PAEDIATRIC RENAL NUTRITION TASKFORCE

Energy and protein requirements in children with CKD stages 2-5 and on dialysis

A practical guide

Contents

Foreword

The Pediatric Renal Nutrition Taskforce (PRNT) is an international team of pediatric renal dietitians and pediatric nephrologists who develop clinical practice recommendations (CPRs) for the nutritional management of various aspects of kidney diseases in children.

In 2019, the taskforce published recommendations regarding energy and protein requirements in children with CKD stages 2-5 and on dialysis describing energy requirements in the context of poor growth, obesity, and different levels of physical activity, together with the additional protein needs to compensate for dialysate losses. The CPR describes how to achieve the dietary prescription for energy and protein using breastmilk, formulas, food and dietary supplements.

This booklet aims to provide a practical guide on how to implement these recommendations in every day clinical practice and should be read in conjunction with the published paper.*

* Shaw V, Polderman N, Renken-Terhaerdt J et al. Energy and protein requirements for children with CKD stages 2-5 and on dialysis–clinical practice recommendations from the Pediatric Renal Nutrition Taskforce. Pediatric Nephrology, 2020. 35: 519–531 doi.org/10.1007/s00467-019-04426-0
https://www.espn-online.org/nutrition-taskforce/

Clinical questions

Question 1

What are the energy requirements?

Assessment of growth, intake and nutritional status
Requirements for optimal growth

Question 2

What are the protein requirements?

Requirements for optimal growth
Modifications for dialysis and uremia

Question 3

How is the nutrition prescription provided?

Dietary management: breastmilk, formulas, fluids and foods

Flow chart
Summarising dietary management

Use the Suggested Dietary Intake (SDI) (Table 1) to formulate nutrition prescriptions and to assess adequacy of dietary intakes

Step 1: Nutritional assessment

For more details see page 8.
Assessment of nutritional status in children with kidney diseases - clinical practice recommendations

