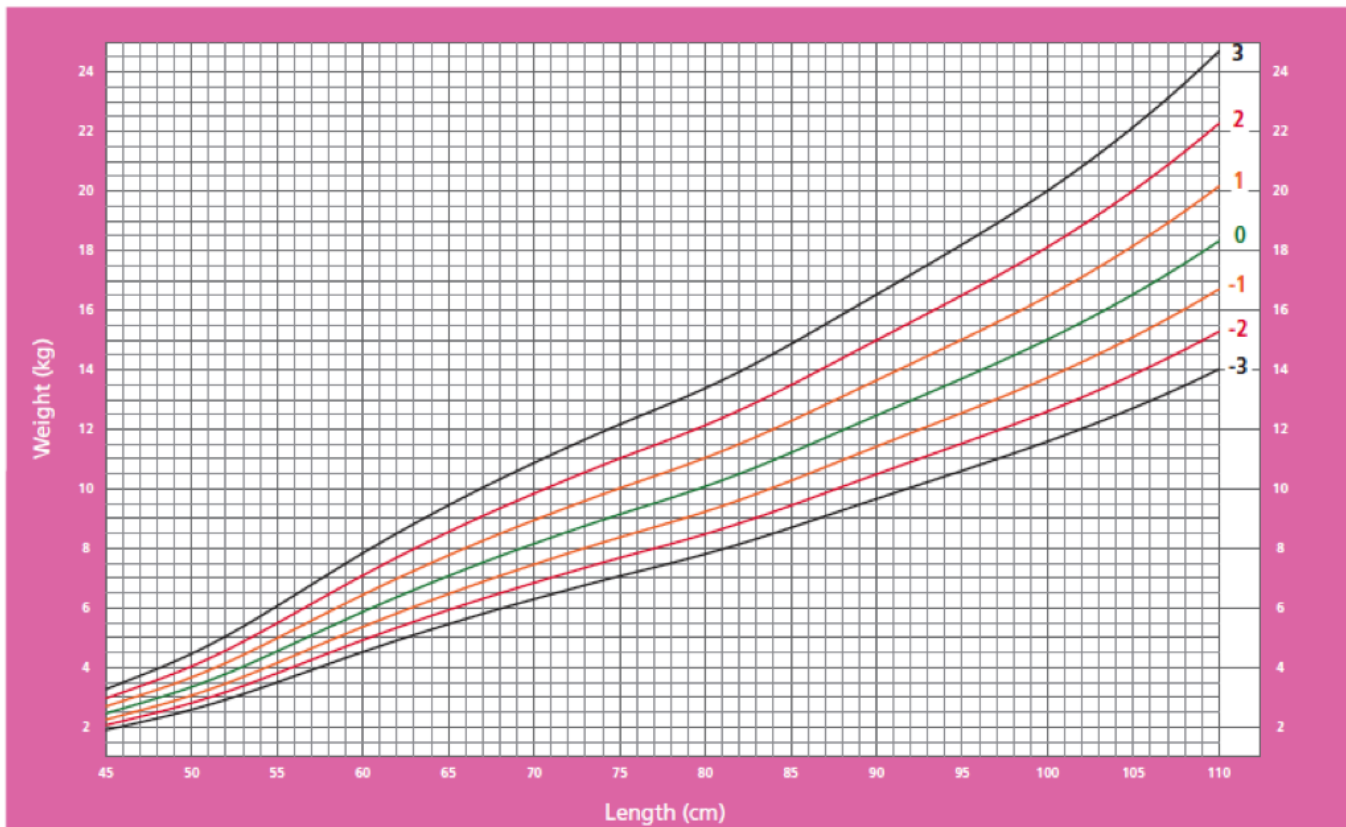


WHO Child Growth Standards

# Weight-for-length GIRLS



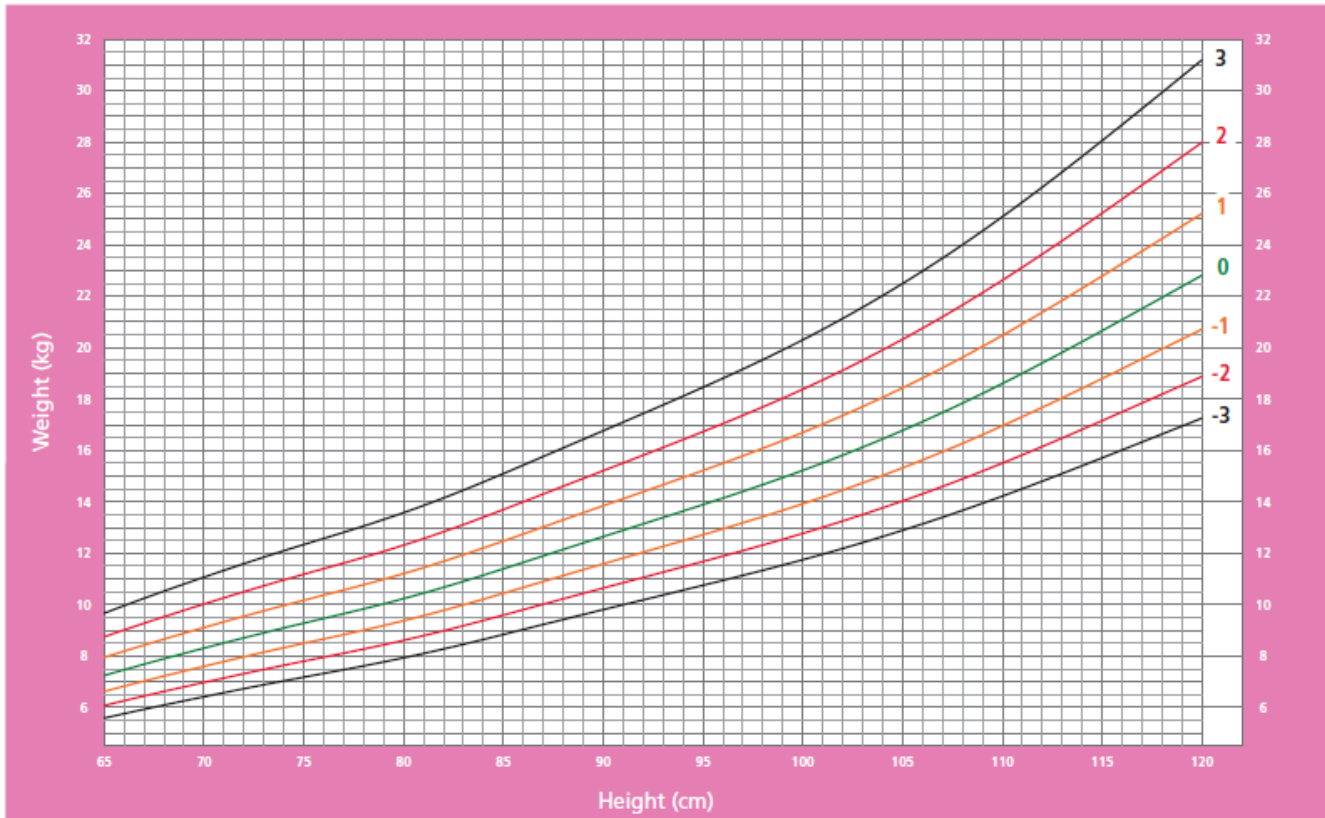
