Pediatric Nutrition and Kidney Disease

Loai Eid, MD, MSHS, FAAP
Consultant Pediatric Nephrologist
Pediatric Nephrology & Hypertension Division Chief
Dubai Hospital - DHA
26th October, 2017
Objectives

• To learn the components of nutrition assessment of the pediatric renal patient

• To understand the factors that contribute to poor nutrition and growth among children with kidney disease

• To know nutrient recommendations for children in different stages of chronic kidney disease and renal replacement therapy
Chronic Kidney Disease (CKD)

- Normal GFR is 100-120 ml/min per 1.73 m²
- Stage 1: Kidney damage GFR >90
- Stage 2: GFR 60-89
- Stage 3a: GFR 45-59
- Stage 3b: GFR 30-44
- Stage 4: GFR 15-29
- Stage 5: GFR <15 (ESRD)
## Causes of Pediatric ESRD: 2006-2010

<table>
<thead>
<tr>
<th>CAUSE</th>
<th>Incidence (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cystic/Congenital malformations</td>
<td>35%</td>
</tr>
<tr>
<td>Glomerular Disease (e.g. FSGS)</td>
<td>23.2%</td>
</tr>
<tr>
<td>Secondary Glomerular Disease/Vasculitis</td>
<td>11.3%</td>
</tr>
<tr>
<td>Interstitial nephritis/pyelonephritis (chronic)</td>
<td>5.2%</td>
</tr>
<tr>
<td>Hypertensive/large vessel disease</td>
<td>5%</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>2%</td>
</tr>
<tr>
<td>Neoplasms/Tumors</td>
<td>2%</td>
</tr>
<tr>
<td>Complications of transplant</td>
<td>1.1%</td>
</tr>
<tr>
<td>Miscellaneous (e.g. SCD, HIVAN)</td>
<td>6.3%</td>
</tr>
<tr>
<td>Unknown</td>
<td>9.7%</td>
</tr>
<tr>
<td>Missing data</td>
<td>3.9%</td>
</tr>
</tbody>
</table>

Source: USRDS (usrds.org)-2012
Goals of Nutrition Therapy in Pediatric Renal Disease

• Maintain adequate intake of macro and micronutrients

• Avoid uremic toxicity, metabolic imbalances, and renal bone disease (MBD)

• Optimize growth and development

• Reduce risk of chronic morbidities and mortality in adulthood
Growth in Chronic Kidney Disease

Factors that impact growth include:

- Poor nutrition
- Sodium wasting
- Renal osteodystrophy
- Corticosteroids therapy
- Metabolic acidosis
- Growth hormone (GH) resistance
Growth in Chronic Kidney Disease

• Nutrition is primary factor during infancy

• Growth hormone during childhood
  – Decreased production of IGF-1
  – Decreased expression and function of growth hormone receptor

• Sex hormones during adolescence

• Nutrition support proven to improve growth in infants (no clear evidence in older children)

Body Composition

• Studies suggest lean mass deficit and excess fat mass relative to height in children with CKD

• GH therapy may promote lower fat mass and greater lean mass for height in these children

Growth Hormone Therapy

- RCTs have shown benefit of rGH in children with CKD (ht SDS and growth velocity)

- International database of 240 children on rGH
  - Demonstrated continuous catch up growth
  - 40% reached normal adult height

Growth Hormone Therapy

Indicated for children with kidney disease when:

• Height or growth velocity SDS score < -1.88

• No metabolic acidosis (C02 ≥ 22)

• Growth potential documented by open epiphyses and good bone health (PTH within acceptable range)

• Adequate nutritional status...but how is this defined?
Defining Malnutrition

- World Health Organization defines as wt/age, ht/age, and wt/ht \( \leq -2 \) SDS for general pediatric population

- Definitions may not apply to children with CKD due to many non-nutritional causes of stunting and delayed maturation

- Wt/age SDS may not accurately reflect nutritional status and must be evaluated in context of ht/age (BMI for age, BMI for ht-age, or wt/length)
Nutrition Assessment:
Parameters to be monitored

- Dietary intake (3 day record or recall)
- Est dry weight-for-age %ile/SDS
- Ht-for-age %ile/SDS and growth velocity
- BMI-for-height-age %ile or SDS
- Head circumference-for-age %ile/SDS (≤3yrs)
- Normalized protein catabolic rate (nPCR)
Malnutrition in Kidney Disease

**Altered/decreased taste sensitivity**
- Accumulation of uremic toxins
- Micronutrient deficiencies (Zinc)
- Decreased # of taste buds