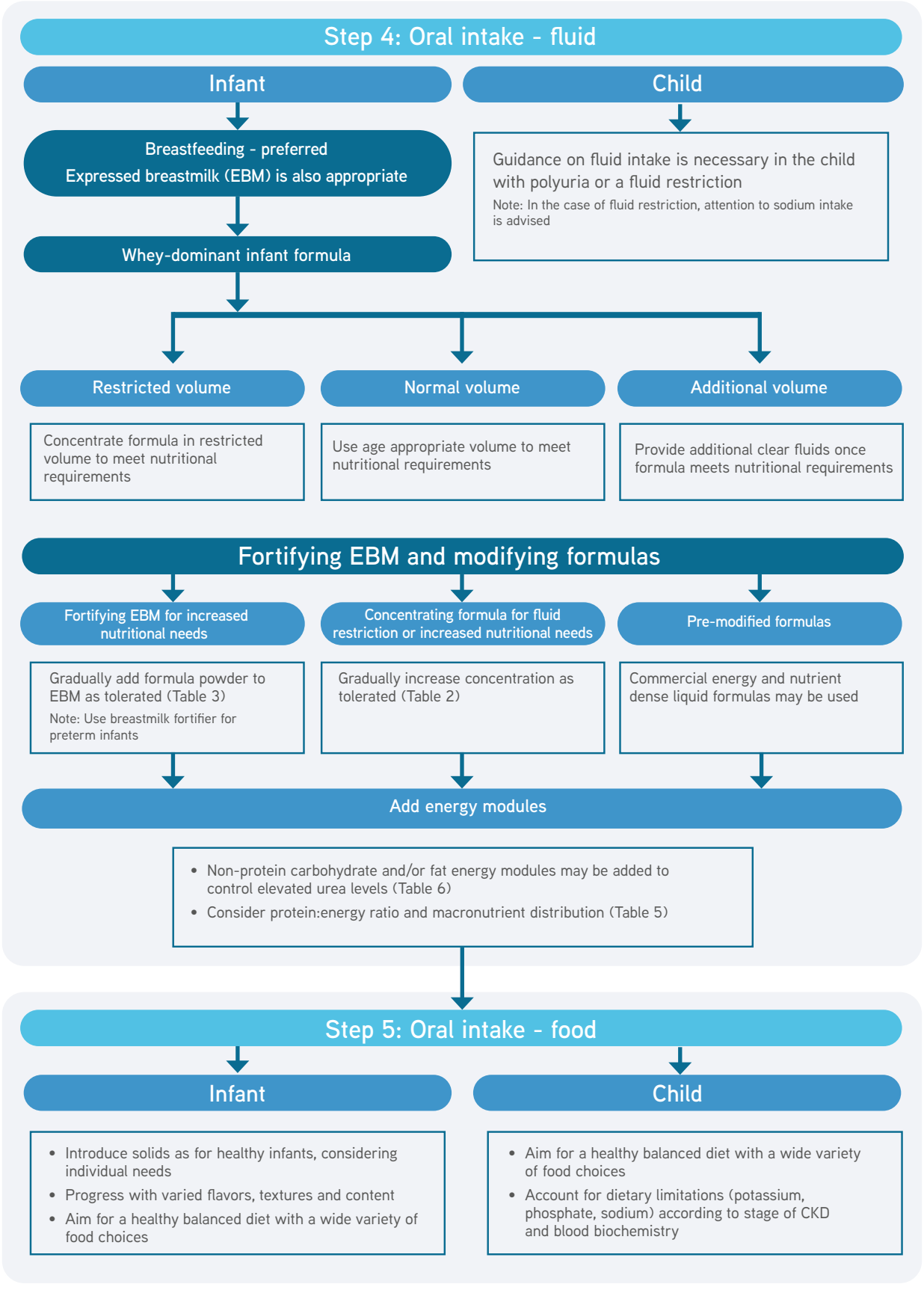
Step 2: Energy requirements

Suboptimal growth	Normal growth	Overweight or obese
Adjust energy towards the higher end of SDI range to promote growth when weight gain and linear growth are suboptimal	Initial prescription of energy intake should approximate that of healthy children of the same chronological age	Adjust energy intake, without compromising nutrition, to achieve appropriate rate of weight gain in those who require weight control

Step 3: Protein requirements

To promote optimal growth	Dialysis	Persistently high blood urea levels
Target protein to the upper end of the SDI Protein intake at the lowest end of the SDI range is the minimum safe amount	To account for protein losses in dialysate, the nutrition prescription for protein may need to be higher than the SDI	After excluding all other causes of high blood urea levels (catabolic state, acute or chronic dehydration, steroid therapy), the protein prescription may be adjusted towards the lower end of the SDI

Flow chart
Continued



Step 6: Nutritional support - oral supplementation

- Intervene promptly when there is a drop in weight centile
- Start oral supplements when dietary intake is inadequate

Fortifying foods

- Add glucose polymers to 'liquid' foods
- Add sugar, glucose, jams, honey or syrups to foods
- Add fats such as vegetable spreads and oils to foods

Fortifying drinks

- Add glucose polymers to plain water, water with fruit flavorings/ cordials, carbonated drinks/sodas

Oral nutritional supplements

- Use nutritionally complete oral liquids (oral nutritional supplements or sip feeds) to provide additional energy and protein, as well as vitamins and minerals

Monitor, assess and review

- Growth parameters
- Dietary limitations
- Barriers to achieving adequate oral intake
- Medical management
- Current or usual dietary intake
- Nutritional requirements
- Blood biochemistry
- Activity level

Insufficient intake to meet nutritional requirements

Step 7: Nutritional support – tube feeding

To improve nutritional status and promote growth, start nutritional support (supplemental or exclusive enteral feeds) in children who are unable to achieve nutritional requirements orally

For more details see page 21 'Delivery of a nutritional prescription by enteral feeding - clinical practice recommendations'

Nasogastric feeding

- Short-term intervention

Gastrostomy feeding

- Long-term intervention

Step 1: Nutritional assessment

Nutritional assessment is fully described in Nelms CL, Shaw V, Greenbaum LA et al. Assessment of nutritional status in children with kidney diseases - clinical practice recommendations from the Pediatric Renal Nutrition Taskforce. Pediatr Nephrol, 2021 doi.org/10.1007/s00467-020-04852-5 The three essential elements are summarised below.

Anthropometry

- Measure weight and determine z-score/standard deviation score (SDS). Use euvolemic (dry) weight when indicated e.g. being on dialysis.
- Measure length and determine z-score/SDS. Use recumbent length for children up to 2 years of age and standing height for those over 2 years. For children unable to stand for an accurate height measurement, recumbent length can be measured or use a surrogate measurement of height.
- Measure head circumference in all children up to 2 years of age. When appropriate centile charts are available, continue to measure head circumference until 3 years of age.
- Plot anthropometric measurements serially using World Health Organization (WHO) growth charts. Country-specific growth charts, if available, may be used beyond 2 years of age.
- Calculate weight-for-length in children younger than 2 years of age and body mass index (BMI) for those over 2 years. Calculate weight-for-length or BMI z-scores/SDS to complement growth chart plots.
- Use height age for determining BMI z-score/SDS if the child is shorter than the 3rd centile, provided they have not reached their adult height.
- For premature infants (32 to 37 weeks gestation), plot weight, length and weight-for-length for both gestational and chronological ages for the first year of life. For premature infants born prior to 32 weeks gestation, continue to plot both gestational and chronological ages until 2 years of age.

Dietary assessment

- Conduct a prospective minimum 3-day diet history when accurate, comprehensive information is needed.
- A retrospective diet recall over a 24-hour period, preferably inclusive of more than one 24-hour period, may also be acceptable.

Biochemical assessment

- Calculate normalized protein catabolic rate (nPCR) in adolescent patients on hemodialysis.
- Only consider serum albumin as a measure of nutritional status after all non-nutritional causes of hypoalbuminemia have been excluded.

