Nutrition Management of Children on Dialysis

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Seattle, WA
No Disclosures
Learning Objectives

- Review current practice guidelines for nutritional management of pediatric dialysis patients
- Discuss strategies for achieving nutritional goals
- Gain appreciation for the numerous nutritional challenges faced by caregivers of children on dialysis
Nutrition Goals for Children on Dialysis

- Promote normal growth and development
- Achieve and maintain optimal nutritional status
- Reduce risk of malnutrition, metabolic abnormalities, uremic toxicity and the consequences
### Phases of Growth

<table>
<thead>
<tr>
<th>From:</th>
<th>Fetal</th>
<th>Infant</th>
<th>Childhood</th>
<th>Pubertal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conception to birth</td>
<td>Birth-18 mos</td>
<td>18 mos-12 yrs</td>
<td>Onset of puberty</td>
<td></td>
</tr>
<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>
Growth Pattern and Dietary Intake in Children with CRI

>80% DRI

*normal* growth

<80% DRI

*reduced* growth velocity

<40% DRI

*cessation* of growth

*Fig. 3*—Relation between growth velocity, expressed as percentage of expected 50th centile velocity, and energy intake, expressed as percentage of that recommended for same age. ($r=0.72; P<0.001$.)

Betts and Magrath, BMJ 1974
Growth in Children with CRI Dating from Infancy

Decreased:
- Energy
- Protein
- Vitamin D

Associated with:
- Anorexia
- Vomiting
- Metabolic Disorders

Betts and Magrath, BMJ 1974
Indications for Nutrition Intervention

- Neonates with Low Birth Wt (<2500 gm) or Birth Wt z-score below -2 SD (<3%ile)
- Polyuria, Inability to concentrate urine
- Impaired ability to ingest or tolerate oral feedings
- Increased metabolic requirements
- Documented inadequate intake or intolerance of nutrients
- Acute wt loss of ≥ 10%
- BMI <5% for Ht Age or > 85% (overweight)
- Inadequate Wt gain, Lt or Ht below – 2SD (3%ile), or decrease in usual growth percentile
- Abnormal nutrition related biochemistry
## Frequency of Nutrition Assessment

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

**Abbreviation:** N/A, not applicable.

*Only applies to adolescents receiving HD.*
Additional Factors

- Medical – other conditions that may affect nutrition status and care
- Socio-economic, Contextual poverty
- Psychological factors
- Medications
Plotting Growth

WHO “Growth Standards”
Birth to 2yrs

CDC Reference Curves
2 yrs +
### KDOQI: Estimating Energy Needs

**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] + 105</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 × [23.7 × 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 × [23.7 × 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>

**Table 4. Physical Activity Coefficients for Determination of Energy Requirements in Children Ages 3 to 18 Years**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Sedentary</th>
<th>Low Active</th>
<th>Active</th>
<th>Very Active</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Typical activities of daily living (ADL) only</td>
<td>ADL + 30-60 min of daily moderate activity (eg, walking at 5-7 km/h)</td>
<td>ADL + ≥60 min of daily moderate activity</td>
<td>ADL + ≥60 min of daily moderate activity + an additional 60 min of vigorous activity or 120 min of moderate activity</td>
</tr>
<tr>
<td>Boys</td>
<td>1.0</td>
<td>1.13</td>
<td>1.26</td>
<td>1.42</td>
</tr>
<tr>
<td>Girls</td>
<td>1.0</td>
<td>1.16</td>
<td>1.31</td>
<td>1.56</td>
</tr>
</tbody>
</table>

NFK KDOQI Clinical Practice Guideline for Nutrition in Children with CKD: 2008 Update
KDOQI: Protein Recommendations

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>Recommended for CKD Stages 4-5 (g/kg/d)</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>1.5-1.8</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>1.2-1.5</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>1.05-1.25</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>0.95-1.15</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>0.85-1.05</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.
Micronutrients

Increased risk of deficiency

- Anorexia
- Diet restrictions
- Poor absorption
- Altered metabolism
- Dialysis related losses
Micronutrients

