The Nutritional Management of Short Bowel Syndrome of Infants and Children

Pediatric Working Group
Western Cape
Red Cross Children's Hospital

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Review: 2009

Scope and Purpose

The Guidelines for Short bowel syndrome have been developed by the Western Cape Paediatric Nutrition Working Group in response to the need for evidence-based guidelines, with respect to the nutrition management of Short Bowel Syndrome.

The aim of this Guideline is to provide an evidence based nutrition management resource tool, which may be used by health professionals involved in the prescription and supply of nutrition support to infants or children with Short Bowel Syndrome.

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

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

Stakeholder Involvement

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

Table 1: Paediatric Working Group Members and Reviewers

	Principal Author	Affiliations
Full Time Members		
Luise Marino	♦ Refeeding Syndrome ♦ Total Parenteral Nutrition ♦ Liver Disease ♦ GORD	Department of Dietetics, Red Cross War Memorial Children's Hospital
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Rigour of Development

A Pubmed search was completed using key words such as “short bowel syndrome in children”. Table 1 was used to define the type of articles desired. 54 articles were identified using the key words. The search was narrowed to include papers graded as being 1+++ to 2+ levels of evidence. [If this was not available change to which ones were included and rationale – e.g. consensus papers etc.]

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

Grading	Level of evidence
1+++ Total: 6	High quality meta analyses, systematic reviews of RCT’s or RCT’s with very low risk of bias
1+ Total: 9	Well conducted meta analyses, systematic review of RCT’s or RCT’s with low risk of bias
1- Total: 0	Meta analyses, systematic reviews of RCT’s or RCT’s with a high risk of bias
2++ Total: 2	High quality systematic reviews of case controlled or cohort studies
2+ Total: 13	Well conducted case control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal
2- Total: 0	Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal
3 Total: 4	Non-analytical studies e.g. case reports, case series. Evidence from non analytical studies e.g. case reports, case series
4 Total:0	Evidence from expert opinion

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

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

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

This guideline has been reviewed by experts in their field.Comments received have been incorporated into the clinical guidelines.

This guideline will be reviewed in 2008 and updated accordingly.

Clarity and Presentation

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

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

Applicability

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

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

Editorial Independence

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

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Nutrition in the Pediatric Short Bowel Syndrome Patient

Summary of Nutrition Recommendations

1. Glossary

Term	Definition
DRVs	Dietary Reference Value
% EWA	Percentage estimated weight for age
% EHA	Percentage estimated height for age
% EWH	Percentage estimated weight for height
HA	Height age
WA	Weight age
WH	Weight for height
MUAC	Mid upper arm circumference Age/MUAC/Interpretation (6 months-14 years): a. Infants 06 – 12 months • < 110mm = moderate malnutrition • <115mm = severe malnutrition b. 1 yr – 5 years • < 110mm = moderate malnutrition • < 135mm = severe malnutrition c. 6 – 9 years • < 135mm = moderate malnutrition • < 155 mm = severe malnutrition d. 10 – 14 years • < 160 mm = moderate malnutrition • < 185 mm = severe malnutrition
MAC	Mid arm circumference
Schofield	Predicting estimated energy requirements (Addendum 7)
SD/WHO Classification of malnutrition	Standard deviation used to determine moderate and severe malnutrition • 0- < -1 SD =Normal • > -2 -- -3 SD = moderately • > -3 SD = severely malnourished
Waterlow criteria	Used to determine malnutrition: *Acute malnutrition: Weight/Height* • Normal WH > 90 % • Mild 81% - 90% • Moderately 70% - 80% Severely < 70% *Chronic malnutrition* • Normal > 95% • Mild 90% - 95% • Mild – moderately 85% - 89% • Severely < 85%
SGA	Small gestational age = < 10^{th} centile
LGA	Large gestational age = >90^{th} centile
AGA	Appropriate gestational age = 10^{th} – 90^{th}
GA	Gestational age
LBW	Low birth weight = 1.5 – 2.5kg
VLBW	Very low birth weight = 1.0 – 1.5kg
ELBW	Extreme low birth weight = <1.0kg
PN	Total parenteral nutrition
EN	Enteral nutrition
EBM	Expressed breastmilk

2. Summary of the nutritional care plan of infants and children with Short Bowel Syndrome

Anthropometry

Measure

Infants:

- Determine birth weight and gestational age
- Determine admission weight and length
- Daily weight check
- Weekly length check
- Weekly head circumference (< age of 3 years)
- MUAC (< age of 6 months - 145 years) to be done monthly

Children:

- Weekly weights
- Weekly heights
- MUAC

Calculate

- % EWA
- % EHA
- % EWH
- Plot head circumference
- Average weight gain since birth for infants (should be a minimum of 10 -20g/day)

Interpret

- Waterlow classifications (wasting and stunting)
- WHO classifications (Z- scores)
- Determine SGA, NGA, LGA
- Also determine LBW, VLBW, ELBW

(Refer to Anthropometry guideline for detailed information)

Biochemistry

Monitor the following	Interpretations
• Urea and creatinine (baseline and every 2nd day)	• Dehydration may be present with high urea
• Electrolytes: sodium, potassium, chloride (baseline and every 2nd day)	• Dehydration may be present if electrolytes are low
• Blood glucose (BG) (4 hourly)	• If low BG, insufficient glucose given or signs of sepsis
• Liver function tests: ALT, AST, GGT, Bilirubin (baseline and every 2nd day)	• Liver function tests needs to be monitor if receiving PN (refer to PN protocol)
• Full blood count: hemoglobin, MCV, WCC, platelets(baseline and every 2nd day)	• Hemoglobin is a growth factor, therefore should be monitored if low. Supplement with iron, folate or B12 according to MCV levels. • WCC and platelets indicator of sepsis

Clinical

Physiology of short bowel	Importance
• Amount of bowel resected	• Less 100cm requires nutritional intervention
• Area or sites of resections	• Ileum is capable of taking over functions of jejunum. Terminal ileum is important for vitamin B12 absorption and bile acids
• Presence of ileocecal valve (ICV)	• Helps with control of transit time and prevents retrograde movement of bacteria
• Presence of colon	• Helps with absorption of excess fluids and electrolytes and the fermentation of soluble fibre helps to provide extra energy, therefore need to promote closure or anastomosis of small bowel to colon as soon as possible.

Dietary

Nutritional Requirements

Diet history

Infants

- Choice of feed since birth till present?
- Has solids been started?
- What complementary foods are given?

Children

- Review through a 24 – 36 hour dietary recall

Importance

- To determine tolerance of various feeds or solids given
- Information can be used in determining nutrition care plan.

Energy • Infants (0 – 12 months)	**Calculations** *Total parenteral nutrition* *(refer to PN guideline for more catergories)* • Sick neonates (ventilated) = 90 kcal/kg/d • Non ventilated = 120 kcal/kg/d • Premature = 90 - 115kcal/kg/d • Infants = 80 – 100kcal/kg/d	**Calculations** *Enteral nutrition* • Premature infants = 110 kcal/kg – 130kcal/kg/d • Sick neonates = 110 kcal/kg/d • Infants = 120 kcal/kg/d
• Children (> 1 years)	• Children = 75 – 90kcal/kg/d	• Children = Schofield x 1.5 - 1.7
Protein • Infants (0 – 12 months)	**Calculations** *Total Parenteral nutrition* *(refer to PN guidelines for more detailed breakdown)* • Premature infants = 1.5g/kg – max 3g/kg/d • Term neonates = 2.5g/kg – 3g/kg/d • Infants = 2.0 g/kg – 2.5g/kg/d	**Calculations** *Enteral Nutrition* *(EAR or minimum 7.5% of total energy or 9% of total energy for catch-up growth)* • Premature infants = 3.4g/kg – 4g/kg/d • Infants = 2.5g/kg – 2.9g/kg/d • Maximum of 4g/kg/day
• Children (> 1 years)	• Children = 1g/kg – 2g/kg/d	• Children = 1.0 g/kg – 2.4g/kg/d
Carbohydrates • Infants (0 – 12 months)	**Calculations** *Total parenteral nutrition* *(refer to PN guidelines for detailed breakdown)* Premature • 8 - 12mg/kg/min glucose/day Term Infants: • Minimum 8 mg/kg/min glucose/day • Maximum 10 mg/kg/min glucose per day	**Calculations** *Enteral nutrition* • Premature = 7 – 20g/kg/d (± 40% of TE) • Infants 30 – 60 % total energy • Concentrations: standard- as not to increase the osmolality
• Children (> 1 year)	• Children 4- 5 mg glucose/kg/min /day	• Children 50% - 60% of Total energy
Fat • Infants (0 – 12 months)	**Calculations** *Total parenteral nutrition* *(refer to PN guidelines)* • Minimum of 0.5 – 1,0 g/kg needed to prevent essential fatty acid deficiency • Maximum of 3g/kg/day • Preterm = minimum 0.25g/kg/day linoleic acid • Term infants = minimum 0.1g/kg/day linoleic acid	**Calculations** *Enteral nutrition* • Preterms = 5.3 – 8.4g/kg/d (40 NPE) • Infants 30% - 50% of NPE • Minimum 3.8g/100kcal • Maximum 6g/100kcal
• Children (>1year)	• Children = minimum 0.1g/kg/day of linoleic acid	• Children 25 – 35 % of NPE