Step 2: Energy requirements

Compare growth standards and reference charts to determine if growth is suboptimal, normal or the child is overweight or obese.

Using WHO child growth standards charts

- Stunting: height-for-age < -2 standard deviations (SD)
- Underweight children < 5 years: weight-for-age < –2 SD
- Overweight children < 5 years: weight-for-height > +2 SD
- Obese children < 5 years: weight-for-height > +3 SD

See growth charts https://www.who.int/toolkits/child-growth-standards/standards

Using WHO growth reference charts

- Thinness children 5-19 years: BMI < -2 SD
- Severe thinness children 5-19 years: BMI < -3 SD
- Overweight children 5-19 years: BMI > +1 SD
- Obese children 5-19 years: BMI > +2 SD

See growth charts https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/bmi-for-age

Consider trends or rate of changes in weight: flattening or acceleration of growth curves (e.g. losing or gaining weight more quickly than intended).

Compare intake from dietary assessment with the Suggested Dietary Intake (SDI) for energy.

Table 1: SDI for energy and protein: Birth* to 18 years

Month	SDI** Energy (kcal/kg/day)	SDI Protein (g/kg/day)	SDI Protein (g/day)
0	93-107	1.52-2.5	8-12
1	93-120	1.52-1.8	8-12
2	93-120	1.4-1.52	8-12
3	82-98	1.4-1.52	8-12
4	82-98	1.3-1.52	9-13
5	72-82	1.3-1.52	9-13
6-9	72-82	1.1-1.3	9-14
10-11	72-82	1.1-1.3	9-15
12	72-120	0.9-1.14	11-14

Table 1: SDI for energy and protein (continued)				
Year	SDI** Energy (kcal/kg/day)		SDI Protein (g/kg/day)	SDI Protein (g/day)
-	Male	Female		
2	81-95	79-92	0.9-1.05	11-15
3	80-82	76-77	0.9-1.05	13-15
4-6	67-93	64-90	0.85-0.95	16-22
7-8	60-77	56-75	0.9-0.95	19-28
9-10	55-69	49-63	0.9-0.95	26-40
11-12	48-63	43-57	0.9-0.95	34-42
13-14	44-63	39-50	0.8-0.9	34-50
15-17	40-55	36-46	0.8-0.9	Male: 52-65 Female: 45-49

Suggested Dietary Intake (SDI) is a novel term. The figures are derived from values published by national and international organizations. The lower and upper limits of the SDI for energy fall within the average amounts given in the published values (i.e. the daily amount of energy considered sufficient to meet the needs of a half a population). The lower and upper limits of the SDI for protein fall within the average amount + 2 SD given in the published values (i.e. the daily amount of protein considered sufficient to meet the needs for nearly all (97.5%) of a population).

* 37/40 weeks gestation. Premature infants have higher energy and protein requirements. The increased need for these and other particular nutrients (sodium, potassium, calcium and phosphorus) must be balanced against the nutritional interventions to control the effects of CKD.

** Suggested Dietary Intake (SDI) is based on the Physical Activity Level (PAL) used by the international bodies: 1-3 yr PAL 1.4; 4-9 yr PAL 1.6; 10-17 yr PAL 1.8. Where guidelines have given a range of energy requirements for different levels of PAL, the lowest PAL has been taken for SDI energy in consideration that children with CKD are likely to have low activity levels.

This table is taken from: Shaw V, Polderman N, Renken-Terhaerdt J et al. Energy and protein requirements for children with CKD stages 2-5 and on dialysis–clinical practice recommendations from the Pediatric Renal Nutrition Taskforce. Pediatric Nephrology, 2020. 35: 519–531, under the Creative Commons Licence (http://creativecommons.org/licenses/by/4.0/).

Aims for energy intake in CKD

Suboptimal growth

↓

Adjust energy towards the higher end of SDI range to promote growth when weight gain and linear growth are suboptimal

Normal growth

↓

Initial prescription of energy intake should approximate that of healthy children of the same chronological age

Overweight or obese

↓

Adjust energy intake, without compromising nutrition, to achieve appropriate rate of weight gain in those who require weight control