Fat and Water Soluble Vitamins
Zinc
Copper
- Supplement if intake low, signs of deficiency, or low blood levels
- Recommend water soluble vitamin for dialysis patients – intake from diet and supplement should not exceed UL

NFK KDOQI Clinical Practice Guideline for Nutrition in Children with CKD: 2008 Update
Vitamin D

- Replete as needed
- Once replete check annually

### Table 22. Recommended Supplementation for Vitamin D Deficiency/Insufficiency in Children with CKD

<table>
<thead>
<tr>
<th>Serum 25(OH)D (ng/mL)</th>
<th>Definition</th>
<th>Ergocalciferol (Vitamin D₂) or Cholecalciferol (Vitamin D₃) Dosing</th>
<th>Duration (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>Severe vitamin D deficiency</td>
<td>8,000 IU/d orally or enterally × 4 wk or (50,000 IU/wk × 4 wk); then 4,000 IU/d or (50,000 IU twice per mo for 2 mo) × 2 mo</td>
<td>3</td>
</tr>
<tr>
<td>5-15</td>
<td>Mild vitamin D deficiency</td>
<td>4,000 IU/d orally or enterally × 12 wk or (50,000 IU every other wk, for 12 wk)</td>
<td>3</td>
</tr>
<tr>
<td>16-30</td>
<td>Vitamin D insufficiency</td>
<td>2,000 IU daily or (50,000 IU every 4 wk)</td>
<td>3</td>
</tr>
</tbody>
</table>

*Note: Conversion factor for Serum 25(OH)D: ng/mL × 2.496 = nmol/L.*

Adapted with permission.¹²¹
First Nutrition

- Breast feeding
- Expressed breast milk
- Formula
- Concentrate EBM or formula with modular products to achieve goal intake

- Delay transition to Cow’s milk due to nutrient profile
Feeding Challenges

CHALLENGES:

- Nausea vomiting
- GI dysmotility, GERD
- Unwillingness to eat
- Feeding disorders

INTERVENTIONS:

- Formula manipulations
- Prokinetics, acid blocking meds, PPI
- Positioning, small, frequent, thick feeds
- Feeding specialists (OT, ST, psychiatrist)
- Tube feeding, continuous feeds, j-tube feeding, fundoplication

Ruley, Ped Neph, 1989; Ravelli, Arch Dis Child, 1992
## Nutrient Content Comparison per 100 kcal

<table>
<thead>
<tr>
<th>Source (kcal/oz)</th>
<th>mL</th>
<th>Pro(g)</th>
<th>Na(mg)</th>
<th>K(mg)</th>
<th>Ca (mg)</th>
<th>P(mg)</th>
</tr>
</thead>
<tbody>
<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>Renastart (30)</td>
<td>100</td>
<td>1.6</td>
<td>50</td>
<td>23</td>
<td>22</td>
<td>57</td>
</tr>
<tr>
<td>Suplena (54)</td>
<td>56</td>
<td>2.5</td>
<td>44</td>
<td>63</td>
<td>59</td>
<td>40</td>
</tr>
<tr>
<td>Nepro (54)</td>
<td>56</td>
<td>4.5</td>
<td>59</td>
<td>59</td>
<td>59</td>
<td>40</td>
</tr>
<tr>
<td>Renalcal (60)</td>
<td>50</td>
<td>1.7</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<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>
</tbody>
</table>
Modular Products
## Macronutrients

### Table 7. Acceptable Macronutrient Distribution Ranges

<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>Children 1-3 y</th>
<th>Children 4-18 y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>45%-65%</td>
<td>45%-65%</td>
</tr>
<tr>
<td>Fat</td>
<td>30%-40%</td>
<td>25%-35%</td>
</tr>
<tr>
<td>Protein</td>
<td>5%-20%</td>
<td>10%-30%</td>
</tr>
</tbody>
</table>
Managing Potassium and Phosphorus in Formula Fed Patients

Potassium
- Bunchman et al, Ped Neph 1991 – Pretreating with SPS
- Hobbs et al, JRN 2010 – Managing hyperkalemia in Infant using Adult Renal Formulas
- Thompson et al, JRN 2013 – Pretreatment of formula and EBM with SPS