**Reduced appetite and nutritional intake**
- Unpalatable prescribed diet and binder regimens/ restriction of favorite foods due to low sodium, potassium, and phosphorus diets
- Delayed gastric motility, reflux, and vomiting
- Uremic inflammation
- Alterations in hormonal and neuropeptide signaling

Malnutrition in Kidney Disease

• Dialysis procedure may promote wasting:
  - AA, peptides, protein, glucose, water-soluble vitamins, and other bioactive compounds

• Polyuria and urinary wasting:
  - Sodium and other electrolytes

• Chronic Inflammatory state
  - Hypercatabolism, anorexia, and increased cytokines.
Neuropeptide Alterations and Appetite

Decline in GFR with CKD progression

Increased cytokines, leptin, and insulin

Down-regulate Neuropeptide Y

Inhibit appetite
The “Renal Diet”

• There is not a standard “Renal Diet”

• Individualized dietary recommendations determined based on:

  ✓ GFR and diagnosis
  ✓ Age and sex
  ✓ Protein and energy status
  ✓ Growth parameters
  ✓ Fluid status: urine output, electrolyte-wasting
  ✓ Oral motor skills
  ✓ Renal Replacement Modality
# Nutrient Needs in CKD Pre-dialysis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Estimated Need</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>100% EER chronological age (Calculated per equations)</td>
</tr>
<tr>
<td>Protein</td>
<td>100 - 140% of DRI (stage 3)</td>
</tr>
<tr>
<td></td>
<td>100 – 120% of DRI (stage 4 &amp; 5)</td>
</tr>
<tr>
<td></td>
<td>Avoid excessive intake</td>
</tr>
<tr>
<td>Sodium / Fluid</td>
<td>Supplement or restrict</td>
</tr>
<tr>
<td>Potassium</td>
<td>Restrict if levels elevated (1-3 mEq/kg/d)</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>100% DRI in early CKD</td>
</tr>
<tr>
<td></td>
<td>80% DRI when phos elevated</td>
</tr>
</tbody>
</table>

Fluid and Sodium Dichotomy in CKD

• Chronic intravascular depletion and impaired growth will occur in children with polyuric salt-wasting CKD, so supplemental NaCl and fluid are needed.

• Conversely, fluid and sodium restriction may be needed in children with hypertension, nephrotic syndrome, and/or oliguria.

Parekh et al. JASN 2001:12:2418-2426
Factors to Consider in Determining Pre-dialysis Protein Needs

- Nutrition intervention with low protein diet does not delay progression of renal failure in children

- Concern over possible harms of strict low protein diet effect on growth in infants

- Excess protein intake contributes to uremia and metabolic acidosis
Factors to Consider in Determining Pre-dialysis Protein Needs

Increased protein intake correlates with

- Increased phosphorus load
- Increased risk of calcifications and bone disease

Zerbi S et al. JCEM 2008;93:1121-1122
Potential Renal Solute Load (PRSL)

- The PRSL refers to all solutes of dietary origin that require excretion by the kidney

- $\text{PRSL} = \frac{N\text{ (mg)}}{28} + \text{Na} + \text{Cl} + \text{K} + \text{Pa}$
  
  Electrolyte units in mM, Pa=total mM phos in milk-based formulas or 2/3 of soy formulas; $N(g) = g\text{ protein}/6.25$
Potential Renal Solute Load

• For patients with decreased renal concentrating ability, choose formula with low PRSL

• PRSL of:
  • Whole cows milk= 46 mOsm/100 kcal
  • Soy infant formula= 24 mOsm/100 kcal
  • Milk infant formula= 20 mOsm/100 kcal
  • Human breast milk= 14 mOsm/100 kcal
## Nutrient Needs in ESRD Hemodialysis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>100% EER chronological age</td>
</tr>
<tr>
<td>Protein</td>
<td>100%DRI + Dialytic losses (0.1 g/kg/d)</td>
</tr>
<tr>
<td>Sodium</td>
<td>Restrict (usual 2g/d)</td>
</tr>
<tr>
<td>Potassium</td>
<td>Restrict 1-3 mEq/kg/d</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Limit to 100%DRI (80% DRI when elevated)</td>
</tr>
<tr>
<td>Fluid</td>
<td>Replace UOP + other losses</td>
</tr>
</tbody>
</table>
Normalized Protein Catabolic Rate (nPCR)

- Calculated measure of dietary protein intake per kg of patient weight
- Trends in nPCR have been shown to correlate with changes in dry weight in adolescent HD patients
- nPCR should be monitored monthly and targeted to age-specific protein guidelines for HD
- Modified Borah equation = 5.43x G/V1 + 0.17
Nutrient Needs in ESRD
Peritoneal Dialysis