Step 3: Protein requirements

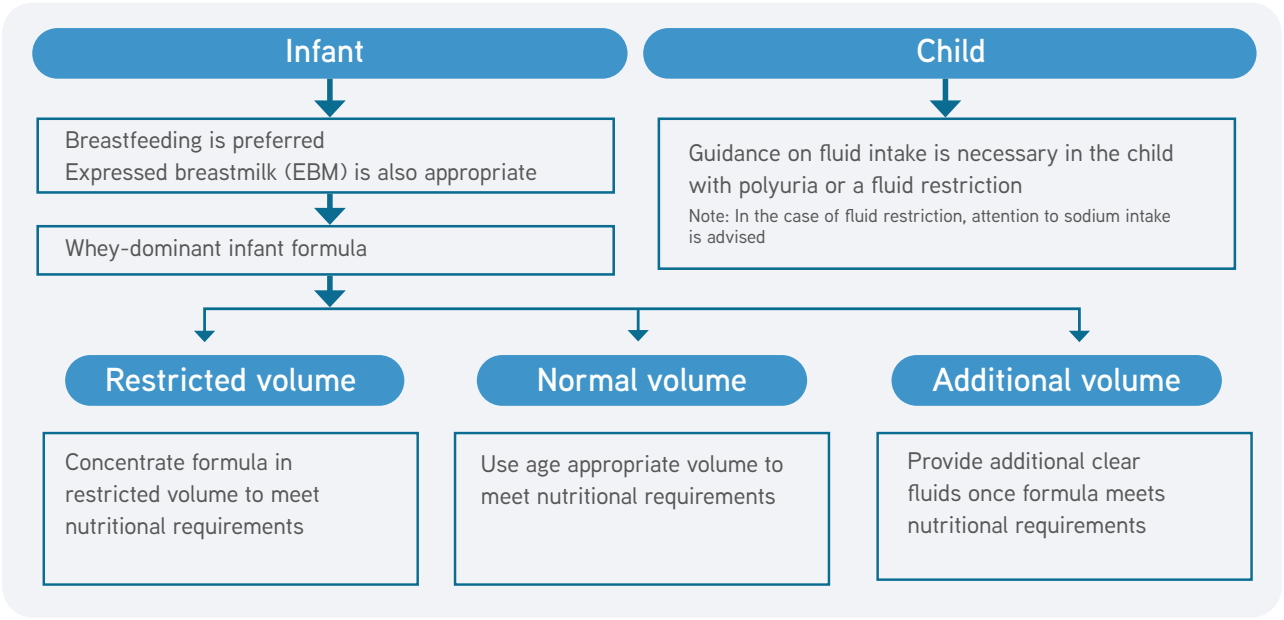
Aims for protein intake in CKD

To promote optimal growth	Dialysis	Persistently high blood urea levels
Target protein to the upper end of the SDI Protein intake at the lowest end of the SDI range is the minimum safe amount	To account for protein losses in dialysate, the nutrition prescription for protein may need to be higher than the SDI	After excluding all other causes of high blood urea levels (catabolic state, acute or chronic dehydration, steroid therapy), the protein prescription may be adjusted towards the lower end of the SDI

Practical points to achieve appropriate energy and protein intake

- Use the SDI for height age if the child is <3rd centile for height. Height age is the age that corresponds to the child's or adolescent's height when plotted on the 50th centile on a growth chart.
- In children on peritoneal dialysis (PD), energy intake from dialysate must be considered. Depending on the glucose concentration of the dialysate, dwell times, number of cycles, time on dialysis along with peritoneal membrane transport status, additional energy from dialysate may range from 7.5 ±7 to 9.08 ±4.13 kcal/kg/day.
- Some children may benefit from the additional dialysate energy. If there is excessive weight gain, the energy from the dialysate must to be taken into account in the nutrition prescription.
- Obesity is increasing in children with CKD. Modification of energy intake and lifestyle changes, including physical activity, may be needed.
- Urea levels may be used as an indicator of protein intake and may help determine if or when a reduction in dietary protein intake might be considered.
- It is not expected that blood urea levels of children with CKD2-5D are in the normal range; low urea levels may indicate insufficient dietary protein intake.
- Urea levels that are chronically higher than expected for the degree of CKD are most commonly due to excessive dietary protein relative to energy intake. Check for secondary causes of elevated urea levels: a catabolic state, acute or chronic dehydration, steroid therapy.
- PD is associated with significant protein losses in the dialysate, with higher losses in small children (0.28 g/kg/day in infants, 0.1 g/kg/day in adolescents).
- Protein intake should be increased above the SDI by at least 0.15-0.3 g/kg/day for children on PD; 0.1 g/kg/day for HD.
- The nutrition prescription for protein must also take into account peritoneal transport status and increased protein losses during peritonitis.

Step 4: Management of oral intake - fluid



Practical points – fluids

- Whey-dominant infant formulas have a protein and electrolyte content closer to that of breastmilk than casein-dominant formulas and are the preferred alternative to breastmilk. They may be beneficial beyond the first year of life.
- Unless there is a specific medical indication, soy-based infant formulas should not be used in the first year of life due to their high phytoestrogen content.
- Powdered infant formulas may be concentrated into smaller volumes when a fluid restriction is indicated or when normal feed volumes exacerbate vomiting or gastro-esophageal reflux.
- Once nutritional requirements are met, any additional fluid requirements (e.g. when there is polyuria) may be given as water.