Micronutrients	Requirements	Adminstration
Fat soluble vitamins • Only to be supplemented if there is fat malabsorption	(Using Liver Failure guidelines for cholestatic diarrhea) **Vitamin A** • Plasma retinol/ RBP: 5, 000 – 10, 000 – 50, 000 IU **Vitamin E** • Plasma E/ total lipids: 25 IU kg/d ***or*** 50mg – 200mg/day • As d-alpha tocopheryl polyethylene glycol-1000 succinate: 2 – 10mg/d orally **Vitamin D** • Plasma 25 – OHD: 2 – 4 ug/kg/day ***or*** 50 ng/kg/day **Vitamin K** • Check prothrombin time and for coagulopathy • Only required if no colon present	Recommended fat soluble vitamin aqueous product: ADEK® ADEK® Dosage: ***Liquid*** • 0 – 12 months: 1 ml per day • 1 – 3 years: 2 ml per day **Tablet** • 4 – 10 years: 1 tablet per day • > 10 years: 2 tablets per day (Addendum)
Vitamin B12 • When the terminal ileum has been resected. • Or > 60% of the terminal ileum is resected.	**Vitamin B12** *(DRI/RDA)* • Infants = 0.4 – 0.5 μg/d • Children = 0.9 – 1.2 μg/d • Adolesence = 1.8 – 2.4μg/d	**Dosage :** 20μg/day for 7 days, then weekly, then every 2 months – 3 months. Injected either intramuscular or IV.
Zinc • Only to be given in the presence of diarrhea or poor weight gain.	**Elemental zinc requirements** **(***DRI/RDA***)** • Infants = 5mg/d • Children = 10mg/d • If poor weight gain = > 15mg/kg/d	Dosage of **Zinplex** (Addendum) (contains zinc picolinate and selenium): Infants = 5ml a day Children (2 – 4 years) = 10ml a day Children (4 – 6 years) = 15ml a day
Selenium • Deficiency can result from fecal losses[2,3]	**Selenium requirements** *(DRI/RDA)* • Infants = 10 – 15 μg/d • Children = 20 – 30 μg/d	**Zinplex** (as above**)**
Calcium • necessary if fat malabsorption is present.	**Calcium** *(DRI/RDA)* • Infants = 210 – 270 mg/d • Children = 500 – 800 mg/d	**Dosage:** Calcium Sandoz : 1 tab gives 500mg Calcium orally
Iron • Supplementation required when microcytic anemia is present.	**Iron** (elemental) *(DRI/RDA)* • Premature infants = 2 - 4 mg/d • Infants = 6 – 10 mg/d • Children = 10mg/d • Maximum 15mg/d	**Dosage:** Ferros salts 2mg/kg/ day elemental iron orally
Fluid	**Calculations** Premature • 180ml/kg - 200ml/kg actual body weight Infants • 150ml/kg Children • Age 1 –6 years = 90 - 100 ml/kg • 6 – 12 years = 60 – 70ml/kg	
Replacement fluids	• Given with every milliltre of fluid losses above normal losses (i.e 40 – 50ml/kg/day)[41] • **Type of fluid: Commercial Oral rehydration solution[3] or** • **WHO ORS[3]:** **1 litre of tap water add** **NaCl 2.5 g + KCl 1.5g + Na_2CO_2 2.5g +** **glucose (table sugar) 20g.**	

Nutritional procedures post surgery

1. Acute phase

Day 1 – 5 post surgical procedure (post op)
- Serves for patient stabilization
- Infusion therapy provided
- Total parenteral nutrition(PN) initiated

Supplements to be started:
- Butyrate
- Probiotics
- Glutamine

Day 0 post op:
- Pediatric maintenance solution started

Day 1 post op
- Initiate PN according Day 1 of the PN prescription sheet. (Refer to PN protocol)

Day 2 – 4 post op:
- Increase PN volume rate according to prescription sheet.
- Dosage of butyrate: 9mmol/L (presently unavailable)
- Probiotic 10^8 per day
- Dosage of glutamine: 0.5g/kg/d orally

2. Adaptive Phase

Day 5:
- Process that can take up to 1 - 2 years to occur
- Trophic feeding started
- Slow progression from PN to EN
- Initiate a trial of EN if bowel sounds are present and ostomy functional
- Start with 5 – 10ml/hr continuously (or 10-20ml/kg/d over 24 hours)

Choice of enteral feed
- Depends on the size and site of bowel left, the presence of the ileocecal valve (ICV) and presence of the colon.
- Close monitoring is necessary to determine tolerance of enteral feeds given.
- Progress to more hydrolysed enteral feed or full PN, if there is poor tolerance of feed.

1. **Small bowel of < 100cm, only jejenum + no ICV + no colon**
   - Breastmilk OR Elemental feed
2. **Small bowel of < 100cm + with ICV + no colon**
   - Breastmilk OR Semi elemental casein dominant feed
3. **Small bowel of < 100cm + with ICV + colon (but not in continuity)**
   - Breastmilk OR Semi elemental casein dominant feed
4. **Small bowel < 100cm + with ICV in continuity with colon**
   - Breastmilk OR Polymeric feed

Feed Advancement
- Monitor tolerance of feed before advancement, looking at

1. ostomy output,
2. stool output (i.e small bowel in continuity),
3. reducing substances,
4. dehydration,
5. gastric aspirates,
6. fecal osmolar gap.

- Tolerance of feed only to be reviewed once a day.
- Not more than one advance of feed rate in a 24 hour period.
- If there is good tolerance then to increase the feed by 5ml/hr (or 10-20ml/kg/d over 24 hour period).
- If not, then reduce rate or withhold feeds for 8 hours and then restart at previous rate.
- Once reached 50% of requirements via EN, to reduce PN in an isocaloric fashion.

1. Ostomy output	1. Ostomy output o If < 2g/kg/hr → advance 10 – 20ml/kg o If 2-3 g/kg/hr → no change and continue as before o If > 3g/kg/hr → reduce rate or withhold feeds ➢ OR if > 40 -50ml/kg/day (i.e normal output) then to reduce or hold feeds
2. Stool ouput (i.e. via rectum)	2. Stool output o If < 10g/kg/d or < 10 stools/d → advance feed o If 10 -20 g/kg/d or 10 – 12 stools/d → no change o If > 20g/kg/d or > 12 stools/d → reduce rate or hold feeds
3. Reducing substance	3. Reducing substances o If <1% (negative) → advance feeds o If = 1% (traces)→ no change o If > 1 %(positive)→ reduce rate or hold feeds
4. Dehydration	4. Dehydration o If signs are absent → advance feed o If signs are present → reduce rate or hold feeds and provide replacement fluids

5. Fecal Osmolar Gap (FOG) • Only done in patients with colon in continuity. • Only done in watery stools – a FOG cannot be done on soft stools.	5. Fecal Osmolar Gap (FOG) a. If stool osmolality is the same or greater than the serum, then a **secretory diarrhea** is present.Then recommend starting Octreotide. b. If stool osmolality is than 50mOsmo/l – 100mOsmol/l less than serum osmolality, then it is a **mild osmotic diarrhea**. Continue feeds and see. Check sugars in the stool. May need to stop feeds or change the carbohydrate content. c. If stool osmolality is over 100mmol/L less than serum osmolality, then it is a **severe osmotic diarrhea**.Stop all enteral feeds and increase PN to full requirements. Diarrhoea should decrease significantly. Reintroduce feeds slowly with glucose ideally as carbohydrate source.
6. Gastric aspirates	6. Gastric aspirates o If < 4 times previous hour's infusion of feed → advance feed o If > 4 times previous hour's infusion of feed → reduce rate or hold feeds
Medications[2,3,25] Recommendations by doctors. Used to help control transit time or any other common complications.	o Loperamide: antimotility agent. o Octreotide: used for secretory diarrhea/ slow down intestinal transit time o Cholestyramine: cholerheic diarrhea to bind bile acids o Clonidine: to help reduce excess fluid/ostomy losses o Broad spectrum antibiotics: used for small bowel bacterial overgrowth
3. Maintenance phase	
• Successful weaning from PN has occurred. • Enteral nutrition must continue for 12 months for intestinal adaptation. • Ongoing monitoring of tolerance of feed.	• Stop PN if meeting 75% of requirements with EN. • Continue with continuous 24 hour EN for at least another week. • Slowly progress to bolus feeding, by giving small 2 hourly oral feeds. • Monitor closely for tolerance of oral feeds, such as vomiting and any changes with stool/ostomy output. • If poor oral skills due to long term PN, pass NGT to give bolus feeds. First attempt orally, then pass rest of feed via NGT. • Refer to speech therapist to assist with oral skills.
Management of Complications	
Continue to monitor complications such as: 1. Bacterial overgrowth	Broad spectrum antibiotics to be given
2. Dehydration	• Correct all electrolyte imbalances • Use of WHO rehydration solution or commercial oral rehydration solution.
3. Micronutrient deficiencies *Refer to above dosage and indications*	• Fat soluble vitamins if fat malabsorption • Vitamin B12 if terminal ileum resected • Calcium Sandoz • Iron • Zinc picollinate • Copper if there is long term use of zinc.
4. Nutrient malabsorption	• Determine the Fecal osmolar gap (addendum) • If osmotic diarrhea then there is carbohydrate malabsorption • If a secretory diarrhea, consider the use of octreotide. • 3 day fecal fat will determine if there is fat malabsorption (steatorrhea) → consider semi- elemental feed (i.e MCT + LCT feed) OR • If on Neocate consider the use of MCTs as a bolus supplementation. • Fat supplementation should not exceed 5 – 6% concentration (5-6g/100ml) for Infants and 7% concentration (7g/100ml) for children.
Introduction of solid/complementary feed • Lactose and sucrose free diet (Addendum)	
Follow up/ Discharge • Regular follow up with dietitian, gastroenterologist, surgeon • Referrel to nearest clinic/ community health centre for Nutrition Supplementation Programme for nutritional support • Referrel to include a motivation letter • A dietitian should monitor any of the above mentioned complications. - Follow up on a monthly basis. - Diet history: lactose + sucrose free diet - Appropriate feed given - Necessary micronutrient supplementation eg. Vitamin B12 • Nutrition Supplementation Programme to include the relevant specialized feeds? Entry and exit criteria would apply according to how long a particular individual requires the specialized feed. • Motivation letter for individual patient to receive product from local clinic or via medical aid scheme if private member	

3. Introduction

Short bowel syndrome (SBS) is a global malabsorption syndrome that results from massive resections. The management of SBS is a multi stage process. Adequate therapy depends on the amount of small bowel resected as well as the site or areas that was resected.[2,3,21,39]