Birth to 2 years (z-scores)



WHO Child Growth Standards

# Weight-for-Height GIRLS

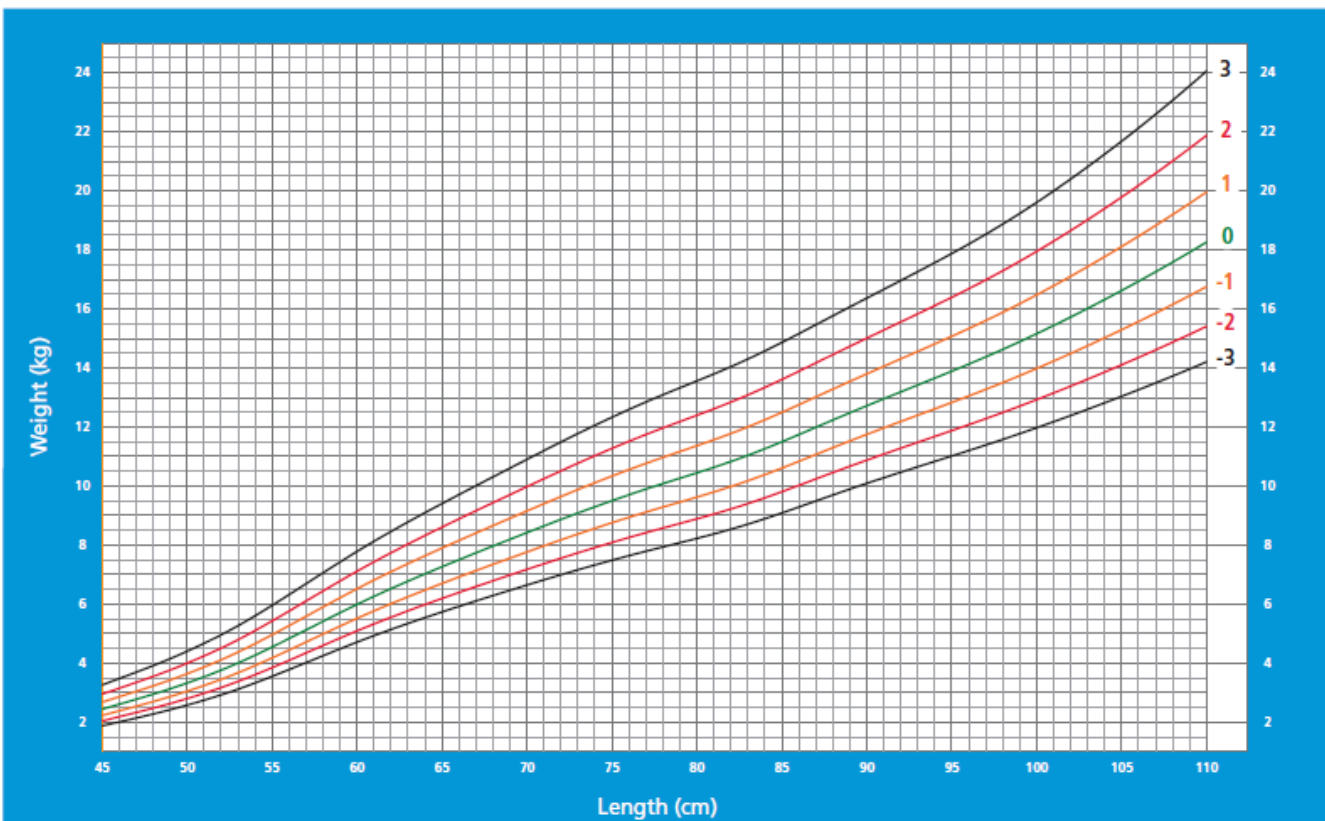
2 to 5 years (z-scores)