Fortifying EBM and modifying formulas

Fortifying EBM for increased nutritional needs	Concentrating formula for fluid restriction or increased nutritional needs	Pre-modified formulas
Gradually add formula powder to EBM as tolerated (Table 3) Note: Use breastmilk fortifier for preterm infants	Gradually increase concentration of formula as tolerated (Table 2)	Commercial energy and nutrient dense liquid formulas may be used

Practical points - concentrating infant formulas and fortifying EBM

- Most standard infant formulas are reconstituted to an approximate 13% concentration (i.e. 13 g powder to 100 ml water, providing 0.67 kcal/ml).
- Concentrate formulas gradually to monitor and ensure tolerance. The increase in osmolality may cause diarrhea, vomiting and gastro-esophageal reflux.
- Consider that concentration of formulas increases the renal solute load along with increased/ excessive amounts of other nutrients such as phosphate, potassium, vitamins (e.g. toxic levels of Vitamin A) and minerals.
- Increase concentration of formula powder by 1-3% daily, up to 20% (providing 1 kcal/ml), depending on the infant's tolerance.
- The energy and protein profiles of 15% (15 g powder to 100 ml water), 17% (17 g powder to 100 ml water) and 20% (20 g powder to 100 ml water) concentrated formulas are shown (Table 2).

Table 2: Concentrating infant formula (typical whey-dominant infant formula)

Concentration	Energy (kcal/100 ml)	Protein (g/100 ml)	Protein: Energy ratio	% CHO (g/100 ml)	% Fat (g/100 ml)
13% (normal strength) 13g powder/100 ml	67	1.3	7.8	7.2	3.6
15% 15g powder/100 ml	77	1.5	7.8	8.3	4.2
17% 17g powder/100 ml	88	1.7	7.8	9.4	4.7
20% 20g powder/100 ml	103	2.0	7.8	11.1	5.5

- Infant formula powder may also be added to EBM at a concentration of 3-6% (i.e. 3-6 g infant formula powder to 100 ml EBM), increasing the total energy density up to 1 kcal/ml (Table 3).
- For preterm infants, breastmilk fortifier may be added to EBM until term age is reached, according to the manufacturer's instructions.

Table 3: **Fortifying expressed breastmilk** (typical whey-dominant infant formula)					
Concentration	Energy (kcal/100 ml)	Protein (g/100 ml)	Protein: Energy ratio	% CHO (g/100 ml)	% Fat (g/100 ml)
100ml mature breastmilk	69	1.3	7.5	7.2	4.1
Plus 3g infant formula powder	84	1.6	7.6	8.9	4.9
Plus 6g infant formula powder	100	1.9	7.6	10.5	5.8

- The energy content of infant formula may also be concentrated using a modular approach using protein powder and/or energy modules to best meet the infant's individual nutritional requirements (Table 4).
- When fluid restriction is indicated and the volume of infant formula is reduced, vitamin and mineral supplementation may be required.
- Commercially available ready-to-feed energy and nutrient dense infant formulas may be a suitable option; however, careful attention to the profile of each formula is warranted to ensure that nutrient needs are met but not exceeded e.g. the phosphate content may be higher in a commercial 1 kcal/ml formula than in infant formula at 20% concentration, which provides the same energy density.

Table 4: **Example modular feed** (adapt ingredients to create a patient specific profile)					
Concentration	Energy (kcal/100 ml)	Protein (g/100 ml)	Protein: Energy ratio	% CHO (g/100 ml)	% Fat (g/100 ml)
13 g infant formula powder	67	1.3		7.2	3.6
0.7 g protein powder	3	0.7		0	0
4.0 ml fat emulsion	18	0		0	2.0
3 g glucose polymer powder	12	0		3	0
+ water up to 100 ml					
per 100 ml	100	2.0	8.0	10.2	5.6

- To achieve optimal growth with appropriate deposition of lean and fat tissue in the healthy infant, the protein-energy (P:E) ratio of the infant formula should ideally be in the range 7-12%. A high P:E ratio is required to promote weight gain or catch-up growth (Table 5).

Table 5: Energy and protein requirements for accelerated weight gain or catch-up growth for malnourished infants (WHO/FAO/UNU, 2007)

Rate of weight gain	Energy kcal/kg/d	Protein g/kg/d	Protein:Energy ratio
10g/kg/day	126	2.8	8.9%
20g/kg/day	167	4.8	11.5%
Optimal P:E ratio for catch-up growth is likely to be 11-15%.			

- In cases of elevated urea or potassium levels, there may be indication to add a source of non-protein energy (carbohydrate and/or fat) to the formula. This addition of extra energy will reduce the P:E ratio. Ensure that, at a minimum, the SDI for protein is provided.
- Suggested addition of energy modules to formula is given in Table 6.
- Glucose polymers may be added in increments, e.g. 1% daily (1 g extra added to 100 ml formula or EBM per day, an additional 4 kcal/100 ml). Gradually increase the amount in order to monitor and ensure tolerance. High concentrations of glucose polymers may cause loose stools and/or increase vomiting.
- Tolerance to increased carbohydrate concentration depends on the age of the infant, and the maturity and absorptive capacity of the gut, with some infants more tolerant to a more rapid addition of a glucose polymer.
- Fat emulsions may be used and should also be added incrementally, e.g. 1% daily (1 ml added to 100 ml formula or EBM per day) to provide an increase of 0.5 g fat per 100 ml (an additional 5 kcal/100 ml).
- Increasing the fat content of formula my cause delayed gastric emptying, nausea and or vomiting.
- Protein powders are added to formulas or EBM to provide a specific amount of protein per kg of body weight.
- Protein supplements should be added in small increments, 0.1 g protein/kg/day, and urea levels measured to detect excessive intake (i.e. urea levels above expected for degree of CKD).

