Nutrition Management of Children on Dialysis

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Seattle Children’s Hospital
No Disclosures
Learning Objectives

• Review factors that affect growth

• Review nutritional goals and recommendations for infants and children on dialysis

• Review aspects of diet requiring modification, and management strategies

• Describe approaches to achieve optimal nutritional status in children on dialysis
Focus of Nutrition Care

Overarching Goals:

▪ Achieve a normal pattern of growth and body composition through maintenance of optimal nutritional status
  ▪ Avoidance/Correction of uremic toxicity, metabolic abnormalities, and malnutrition
▪ Reduce risk of chronic morbidities and mortality in adulthood

Barriers to Optimizing Growth and Nutritional Status

- Malnutrition
- Metabolic acidosis
- Anemia
- Fluid and Electrolyte Imbalance
- Long-term use of corticosteroids
- Alterations in bone metabolism
Malnutrition

Inadequate Intake and Nutrient Deficiencies

• Anorexia and poor appetite
  • Uremia, acidosis and anemia can cause taste alterations
• Oral food aversions and dislike of solid foods
• GI Disturbances
  • GERD, nausea/emesis, constipation, diarrhea
  • Delayed gastric emptying
  • Increased IP pressure during PD
  • Food Allergies/Intolerances
• Fluid and dietary restrictions limiting food availability and variety
• Vitamin, mineral and protein losses through dialysis
• Cultural influences
• Psychosocial issues
# Phases of Growth

<table>
<thead>
<tr>
<th>From</th>
<th>Conception to Birth</th>
<th>Birth to 18 months</th>
<th>18 months to 12 years</th>
<th>Onset of Puberty</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of total growth</td>
<td>30</td>
<td>15</td>
<td>40</td>
<td>15</td>
</tr>
<tr>
<td>Dependent on</td>
<td>Nutrition Placenta</td>
<td>Nutrition Good health</td>
<td>Growth hormone Thyroid hormone Good health</td>
<td>Growth hormone Testosterone /Estrogen Good Health</td>
</tr>
</tbody>
</table>

- Phases: Fetal, Infant, Child, Pubertal
- Development stages:
  - From Conception to Birth
  - Birth to 18 months
  - 18 months to 12 years
  - Onset of Puberty

- Factors influencing growth:
  - Nutrition
  - Placenta
  - Good health
  - Growth hormone
  - Thyroid hormone
  - Good health
  - Testosterone /Estrogen
  - Good Health
Growth Pattern and Dietary Intake of Children with CKD

>80% DRI –
  • **Normal** growth

<80% DRI –
  • **Reduced** growth velocity

<40% DRI –
  • **Cessation** of growth

Betts & Magrath, BMJ 1974
Growth Assessment

- Estimated dry weight and weight for age %ile or SDS (std deviation score)
  - Consider fluid status
- Recumbent Length (<2 years) or standing height-for-age (>2 years) %ile or SDS
  - Calculate mid-parental height to evaluate growth potential
- Head circumference-for-age %ile or SDS (up to 36 months)
- Weight-for-length (<2 years) or BMI (>2 years) for height age %ile (age at which height is at 50%ile)
  - <5%ile classified as underweight
  - BMI <5%ile and >95%ile for age associated with increased morbidity and mortality
- Length/height and weight velocity for age percentile
Growth assessment should be performed twice as often as that of a healthy child of the same age.

Table 1. Recommended Parameters and Frequency of Nutritional Assessment for Children with CKD Stages 2 to 5 and 5D

<table>
<thead>
<tr>
<th>Measure</th>
<th>Minimum Interval (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age 0 to &lt;1 y</td>
</tr>
<tr>
<td></td>
<td>CKD 2-3   CKD 4-5</td>
</tr>
<tr>
<td>Dietary intake</td>
<td>0.5-3      0.5-3       0.5-2</td>
</tr>
<tr>
<td>Height or length-for-age percentile or SDS</td>
<td>0.5-1.5    0.5-1.5     0.5-1</td>
</tr>
<tr>
<td>Height or length velocity-for-age percentile or SDS</td>
<td>0.5-2      0.5-2       0.5-1</td>
</tr>
<tr>
<td>Estimated dry weight and weight-for-age percentile or SDS</td>
<td>0.5-1.5    0.5-1.5     0.25-1</td>
</tr>
<tr>
<td>BMI-for-height-age percentile or SDS</td>
<td>0.5-1.5    0.5-1.5     0.5-1</td>
</tr>
<tr>
<td>Head circumference-for-age percentile or SDS</td>
<td>0.5-1.5    0.5-1.5     0.5-1</td>
</tr>
<tr>
<td>nPCR</td>
<td>N/A        N/A          N/A</td>
</tr>
</tbody>
</table>