The main aim of the medical and nutritional management of these patients is to improve the adaptive process of the remaining bowel. The nutrition status of these children may be significantly compromised leading to malnutrition including stunting and wasting. Failure to thrive has also been documented in SBS pediatrics.[33]

The time period for each individual to reach adaptation varies depending on numerous factors. Therefore all therapeutic decisions needs to be measured in months and years rather not days and weeks. A multidisciplinary approach is required to ensure good growth is maintained and the adaptation phase is successfully managed.[21]

4. Short Bowel Syndrome (SBS)

4.1 Definition:

Short bowel syndrome is due to insufficient absorptive capacity resulting from massive small bowel resections. SBS may occur when more than 50% of small bowel has been resected or if less than 100cm of small bowel is left.[21]

In SBS there is loss of absorption function, inability to secrete gastrointestinal (GI) regulatory peptides, trophic hormones and loss of GI immune function. It is particularly more severe when there is resection of the ileocecal valve and if the colon is resected as well.[2,3,21,32,41]

Common causes of SBS in children include necrotising enterocolitis, malrotation and congenital aberrations such as gastroschisis. Medical therapy inclusive of dietary prescription depends on the degree of short bowel lost and the resulting functional disturbances.[2,3,21,32,41]

4.2 Incidence

The true incidence of SBS is unknown. However, data derived from patients receiving home PN indicate an incidence of severe SBS of 1-2 cases per 100 000 inhabitants per year.[21]

4.3 Physiology of the gastrointestinal tract

The physiology and functions of the gastrointestinal tract needs to be explained in order to adequately manage SBS.

The gastrointestinal tract is involved in the digestion and absorption of the nutrients ingested. It starts with the mouth following all the way through to the large intestine. Most of the vital nutrients are absorbed in the small intestine.[13]

The small intestine is completely formed by 20 weeks gestation age. It grows until 115 cm in length by 27 weeks gestation age and is approximately 250cm in length by full term gestation age. In contrast adult intestine is 600 to 800cm in length. The mucosal surface area in infants is 950cm^2 and 7500 cm^2 in adults.[13]

The small intestine is divided into 3 parts: the duodenum, jejunum and ileum. The duodenum is the site in which pancreatic enzymes are released.The main absorptive areas are the jejunum and the ileum. The jejunum absorbs a large amount of the digested nutrients because of its larger absorptive surface area. The resection of the jejunum does not cause severe malabsorption as the ileum is able to adapt and take on the functions of the jejunum. The functions of the gastrointestinal tract is outlined in Addendum 1.[37]

The ileoceceal valve is the site that connects the ileum to the large intestine. The ileocecal valves main function is to slow down the transit time of nutrients passing through into the large intestine. Also it

prevents any backflow of the contents and the high concentrations of bacteria found in the large intestine. Intact ICV is associated with better survival and adaptation rates.[13,29]

The “ileal brake” occurs when nutrients are exposed to the terminal ileum. Loss of this function results in gastric hypersecretions and accelerates small bowel transit aggravating diarrhea.[21,41]

Gastric emptying is significantly slower in patients with residual colon in continuity. The loss of inhibition on gastric emptying and intestinal transit inpatients without colon is related to a significant decrease in peptide YY(PYY), glucagon-like peptide 1 (GLP-1) and neurotensin. PYY is normally released from the L cells in the ileum and the colon when stimulated by fat and bile salts. Naturally these cells are missing if distal ileal and colon are resected.[2,3]

The large intestine is also important for further absorption of fluids and electrolytes. Microflora plays a role in the fermentation of carbohydrates to short chain fatty acids, which then can be use as an energy source. It is recommended that any significant portion of colon (e.g > 30%) remaining in SBS patients be re-anastomosed to the small intestine, either a primary or staged procedure.[29,30]

Patients can be grouped into 2 subgroups;

1. without a colon and
2. with an intact colon in continuity.

4.4 Intestinal Rehabilitation

Intestinal adaptation is the best option for patients with SBS. In humans, intestinal adaptation begins within 24-48 hours of resection and includes morphological and functional changes of the remaining bowel. [34] Also there are changes in the colonic production and absorption of short chain fatty acids, which improves the intestinal vitality and maximise efficiency of energy and fluid absorption.[30]

After massive small bowel resection, remaining bowel hypertrophies and becomes more efficient in nutrient absorption. This involves all layers of the bowel wall, and leads to dilatation, heightening and lengthening of the villi, deepening of the crypts and thickening of the remaining small bowel. There is also increasing rate of enterocyte proliferation, which all results in an increase absorptive surface area. The increase in mucosal mass can only occur if chyme is present in the lumen.[26]

This process may take 1 to 2 years to evolve. Several factors are involved in the functional adaptation process and the clinical outcomes. These include the presence or absence of the colon and the ileocecal valve, the length of the remaining bowel, the health of the remaining bowel and any comorbid conditions.[21,32,33,41]

The length of the remaining bowel required to prevent dependence on TPN is ~ 100cm in the absence of an intact and functional colon or 60 cm in the presence of a functional colon. However the degree of adaptation and TPN dependence may still be highly individualised.[32]

There is not much data in humans showing any hormonal involvement in adaptation, but in animal studies it is suggested that enteroglucagon, glucagon peptide II, epidermal growth factor, growth hormone, cholecystokinin, gastrin, insulin and neurotensin are all involved in adaptation.[34,3]

There are luminal nutrients that are also involved in the functional changes during intestinal adaptation.[46] These factors will be discussed later.

4.5 Predictors of mortality

The key predictors of mortality in SBS include cholestasis (conjugated bilirubin > 2.5 mg/dL), and the percentage of remaining small bowel length and the presence of ICV are the primary predictors of weaning PN. Data also shown that small bowel remnants less than 50cm correlated with catheter sepsis and bacterial translocation. Since these two factors may exacerbate cholestasis, reduced small bowel length may contribute indirectly to development of cholestasis.[33, 3]

5. Nutritional Management of Short Bowel Syndrome

5.1 Aims, goals and objectives

The main aim of nutritional management is to achieve intestinal adaptation of the remaining small bowel by providing the appropriate route and type of nutrition.

The main goals and objectives are to:

- Ensure sufficient nutrients, i.e energy and protein to promote growth of the infant or child.
- To monitor fluid and electrolyte imbalance,
- Prevent dehydration and provide the appropriate fluid replacements.
- To prevent any vitamin or trace element deficiencies associated with malabsorption.[2,3,21,32,41]

5.2 Anthropometry

- **Weight and height**

Measure

Infants:

- Determine birth weight and gestational age with the use of the Road-to-Health card.
- Daily weights to be done using the appropriate scale.
- Weekly lengths to be done, preferably with a board length measure.
- Weekly head circumference (< age of 3 years)
- Mid-upper arm circumference (< age of 5 years) and interpreted.

Children:

- Weekly weights and heights
- MUAC for ages less than 5 years.

Calculate

- Percentage expected weight for age, expected height for age and expected weight for height.
- Plot head circumference on appropriate growth charts.
- Average weight gain since birth for infants (should be a minimum of 10 - 20g/day)

Interpret

- Waterlow classifications (wasting and stunting)
- WHO classifications (Z- scores)
- Determine whether SGA, NGA, LGA
- Also determine LBW, VLBW, ELBW

Refer to Anthropometry guideline for more detailed description of techniques when doing measurements and interpreting the results.

5.3 Biochemistry

Monitor the following biochemistry values. If a child is failing to gain weight despite appropriate nutritional support, the following biochemical growth factors may be contributing and should be evaluated. All baseline bloods to be done before commencing PN and monitored according to the PN guidelines.

The following bloods needs to be checked at baseline and then every second day especially if parenteral nutrition is provided.

- Urea and creatinine:

Elevated levels may be an indication of dehydration.

- Electrolytes: sodium, potassium, chloride:

Low levels may be an indication of dehydration. Sodium levels should be corrected, as it is a growth factor.

- Blood glucose (BG):

If low BG, insufficient glucose might be given or it could be related to sepsis.

- Liver function tests: ALT, AST, GGT, Bilirubin:

Liver function tests needs to be monitor if receiving PN (refer to PN protocol)

- Full blood count: hemoglobin, MCV, WCC, platelets:

Hemoglobin is a growth factor, therefore should be monitored if low. Supplement with iron, folate or B12 according to MCV levels. WCC and platelets indicator of sepsis

5.4 Clinical

The nutrition care plan is largely based on factors related to the surgical resections of the small bowel, namely:

- Amount of bowel resected

Less 100cm requires nutritional intervention.

- Area or sites of resections

Ileum is capable of taking over functions of jejunum. Terminal ileum is important for vitamin B12 absorption and bile acids.

- Presence of ileocecal valve (ICV)

Helps with control of transit time and prevents retrograde movement of bacteria.

- Presence of colon

Helps with absorption of excess fluids and electrolytes and the fermentation of soluble fibre helps to provide extra energy, therefore need to promote closure or anastomisis of small bowel to colon as soon as possible.