WHO Child Growth Standards

# Weight-for-length BOYS

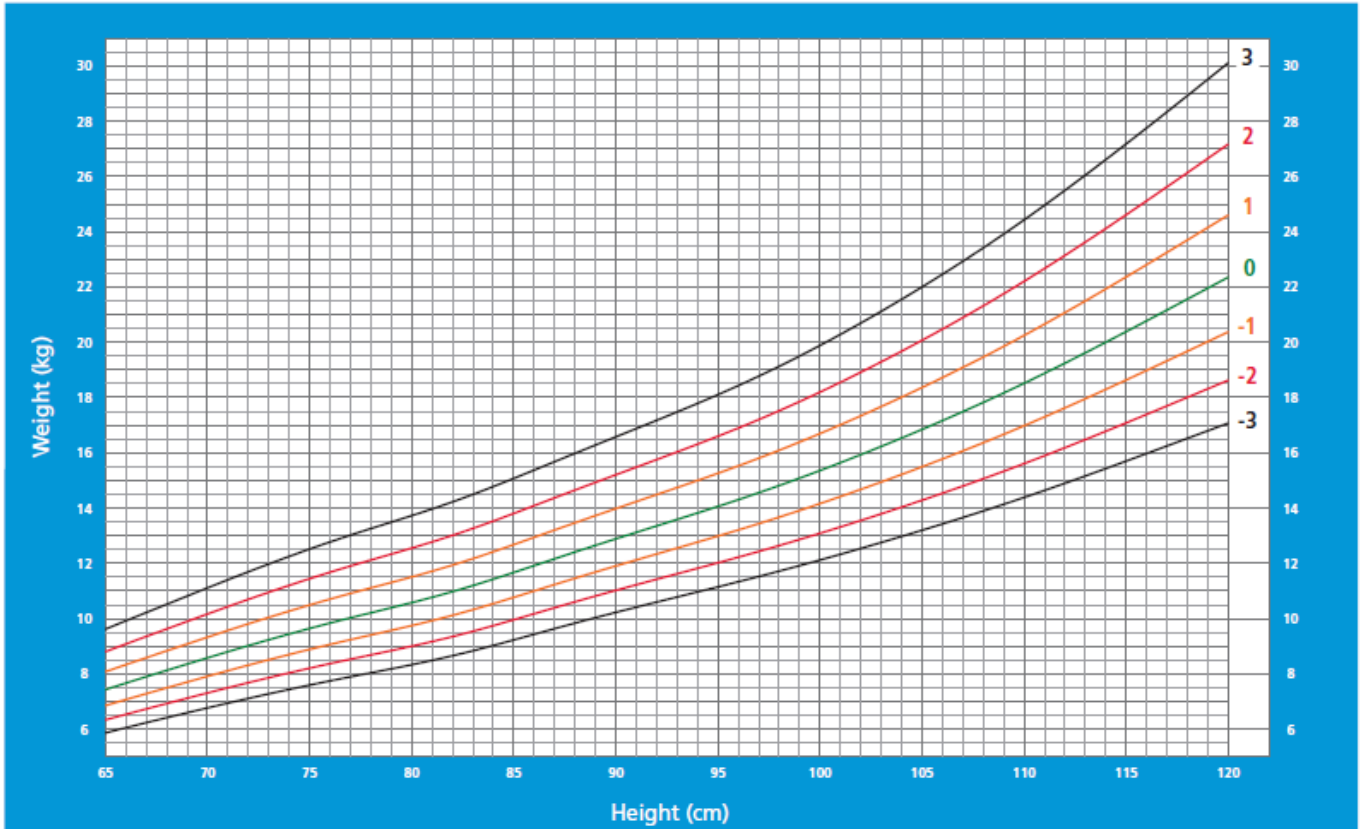
Birth to 2 years (z-scores)