Phosphorus
- Ferrara et al, Ped Neph 2004 – Pretreat of EBM with Sevelamer
- Raaijmakers et al, Perit Dial Int 2013 – Pretreatment of EBM and cow’s milk with Sevelamer

Both
- Taylor et al, Ped Neph 2015 – Pretreatment of renal formulas alters profile
Tube Feeding

Indications:
- Oral supplementation

Routes:
- NG/ G/ GJ

Encourage:
- Regular non-nutritive sucking and oral stimulation for infants
- Optimal daytime oral intake with O/N feeds in children
Nutrition Support Study

IPPN (International Pediatric PD Network) 2007-2009

To analyze growth in infants on PD <2 yrs - 150 infants:

- 32% NG
- 25% PEG
- 22% oral supplements
- 21% no supplemental feeding

- PEG /NG had significantly higher Ht and BMI SDS
- Ht velocity was greater in the enterally-fed infants
## Return to Complete Oral Feeding

<table>
<thead>
<tr>
<th>Study</th>
<th>Age at start of Tube Feed</th>
<th>Duration of feed*(mos)</th>
<th>n</th>
<th>Time post Tx* (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Warady, 1990</strong></td>
<td>Birth – 1 mos</td>
<td>19 (12-43)</td>
<td>6/6</td>
<td>2 (1-18)</td>
</tr>
<tr>
<td><strong>Dello Strollogo 1997</strong></td>
<td>6.5 mos (5d-4 y)</td>
<td>20.5 (9-32)</td>
<td>12/12</td>
<td>6 (0to &gt;24)</td>
</tr>
<tr>
<td><strong>Coleman, 1998</strong></td>
<td>2.3 (0.2-10.3)</td>
<td>14.5 (2.5-56)</td>
<td>13/13</td>
<td>2.8 (0.8-8.3)</td>
</tr>
<tr>
<td><strong>Kari, 2000</strong></td>
<td>0.7 yr (0-4.5)</td>
<td>23(1-82)</td>
<td>64/66</td>
<td>&lt; 6</td>
</tr>
<tr>
<td><strong>Pugh, 2006</strong></td>
<td>1.7 yr (0.3-4.3)</td>
<td>29(6-106)</td>
<td>16/16</td>
<td>≤10</td>
</tr>
</tbody>
</table>

*Median (range)*
Oral Supplements
Intradialytic Parenteral Nutrition

IDPN:
- Allows augmentation of inadequate nutritional intake for malnourished children on HD, unable to meet requirements orally or through tube feeding

IV – via venous drip chamber during HD
- Amino acids
- Dextrose
- Lipids
Intradialytic Parenteral Nutrition

IDPN + PO

- 100-150% energy requirements
- ↑ weight ↑ BMI ↑%ideal body weight
- ↑ oral caloric intake
- albumin unchanged

Adverse events:
- hyperglycemia,
- lipid intolerance
- hypophosphatemia

Krause, JRN 2002; Goldstein, Pediatr Nephrol 2002; Orellana, JRN 2005
Oral Diet Modifications

“Renal” Diet – individualize to the patient

- Fluids
- Sodium
- Potassium
- Calcium
- Phosphorus (Protein)
Fluids

Output
- Urine
- Insensible losses
- Ultrafiltration

Input
- 80% fluids are pourable
- 20% are from foods
  - Liquid at room temperature
  - High fluid content
- Infant formulas ~90%
- Pediatric and adult formulas ~70-85%
Sodium

Source: CDC.gov
Sodium

Source: US census data
Sodium Intake – Preschool Age

Daily sodium intake by age and race/ethnicity

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Black</th>
<th>White</th>
<th>Mexican American</th>
<th>Upper intake level*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants</td>
<td>500 mg</td>
<td>400 mg</td>
<td>600 mg</td>
<td>1300 mg</td>
</tr>
<tr>
<td>1-3 years</td>
<td>2000 mg</td>
<td>1500 mg</td>
<td>1700 mg</td>
<td>1900 mg</td>
</tr>
<tr>
<td>4-5 years</td>
<td>2700 mg</td>
<td>2400 mg</td>
<td>2200 mg</td>
<td>2400 mg</td>
</tr>
</tbody>
</table>

* In 2005, the Institute of Medicine (IOM) established a Tolerable Upper Intake Level for sodium of 2,300 mg per day for adults. It represents the highest daily intake that does not appear to carry risks of negative health effects in normal, healthy people. Levels for children were inferred from adult levels based on typical age-specific caloric intake. No level was set for infants.