Practical points – increasing energy content of pediatric formulas

- Energy modules can be added to commercial pediatric enteral formulas and nutritionally complete oral liquids (oral nutritional supplements or sip feeds) designed for children over 1 year of age (Table 6).

Table 6: Suggested addition of energy modules to formulas

Energy module	Age	Amount of CHO/fat module added to formula	Final concentration of CHO/fat in formula
Glucose polymer	<6 months	3-5g (+ 7g CHO from infant formula)	10-12
	6m-1y	5-8g (+ 7g CHO from infant formula)	12-15
	>1yr	8-18g (+ 12g CHO from pediatric formula)	20-23
Fat emulsion (50% fat content)	<1yr	3-5ml (+ 3.5g fat from infant formula)	5-6
	>1yr	9ml (+ 4.5g fat from pediatric formula)	9

CHO, carbohydrate. CHO and fat content of formulas may vary. Adapted from Shaw V (ed) Clinical Paediatric Dietetics, 5th edition, 2020, p 15.

Step 5: Management oral intake - food

Infant

- Introduce solids as for healthy infants, considering individual needs
- Progress with varied flavors, textures and content
- Aim for a healthy balanced diet with a wide variety of food choices

Child

- Aim for a healthy balanced diet with a wide variety of food choices
- Account for dietary limitations (potassium, phosphate, sodium) according to stage of CKD and blood biochemistry

- Children with CKD may not achieve adequate oral intake due to gastro-oesophageal reflux, reduced appetite, altered smell and taste and abnormal hormone regulation (Appendix 1).
- Solid foods should be introduced as recommended for healthy infants, with progression to varied textures and content according to the infant's cues and oral motor skills.
- Oral feeding is the preferred route whenever possible. Even when oral intake is limited, oral stimulation is desirable to prevent development of food aversion.
- The nutritional content of solid food must be balanced against that provided by the formula to achieve optimum intake of energy, protein and other nutrients.
- Dietary limitations in potassium and phosphate may be necessary according to the stage of CKD and abnormal blood biochemistry (see the practical guides for The dietary management of Potassium, and Calcium and Phosphate). A renal-specific low potassium or phosphate formula may be provided in order that dietary restrictions may be liberalized to allow a greater variety of foods to be offered. A more liberal oral intake may encourage more normal development and feeding behaviors.
- From one year of age, Young Child Formulas (commercially available fortified milk drinks with a suitably low phosphate and potassium content, specifically designed for toddlers) may be useful as they contain iron, vitamin D and n-3 polyunsaturated fatty acids, which may enhance the diet.
- In the case of significant feeding difficulties, consider referral to speech and language therapy. Input from a psychologist, including family therapy, may also be considered.

Intervene promptly when there is a drop in weight centile

Start oral supplements when dietary intake is inadequate

Step 6: Nutritional support – oral supplementation

Fortifying foods | Fortifying drinks | Oral nutritional supplements

- High energy foods with a low protein content may be useful additions to the diet to achieve energy needs without providing excess protein (Table 7).
- Complex carbohydrates with a higher fiber content are desirable; however refined carbohydrates may be better accepted by a child with a poor appetite.
- Table 8 shows foods with a high protein content, which may need to be given in controlled amounts. The phosphate and potassium contents of these foods may need to be considered.

Table 7: High energy low protein foods

Food	Portion size	Energy (kcal/ portion)
Refined carbohydrates		
Honey, jam, marmalade	1 teaspoon	40
Golden syrup	1 teaspoon	54
Sugar	1 teaspoon	20
Sweets/candy		
Fruit gums	1 tube	70
Turkish delight	1 square	44
Boiled sweets	1 sweet	5
Chew sweets	1 sweet	15
Peppermints	1 sweet	12
Marshmallows	5 large	100
Mints	30g	100
Jelly beans	15	100
Fats		
Margarine	1 tablespoon	100
Mayonnaise	1 tablespoon	100
Vegetable oil	1 tablespoon	100

Food	Portion size	Energy (kcal/ portion)
Starchy carbohydrates		
Fried bread	1 slice	176
Muffin - English style	1	157
Flapjack	100g	290
Short-sweet biscuit	1	46
Shortbread biscuit	1	47
Iced cake	1	260
Madeira cake	1 slice	157
Sponge cake – jam filled	1 slice	181
Sponge cake – butter icing	1 slice	294
Swiss roll	1 slice	83
Crumpets	1	71
Danish pastry	1	411
Doughnut – jam	1	252
Doughnut – ring, iced	1	498
Jam tart	1	129
Scone - plain	1	174
Meringue - individual	1	30
Scotch pancake	1	188
Pancake - crepe	1	161
Teacake	1	181
Battenberg cake	1 slice	99
Cherry cake	1 slice	165

* Where available, refer to country specific composition tables.