• Calories: usual for chronological age – calories absorbed from PD solution (~40%)

• Protein: 100%DRI + dialytic losses
  • Losses range from 0.15-0.3 g/kg/d depending on age

• Fluid and Electrolytes: Individualize therapy

• Phosphorus: limit to 100% DRI (80% DRI when elevated)

• Potassium restriction rarely needed
Estimating Kcals Absorbed from PD

- Multiply total dialysate volume (24hrs) x concentration of dextrose solution (1.36%, 2.27%, or 3.83%) = Total grams of dextrose

- Multiply total grams of dextrose by estimated absorption (40% for CCPD; 43% +/-15% absorbed for acute PD in critical care setting)

- Multiply grams dextrose by 3.4 Kcal/gram

### 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.
Bone Management: Calcium CKD and Dialysis

- Minimum calcium intake: 100% DRI from diet + binders
- Maximum calcium: 200% DRI from diet + binders

<table>
<thead>
<tr>
<th>AGE GROUP</th>
<th>DRI (mg/d)</th>
<th>MAX Calcium Intake (200%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 mon</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>6-12 mon</td>
<td>260</td>
<td>520</td>
</tr>
<tr>
<td>1-3 years</td>
<td>700</td>
<td>1400</td>
</tr>
<tr>
<td>4-8 years</td>
<td>1000</td>
<td>2000</td>
</tr>
<tr>
<td>9-18 years</td>
<td>1300</td>
<td>2600</td>
</tr>
</tbody>
</table>
Bone Management: Phosphorus
Limit intake to 80% of DRI when PTH and PHOS are elevated

<table>
<thead>
<tr>
<th>AGE</th>
<th>PHOS DRI (mg/d)</th>
<th>HIGH PTH, HIGH Phos Limit (mg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 mon</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>6-12 mon</td>
<td>275</td>
<td>220</td>
</tr>
<tr>
<td>1-3 years</td>
<td>460</td>
<td>370</td>
</tr>
<tr>
<td>4-8 years</td>
<td>500</td>
<td>400</td>
</tr>
<tr>
<td>9-18 yrs</td>
<td>1250</td>
<td>1000</td>
</tr>
</tbody>
</table>
Phosphorus Binders

Calcium Based
- Calcium carbonate
- Calcium acetate
- Calcium carbonate suspension

Non-Calcium Based
- Renagel (Sevelamer hydrochloride)
- Renvela (Sevelamer carbonate)
- Fosrenol (Lanthanum carbonate)*

http://excelchemistry.wikispaces.com/Lanthanum
Vitamins and Trace Elements
CKD Stage 3-5 and Dialysis

**CKD 3-5**: goal to meet 100% DRI from diet for all vitamins, copper, and zinc; supplement only if deficient

**Dialysis**: add a daily water soluble vitamin supplement (dose for age):

- Nephrovite (tablet)
- Nephrocap (capsule)
- Nephronex (liquid)
Vitamin D
CKD and Dialysis

- **25-OH Vitamin D**: monitor levels yearly; if <30, supplement with cholecalciferol or ergocalciferol
  - 5-15 ng/dL: 4000 Units/d x 12 weeks
  - 16-30 ng/dL: 2000 Units/d x 12 weeks

- **1,25-OH Vitamin D**: initiate when serum PTH above target range for CKD stage

<table>
<thead>
<tr>
<th>CKD Stage</th>
<th>GFR Range</th>
<th>Target PTH (pg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>60-89</td>
<td>35-70</td>
</tr>
<tr>
<td>3</td>
<td>30-59</td>
<td>35-70</td>
</tr>
<tr>
<td>4</td>
<td>15-29</td>
<td>70-110</td>
</tr>
<tr>
<td>5</td>
<td>&lt;15</td>
<td>200-300</td>
</tr>
</tbody>
</table>
Nutrition After Renal Transplantation

- Goal is to meet nutritional requirements while minimizing comorbidities associated with chronic immunosuppressive medications:
  - Rapid weight gain/obesity
  - Dyslipidemia
  - Hypertension
  - Post-Transplant diabetes mellitus
  - Steroid-related osteoporosis
Dietary Modifications After Transplant

- Frequent dietary counseling to manage post-transplant weight gain, especially in the first 6 months

- Healthy diet with emphasis on limiting intake of saturated fats, simple sugars, and sodium

- Calcium and Vitamin D intake should meet 100% DRI
THANK YOU!