Abbreviation: N/A, not applicable.
*Only applies to adolescents receiving HD.
## Plotting Growth

<table>
<thead>
<tr>
<th>Infants (WHO growth charts 0-24 mo)</th>
<th>Pediatrics/Adolescents (CDC growth charts 2-18 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight-for-age</td>
<td>Weight-for-age</td>
</tr>
<tr>
<td>Length-for-age</td>
<td>Height-for-age</td>
</tr>
<tr>
<td>Weight-for-Length</td>
<td>BMI-for-age</td>
</tr>
<tr>
<td>Head Circumference-for-age</td>
<td></td>
</tr>
</tbody>
</table>

**Prematurity**
- Use Fenton Premature growth charts up to 50 weeks
- Plot weight and length for corrected age up to 36 months
WHO Length: Girls, 0 to 2 years

Example
Nutrition Assessment

Other Tools:

- Mid Upper Arm Circumference (MUAC) – validated as marker of nutrition status in general pediatric population
- Waist-to-Ht Ratio (>0.49)
- Subjective Global (Nutrition) Assessment (SGA/SGNA)
- Nutrition Focused Physical Exam (NFPE)
- Bio-electric Impedance Analysis (BIA)
- Bioimpedance Spectroscopy (BIS)

Mastrangelo, Ped Neph 2013; Eng, NDT 2017; Addo, AJCN 2016; Modi, J Nutr 2015; Secker, AJCN 2007; Steiber, JRN 2007; Steiber, JRN 2004; Secker, JAND 2012; Secker, JRN 2011; Corkins, NCP 2015; Corkins, NCP 2016; Esper, NCP 2015
Obesity, Dyslipidemia

- Increasing worldwide, including children with CKD
- International Pediatric PD Network (IPPN)
  - 19.7% prevalence of overweight/obesity in children at initiation of PD

- CKiD Data
  - Median energy/protein consumption exceeded recommendations in all age groups
  - 13% met activity goal
  - 98% exceed recommended screen time

Treating Growth Failure

• Metabolic abnormalities should be corrected and nutrition optimized prior to starting growth hormone
• Should be initiated pre-transplantation and pre-puberty
• KDOQI- guidelines for initiating growth hormone
• Varies by institution

Estimating energy requirements

- 100% of the EER for chronological age at healthy weight
- Adjusted for PAL (physical activity factor) and body size
- Further adjustment based on rate of weight gain or loss
- Malnourished children typically have higher energy requirements to support “catch-up” growth
- Children on PD-
  - Dextrose absorbed from dialysate may need to be considered for infants and children who are gaining weight more quickly than expected.
- Special equations for children who are overweight/obese

### Table 2. Equations to Estimate Energy Requirements for Children at Healthy Weights

<table>
<thead>
<tr>
<th>Age</th>
<th>Estimated Energy Requirement (EER) (kcal/d) = Total Energy Expenditure + Energy Deposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 mo</td>
<td>EER = [89 × weight (kg) − 100] + 175</td>
</tr>
<tr>
<td>4-6 mo</td>
<td>EER = [89 × weight (kg) − 100] + 56</td>
</tr>
<tr>
<td>7-12 mo</td>
<td>EER = [89 × weight (kg) − 100] + 22</td>
</tr>
<tr>
<td>13-35 mo</td>
<td>EER = [89 × weight (kg) − 100] + 20</td>
</tr>
<tr>
<td>3-8 y</td>
<td>Boys: EER = 88.5 − 61.9 × age (y) + PA × [26.7 × weight (kg) + 903 × height (m)] + 20</td>
</tr>
<tr>
<td></td>
<td>Girls: EER = 135.3 − 30.8 × age (y) + PA × [10 × weight (kg) + 934 × height (m)] + 20</td>
</tr>
<tr>
<td>9-18 y</td>
<td>Boys: EER = 88.5 − 61.9 × age (y) + PA × [26.7 × weight (kg) + 903 × height (m)] + 25</td>
</tr>
<tr>
<td></td>
<td>Girls: EER = 135.3 − 30.8 × age (y) + PA × [10 × weight (kg) + 934 × height (m)] + 25</td>
</tr>
</tbody>
</table>

Source: ref 175.