WHO Child Growth Standards

# Weight-for-height BOYS

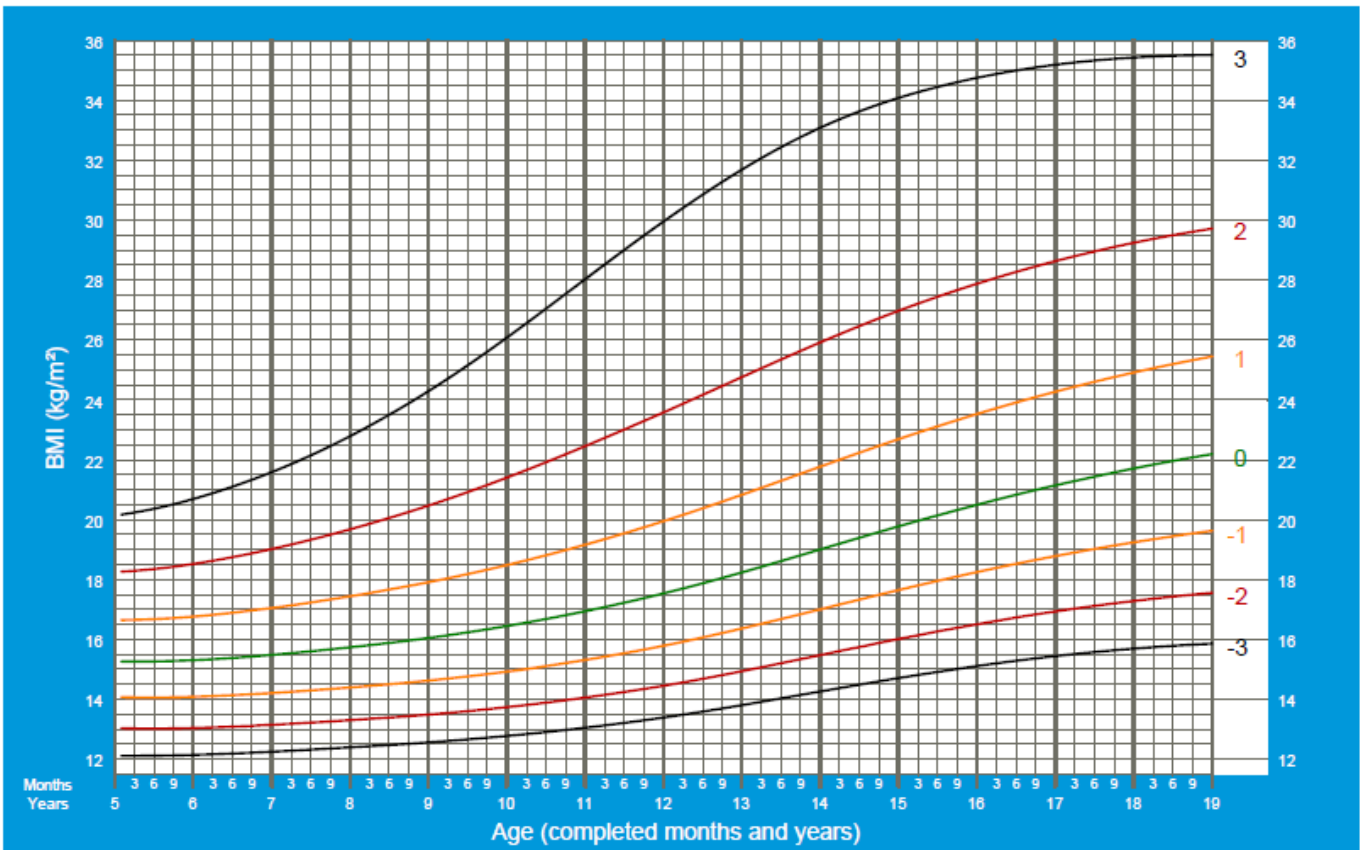
2 to 5 years (z-scores)