5.5 Dietary

5.5.1 Nutritional Requirements

a) Energy

The following Table gives parenteral and enteral nutrition requirements. (Note: Refer to PN guidelines for more detailed catergories)[32,37,52]

Age	Energy requirements	
	Total Parenteral Nutrition	***Enteral Nutrition***
Infants (0 –12 months)	*(refer to PN guideline for more catergories)* • Sick neonates (ventilated) = 90 kcal/kg/d • Non ventilated = 90 - 110 kcal/kg/d • Premature = 90 - 115kcal/kg/d • Infants = 80 – 90kcal/kg/d	• Premature infants = 110 kcal/kg – 130kcal/kg/d • Sick neonates = 110 kcal/kg/d • Infants = 120 kcal/kg/d
Children (> 1 years)	• Children = 75 – 90kcal/kg	• Children = Schofield X 1.5- 1.7

For children above the age of one the Schofield height-weight equation with factor of 1.5 – 1.7 is recommended.[32,53,54] The Schofield height-weight equation is the most closely related to the indirect calorimetry in children (Addendum 7).[53,54]

b) Protein:

Protein requirements are as follows[32,37,52,54]:

Age	Protein Requirements	
	Total Parenteral Nutrition	***Enteral Nutrition***
Infants (0 –12 months)	*Total Parenteral nutrition (refer to PN guidelines for more detailed breakdown)* • Premature infants = 1.5g/kg – max 3g/kg/d • Term neonates = 2.5g/kg – 3g/kg/d • Infants = 2.0 g/kg – 2.5g/kg/d	*(EAR or minimum 7.5% of total energy or 9% of total energy for catch-up growth)* • Premature infants = 3.4g/kg – 4g/kg/day • Infants = 2.5g/kg – 2.9g/kg/d • Maximum of 4g/kg/day
Children (> 1 years)	• Children = 1g/kg – 2g/kg/d	• Children = 1.0 g/kg – 2.4g/kg/d

c) Fluid
Fluid maintenance requirements vary with age and are typically used to determine the PN fluid amounts.[52]

Table : Fluid requirements

Age group	Amounts
• Premature infants	180 ml/kg – 200ml/kg actual body weight
• Term infant	150ml/kg
• Children (1-6years)	90 – 100ml/kg
• Children (6 – 12 years)	60 – 70ml/kg

Enteral nutrition calculations can also be used with these baseline requirements but replacement fluid losses are added above these amounts.

Replacement fluids are given to replace high output losses. Oral rehydration solution should be used as a replacement fluid (eg. commercial products or WHO rehydration containing sodium concentration of 75 – 90mEg/L). The amount of fluid given is a 1:1 ratio for every millitre of losses above the acceptable/ normal range i.e 40 –50 ml/kg.[3]

WHO Oral rehydration solution formula:[2,3]
- In 1 litre of tap water add
- NaCl 2.5g
- KCl 1.5g
- Na_2CO_2 2.5g
- Glucose 20g (table sugar)

d) Carbohydrates requirements [32,37,52]

Age	Carbohydrates Requirements	
	Total Parenteral Nutrition	***Enteral Nutrition***
Infants (0 –12 months	*Total parenteral nutrition* *(refer to PN guidelines for detailed breakdown)* Premature • 8 - 12mg/kg/min glucose/day Term Infants: • Minimum 8 mg/kg/min glucose/day • Maximum 10 mg/kg/min glucose per day	*Enteral nutrition* Premature • 7 – 20g/kg/d (± 40% of TE) Infants • 30 – 60 % total energy • Standard concentrations so not to increase the osmolality
Children (> 1 years)	Children • 4- 6 mg/kg/min glucose/day	Children • 50% - 60% of Total energy

e) Fat requirements[32,37,52]

Age	Fat requirements	
	Total Parenteral Nutrition	***Enteral Nutrition***
Infants (0 –12 months)	*Total parenteral nutrition* *(refer to PN guidelines)* • Minimum of 0.5 – 1,0 g/kg needed to prevent essential fatty acid deficiency • Maximum of 3g/kg/day • Preterm = minimum 0.25g/kg/day linoleic acid	*Enteral nutrition* • Preterms = 5.3 – 8.4g/kg/d (40 NPE) • Infants 30% - 50% of NPE • Minimum 3.8g/100kcal • Maximum 6g/100kcal
Children (> 1 years)	Term and older children = minimum 0.1g/kg/day of linoleic acid	• Children 25 – 35 % of NPE

f) Micronutrients[32]

The following micronutrients outlined in the Table are the common deficiencies found in SBS. There are no specific requirements for pediatric SBS, therefore at this stage have used Recommended Daily Allowances (RDA) or Dietary Reference Intakes (DRI). Guidelines for fat malabsorption, taken from the chronic liver failure clinical guideline.

Micronutrient	Administration And Indications	RDA or DRI amounts	
		Infants	**Children**
Fat soluble vitamins: **Vitamin A** **Vitamin E** **Vitamin D** **Vitamin K**	*Indications* • Only if fat malabsorption is present. • Available fat soluble vitamin aqueous product: ADEK® *Requirements taken from Chronic Liver Failure Guideline:* **Vitamin A** • Plasma retinol/ RBP: 5, 000 – 10, 000 – 50, 000 IU **Vitamin E** • Plasma E/ total lipids: 25 IU kg/d ***or*** 50mg – 200mg/day As d-alpha tocopheryl polyethylene glycol-1000 succinate: 2 – 10mg/d orally **Vitamin D** • Plasma 25 – OHD: 2 – 4 ug/kg/day ***or*** 50 ng/kg/day **Vitamin K** • Check prothrombin time and for coagulopathy *Administration:* ADEK® Dosage: (Addendum) – *Liquid* 0 – 12 months: 1 ml per day 1 – 3 years: 2 ml per day – Tablet 4 – 10 years: 1 tablet per day > 10 years: 2 tablets per d	**Vitamin A** • 375 μg RE **Vitamin E** • 4mg α TE **Vitamin D** • 5 μg	**Vitamin A** • 400 – 500 μg **Vitamin E** • 6 – 7 mg α **Vitamin D** • 5 μg
Vitamin B12	• Given intramuscular • Dosage : 20μg/day for 7 days, then weekly, then every 2 months – 3 months.	• 0.4 – 0.5 μg	• 0.9 – 1.2 μg
Zinc	• Only to be used if poor weight gain and diarrhea present • Product: Zinplex (zinc piccolinate) Zinplex contains **zinc picolinate**, **selenium** amino acid chelate and vitamin C (Addendum) • Dosage: Infants = 5ml a day Children (2 – 4 years) = 10ml a day Children (4 – 6 years) = 15ml a day	• 5mg • if poor weight gain give > 15mg/kg/day	• 10mg
Selenium		• 10 –15 μg /d	• 20 – 30 μg/d
Calcium	• Calcium Sandoz • 1 tab = 500mg calcium orally	• 210 – 270mg	• 500 – 800mg
Iron	• Ferrous salts • Dosage: Ferros salts 2mg/kg/ day elemental iron orally	• Prems 2 –4 mg • Infants 6 –10mg	• 10mg (max 15mg)

5.5.2 Nutritional procedures

The nutritional management of SBS involves 3 phases, namely:[21]

1. **Acute phase**
2. **Adaptation phase**
3. **Maintenance phase**

5.5.2.1 Acute phase

- This occurs directly after the resection of the small bowel.
- General lasts less than 4 weeks
- This phase serves for patient stabilization.

On Day 0 post surgery:

- Given infusion therapy (e.g. pediatric maintenance solutions).

Day 1 post surgery

- PN is started and serve as the sole source of energy needs for the growth of the infant or child.
- PN is prescribed because during this phase there is massive loss of fluids, which is not only due to insufficient absorption of nutrients, but also may be aggravated by other physiological mechanisms such as:
  - ✓ Massive gastric hypersecretions
  - ✓ Malabsorption of bile acids
  - ✓ And loss of the 'ileal brake' mechanism
- Therefore in addition to PN, gastric acid secretion inhibitors are given to reduce the intraluminal fluid load.
- In severe cases somatotrophin- analogue octreotide can be given as well.

Day 2 – 4 post surgery:

- Initiate PN according to PN prescription sheet: Day 1: 1.5g/kg protein/lipid followed by Day 2 of 2.5 – 3g/kg protein/lipid
- Supplements to be prescribed: butyrate, probiotic (10^8) and glutamine (0.5g/kg/day orally)

a) Parenteral Nutrition (PN)
(Refer to PN guidelines for details)

PN has been the gold standard practice in the treatment for infants and children who are unable to eat or to absorb enterally provided nutrients. This has caused a change in the prognosis of SBS patients as well as the management. The expected survival rates of infants with congenital gastrointestinal anomalies and gut failure have improved significantly. PN is used to allow for the growth of infants while intestinal adaptation is being achieved.[21]

Composition of PN
Refer to PN guidelines

Complication of PN

Long term PN is associated with complications such as sepsis, occlusion, breakage or thrombosis of the central venous catheter as well as hepato-biliary complications. Liver failure can result and has been shown to be the largest cause of death in infants with SBS.[46] In order to reduce these complications every attempt should be made to establish enteral nutrition in the adaptation phase as soon as possible.

Table : Steps to reduce the risk of PN-Associated cholestasis[51]

Method	Comments
• Avoid overfeeding • Cycle PN off at least 2 – 6 hours per day • Aggressively treat and prevent infections • Promote early enteral nutrition	• 90 – 100 kcals/day especially for less than one year of age. • promotes cyclic release of gastrointestinal hormones • meticulous central venous catheter care; treat bacterial overgrowth • ultimate goal of therapy.

The duration of PN for SBS patients depends on the length of residual small bowel and whether the ICV is present. Study shown that with a length of less than 40cm would remain dependent on TPN. Patients who had a residual small bowel length of 57cm with 80% having ICV had a TPN duration of 16 months.[17]

5.5.2.2 Adaptation phase[2,3,21,41,51]

- Depending on each individual, a trial of enteral nutrition can be started on day 4 or 5 postoperatively.
- The patient should be hemodynamically stable and has passed stool or a functional stoma.
- This phase could last up to 1 – 2 years.
- This is the time that maximal absorption capacity needs to be achieved.
- Enteral feeding is only initiated once ileus has resolved and bowel sounds have returned.
- Enteral nutrition is given gradually at small volumes to determine the level of tolerance of the gut.
- Start with 5 – 10 ml/hr given continuously over a 24 hours until goal rate of EN is achieved.
- Feed advancement depends on the tolerance of feed determined by monitoring the ostomy or stool output and what is present in the stool.
- The volume of the enteral feeds is gradually increased as parenteral feedings are decreased in an isocaloric fashion.