# Recommended Dietary Protein Intake

## Table 12. Recommended Dietary Protein Intake in Children with CKD Stages 3 to 5 and 5D

<table>
<thead>
<tr>
<th>Age</th>
<th>DRI  (g/kg/d)</th>
<th>Recommended for CKD Stage 3 (g/kg/d)</th>
<th>(100%-140% DRI)</th>
<th>Recommended for CKD Stages 4-5 (g/kg/d)</th>
<th>(100%-120% DRI)</th>
<th>Recommended for HD (g/kg/d)*</th>
<th>Recommended for PD (g/kg/d)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 mo</td>
<td>1.5</td>
<td>1.5-2.1</td>
<td></td>
<td>1.5-1.8</td>
<td></td>
<td>1.6</td>
<td>1.8</td>
</tr>
<tr>
<td>7-12 mo</td>
<td>1.2</td>
<td>1.2-1.7</td>
<td></td>
<td>1.2-1.5</td>
<td></td>
<td>1.3</td>
<td>1.5</td>
</tr>
<tr>
<td>1-3 y</td>
<td>1.05</td>
<td>1.05-1.5</td>
<td></td>
<td>1.05-1.25</td>
<td></td>
<td>1.15</td>
<td>1.3</td>
</tr>
<tr>
<td>4-13 y</td>
<td>0.95</td>
<td>0.95-1.35</td>
<td></td>
<td>0.95-1.15</td>
<td></td>
<td>1.05</td>
<td>1.1</td>
</tr>
<tr>
<td>14-18 y</td>
<td>0.85</td>
<td>0.85-1.2</td>
<td></td>
<td>0.85-1.05</td>
<td></td>
<td>0.95</td>
<td>1.0</td>
</tr>
</tbody>
</table>

DRI + 0.1 g/kg/d to compensate for dialytic losses.

†DRI + 0.15-0.3 g/kg/d depending on patient age to compensate for peritoneal losses.

Pediatric Renal Nutrition Taskforce (PRNT)

- International team of pediatric RDs and nephrologists
- Established to develop Clinical Practice Recommendations (CPRs) for energy and protein requirements for children with CKD 2-5 and 5D
### SDI: Suggested Dietary Intake

Based on the range from various international bodies research recommendations

<table>
<thead>
<tr>
<th>Month</th>
<th>SDI energy (kcal/kg/day)</th>
<th>SDI protein (g/kg/day)</th>
<th>SDI protein (g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>95–107</td>
<td>1.52–2.5</td>
<td>8–12</td>
</tr>
<tr>
<td>1</td>
<td>93–120</td>
<td>1.52–1.8</td>
<td>8–12</td>
</tr>
<tr>
<td>2</td>
<td>95–120</td>
<td>1.4–1.52</td>
<td>8–12</td>
</tr>
<tr>
<td>3</td>
<td>85–98</td>
<td>1.4–1.52</td>
<td>8–12</td>
</tr>
<tr>
<td>4</td>
<td>82–98</td>
<td>1.3–1.52</td>
<td>9–13</td>
</tr>
<tr>
<td>5</td>
<td>72–82</td>
<td>1.3–1.52</td>
<td>9–13</td>
</tr>
<tr>
<td>6–9</td>
<td>72–82</td>
<td>1.1–1.3</td>
<td>9–14</td>
</tr>
<tr>
<td>10–11</td>
<td>72–82</td>
<td>1.1–1.3</td>
<td>9–15</td>
</tr>
<tr>
<td>12</td>
<td>72–120</td>
<td>0.9–1.14</td>
<td>11–14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>SDI energy (kcal/kg/day)</th>
<th>SDI protein (g/kg/day)</th>
<th>SDI protein (g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>81–95</td>
<td>79–92</td>
<td>0.9–1.05</td>
</tr>
<tr>
<td>3</td>
<td>80–82</td>
<td>76–77</td>
<td>0.9–1.05</td>
</tr>
<tr>
<td>4–6</td>
<td>67–92</td>
<td>64–90</td>
<td>0.85–0.95</td>
</tr>
<tr>
<td>7–8</td>
<td>60–77</td>
<td>56–75</td>
<td>0.9–0.95</td>
</tr>
<tr>
<td>9–10</td>
<td>55–69</td>
<td>49–63</td>
<td>0.9–0.95</td>
</tr>
<tr>
<td>11–12</td>
<td>48–63</td>
<td>43–57</td>
<td>0.9–0.95</td>
</tr>
<tr>
<td>13–14</td>
<td>44–63</td>
<td>39–50</td>
<td>0.8–0.9</td>
</tr>
<tr>
<td>15–17</td>
<td>40–55</td>
<td>36–46</td>
<td>0.8–0.9</td>
</tr>
</tbody>
</table>