WHO Child Growth Standards

# BMI-for-age BOYS

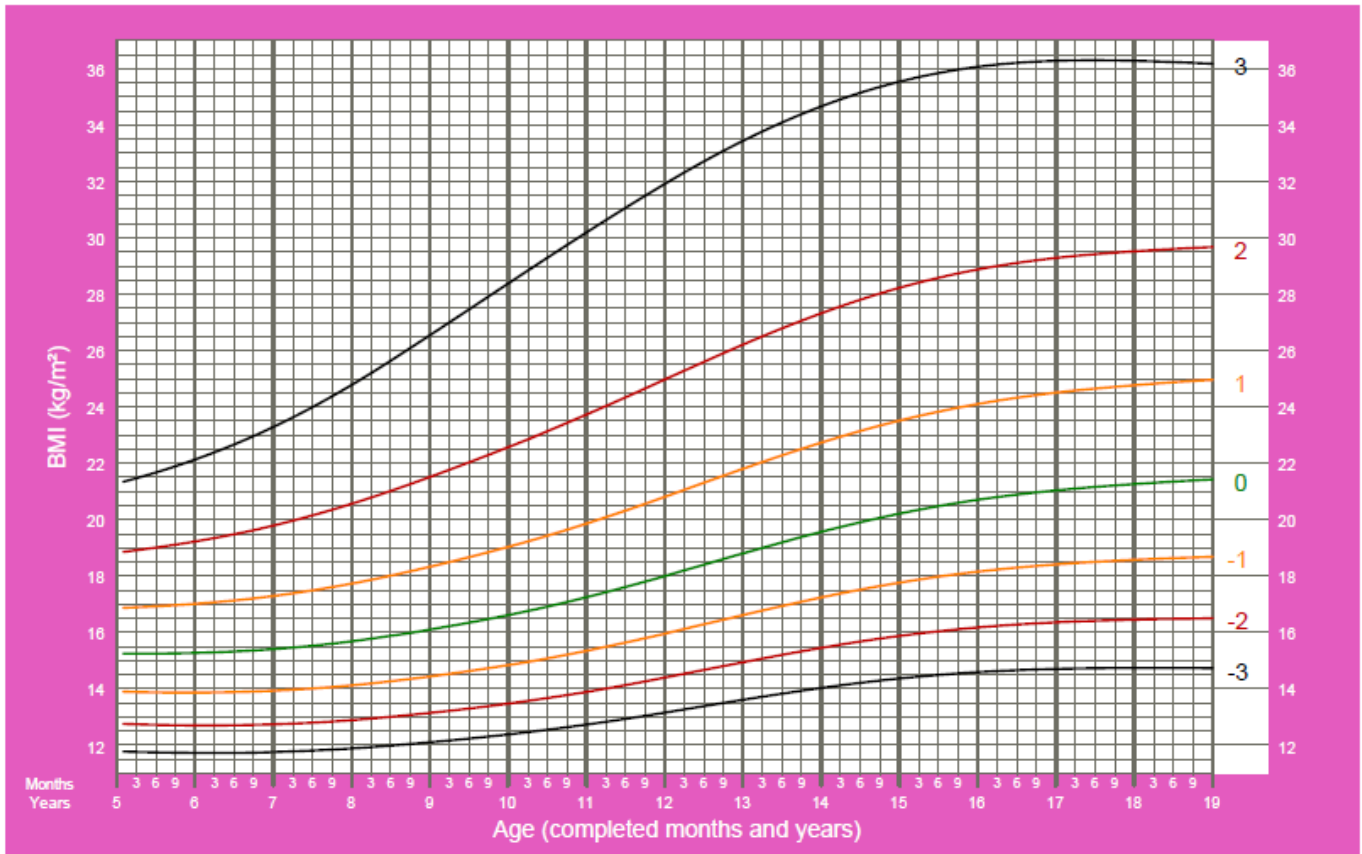
5 to 19 years (z-scores)



2007 WHO Reference

# BMI-for-age GIRLS

5 to 19 years (z-scores)