Compositional data sourced and adapted from Public Health England: McCance and Widdowson's The Composition of Foods Integrated Dataset 2019.

Use the table below to document energy sources available in your country.

Food	Portion size	Energy (kcal/ portion)

Table 8: High protein foods

The following foods, in the portion indicated, contain approximately 7 grams of protein. If the amount of protein in the diet requires modification, and for increased compliance and flexibility, these foods can be swapped for each other.

Food	Portion size
Dairy foods and egg (HBV)*	
Cow's milk	200ml
Fromage frais	2 small 60g pots
Hard cheese	1 thin slice (25g) or 1 heaped tbsp grated
Cottage cheese	4 tbsp (80g)
Cream cheese	2 tbsp (100g)
Egg	1 medium (50g)
Meat (HBV)	
Ham (gammon joint, boiled, cooked)	1½ average slices (30g)
Ham slices (pre-packed)	3 wafer thin slices (33g)
Minced beef (stewed extra lean)	3 tbsp (30g)
Roast beef (topside, well-done, lean)	1 thin slice (20g)
Beef slices (sandwich meat pre-packed)	2 wafer thin slices (20g)
Chicken (breast, grilled, no skin)	¼ small fillet (22g)
Chicken slices (pre-packed)	2 wafer thin slices (22g)
Chicken nugget (average baked)	3 (48g)
Pork (loin chop, grilled)	⅓small chop (20g)
Pork (roasted)	1 thin slice (20g)
Lamb (roasted)	1 thin slice (25g)
Lamb (mince, stewed)	3 tbsp (30g)
Sausage, (grilled, pork)	1 (57g)
Meat substitute (LBV)**	
Quorn (mince), cooked	5 tbsp (50g)

Food	Portion size
Fish (HBV)	
Salmon (baked)	⅓ average steak (30g)
White fish, (cod, flesh, baked, cooked)	½ small fillet (30g)
Tuna (tinned in water, drained)	⅓ small can (30g)
Mackerel (flesh only, grilled)	½ fillet (30g)
Fishcakes (white fish, coated in breadcrumbs, baked)	1½ (80g)
Fishfingers, (cod, grilled/baked)	2 (56g)
Legumes (lentils, pulses, beans) (LBV)	
Lentils (red split boiled in unsalted water)	2 tbsp (85g)
Chickpeas (canned, reheated, drained)	2 tbsp (80g)
Black eye beans (whole, dried, boiled in unsalted water)	2 tbsp (80g)
Butter beans (dried, boiled in unsalted water)	3 tbsp (100g)
Cannellini beans (dried, cooked in unsalted water)	5 tbsp (150g)
Red kidney beans (canned in water, reheated, drained)	3 tbsp (100g)
Peas (frozen, boiled in unsalted water)	4 tbsp (100g)
Baked beans (canned in tomato sauce)	4 tbsp (1 small 135g tin)
Hummus (average retail)	3 tbsp (90g)
Nuts (LBV) (no skin or shells)	
Almonds	35g (35 nuts)
Cashew	35g (20 nuts)
Peanuts	1 small 25g bag (20 nuts)
Pistachio	35g (50 nuts)
Walnuts	35g (9 nuts)

* High biological value (HBV) protein foods from animal sources (meat, fish, poultry, egg, dairy) contain the right proportion of essential amino acids for growth and protein repletion

** Low biological value (LBV) foods from plant sources (soy products, legumes, meat substitutes, nuts and whole grains) have an incomplete profile of essential amino acids

tbsp, rounded tablespoon

* Where available, refer to country specific composition tables.

Compositional data sourced and adapted from Public Health England: McCance and Widdowson's The Composition of Foods Integrated Dataset 2019.

- When dietary intake is inadequate, start supplementation.
- Add energy modules to food and drinks to further improve energy intake.