#### Table 3: Summary of recommendations

<table>
<thead>
<tr>
<th>Category</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Energy requirements</td>
<td>1.1 We suggest that the initial prescription for energy intake in children with CKD2–5D should approximate that of healthy children of the same chronological age.</td>
</tr>
<tr>
<td></td>
<td>1.2 To promote optimal growth in those with suboptimal weight gain and linear growth, we suggest that energy intake should be adjusted towards the higher end of the suggested dietary intake (SDI).</td>
</tr>
<tr>
<td></td>
<td>1.3 In overweight or obese children, adjust energy intake to achieve appropriate weight gain, without compromising nutrition.</td>
</tr>
<tr>
<td>2 Protein requirements</td>
<td>2.1 We suggest that the target protein intake in children with CKD2–5D is at the upper end of the SDI to promote optimal growth.</td>
</tr>
<tr>
<td></td>
<td>The protein intake at the lowest end of the range is considered the minimum safe amount and protein intake should not be reduced below this level.</td>
</tr>
<tr>
<td></td>
<td>2.2 We suggest that the protein intake in children on dialysis may need to be higher than the SDI for non-dialysis patients to account for dialysate protein losses.</td>
</tr>
<tr>
<td></td>
<td>2.3 In children with persistently high blood urea levels, we suggest that protein intake may be adjusted towards the lower end of the SDI, after excluding other causes of high blood urea levels.</td>
</tr>
</tbody>
</table>
Monitoring Protein Status

- Albumin and pre-albumin
  - Acute phase proteins
    - Suppressed in the setting of inflammation and edema
    - Low levels associated with increased mortality and morbidity
    - Not good markers of malnutrition and nutritional status
- Assess BUN: Creatinine
- Nitrogen balance studies
  - nPCR = normalized protein catabolic rate (adolescents on dialysis)
Evaluating Dietary Intake

• Methods of assessing intake
  • 24-hour food recall
  • 3 day food record
  • Food frequency questionnaire
  • iPhone apps

• Early identification of food preferences, allergies and intolerances
  • Important to create an individualized meal plan
Feeding in Infants and Toddlers

• Breastfeeding/Expressed Breast Milk preferred method for feeding
• Whey dominant infant formulas recommended if EBM not available
  • Low electrolyte and mineral formulas if K/phos restrictions needed
  • Fortify with formula powder or modular products to meet nutrition goals if fluid restrictions indicated
• Healthy infants show readiness for solids at 4-6 months
  • Frequently show delayed progression through normal stages of eating
  • Encourage families to follow the same eating and development timeline as that of a healthy child
    • Age appropriate introduction of solids
    • Minimize dietary restrictions if feasible and identify favorite foods
Feeding in school-age children

• Typically eat independently
• Continue oral stimulation and involve feeding therapy
  • Even if oral intake limited
• Consider school experience
• Include the child in discussions between caregivers and medical staff related to diet, nutrition, growth and medications
Adolescents

- Irregular eating patterns and meal skipping compromise patient’s ability to meet nutritional needs
- Should be directly involved in meal planning and diet education
- Nutrition education should focus on cafeteria food, processed foods, fast foods, snacks and alternative drinks, high in sodium and phosphorus additives
Nutrition Support

• Most children on dialysis (especially infants and toddlers) require supplemental to full nutrition support to meet requirements
  • Start with oral supplements if possible
  • Formula regimen guided by age, CKD stage, electrolyte and mineral imbalances, fluid allowance, food allergies/intolerance, GI symptoms
  • Blended Tube Feeding (BTF) may be better tolerated in patients with GI disturbances
IPPN (International Pediatric PD Network) 2007-2009