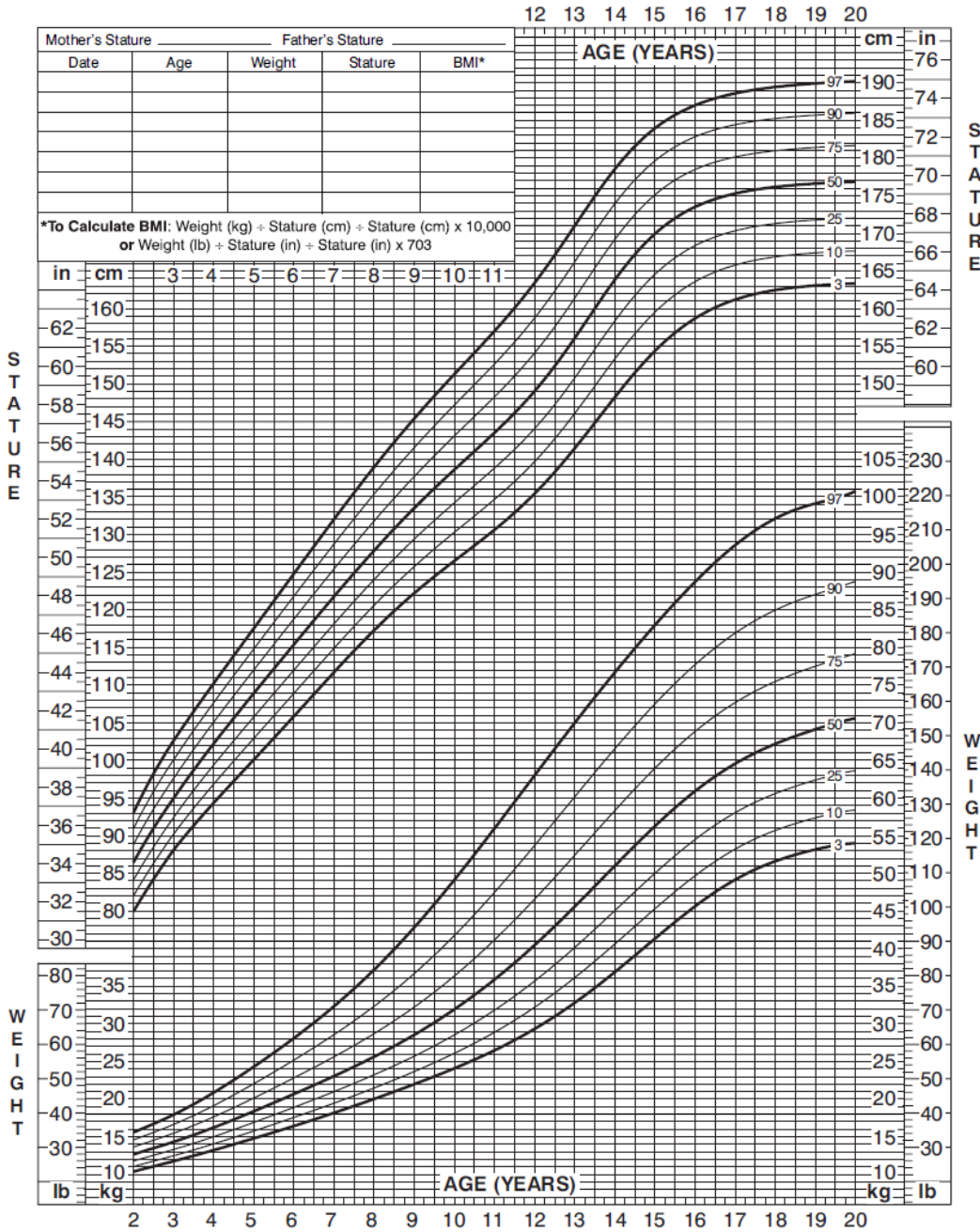
2007 WHO Reference

2 to 20 years: Boys

Stature-for-age and Weight-for-age percentiles

NAME \_\_\_\_\_

RECORD # \_\_\_\_\_



Published May 30, 2000 (modified 11/21/00).  
SOURCE: Developed by the National Center for Health Statistics in collaboration with  
the National Center for Chronic Disease Prevention and Health Promotion (2000).  
<http://www.cdc.gov/growthcharts>



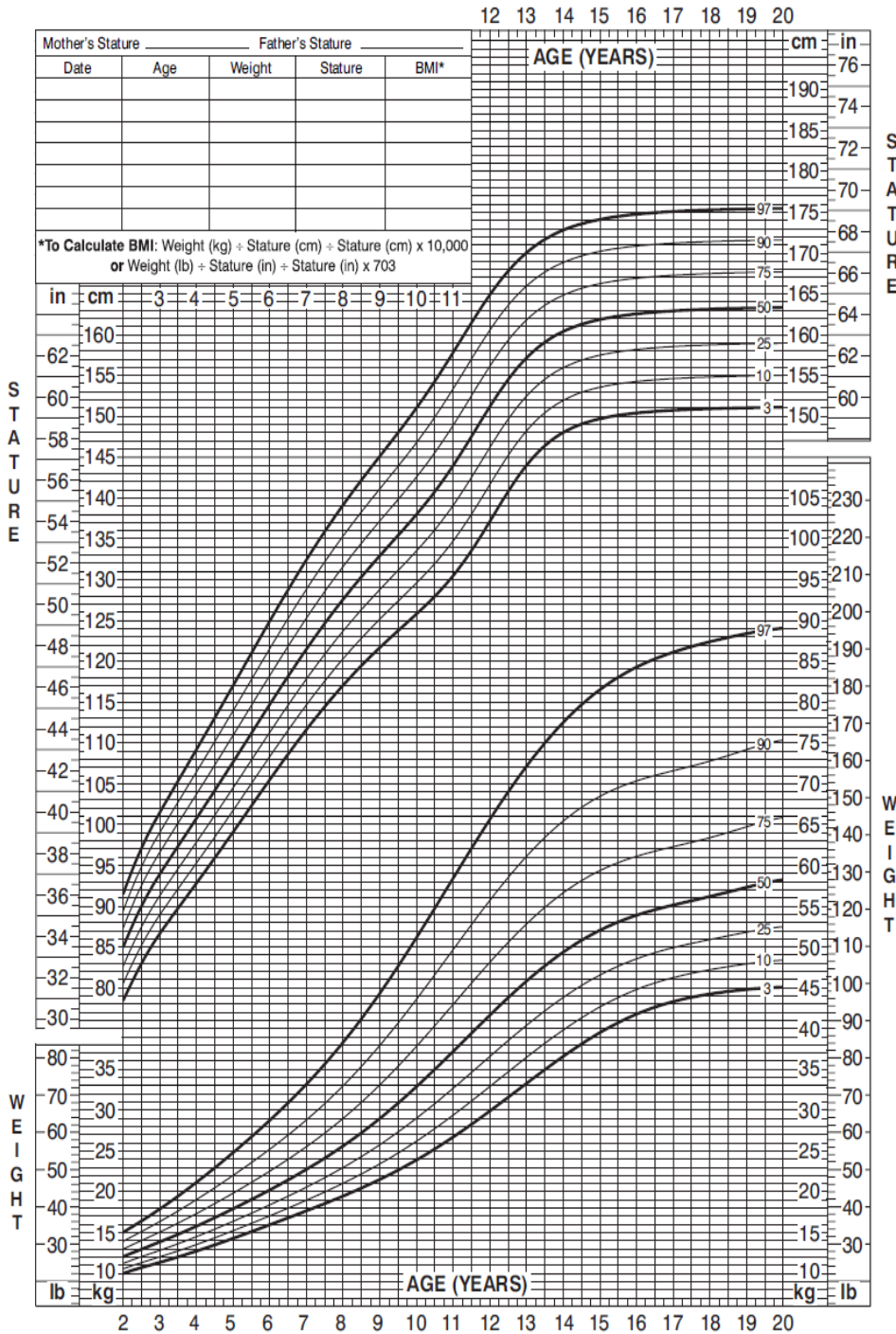
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2 to 20 years: Girls