Table 9: Adding extra energy to food and drinks	
Glucose polymer powders and combined fat/glucose polymer powders – have a neutral taste and dissolve easily in 'liquid' or moist foods	Add to sweet foods such as porridge and other hot breakfast cereals, soft desserts such as custards and mousses Add to savoury foods such as soup, mashed potato, baked beans
Sugar, glucose, jams, honey or syrups – will impart a sweet taste which may limit their use	Add to breakfast cereals, desserts; spread on bread, toast, pancakes, crumpets, buns, scones
Fats such as vegetable spreads and oils – choose those with a high content of omega-3 fats, such as soya, walnut, linseed or rapeseed oil, or high in monounsaturated fat such as olive oil	Add to vegetables, rice, pasta, couscous, millet, yam, potatoes Spread on bread, toast, pancakes, crumpets, buns, scones
Glucose polymer powders - can be added to beverages at high concentrations without an osmotic effect on the gut Combined fat/glucose polymer powders	Add to plain water, water with fruit flavorings/ cordials, carbonated drinks/sodas, fruit juices (provided there is no potassium restriction) Add to the above beverages - they impart a white color and a 'milky' mouth feel Start with 5% (5 g added to 100 ml) and gradually increase to 20-30%, as tolerated
Sugar and glucose may be added to drinks, but the quantity may be limited due to their sweet taste and osmotic effect on the gut	

- Nutritionally complete oral liquids (oral nutritional supplements or sip feeds) are suitable for toddlers, older children and adolescents; they provide energy, protein and a range of vitamins and minerals.
- If there are concerns with elevated electrolyte levels, a palatable high energy pediatric renal-specific oral nutritional supplement can be used, if available.
- Standard pediatric enteral formulas can be used if the child will drink them.
- Standard adult enteral and renal-specific formulas can be modified, to meet the nutritional requirements of infants and children. Pay particular attention to potential excesses in vitamin and mineral contents.
- Other options to increase energy intake include 'milks' derived from plants, such as soy, oat, almond or coconut, without calcium phosphate fortification. It is not advisable to give rice milk to infants and young children due to its high arsenic content.
- Protein-free milk replacement drinks, which have low phosphate contents, also provide extra energy.

Monitor, assess, review

- Monitor growth parameters: euvolemic weight, length (<2 years), height (>2 years), head circumference (<2 years or <3 years when appropriate centile charts are available), weight-for-length (<2 years), BMI (>2 years).
- Assess and interpret anthropometric data; diet history including developmental/feeding skills, food intolerances, dietary limitations; exercise/activity level; socioeconomic factors (social/financial) along with clinical assessment including physical, biochemical and hematological status.
- Repeat and review; identify trends to determine required modifications to the nutrition care plan.

To improve nutritional status and promote growth, start nutritional support (supplemental or exclusive enteral feeds) in children who are unable to achieve nutritional requirements orally

Step 7: Nutritional support – tube feeding

Nasogastric feeding	Gastrostomy feeding
Short-term intervention	Long-term intervention

Full details regarding tube feeding are given in Rees L, Shaw V, Qizalbash L et al. Delivery of a nutritional prescription by enteral tube feeding in children with chronic kidney disease stages 2-5 and on dialysis – clinical practice recommendations from the Pediatric Renal Nutrition Taskforce. Pediatr Nephrol, 2021. 36: 187–204 doi.org/10.1007/s00467-020-04623-2

Appendix 1: Barriers to children with CKD achieving an adequate oral intake	
Gastro-esophageal reflux (GER)	A major cause for poor growth in infants: in 22 malnourished infants with CKD (GFR 18.1+-12, range 4-44), feeding/ eating behavior was abnormal as assessed by parental questionnaire (1): - 73% had significant GER - 59% often refused food - 52% vomited excessively - 70% of caregivers were worried about their infant's nutrition - 78% of caregivers entertained their child during feeding - 50% bargained with child - 71% force-fed their child
Dysgeusia	Smell and taste function may be impaired (2): - Lower mean taste identification scores compared to controls - Decreasing taste function with decreasing GFR, but no differences in odor identification - No significant association between the total taste identification scores and BMI
Appetite-regulating hormones: ghrelin and leptin	Leptin is a hormone produced predominantly by adipose cells; it inhibits hunger: - Leptin levels elevated in predialysis, HD and PD patients (3,4) - Leptin levels higher in HD patients than in PD patients or controls (5,6), not well eliminated by HD (7) - Leptin levels may be elevated after renal transplant (8) - Inverse correlation between leptin levels and GFR and leptin in some (9), but not all (10) studies - Higher leptin levels in children with a glomerular etiology of CKD compared with children with a non-glo merular cause; higher levels in females than males; higher levels in obese than non-obese children (10) Ghrelin is a hormone produced in the gastrointestinal tract. Its acylated form induces hunger and increases gastric acid secretion and gastrointestinal motility. Unacylated ghrelin inhibits appetite; increased levels might contribute to PE wasting. Plasma total ghrelin mainly reflects unacylated ghrelin: - Plasma total ghrelin levels are elevated compared to healthy controls and renal transplant patients (8,11) - Negative correlations reported between GFR and total ghrelin levels (8,12) - Unacylated ghrelin levels higher than controls, highest in HD patients; unacylated ghrelin levels similar in CKD stages I-4, increasing in stages 5 and dialysis (13) - No change in acylated ghrelin levels according to the degree of renal impairment or between CKD patients and healthy controls (8,12,13) - HD eliminates ghrelin to levels comparable to healthy controls after dialysis, whereas ghrelin levels in PD patients are elevated, comparable to conservatively managed patients (7)

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