• Analyzed growth in 150 patients on PD <2 yrs of age
  • 32 % NG
  • 25% PEG
  • 22% oral supplements
  • 21% no supplemental feeding

Results:
• PEG /NG had significantly higher Ht and BMI SDS
• Ht velocity was greater in the enterally-fed infants

Conclusion:
• Early institution of enteral feeding improves longitudinal growth in infants receiving chronic PD

Rees et al, JASN 2011
## Comparison of Common Formulas

<table>
<thead>
<tr>
<th>Source (std kcal/oz)</th>
<th>ml</th>
<th>Prot (g)</th>
<th>Na (mg)</th>
<th>K (mg)</th>
<th>Ca (mg)</th>
<th>Phos (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow’s Milk</td>
<td>159</td>
<td>5.1</td>
<td>79</td>
<td>248</td>
<td>200</td>
<td>148</td>
</tr>
<tr>
<td>Human Milk (20)</td>
<td>142</td>
<td>1.5</td>
<td>25</td>
<td>75</td>
<td>46</td>
<td>20</td>
</tr>
<tr>
<td>Similac PM 60/40 (20)</td>
<td>147</td>
<td>2.2</td>
<td>23</td>
<td>80</td>
<td>56</td>
<td>28</td>
</tr>
<tr>
<td>Nephea Kids (37)</td>
<td>82</td>
<td>1.3</td>
<td>41</td>
<td>4</td>
<td>31</td>
<td>5</td>
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<tr>
<td>Kindergen (30)</td>
<td>100</td>
<td>1.5</td>
<td>46</td>
<td>24</td>
<td>22</td>
<td>19</td>
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<td>Renastart (30)</td>
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<td>1.6</td>
<td>49</td>
<td>22</td>
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<td>19</td>
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<td>Suplena (54)</td>
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<td>2.5</td>
<td>44</td>
<td>63</td>
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<td>Nepro (54)</td>
<td>56</td>
<td>4.5</td>
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<td>59</td>
<td>59</td>
<td>40</td>
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<td>Renalcal (60)</td>
<td>50</td>
<td>1.7</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>5</td>
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<td>Product</td>
<td>Nutrient</td>
<td>Form</td>
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<tr>
<td>Duocal</td>
<td>Carbohydrate/Fat</td>
<td>Powder</td>
<td></td>
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<tr>
<td>Solcarb</td>
<td>Carbohydrate</td>
<td>Powder</td>
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<tr>
<td>Complete amino acids</td>
<td>Protein</td>
<td>Powder</td>
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<tr>
<td>Microlipid</td>
<td>Fat</td>
<td>Emulsified Oil</td>
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<tr>
<td>MCT Oil</td>
<td>MCT Oil</td>
<td>Liquid</td>
<td></td>
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<tr>
<td>Liquid Protein</td>
<td>Protein</td>
<td>Liquid</td>
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<tr>
<td>Beneprotein</td>
<td>Protein</td>
<td>Powder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Blended Tube Feedings

Benefits

• Improvement in GI symptoms and bowel function (emesis, reflux, diarrhea)

• Can tailor the recipe to each patient’s needs

• Parents love being able to give their kids real food

Challenges

• More time consuming

• Diet and fluid restrictions can make it difficult to meet nutrient requirements

Can be more expensive

Increased complications with feeding delivery
Intradialytic Nutrition Therapies

**Intradialytic Parenteral Nutrition (+PO)**
- Amino acids, Dextrose, Lipids
- ↑ Wt, BMI, %IBW
- ↑ oral caloric intake
- Costly
- Adverse events
  - Hyperglycemia
  - Lipid intolerance
  - Hypophosphatemia

**Intradialytic Lipid Infusion (+PO)**
- Lipids only
- ↑ albumin, pre-HD BUN, nPCR, cholesterol
- ↑ Wt velocity and SDS, ↑ BMI
- Less costly
- No adverse events reported

Krause, JRN 2002; Goldstein, Ped Neph 2002; Orellana, JRN 2005; Haskin, JRN 2017
“Renal” Diet

Modifications to:
- Phosphorus, sodium, potassium and fluid
There is no “one size fits all”
- Be as liberal as possible to start
- Implement restrictions as indicated
- Individualize for:
  - Age
  - Stage of development
  - Food preferences
  - Biochemistry
- More liberal if residual renal function, on PD or daily HD
“Renal” Diet

What are children with CKD actually eating?