Choice of enteral feed
- Depends on the size and site of bowel left, the presence of the ileocecal valve (ICV) and presence of the colon.
- Close monitoring is necessary to determine tolerance of enteral feeds given.
- Progress to more hydrolysed enteral feed or full PN, if there is poor tolerance of feed
- Breastfeeding if first choice of feed. Alternatively if there is:

a) Small bowel of < 100cm, only jejenum + no ICV + no colon
- **Breastmilk OR Elemental feed**

b) Small bowel of < 100cm + with ICV + no colon
- **Breastmilk OR Semi elemental casein dominant feed**

c) Small bowel of < 100cm + with ICV + colon (but not in continuity)
- **Breastmilk OR Semi elemental casein dominant feed**

d) Small bowel < 100cm + with ICV in continuity with colon
- **Breastmilk OR Polymeric feed**

- PN is continued during this time to provide the calorie requirements of the patients. Only once full enteral nutrition is established will PN be discontinued.

- Continuos enteral nutrition is preferred over bolus administration to assist with better absorption as the release of nutrients are much slower.
- Oral feeding should still be attempted, at the appropriate age, to prevent any food aversion.

a) Enteral Nutrition (EN)

Enteral Nutrition (EN) is the key to successful management of SBS. The choice of feed, when to start and how quickly to increase rate of the feed are important decisions to make in the long-term management of children with SBS.

Three aspects of enteral nutrition may play a role in the process of intestinal adaptation[21,41].
1) The presence of food in the gut lumen
2) The complexity of the diet
3) The presence of specific luminal nutrients.

Enteral Nutrition Composition

The choice of feed is based on the macronutrient make up of the feed that will allow for maximal intestinal adaptation.

Complex enteral formulas provide the greatest intestinal adaptation. However the increased intestinal permeability and disrupted mucosal barrier, certain nutrients are not tolerated well.

a) Protein

Infants with SBS often have an increased epithelial permeability to food antigens as a result of possible bacterial overgrowth, poor motility or a dilated gut. Therefore infants with SBS are likely to develop an allergic response to any protein in the formula. As a result hypoallergenic formulas are preferred during the first year of life to reduce the risk of allergic injury to the gut.[35,39,40,41]

Type of hypoallergenic feed, which is clinically lactose free is, Alimentum (Abbott). This is a casein dominant, peptide based formula.

To further lessen the risk of an allergic reaction, and amino acid formula can be used, for example, Neocate (Nutricia, SHS). Therefore hydrolyzed or elemental diets would be the preferred choice of feed if no breast milk is available, more so in those infants with massive resections.[8]

The use of semi-elemental feeds has been the common practice for the last 25 years for SBS, without any supportive scientific evidence. A comparison made between nonhydrolyzed protein and hydrolyzed protein formula had similar effects with respect to intestinal permeability, weight gain and nitrogen balance in children. Also complex diets are better tolerated and more palatable. It may also stimulate the bowel to faster adaptation than a semi elemental diet[24].

The American Gastroenterology Association position statement also discusses whether peptide based diets are needed. Studies mentioned in the review, explain that there is no difference in the absorption of nutrients when using a peptide based diet compared to a polymeric standard diet. However the data is based on older children and adult studies that had small sample sizes and heterogenous study populations. [3] Infants, in comparison, do not tolerate a complex formula, especially during the first year of life and more so if there has been damage to the gastrointestinal tract.[31]

Recommendations for neonates and infants is to encourage breastfeeding, but if unable to initially use an amino acid –based formula such as Neocate and then gradually progress to a more complex formula containing casein hydrolysate and then a standard intact protein, once over the age of one.[22]

b) Fats

Long term survival after bowel resection is highly dependant on the process of mucosal adaptation. The process is dependent on enteral nutrition, which contains luminal nutrients that provide stimulation for intestinal adaptation.

Certain lipids, especially polyunsaturated fatty acids (PUFA) from marine oil, are highly trophic to the small intestine. Its mechanism of action is presumed to involve the stimulation of peptide YY release.[12]

Arachdonic acid (AA) and dehexonoheic acid (DHA) added to the diet of animals with SBS, had an increase in mucosal adaptation in a dose dependent manner. The results observed were primarily in the ileum, probably because of its greater capability for adaptation than the duodenum or the jejenum.[23]

AA appears to be a potent stimulator of adaptation, more so than its precursor linoleic acid. The possible reason is because AA is a substrate for prostaglandins metabolism and prostagalandins may be important in regulating gut adaptation.[40]

Medium chain fatty acids (MCTs) are more water soluble than long chain fatty acids (LCTs). They do not require digestion prior to absorption, offering a significant absorptive advantage to the individual with limited mucosal surface area. But long term outcome of SBS patients is dependent on the degree of mucosal hyperplasia than absorption capabilities.

Mucosal adaptation occurs to a lesser degree when a high percentage MCTs are used.[42,31] LCTs has shown to stimulate certain trophic hormones in the distal bowel. Mucosal weight changes were found predominantly in the distal bowel, when LCTs were given. There is also an improvement in the mucosal function following LCT feed, which animal studies have demonstrated. There is enhanced leucine uptake in the distal bowel and enhanced sucrase activity in the proximal bowel.[42] This study further showed an improvement in weight gain with LCT feeds, which they concluded could be related to the overall improvement in the absorption of the nutrients.[42]

MCTs have been prescribed when the assimilation of dietary LCT is diminished. A reduction in steatorrhea has been taken as the clinical argument for this treatment and emphasis has been placed on the more rapid absorption of MCT in the small bowel. However, research indicates that MCTs are only of benefit if the colon is in continuity with the small bowel. Otherwise will increase the output of ostomy losses due to the high osmolality. In addition to this, MCTs have been shown to decrease the absorption of other nutrients such as protein and carbohydrates in patients with jejenostomy or ileostomy.[19] In addition, excess intake of MCTs may result in nausea, vomiting and ketosis.[2,3]

MCTs are absorbed in the colon because of its water soluble characteristic in contrast to the lipophilic LCTs. MCTs are more dense source of energy, and are not associated with gas production, therefore may be useful in optimising enteral energy absorption in SBS patients, but only with a preserved colon.[2,3]

The choice of fat would then depend on whether there is fat malabsorption and a colon present. Only if this is fat malabsorption present would a feed consisting of both MCT and LCT be of benefit. If the infant is on a predominant LCT feed, need to consider additional MCT supplementation if steatorrhea is present. Otherwise to continue with a predominant LCT feed.

c) Carbohydrates

As a result of gut resections there is a lack of mucosal dissacharides. Sucrose and lactose are commonly poorly tolerated due to the loss of brush border enzymes, lactase and sucrase.
This is associated with osmotic diarrhea.

Glucose is easily absorbed, but has a significantly higher osmolality, increasing water and electrolyte losses. Low osmolality glucose polymers or starch which can be digested by some preserved enzyme maltase are preferred.[37]

High carbohydrate diets produce an osmotic load on the gut and causing osmotic fluid losses via the ostomy.[40] Prescribing diets high in carbohydrates would not be of benefit for SBS without continuity with colon.

Children remain intolerant to excessive carbohydrates as simple sugars, when solids are started. This was particularly noted over festive seasons.[40] More protein and fat should be encouraged with less vegetables and fruits. Only larger and varied amounts of vegetables and fruit are allowed when a complex enteral formula has started at 2 years of age.

Carbohydrate malabsorption can occur in SBS, but would be of limited importance if the colon is intact, as the bacteria present helps to ferment the 80% of the carbohydrate not absorbed to short chain fatty acids. This would then contribute energy or fuel for enterocyte and colonocytes.[2,3,21]

d) Micronutrients

The most common micronutrient deficiencies are the fat soluble vitamins, such as, vitamin A, D and E, since steatorrhea is a common complication of SBS. Vitamin K (60%) is synthesized by the colonic bacteria, therefore supplementation would not be necessary if the colon is present.[2,3] Water soluble vitamins are less likely to occur, except vitamin B12 if the whole or > 60% of the terminal ileum as been resected. Folate supplementation would be required if proximal jejunum has been resected.[2,3]

Trace metal deficiencies such as zinc and calcium are also common.[38,40] Patients with SBS lose a significant amount of zinc and selenium in their feces.[2,3] Zinc deficiencies has shown to be related to growth abnormalities, delayed wound healing ad cellular immunity dysfunction. Selenium deficiency has been related to cardiomyopathy, peripheral neuropathy, proximal muscle weakness and pain.[2,3]

Magnesium (Mg) can be lost in jejenal or ileal effluent. Patients may have still magnesium deficiencies despite having normal serum levels. Therefore it is important to measure 24 hour urine Mg losses.[2,3] Magnesium deficiencies are difficult to treat because enterally administered magnesium salts results in osmotic diarrhea.

Calcium deficiency can occur as unabsorbed fatty acids in the small bowel could bind to calcium, forming calcium soaps. This decreases the intraluminal availability of calcium resulting in high levels of unbound oxalates being absorbed. This makes SBS patients at risk for hyperoxaluria and calcium-oxalate kidney stones.[2,3]

Patients with a colon incontinuity should restrict oxalate containing foods, especially if there is steatorrhea. In addition a low fat diet and a calcium supplementation should be considered to prevent the formation of renal stones.[27]

b) Type of Enteral Nutrition

1. Breastmilk

Breastmilk is the superior choice of feeding due to numerous epithelial growth factors present particularly in the colostrums[29].

The use of breastmilk has shown a shorter duration of PN in patients with SBS. The mean duration of TPN in those who received breastmilk was 290 days vs 720 days in the non breastfed infants.[4]

Breastmilk contains high levels of IgA, nucleotides, leukocytes and other components that boosts the neonates immature immune system. Other factors found as well in breastmilk to assist with intestinal adaptation are:

i. Long chain fatty acids
ii. Free amino acids including glutamine
iii. Growth factors such as growth hormone and epidermal growth factors

Breastmilk also provides a protective colonic bacterial flora. Lactoferrin, a glycoprotein found in high concentrations in breastmilk, delivers iron to the intestinal epithelium, stimulates proliferation and differentiation of the crypt cells, influences brush border enzyme activity and functions as a scavenger for iron to prevent free radical – mediated tissue damage.[31]

2. Semi elemental formulas

A semi elemental feed is defined as a nutritional complete and has the protein hydrolysed to peptides. The fat content is made up of both LCTs and MCTs.The choice of semi elemental feed should be casein dominant feed, to ensure that the feed is completely lactose free. The available semi elemental feeds are for :

- Infants, Alimentum (Abbot) and for
- Children (> 1 year) is Peptamen Junior (Nestle)

Refer to addendum for nutritional content of the above feeds.