NAME \_\_\_\_\_

Stature-for-age and Weight-for-age percentiles

RECORD # \_\_\_\_\_



Published May 30, 2000 (modified 11/21/00).

SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000). <http://www.cdc.gov/growthcharts>



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**Annexure 3: Predictive equations for resting energy expenditure (REE)**

Schofield equation for calculating RMR (kCal/d)		
Age	Male	Female
0 – 3 years	$(60.9 \times \text{kg}) - 54$	$(61.0 \times \text{kg}) - 51$
3 – 10 years	$(22.7 \times \text{kg}) + 495$	$(22.5 \times \text{kg}) + 499$
0 – 3 years	$0.167\text{ABW} + 1517.4\text{H} - 617.6$	$16.252 \text{ABW} + 1023.2\text{H} - 413.5$
3 – 10 years	$19.59\text{ABW} + 130.3\text{H} + 414.9$	$16.696\text{ABW} + 161.8\text{H} + 371.2$
10-18 years	$16.25\text{W} + 137.2\text{H} + 515.5$	$8.365\text{W} + 465\text{H} + 200.0$

Calculating RMR using WHO equation from weight		
Age	Male	Female
0 – 3 years	$(60.9 \times \text{kg}) - 54$	$(61.0 \times \text{kg}) - 51$
3 – 10 years	$(22.7 \times \text{kg}) + 495$	$(22.5 \times \text{kg}) + 499$
10 – 18 years	$(17.5 \times \text{kg}) + 651$	$(12.2 \times \text{kg}) + 746$
18 – 30 years	$(15.3 \times \text{kg}) + 679$	$(14.7 \times \text{kg}) + 496$

Physical activity factors	
Sleeping (ICU; sedation and muscle relaxation)	1.0
Hospitalised	
• Not ambulant	1.2
• Ambulant	1.3
At home	
• Relatively inactive	1.4
• Very active	1.9
Stress factors	
Trauma	
• Little (e.g. long bone fracture)	1.2
• Central nervous system	1.3
• Moderate to severe (multiple)	1.5
Sepsis	
• Moderate	1.3
• Severe	1.6

**DRIs: Acceptable macronutrient distribution ranges (% energy)**

	1-3 years	4-18 years
<b>Fat</b>	30-40	25-35
n-6 PUFAs (linoleic acid)	5-10	5-10
n-3 PUFAs ( $\alpha$ -linolenic)	0.6-1.2	0.6-1.2
<b>CHO</b>	45-65	45-65
<b>Protein</b>	5-20	10-30