CKiD Data

- Consuming more energy, protein, sodium and phosphorus than recommended
- Milk largest contributor to kcal, protein, phosphorus, and potassium
- Fast foods major contributors to fat, sodium, energy, and phosphorus

Important to educate patients and families about healthier food choices early to establish healthy eating habits later in life!

Hui, Ped Neph 2017; Chen, Ped Neph 2017
Sodium and Fluids

Polyuria & Na+ Wasting

- Obstructive uropathies
- Renal dysplasia
- Na+ depletion in infants on PD

Goals:

- Adequate hydration
- Na+ supplementation
- Promote muscle development, bone mineralization
- Prevent growth retardation

Na+ & Fluid Retention

- Primary glomerular disease
- Oliguric or anuric

Goals:

- Fluid restriction
- Na+ restriction
- Prevent volume overload, HTN
- Decrease risk of CVD and LVH
Managing Sodium

- Processed ☐ Fresh
- Salt ☐ Herbs and no Na+ spices
- Restaurants ☐ Home prepared
- Limit Na+ to 1500-2000 mg daily (based on age)
- Read food labels

Choose mostly foods that have 140 mg of sodium or less

Low Sodium: < 35 mg
35 to 140 mg
140 to 250 mg
250 to 500 mg
> 500 mg

Medium to High Sodium
Managing Fluid

- Limit Na+ intake
- Small amounts divided through day
- Count obvious and hidden fluids
  - Fruits and vegetables
  - Popsicles
  - Soups
- Freshen mouth without drinking fluids
Potassium

- Reduce potassium intake from food
  - Consider potassium additives (potassium citrate)
- Use of adult renal formulas or modulars in combination with infant formulas
- Pre-treat and decant formula or EBM with sodium polystyrene sulfonate to partially remove potassium
  - Safer alternative to oral/rectal administration
  - Electrolyte derangements
  - Caution when using in patients needing sodium restriction
- Increased losses with PD
<table>
<thead>
<tr>
<th>Low K+ (5-150mg/serving)</th>
<th>Serving Size</th>
<th>Medium K+ (150-250mg/serving)</th>
<th>Serving Size</th>
<th>High K+ (250-500+mg/serving)</th>
<th>Serving Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-3 servings/day</td>
<td>1-2 servings/day</td>
<td>1 serving/day</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FRUITS AND VEGETABLES**

| Berries (Blue, black, raspberries, strawberries) | ½ cup | Apple, Pear | 1 medium | Banana, orange, nectarine, kiwi | 1 medium |
| Pears canned, Pineapple, Applesauce | ½ cup | Cherries | 8-10 | Tomato | 1 medium |
| Bean (green/wax), Corn | ½ cup | Grapes | 10-15 | Tomato Paste | 1/8 cup |
| Cauliflower, Peas, Cucumber | ½ cup | Mango | ½ medium | Potato | ½ cup or 1 small |
| Lettuce | 1 cup | Broccoli, Brussel Sprouts, Carrots | ½ cup | Squash, yams, sweet potatoes | ½ cup |
| Salt substitute | 1/4 tsp | ¼ tsp |

**BEVERAGES**

| Apple juice | ½ cup | Grapefruit Juice, Grape juice (canned) | ½ cup | Milk | 1 cup |
| Grape juice (frozen), Cranberry juice | 1 cup | Pineapple juice Apricot nectar | ½ cup | OJ, Prune juice, Tomato Juice, V-8 | ½ cup |
| Crystal Light, Capri Sun, Kool Aid, Lemonade, Iced Tea | 1 cup | Soy milk | ½ cup | Instant Breakfast type drinks | 1 cup |
Potassium

Think portion size!