3. Elemental formulas

An elemental feed is defined as a nutritional complete with the protein hydrolyzed to amino acids. The fat content is predominantly made up LCTs. It is lactose free.The available elemental feeds are:

- Infant formula available is Neocate (Nutricia,SHS)
- Children feed (> 1 year) is Neocate Advance (Nutricia, SHS)

Refer to addendum for nutritional content of the above feeds.

c) Feed Advancement

The main principles to follow with feed advancement are[51]:

1. Principle 1: Quantify feeding intolerance primarily by stool or ostomy output and secondarily by reducing substances.
2. Principle 2: Tolerance assessed no more than twice a day in a 24 hour period. Not more than one feed advance in a 24 hour period.
3. Principle 3: If good tolerance advance feeds by 5-10ml/hr or 10 –20ml/kg over a 24 hour period.
4. Principle 4: Isocaloric reductions in PN support should be undertaken simultaneous with feeding advancement.

Factors to monitor tolerance of enteral nutrition[51]:

1. Stool output (i.e via rectum):
   - If < 10g/kg/d or < 10 stools/d → advance feed
   - If 10 -20 g/kg/d or 10 – 12 stools/d → no change
   - If > 20g.kg.d or > 12 stools/d → reduce rate or hold feeds

2. Ileostomy output
   - If < 2g/kg/hr → advance 10 – 20ml/kg
   - If 2-3 g/kg/hr → no change and continue as before
   - If > 3g/kg/hr → reduce rate or hold feeds
   - OR if amount of the ileostomy output > 40 -50ml/kg/day then to reduce or hold feeds[41]

3. Stool reducing substances
   - If <1% (negative)→ advance feeds
   - If = 1% (traces)→ no change

   If > 1 % (positive)→ reduce rate or hold feeds

4. Signs of deydration
   - If signs are absent → advance feed
   - If signs are present → reduce rate or hold feeds

5. Fecal Osmolar Gap (FOG):

The FOG helps to determine more clearly what kind of diarrhea is present by determining the electrolyte and water in the stool that has not been reabsorbed by the colon.

- If stool osmolality is the same or greater than the serum, then a **secretory diarrhea** is present. Octreotide is recommended to reduce this output.
- If stool osmolality is less than 50mmol/L less than serum osmolality, then it is a **mild osmotic diarrhea**. Recommendations are to continue feeds and monitor sugars in the stool. May need to stop feeds or change the carbohydrate content.
- If stool osmolality is over 100mmol/L less than serum osmolality, then it is a **severe osmotic diarrhea**. All enteral feeds are to be stopped and the PN to be increased to reach full requirements. Diarrhea should decrease significantly. Reintroduce feeds slowly with glucose ideally as carbohydrate source.

6. Gastric aspirates
   - If < 4 times previous hour's infusion of feed → advance feed
   - If > 4 times previous hour's infusion of feed → reduce rate or hold feeds

Other factors to monitor:

- Ensure requirements are being met via PN, EN or oral feeds.
- Those with intact colon, to check frequency and consistency of stools.
- Carbohydrate and pH content of stool / ostomy losses is also helpful.
- A pH of less than 5.5 is indicative of carbohydrate malabsorption.
- Weekly weight checks and
- blood values of electrolytes, urea and creatinine to be done weekly if output is more than than normal i.e 40 – 50 ml /kg/day.[41]

5.5.2.3 Maintenance phase

- Having established intestinal adaptation and successfully weaned off TPN, permanent nutritional maintenance therapy is required.
- PN should be discontinued if 75% of the nutritional requirements are met with EN
- The time frame depends on how quickly full EN is achieved. EN must ideally continue for 12 months to achieve intestinal adaptation.
- Slowly progress to bolus feeding, by giving small 2 hourly oral feeds.
- Pass NGT if oral feeds poorly tolerated. First attempt orally, then pass the remaining feed through NGT.
- Refer to speech therapist if there is poor oral skills.
- Ongoing involvement of medical nutrition team is needed as nutrient deficiencies states are more likely to present without TPN. Chronic complications may cause set backs in the enteral feeding tolerance.

a) Complications of SBS

1. Bacterial overgrowth

Small bowel bacterial overgrowth (SBBO) is a common complication of short bowel syndrome. Normal bacterial counts vary from 10^3 organisms/ ml proximally to much higher counts in the distal small bowel.[12]

These bacteria are inhibited by gastric acid in the gastrointestinal tract and the peristalsis helps to prevent retrograde reflux of bacteria below. SBBO is therefore common because in SBS there is loss of motility, slow transit and patients are on acid suppression therapy. SBBO should also be detected if ileocecal valve is absent.

SBBO causes inflammation to the gut, thereby limiting nutrient transport and damages the absorptive surface; aggravating stool losses.

Bacteria could also compete with the host for vitamin B12 and other nutrients. Gastrointestinal losses could also occur. Symptoms of SBBO are; cramps, bloating and diarrhea.

Diagnoses of SBBO can be confirmed by aspiration and culture of small bowel fluids. D-lactase levels could also be measured which are greatly elevated in children. Hydrogen breath test can also be used, but difficult to interpret if it is small or large bowel.

Oral antibiotic therapy is the first method of treatment. Sulfasalazine or other immunosuppressions can be given if SBBO has caused colitis.[12]

2. Diarrhea and malabsorption

Another complication of short bowel syndrome is high output as a result of intestinal failure. Further investigations need to be made to determine what kind of diarrhea is present, that is, if it is a secretory or osmotic diarrhea, and if any malabsorption may be present. This helps to direct the medical or nutritional management of the large output.

Determining the fecal osmolar gap (only those with intact colon) will define whether it is secretory or osmotic diarrhea. If the value is the same as serum osmolality, then it is defined as a secretory diarrhea and a value above 100mmol/L would be an osmotic diarrhea. If secretory diarrhea is present the necessary drug therapy would be required. In the case of an osmotic diarrhea, the choice of enteral nutrition needs to be evaluated. (Refer to addendum 4)

Steatorhea can occur especially if the terminal ileum has been resected. Measuring a three day fecal fat will help to define if fat malabsorption is present. At this stage a semi elemental feed with both MCTs and LCTs would be of benefit. Fat soluble vitamin supplementation would vital if steatorrhea is present

3. Dehydration

Water absorption occurs as a passive process with different rates in different areas.
The duodenum and jejunum are the major sites of water absorption in the small bowel because the mucosa is relatively more permeable to water. In contrast the ileum has smaller pores, and is more restrictive to water movement. The upper part of the small bowel plays an important role in water

absorption after a hypotonic meal, whilst the lower part is more important after a hypertonic meal.[26] Tolerance to enteral nutrition will depend upon site of resection.

If there is poor tolerance to enteral nutrition, it is likely an increased in stoma output will be seen, resulting in fluid and electrolyte imbalances. If not monitored and corrected, dehydration will occur. Excessive fluid and electrolyte ostomy losses need to be replaced based on the measured volume and the electrolyte content of these secretions with the use of a separate fluid and electrolyte solution.[31]

Recommendation as a replacement fluid is the World Health Organisation (WHO) rehydration fluid or the commercial oral rehydration solution.[3] The formula for the WHO oral rehydration solution is as follows:

- ✓ In 1 litre of tap water add
- ✓ NaCl 2.5g
- ✓ KCl 1.5g
- ✓ Na_2CO_2 2.5g
- ✓ Glucose 20g (table sugar)

Replacement fluids to give for every milliliter of losses above normal losses (i.e 40 -50 ml/kg/day)

b) Introduction of oral feeding or solids

- Solids should be encouraged in the infants (> 6 months) to avoid food aversions.
- This allows for the development of the infants oral skills, so that when bowel adaptation has occurred there are no behavioral hindrances.
- Complementary feeding should be high in fat and low simple carbohydrates.
- No lactose or sucrose should be given during this phase (Addendum 5).

6. Medical Therapy

1) Drug therapy

Absorption of nutrients as well as symptoms resulting from malabsorption can be improved by drugs acting on various levels. Therefore the rationale treatment approaches of SBS often include the combination of drugs which influence gut secretory and motor functions.[21]

- Loperamide and codeine act on opiate receptors and slow intestinal transit.
- Octreotide is a somatostatin analogue which strongly inhibit not only gastric acid therefore strongly reduce intraluminal fluid load.[2,3] Octreotide is recommended when secretory diarrhea is present.

However octreotide may inhibit bowel adaptation, therefore it should only be used for patients with large stool output.[12]

- Cholestyramine is effective in cholerheic diarrhea through binding of bile acids. But need to be cautious with those who have steatorrhea as it could worsen fat malabsorption.
- Broad spectrum antibiotics can be used for the treatment of bacterial overgrowth.
- Clonidine: an α_2-adrenergic receptor agonist used to reduce intestinal fluid and electrolyte losses. Adult study showed that use of clonidine reduced the ostomy output from an average of 4litres to 1.5litres.[25]

7. Growth factors for intestinal adaptation

9.1 Glutamine

Glutamine(amino acid) is the main fuel for enterocytes and is also a substrate for the synthesis of nucleic acids.[28]

Glutamine helps to prevent mucosal atrophy and deterioration on the gut permeability in patients receiving only PN. Some studies, however, shown no difference in terms of fluid or sodium retention. Also no difference in the small bowel morphology, transmit time, D-xylose absorption or stool output was seen.[12]

Recommended dosage 0.5 g/kg/day of glutamine.