Source: CDC.gov, 2013
Sodium Intake – School Age

How much sodium do children eat?
Most children are eating too much sodium daily, and teens are consuming foods higher in sodium than younger children.

10 sources of sodium in children’s diets
About 43% of sodium eaten by children comes from just 10 common food types:
- Pizza
- Bread/rolls
- Cold cuts/cured meats
- Savory snacks
- Sandwiches
- Cheese
- Chicken patties/nuggets, etc.
- Pasta mixed dishes
- Mexican mixed dishes
- Soups


Sodium

- Replaced packaged/processed foods with fresh foods
- Limit restaurant foods
- Replace salt with herbs and spices in food preparation
- Avoid the salt shaker at the table
- Read food labels – choose foods that are low in sodium – less than 140 mg/serving
- Consider sodium provided by medications
Sodium

Always read the Nutrition Facts label to compare foods. Choose foods with the lowest Percent Daily Value (%DV) for sodium. The %DV lets you see if a food is high or low in sodium. 5% or less is low and 20% or more is high.

- Check the label on fresh meats and poultry. Sodium additives can be used to make meat last longer.

- Look for foods labeled: sodium free, salt free, very low sodium, low sodium, reduced or less sodium, light in sodium, no salt added, unsalted, and lightly salted.

Check the Ingredient Label for Added Sodium

- Salt (sodium chloride)  
- Monosodium glutamate or MSG  
- Baking soda (sodium bicarbonate)  
- Baking powder  
- Sodium nitrate  
- Sodium sulfite  
- Sodium phosphate  
- Sodium alginate  
- Sodium benzoate  
- Sodium hydroxide  
- Sodium propionate

Source: niddk.nih.gov – NKDEP
Potassium

Excretion maintained until GFR <15 ml/min/1.73 m²

Increased risk of hyperkalemia:

- acidosis
- urinary obstruction
- K+ - sparing diuretic
- ACEI
- beta blockers
- Rhabdomyolysis, hemolysis
Potassium
Calcium

Table 20. Recommended Calcium Intake for Children with CKD Stages 2 to 5 and 5D

<table>
<thead>
<tr>
<th>Age</th>
<th>DRI</th>
<th>Upper Limit (for healthy children)</th>
<th>Upper Limit for CKD Stages 2-5, 5D (Dietary + Phosphate Binders*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 mo</td>
<td>210</td>
<td>ND</td>
<td>≤420</td>
</tr>
<tr>
<td>7-12 mo</td>
<td>270</td>
<td>ND</td>
<td>≤540</td>
</tr>
<tr>
<td>1-3 y</td>
<td>500</td>
<td>2,500</td>
<td>≤1,000</td>
</tr>
<tr>
<td>4-8 y</td>
<td>800</td>
<td>2,500</td>
<td>≤1,600</td>
</tr>
<tr>
<td>9-18 y</td>
<td>1,300</td>
<td>2,500</td>
<td>≤2,500</td>
</tr>
</tbody>
</table>

Abbreviation: ND, not determined.

*Determined as 200% of the DRI, to a maximum of 2,500 mg elemental calcium.
Calcium Intake

- Consider Calcium burden from diet, formulas, medications
- Supplement to DRI if dietary intake is suboptimal – carbonate, acetate, lactate, gluconate salts.