Think cumulative!
Phosphorus

- Early nutrition intervention key to addressing CKD-MBD and consequences
  - Cardiovascular disease
  - Poor transplant outcomes
  - Bone damage post transplant

KDIGO CKD-MBD Update Work Group, Kidney Int 2017; Wesseling-Perry CJASN 2012; Wesseling-Perry NDT 2011
# Phosphorus Management

<table>
<thead>
<tr>
<th>Recommended Phosphorus Intake mg/d</th>
<th>Age (y)</th>
<th>DRI (mg/d)</th>
<th>High PTH</th>
<th>High PTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Normal Phos</td>
<td>High Phos</td>
</tr>
<tr>
<td>0-6 mo</td>
<td>100</td>
<td>&lt;100</td>
<td>&lt;80</td>
<td></td>
</tr>
<tr>
<td>7-12 mo</td>
<td>275</td>
<td>&lt;275</td>
<td>&lt;225</td>
<td></td>
</tr>
<tr>
<td>1-3</td>
<td>460</td>
<td>&lt;460</td>
<td>&lt;370</td>
<td></td>
</tr>
<tr>
<td>4-8</td>
<td>500</td>
<td>&lt;500</td>
<td>&lt;400</td>
<td></td>
</tr>
<tr>
<td>9-18</td>
<td>1250</td>
<td>&lt;1250</td>
<td>&lt;1000</td>
<td></td>
</tr>
</tbody>
</table>

## Sources of Phosphorus

<table>
<thead>
<tr>
<th>Inorganic</th>
<th>Organic</th>
<th>Phosphorus-based Food Additives (up to 1000 mg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal</td>
<td>Plant</td>
<td>Dairy Derived</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HIGH Phos/Prot (Meat, Fish, Poultry)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LOW Phos/Prot (Egg white 1.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plant Derived (Lentil 20)</td>
</tr>
</tbody>
</table>

Adapted from Adema et al, JRN 2014; Carrigan JRN 2014; Uribarri, Semin Dial 2003
Phosphorus Management

Decrease Phosphorus Intake

- Offer low phosphorus formulas.
- Delay introduction of cow’s milk.
- Limit intake of dairy
  - Offer low phosphorus proteins
- Limit or avoid sources of inorganic phosphorus
  - (food additives)

Adjust phosphorus binder dose and timing to meals, snacks, tube feeds
Pre-treat and decant formula with Sevelamer (Similar to Kayexalate)
- Can be useful in patients on continuous feeds or volume restrictions
- Time intensive
- Requires a fairly large dose of sevelamer for efficacy
- Alters nutrient profile
Calcium

- Important role in bone health in children
- Adequate is necessary, excess should be avoided
  - KDOQI: Goal intake 100% DRI for age – max 200%
  - Consider Calcium burden from diet, formulas, medications

<table>
<thead>
<tr>
<th>Age</th>
<th>DRI (mg/d)</th>
<th>Upper Limit (Diet + Binders)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 months</td>
<td>200</td>
<td>&lt;420</td>
</tr>
<tr>
<td>7-12 months</td>
<td>260</td>
<td>&lt;540</td>
</tr>
<tr>
<td>1-3 years</td>
<td>700</td>
<td>&lt;1000</td>
</tr>
<tr>
<td>4-8 years</td>
<td>1000</td>
<td>&lt;1600</td>
</tr>
<tr>
<td>9-18 years</td>
<td>1300</td>
<td>&lt;2500</td>
</tr>
</tbody>
</table>

# Calcium

<table>
<thead>
<tr>
<th>Phosphorus Binder</th>
<th>Elemental Ca (% of total)</th>
<th>Elemental Ca (mg/dose)</th>
<th>Phosphorus Bound mg (mg per 100 mg Ca2+ delivered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Acetate (667 mg)</td>
<td>25</td>
<td>167</td>
<td>45 (27 mg P/100 mg Ca2+)</td>
</tr>
<tr>
<td>Calcium Carbonate (1250 mg)</td>
<td>40</td>
<td>500</td>
<td>39 (8 mg P/100 mg Ca2+)</td>
</tr>
</tbody>
</table>
Vitamins

• Requirements = 100% DRI
• Adult renal formulas provide 100% of requirements without supplement
• Diet + Supplement < tolerable upper intake level (UL)
• Increased risk of deficiency
  • Intake limited by anorexia
  • Diet restrictions
  • Losses via dialysis
  • Interference with absorption, excretion, metabolism
• Children with CKD stage 5D should receive a water-soluble vitamin supplement

Vitamin D

• High prevalence of Vit D insufficiency in children with CKD

• Current KDOQI Guidelines:
  • Measure 25-hydroxy vitamin D at least annually
  • If <30 ng/ml (75 mmol/L) supplement with D2 or D3
  • In the repletion phase, check PO4 and Ca levels after 1 month
  • When replete, supplement vitamin D continuously and monitor yearly