## Annexure 4: Parenteral nutrition monitoring tool

Parenteral nutrition monitoring tool	Compliant	Non-compliant	N/A
• Is there a copy of the latest official edition of the parenteral nutrition guideline available in the unit?			
• Is there a nutrition support team (NST) in the facility (dietitian, pharmacist, surgeon, physician, parenteral nutrition, other)			
• The NST been trained on the parenteral nutrition guideline and standard operating procedures (SOPs)			
• Healthcare workers involved in CVC insertion been trained on CVC insertion, care and maintenance in central line-associated blood stream infection (CLABSI)			
• Appropriate trained nursing staff are ensured in intensive care units where nurses manage patients with central venous catheters (CVC's)			
<b>Storage/refrigeration</b>			
• Temperature of parenteral nutrition supplies maintained at less than 5°C			
• Stock rotation observed i.e. FIFO			
• Expired stock			
<b>Sterile technique</b>			
• Pharmacist, ward staff and dietitian trained in the use of sterile technique for handling of parenteral nutrition			
• Staff wash their hands before handling of parenteral nutrition			
• Hand wash facilities equipped with: <ul style="list-style-type: none"> <li>○ hand wash basin</li> <li>○ hot water</li> <li>○ antibacterial soap</li> <li>○ container for paper towels</li> <li>○ paper towels</li> <li>○ pedal bin or paper bin without lid</li> </ul>			
<b>Surveillance</b>			
• Daily culture and sensitivity testing for bacteria and fungi			
• Register for patients on TPN (pharmacy), i.e. name, registration number, age, date, time, signature of doctor, batch number			
<b>Insertion of catheter</b>			
• Is this done as a surgical procedure after scrubbing, gowning and gloving?			
• Operator, date and time of catheter insertion are recorded on a standardised form or register			
• Does the dressing allow easy observation of insertion site and surrounding tissues?			
• CVC insertion sites are examined every shift for tenderness at the site, fever with no obvious source, or other manifestations suggesting infection			
<b>Administration of solution</b>			
• Parenteral nutrition solution administered after X-ray to confirm the position of the catheter			
• The parenteral nutrition solution runs for 24 hours after which the remaining solution and giving set is discarded			
• There is a dedicated lumen for parenteral nutrition			
Other ports on the catheter are used for :			
• IV solutions or medications			
• blood or blood products			
• to measure CVP			
• Bag have a signed sticker indicating start and end time			
<b>Care of giving sets</b>			
• Giving sets changed every 24 hours and labelled with date it was changed			
• The extension set is clamped when changing the giving set, to prevent air embolus			
• Aseptic technique is used when changing parenteral nutrition bags and giving sets			
<b>Removal of the line</b>			
• Cut the distal end of the catheter with sterile scissors, place it in a sterile container and send for quantitative culturing at the laboratories			

<b>Change of dressing</b>			
• Aseptic technique observed for this sterile procedure			
• Keep records and reports of any skin appearance and inflammation			
• Catheter removed if any sepsis is present			
• If there is a suspected infection: <ul style="list-style-type: none"> <li>○ is the catheter tip sent for MCS?</li> <li>○ is a sample of the TPN from the bag sent for MCS?</li> <li>○ are blood cultures sent from a peripheral site?</li> </ul>			
<b>Nursing responsibilities</b>			
• The insertion site properly maintained to protect from infection			
• The catheter line kept dry and checked for leaks			
• The catheter insertion site inspected four-hourly and PRN and records kept			
• The catheter insertion site cleaned and a clean wound dressing applied under strict aseptic technique principles <ul style="list-style-type: none"> <li>○ Are records kept?</li> </ul>			
<b>Observations</b>			
• The patient weighed daily or weekly			
• Six-hourly vital signs observed: <ul style="list-style-type: none"> <li>○ Are any abnormal observations reported to the doctor and documented in the nursing process?</li> </ul>			
• Six-hourly glucose testing			
• The patient closely observed for signs and symptoms of any complications			
Records available Are the following records available?			
• Nursing care given			
• Date, time, site name of doctor inserting parenteral nutrition line			
• Type of parenteral nutrition solution put up and quantity administered			
• Change of: <ul style="list-style-type: none"> <li>○ parenteral nutrition solutions</li> <li>○ dressing</li> <li>○ insertion site</li> </ul>			
• Observations			
• Reported abnormalities to doctor e.g.: <ul style="list-style-type: none"> <li>○ abnormality</li> <li>○ date and time of report</li> <li>○ name and signature of reporting officer</li> </ul>			
• Biochemistry completed			
<b>Nutrition records</b>			
• Initial nutrition prescription (energy and protein) calculated by a dietitian and available in patient's notes			
• Nutrition prescription include: <ul style="list-style-type: none"> <li>○ total volume/kg/day</li> <li>○ rate (ml/hr)</li> <li>○ protein g/kg/day</li> <li>○ total kcal/kg/day</li> <li>○ glucose oxidation rate mg/kg/min</li> </ul>			
• Starting and weaning regimen			
• Daily review by dietitian			
• Daily documentation of nutrition orders			
• Baseline biochemistry: U and E, CMP, LFT, FBC – review by dietitian			
• Review of 2 x weekly biochemistry: U and E, CMP, LFT, FBC – review by dietitian			
• six-hourly glucose monitoring			
• parenteral nutrition prescription signed by a doctor			
• parenteral nutrition administered using a volumetric pump			

**Annexure 5: Summarised report of parenteral nutrition audit**

	<b>Comments and remarks</b>	<b>Recommendations</b>	<b>Proposed action</b>
Parenteral nutrition guideline			
Storage/refrigeration			
Sterile technique			
Surveillance			
Insertion of catheter			
Administration of solution			
Removal of the line			
Care of giving sets			
Change of dressing			
Nursing responsibilities			
Observations			
Records available			
Nutrition records			

**Signature of assessor:** \_\_\_\_\_

**Date:** \_\_\_\_\_



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