<table>
<thead>
<tr>
<th>Binder</th>
<th>% Elemental Ca</th>
<th>Elemental Ca (mg)</th>
<th>mg Phos Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Acetate (667 mg)</td>
<td>25</td>
<td>167</td>
<td>45 (27 mg per 100 mg Ca)</td>
</tr>
<tr>
<td>Calcium Carb (1250 mg)</td>
<td>40</td>
<td>500</td>
<td>39 (8 mg per 100 mg Ca)</td>
</tr>
</tbody>
</table>
### Phosphorus

**Table 23. Recommended Maximum Oral and/or Enteral Phosphorus Intake for Children With CKD**

<table>
<thead>
<tr>
<th>Age</th>
<th>DRI (mg/d)</th>
<th>High PTH and Normal Phosphorus*</th>
<th>High PTH and High Phosphorus†</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 mo</td>
<td>100</td>
<td>≤100</td>
<td>≤80</td>
</tr>
<tr>
<td>7-12 mo</td>
<td>275</td>
<td>≤275</td>
<td>≤220</td>
</tr>
<tr>
<td>1-3 y</td>
<td>460</td>
<td>≤460</td>
<td>≤370</td>
</tr>
<tr>
<td>4-8 y</td>
<td>500</td>
<td>≤500</td>
<td>≤400</td>
</tr>
<tr>
<td>9-18 y</td>
<td>1,250</td>
<td>≤1,250</td>
<td>≤1,000</td>
</tr>
</tbody>
</table>


* ≤ 100% of the DRI.
† ≤ 80% of the DRI.
Phosphorus

Natural component of food
80% of DRI (1000-1200mg/d) provided by:
- milk and milk products
- meat, poultry, fish
- whole grains

Limited removal through dialysis
### **PO₄ to Protein Ratio of Foods**

Table 13. Average Ratio of Phosphorus to Protein Content in Various Protein-Rich Foods

<table>
<thead>
<tr>
<th>Food Category</th>
<th>Ratio of mg Phosphorus to g Protein</th>
<th>Ratio Adjusted for Digestion/Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg white</td>
<td>1.4</td>
<td>1</td>
</tr>
<tr>
<td>Meat</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Tofu</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Egg</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Legumes</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>Lentils</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>Nuts</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>Milk</td>
<td>29</td>
<td>21</td>
</tr>
<tr>
<td>Seeds</td>
<td>50</td>
<td>29</td>
</tr>
</tbody>
</table>

*Note: Mathematical estimations based on protein digestibility-corrected amino acid scores (PDCAA) and data on estimated phosphorus bioavailability.*

Figure 1. Schematic representation of differences in bioavailability among different dietary sources of phosphorus. The sources that are low in the diagram represent the lowest uptake of phosphorus from the gastrointestinal tract. Dairy source is depicted separately because in general it has an unfavorable phosphorus-to-protein ratio. See text for detailed explanation.
Phosphorus

Additives in food manufacturing – several functions

- Foods with PHOS based food additives are nearly 70% higher in phosphorus content compared to their natural version

- May contribute as much as 1000 mg/d to intake

- The added phosphorus content is not accounted for in data bases.

Benini et al, JRN 2011; Sullivan et al, JRN 2007; Uribarri and Calvo, Semin Dial 2003
Phosphorus

- **Low** phosphorus infant feedings (Breast milk, PM 60/40, Suplena) and **Delay** introduction of cow’s milk, use non-dairy substitutes

- **Limit**: intake of highly bioavailable forms of phosphorus – dairy foods, some protein foods, foods containing added phosphorus

- **Adjust** binder dose, timing to content of meals/snacks/ TF

- **Read** ingredient lists for “PHOS” based additives
My Plate for CKD

ChooseMyPlate.gov

Proscia, JRN 2014
Diet Prescription

- Restrict *only* when clearly needed
- Individualize for:
  - age,
  - stage of development
  - food preferences
- As liberal as possible! - restrict further depending on response
- Less restricted if RRF, on PD or daily HD
Education and Support

- Initiate nutrition education at start of nutrition interventions, first introduction of solid foods
- Frequent Re-Education
- Creative Strategies
- Identify preferred learning style(s)
- Variety of teaching styles and tools
- Utilize incentive programs – building on skills
- Involve the team through every step