Vitamin A

- Not removed by dialysis
- Rapidly absorbed and slowly cleared
- RBP catabolized in the renal tubules
- Vitamin A/RBP accumulation common and increases with stage of CKD
  - Elevated in majority of CKD and dialysis patients
- Sources
  - Preformed vitamin A (retinol) absorption rates = 70-90%
    - Supplements/fortification, fish liver oil, liver, egg
  - Provitamin A (beta-carotene) absorption rates = 20-50%
    - Carotenoids from plant sources
    - Cannot cause toxicity
- Vitamin A supplements contraindicated
Vitamin A

Signs/symptoms and complications of toxicity:

- Headaches, dry itchy skin, anorexia, bone pain, nausea/emesis
- Hypercalcemia
- Effects on bone
  - Increased hip fractures
- Intracranial hypertension
- Bulging fontanelle
- Pseudotumor cerebri
- Hepatomegaly
Vitamin A

- Intervention
  - Limit intake to DRI for age
  - Use modulars in formula to lower vitamin A administration
  - Promote intake of “real” food when appropriate
    - Formula and supplements contain high amounts of retinol
  - Use unfortified milks and foods
Other Vitamins

Vitamin E

- Commonly elevated in children on dialysis
- Insufficient evidence to recommend supplementation

Vitamin K

- Depleted with Antibiotic use
- Monitor for signs of deficiency

Water soluble vitamins

- No concrete guidelines/recommendations for specific monitoring
- Some institutions test periodically
- Recommend testing if signs/symptoms of deficiency or poor oral intake

MINERALS

MAGNESIUM
- Elevated levels found in dialysis patients

ZINC
- Commonly low in children on dialysis
- Varying response to supplementation
  - KDOQI - regular monitoring in patients on low protein diet or with poor intake
  - Monitor signs/symptoms of deficiency/toxicity

COPPER
- High and low levels found
- No clear recommendations for supplementation
  - Measure levels if deficiency or toxicity is suspected

SELENIUM
- Commonly low in children on dialysis
- Monitor signs/symptoms of deficiency
Education and Counseling

• Education with first intervention
• Frequent re-education
  • Be positive – focus on allowances
  • Incorporate personal preferences
  • Provide pleasure with food
• Role of cognitive function and developmental stage
• Health Literacy – child and caregivers

NKF, Am J Kidney Dis. 2009; Lum, Child, Care Health Dev 2017; Ellyn Satter Institute;
Beto, Int J Neph and Renovasc Dis, 2016; Morris, J Ren Care 2015; Chen, CJASN 2018;
Education and Counseling

Learning styles

• Motivational Interviewing
  • Patient-centered goals
• Teach Back Method
• Creative Strategies
  • Technology, game-based learning
    • Apps, videos, games
  • Incentive programs
  • Multidisciplinary approach

Swap This, for That: Starbucks

Swap it out
- Cold cream brew
- Nitro flat white
- Iced pumpkin spice latte
- Mocha
- White choc mocha
- Mocha or mocha coolde frap-

Tips when choosing a drink
- Best choice: drinks without added milk or creamers
- If consume milk-containing coffee drinks, limit milk to 4 ounces
- Swap out cow’s milk or cream for soy milk, almond milk or rice milk to help lower potassium and phosphorus content
- Some milk substitutes have added phosphorus or calcium. Check the label/brand
  - Starbucks almond and coconut milk contain some phosphate additives

- Herbal tea
- Cold brew coffee
- Caffé vanilla or espresso Frappuccino with soymilk and no whip
- Mango dragonfruit or strawberry acai lemonade or very berry hibiscus refresher
- Iced Americano
- Iced pumpkin spice latte with soymilk and no whip
- Iced caffè latte with soymilk
- Iced cinnamon dolce latte with soymilk and no whip
- Iced caramel cloud macchiato with soymilk (caramel sauce has some dairy)
- Matcha green tea latte with soymilk
- London fog tea latte with soymilk
Thank you
References

Growth and Nutritional Assessment


References

Growth and Nutritional Assessment

Fluids/Electrolytes

• Thompson KL, Flynn JT, Okamura D, Zhou L. Pretreatment of Formula or Expressed Breast milk with sodium polystyrene sulfonate (Kayexalate) as a treatment for hyperkalemia in infants with acute or chronic renal insufficiency. JREN. 2013. 23 (5): 333-339.

Feeding Intolerance and HBTF


Bone Metabolism