9.2 Growth hormone (GH)

GH is a single chain polypeptide consisting of 191 amino acids. Exogenous administration of this hormone has been shown to increase colonic mass, enhance sodium and water absorption in the small and large intestine, increase amino acid transport by enterocytes, and promote mucosal hyperplasia after extensive small bowel resection in animals.[30]

Studies have shown that the treatment with GH increased energy absorption, macronutrient absorption, body weight, lean body mass and D-xylose absorption. Plasma citrulline levels were not increased following the therapy suggesting that the improvements were not related to an increase in enterocyte mass. Rather it been speculated that the improvements were related to an enhanced functional adaptation at the enterocyte level.[12]

However more recent studies have shown that treatment of GH alone is not as effective if given in combination with glutamine and a modified diet. There has been an increase in the calorie, protein, carbohydrate, water and sodium absorptive efficiency with a decrease in stool output[30.] Another study showed a reduction in PN when also given the combination of GH, glutamine and optimal diet.[11]

9.3 *Probiotics*

Probiotic bacteria, even in the absence of prebiotics, are capable of stimulating growth of the mucosa in the lower gastrointestinal tract. It helps provide fuel for enterocytes by fermenting short chain fatty acids. The short chain fatty acid also promotes sodium and water absorption and suppresses colonic propulsive motility, thereby reducing diarrhea.[7]

Recommendation: Culture of 10^8

9.4 Fibre and Short chain fatty acids (Butyrate)

Insoluble fibre (eg. wheat bran) causes bulking of the stool and leads to a decrease in the whole transit time, whereas soluble fibre (eg. pectin. guar gum) slows gastric emptying and overall gut transit resulting in a mild antidiarrheal effect.

Soluble fibre is water soluble and found primarily in the following (in descending order of concentration), oatmeal, oat bran, psyllium, barley, atichokes, strawberries, legumes, prunes, grapefruit and squash.[2,3]

Soluble fibre is also fermented by bacteria in the gut to yield short chain fatty acids (including butyrate, proprionate and acetate).[2,3,12] The colon is a capable of absorbing nutrients with an energy content of up to 540kcal (in adults) resulting from one bacterial metabolism of carbohydrate to short chain fatty acids.[27]

Supplementation of enteral nutrition with pectin improves adaptation of the remaining gut. Short chain fatty acids, butyrate particularly, shown to be a potent promoter of intestinal adaptation. Animal studies further shown that enteral supplementation with butyrate leads to intestinal food digestion and absorption during SBS, possibly because of improved intestinal adaptation.[48]

Supplementation of short chain fatty acids to PN reduces PN induced atrophy and stimulates both structural and functional aspects of intestinal adaptation after surgical resections. There is evidence to support that systemic short chain fatty acid and dietary fiber stimulate the secretion of the intestinotrophic hormone peptide glucagon-like peptide-2 (GLP-2). A dosage of 9mmol/L butyrate has shown to be responsible for the increases in structural indices of adaptation compared to acetate and propionate. Butyrate enhanced the intestinal structure (i.e crypt- villus architecture), especially in the residual ileum.[6]

Thus supplementation PN with butyrate would be of beneficial to infants with SBS, maximizing their absorptive area, thereby enabling these infants to successfully transition to enteral feedings.

8. Follow up and Discharge Procedures

- A dietitian should monitor any of the above mentioned complications.
  - Follow up on a monthly basis.Diet history: Lactose and sucrose free diet.
  - Ensure Calcium supplement prescribed.
  - Appropriate feed given
  - Necessary micronutrient supplementation eg. Vitamin B12
  - Ensure that all medications and supplements are sucrose free.

- Nutrition Supplementation Programme to include the relevant specialized feeds?
- Motivation letter for individual patient to receive product from local clinic or via medical aid scheme

9. Conclusion

Most infants and children with SBS have a good prognosis if effective nutritional and medical therapy is provided for intestinal adaptation. Careful attention to detail and close monitoring for complications, deficiencies and acute changes in the clinical course is the key to optimal care of SBS patients.

Addendum 1:
Table: Nutritional content of infant (0-1yr) formulas and breastmilk per 100ml

	Breastmilk	Alimentum	Neocate
		Semi elemental	elemental
Energy (kcal)	67	67	71
Protein (g) Protein source	1.2	1.86 Hydrolyzed casein	1.95 Amino acid
Fat (g) Ratio n6:n3 %MCT %LCT	3.6	3.75 50 50	3.5 10:1 5 95
Carbohydrate (g)	7.4	6.9	8.1
Minerals Calcium (mg) Phosphorous (mg) Magnesium (mg) Iron (mg) Zinc (mg) Manganese (mg) Copper (mg) Iodine (μg) Sodium (mg) Potassium (mg) Chloride (mg) Selenium (μg) Chromium(μg) Molybdenum (μg)	 35 0.1 15 60 43 15	 70.9 50.7 5.07 1.22 0.5 0.05 0.5 0.1 29.8 79.8 54.1 1.22	 49 35 5.1 1.05 0.75 0.06 0.06 7 18 63 43.5 1.65 1.5 2.14
Vitamins Vitamin A (μg RE) Vitamin D (μg) Vitamin E (μg TE) Vitamin K (μg) Vitamin C (mg) Thiamin (mg) Riboflavin (mg) Vitamin B6 (mg) Vitamin B12 (μg) Niacin (mg) Folic acid (μg) Pantothenic acid (mg) Biotin (μg) Choline (mg) Inositol (mg)		 203IU 30.4IU 2.03IU 10.14 6.1 0.04 0.06 0.04 3.04 0.91 10.1 0.5 3 8 3.4	 79 1.3 0.5 3.2 6 0.06 0.09 0.08 0.19 0.68 6 0.4 3.9 7.5 15
Osmolarity (mOsm/kg water)		370	360

Addendum 2

Table: Nutritional content of feeds for 1-10years

	Peptamen Junior	Neocate Advance	Pediasure Fibre
	Semi elemental	elemental	polymeric
Energy (kcal)	100	100	100
Protein (g) Protein source	3 hydrolyzed whey	2.5 amino acid	2.8 80% casein + 20% whey
Fat (g) Ratio n6:n3 %MCT %LCT	3.9 5:1 60 40	3.5 4:1 35 65	4.97 20 80
Carbohydrate (g)	13.8	14.6	10.9
Minerals Calcium (mg) Phosphorous (mg) Magnesium (mg) Iron (mg) Zinc (mg) Manganese (mg) Copper (mg) Iodine (μg) Sodium (mg) Potassium (mg) Chloride (mg) Selenium (μg) Chromium(μg) Molybdenum (μg)	 92 61 12 1 1 0.051 0.08 8 66 135 81 2.5 2.5 3.5	 50 39 12.5 0.62 0.5 0.05 0.06 7 60 117 92 2.5 1.25 3.5	 56 53 16 1 1 0.1 100 10 60 110 100 2.8 2.5 4
Vitamins Vitamin A (μg RE) Vitamin D (μg) Vitamin E (μg TE) Vitamin K (μg) Vitamin C (mg) Thiamin (mg) Riboflavin (mg) Vitamin B6 (mg) Vitamin B12 (μg) Niacin (mg) Folic acid (μg) Pantothenic acid (mg) Biotin (μg) Choline (mg) Inositol (mg)	 150 IU 40 IU 1.5 IU 4 8 0.06 0.08 0.08 0.15 0.6 20 0.3 1.5 25	 37 0.81 0.58 3.5 3.3 0.06 0.08 0.08 0.07 0.95 10 0.25 2 19.2	 45 1 1.5 4 5 0.15 0.2 0.1 0.2 1.2 15 0.3 5 15 4
Osmolarity (mOsm/kg water)	360	610	345

Addendum 3: Management of Short Bowel Syndrome

Goal: To ensure that each patient with Short Bowel Syndrome attains/ maintains an optimal nutrition status.

To read the chart: Follow the arrows

Start Here

Assess patient using the following approach:
- A = Anthropometry
- B = Biochemistry
- C = Clinical
- D = Dietary
- Implement nutrition support where appropriate

Small bowel length of < 100cm
OR massive resection of small bowel

Phase 1: Acute phase (1 – 4 days)
Initiate PN:
- Day 1: 1.5g/kg protein/lipid;
- Day 2: 2.5 – 3g/kg lipid protein

Fluid management:
- Day 1: 100 mls/kg;
- Day 2: 150 – 170ml/kg day 2

Supplements
- Butyrate: ideally, but presently not available
- Probiotics: 10^8 daily
- Glutamine: 0.5g/kg/day orally

Start Enteral Feeds > day 4
- Start small enteral feeds e.g. 5 – 10ml/hr continuously until goal rate is achieved.
- Tolerance assessed not more than once x day
- Only one rate advancement in a 24 hour period.
  If tolerated well, increase feed by 2ml/hr or 10 – 20 ml/kg over 24 hour period
- Monitor stomal output if this exceeds > 50ml/kg. Hold feeds for 8 hours, then restart at previous rate..
- If stool output increases following the incremental increase reduce rate to previous increment for 24 hours.
- Once reached 50% total energy with EN, reduce PN accordingly still meeting energy & protein requirements

Choice of enteral feeds: **In infants the feed of choice is always BREASTMILK**

- **Only Jejenum**
- **No Ileocecal Valve**
- **No Colon**

Phase 2: Adaptation
- Start with Breastmilk
- Or if unavailable **elemental feed** [Free amino acids, LCT, maltodextrin]

Continue with supplements including:
- MVT [sugar free syrup]
- Zinc supplementation
- Vitamin B12
- Appropriate drug therapy:

- **Ileocecal Valve present**
- **Colon absent OR**
- **Colon present but not in continuity e.g. end small bowel stoma**

Phase 2: Adaptation
- Start with Breastmilk
- Or if unavailable containing **semi-elemental feed** [casein based, maltodextrin, MCT & LCT]

Continue with supplements including:
- MVT [sugar free syrup]
- Zinc supplementation
- Vitamin B12
- Appropriate drug therapy:

- **Ileocecal valve present**
- **Colon present in continuity e.g. end anastamosis to terminal ileum.**

Phase 2: Adaptation
Standard Polymeric feed
- Start with Breastmilk
- Or if unavailable standard polymeric feed.

Phase 3: Maintenance
- Ongoing monitoring of tolerance of enteral nutrition.
- Stop TPN, once 75% TE met with EN
- Ideally breastfeeds or specialised milks in those with SBS should continue for 1 year to allow for intestinal adaptation.
- Slowly progress to bolus oral feeding, by giving small 2 hourly feeds.
- Monitor tolerance of bolus feeds oral feeding, such as vomiting.
- Give bolus NGT feeds if there is poor oral skills.
- First attempt orally and rest passed through NGT.
- Refer to speech therapist if poor oral skills.
- Solids (lactose free diet) can be started at appropriate age.

Follow up/Discharge
- Schedule a monthly follow up with dietitian
- Motivation to supply specialized feeds to local clinics or via medical scheme for private member.

Monitor tolerance of EN:
- ***If Stool output : > 40 – 50 ml/kg*** reduce rate and provide 8 hours of bowel rest.
- ***Stool consistency & frequency:*** watery, green, mucoid, turn nappy to plastic side if watery diarrhoea is suspected to be able to quantify consistency.
- ***FOG (osmotic or secretory diarrhea);*** secretory diarrhoea manage with octreotied, osmotic if on polymeric feed try semi elemental, if on semi elemental or elemental provide PN with 10 days of bowel rest. NB: Elemental feeds should not be given to manage diarrhoea as they have a high osmolality.
- ***Low electrolytes:*** replace with ORS
- ***Daily weight:*** >20 – 30g/day < 1 year and 10g/day in > 1 year.
- ***Fat malabsorption:*** send 3 day faecal fat
- Reducing substances: presence if on polymeric provide semi elemental, if on semi elemental or elemental provide 10 days bowel rest with PN
- ***pH of stool:***
- Gastric aspirate: if more than 4 x previous hours infusion; withhold feeds for 12 hours

Addendum 4

Fecal osmolar Gap (FOG)

1. Assume plasma osmolality is 290 mOsmo/L.
2. Calculate stool osmolality:2 x stool (Na + K) subtract the figure calculated from 290mOsmol/L.
3. The Gap is made up by non-absorbed carbohydrate particles e.g. watery stool.
4. A FOG cannot be done on soft/ mucoid stools

Secretary Diarrhoea

1. If stool osmolality is the same or greater than the serum e.g. 290mOmol/l, then a secretary diarrhoea is present.
2. Stop feeds and consider the use of Octeotride in addition to TPN – in consultation with GIT Consultant.

Mild Osmotic Diarrhoea > 50 – 100 mOsmol/L

3. If the difference between the stool osmolality is between 50 - 100mOsmo/L, then it is a mild osmotic diarrhoea.
4. Continue feeds but may need to change the carbohydrate content e.g. lactose and sucrose free.

Severe Osmotic Diarrhoea > 100 mOsmol/L

5. If the difference between the stool osmolality is more than 100mOsmol/L, there is severe osmotic diarrhoea.
6. Stop all oral feeds.
7. As a result the diarrhoea should decrease significantly.
8. Consider providing bowel rest with TPN for 10 – 14 days.
9. Reintroduce feeds slowly using lactose and sucrose free feed, containing a maltodextrin polymer or glucose as the carbohydrate source e.g. a semi elemental feed.
10. If diarrhoea recurs recheck FOG and the presence of sugars in the stool via chromatography.

Addendum 5
Minimal Lactose and Sucrose diet

- Lactose is the sugar in cow's milk. All milk and milk products must be excluded from the diet.
- Sucrose is cane sugar, which includes white, brown, caramelised, castor and icing sugar.
- Food containing these products must be excluded from the diet.
- Some vegetables and fruit also contain sucrose and should be avoided.
- Always read lables carefully. Avoid the food if it contains any of the forbidden foods.

Food Type	Foods allowed	Foods to Avoid
Dairy products	• Only the prescribed infant formula OR • Age appropriate lactose free milk product	• Cow's milk: fresh, long life, evaporated, condense milk, Yoghurt, flavoured • Milkshakes, ice cream • Avoid products containing whey, milk solids, casein • Avoid products containing sucrose like Coffee-mate
Meat, Fish , Poultry	• All fresh or frozen meat, chicken, fish • Eggs (only from 1 year of age)	• Canned meat, meat and fish pastes • Sausages, fish fingers • Bacon and ham
Pulses and legumes	•	•
Vegetables	• most vegetables, except →	• potatoes • parsnips, carrots • peas, onions • sweet potato • sweetcorn,beetroot
Fruits	• only fruits containing less than 1g/100g, like • grapes • lemons • pears • raisins • strawberries **Note: Stop if causes diarrhea**	• **Most of fruits to be avoided for at least 2 months, then reintroduced one at a time, starting with the low sucrose fruits.**
Bread and Cereals	• Rice, maize, barley, oats, wheat, rye. • Most breads, those not sweetened • Cracker biscuits • Provitas, ryvitas • Spaghetti and other pasta	• Sweetened breads and buns • Cakes, biscuits and pastries • Pasta dishes (ready made) • Sweetened breakfast cereals.
Fats	• Margarine without milk solids, eg Pick n Pay Choice range • Sunflower and canola oil • Olive oils	• peanut and soya oil
Drinks	• tea, coffee, cocoa (unsweetened) • glucose drinks	• fruit juices, milkshakes, chocolates drinks • diabetic and dietetic drinks containing sorbitol
Soups	• homemade soups with permitted ingredients	• tinned and packed soups
Miscellaneous	• marmite, salt pepper, herbs, mustard, spices • gelatine • nuts • homemade popcorn	• honey, jam, sugar, icing sugar, castor sugar • fructose powder, sorbitol • diabetic foods containing sorbitol • chocolate, sweets • puddings, jelly • tomato paste and puree • salad dressings, sauces, chutney • toothpaste containing sucrose

Addendum 6

Energy Calculations

Table 1: Selected Dietary Reference Values (DRV's) for Infants and Children requiring Oral/Enteral Nutrition [53,54]

Age	Weight (kg)	KJ/kg/day	Kcal/kg/day	Protein g/kg/day
Males				
0 – 3months	5.1	420 – 480	100 – 115	2.1
4 – 6	7.2	400	95	1.6
7 – 9	8.9	400	95	1.5
10 –12	9.6	400	95	1.5
1 – 3 years	12.9	400	95	1.1
4 – 6	19.0	380	90	1.1
7 – 10		8240/day	1970/day	28.3g/day
11 – 14		9270/day	2220/day	42.1g/day
15 – 18		11510/day	2755/day	55.2g.day
Females				
0 – 3 months	4.8	420 – 480	100 – 115	2.1
4 – 6	6.8	400	95	1.6
7 – 9	8.1	400	95	1.5
10 –12	9.1	400	95	1.5
1 – 3 years	12.3	400	95	1.1
4 – 6	17.2	380	90	1.1
7 – 10		7280/day	1740/day	28.3g/day
11 – 14		7920/day	1845/day	42.1g/day
15 - 18		8830/day	2110/day	45.4g/day

Table 2: Schofield Equation for Calculating Resting Metabolic Rate (RMR) – Kcal/day[53,54]

Age (yr)	Male	Female
< 3	0.167(W) + 1517.4(H) –617.6	16.252(W) + 1023.2(H) – 413.5
3 – 10	19.59(W) + 130.3(H) + 414.9	16.696(W) + 161.8(H) + 371.2
10 –18	16.25(W) + 317.2(H) + 515.5	8.365(W) + 465(H) + 200.0
> 18	15.057(W) + 10.04(H) + 705.8	13.623(W) + 283(H) + 98.2

Table 3: FAO/WHO/UNU kcal/day[53,54]

Age (yr)	Male	Female
3 – 10	22.7 (W) + 495	22.5 (W) + 499
10 - 18	17.5 (W) + 651	12.2 (W) + 746

PHYSICAL ACTIVITY FACTORS[1]	
ACTIVITY	**ACTIVITY FACTOR (AF)**
• Sleeping (ICU, Sedation and muscle relaxation)	1.0
Hospitalized • Non Ambulant • Ambulant	 1.2 1.3
At Home • Relatively inactive • Very active	 1.4 1.9

STRESS FACTORS

DISEASE	STRESS FACTOR
Trauma • Little (long bone fracture • Central Nervous System • Moderate to severe (multiple)	 1.2 1.3 1.5
Sepsis • Moderate • Severe	 1.3 1.6

Addendum 7:

Vitamin ADEK content

Table 2: ADEK® Composition

	% Daily values for children				% Daily values for adults	
	Amount per ml	0-6 months % DRI	7 – 12 months % DRI	1 – 3 years % DRI	Per table	% Based on 2,000kcal diet
Calories	5					
Total CHO	1g					
Vitamin A (as palmitate and 50% as beta carotene)	3170 IU	250	250	240	9000 IU	180
Vitamin C (as ascorbic acid)	45mg	150	130	115	60 mg	100
Vitamin D (as cholecalciferol)	400 IU	75	100	100	400 IU	100
Vitamin E (as d -alpha tocopheryl)	40 IU	900	670	450	150 IU	500
Vitamin K (as phttonadione)	100 ug	*	*	*	150 ug	190
Thiamin	0.5 mg	165	125	70	1.2 mg	80
Riboflavin	0.6 mg	150	120	75	1.3 mg	80
Niacin (as niacinamide)	6 mg	120	100	65	10 mg	50
Folic acid	-	-	-	-	0.2 mg	50
Vitamin B6 (as pyridoxine)	0.6 mg	200	100	60	1.5 mg	80
Vitamin B12 (as cyanocobalamin)	4 mg	1300	800	570	12 ug	200
Biotin	15 mg	150	100	75	50 ug	15
Pantothenic acid (as d-pantothenol)	3 mg	150	100	100	10 mg	100
Zinc (as sulphate)	3 mg	100	100	50	7.5 mg	50

Addendum 8:

Zinplex content

Composition per 5 ml:

- 10 mg zinc picollinate: 5 ml will provide 2mg elemental zinc
- 10 μg/5ml selenium
- 20mg/5ml of Vitamin C

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